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Trends in Emerging Markets Finance, Institutions and Money

Edited by
Duc Khuong Nguyen and Stéhane Goutte

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Trends in Emerging Markets Finance, Institutions and Money

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Special Issue Editors

Duc Khuong Nguyen
Stéphane Goutte

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About the Special Issue Editors

Duc Khuong Nguyen is Professor of Finance and Deputy Director for Research at IPAG Business School (France). He holds a Ph.D. in Finance from the University of Grenoble Alpes (France) and an HDR (Habilitation for Supervising Scientific Research) degree in Management Science from University of Cergy-Pontoise (France), and he completed an executive education program in "Leadership in Development" at Harvard Kennedy School (United States). He is also President of the Association of Vietnamese Scientists and Experts (AVSE Global) and a Visiting Professor of Finance at International School, Vietnam National University. His research articles are published in various refereed journals, such as European Journal of Operational Research, Journal of Banking and Finance, Journal of Economic Dynamics and Control, Journal of Empirical Finance, Journal of International Money and Finance, Journal of Macroeconomics, Macroeconomic Dynamics, and Review of International Economics. Dr. Nguyen has edited many books on corporate finance and financial market issues and serves as a subject editor and associate editor of several finance journals. He is the co-founder (with Sabri Boubaker) of the Paris Financial Management Conference (2013–) and Vietnam Symposium in Banking and Finance (2016–).

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Preface to "Trends in Emerging Markets Finance, Institutions and Money"

During a speech at the University of Maryland in her role as Managing Director of the International Monetary Fund, on 4 February 2016, Christine Lagarde pointed out the increasing importance of emerging market countries as a locomotive of global growth (80% since the global financial crisis of 2008), job creation, poverty reduction and international trade activities. Together with other developing economies, they have contributed up to 60% of global GDP. However, emerging markets are still found to be vulnerable to external shocks; this vulnerability is essentially due to their ongoing maturing institutions and increased financial tights with their developed counterparts. High exposure to decreases in capital outflows following a more-rapid-than-expected tightening of the US monetary policy is another challenge that could hinder the economic growth and financial development of emerging markets. The recent geopolitical competition and trade war have also put emerging markets at risk, particularly those that continue to rely on international trade.

This Special Issue dedicates special attention to the current dynamics of emerging financial markets, as well as their perspectives on development as a key driver for sustainable firms and economies. Accordingly, the focus is particularly placed on market integration and interdependence, valuations and risk management practices, and the financing means for inclusive growth.

This book highlights a large panel of contributions in different sectors and cases using various methodologies and approaches. These include but are not restricted to the following:

- A study whose aim is to understand and identify the main factors that can influence the performance and efficiency of 94 commercial listed banks from Eurozone countries through a dynamic evaluation;
- An investigation of the impact of corporate diversification and financial structure on the firms' financial performance;
- An examination on the extent that this link has been attracting attention from policymakers, academics, and practitioners for some time, particularly for emerging countries;
- An exploration of the relationship between the degree of financial risk disclosure and a firm's financial attributes;
- An analysis of the impact of a short-selling ban on market efficiency for the Dhaka Stock Exchange (DSE) through the consideration of runs in daily stock returns and then the formation of a distribution of return clusters according to their duration;
- A comparison of the performance of several methods to calculate the value-at-risk of the six main ASEAN stock markets.

Duc Khuong Nguyen, Stéphane Goutte
Special Issue Editors

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Article

European Bank's Performance and Efficiency

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Abstract: The research interest in bank profitability and efficiency is linked to the economic situation and an important issue for policymakers is to ensure economic stability. Nevertheless, managerial decisions and the environment could play a critical role in ensuring proper and efficient allocation of the resources. The purpose of this study is to understand which are the main factors that can influence the performance and efficiency of 94 commercial listed banks from Eurozone countries through a dynamic evaluation, in the period between 2011 and 2016. To achieve this aim, the generalized method of moments estimator technique is used to analyze the influence of some bank-specific characteristics, controlled by management, on the profitability as a measure of bank performance. After that, through the value-based data envelopment analysis (DEA) methodology, those factors are considered in determining the efficient banks. The results show that banking efficiency depends on set bank-specific characteristics and that the effect of determinants on efficiency differs, considering the macroeconomic conditions.

Keywords: determinants of bank performance; generalized method of moments; value-based DEA; multi-criteria decision aiding

JEL Classification: G21; G15; C33; C44; C61

1. Introduction

The research interest in bank efficiency has been recognized for a long time since banks play a central role in the economic development and growth of a country. The presence of an increasingly competitive market reinforces the great importance of assessing banks' performance to continuously improve their financial condition (Beck et al. 2000; Rajan and Zingales 1998). However, an efficient and profitable banking system is even more important for countries characterized as belonging to the civil law model, more oriented to the banking system, and less to the capital market system[1].

Due to liberalization and internationalization, competition in the financial sector has increased and, consequently, the pressure to obtain higher levels of profitability and efficiency increased as well (Meles et al. 2016). Moreover, the world banking sector, with the recent global financial crisis, had difficulty accessing financing, causing problems in terms of financial autonomy. This event has given greater importance to the banking sector concerning the global economy.

[1] For an interesting seminal paper which attempts to combine insights from the theory of corporate finance, institutional economics, and different legal and economic systems, see La Porta et al. (1998). See also Levine (2002) for a summary of the theoretical views on bank-based and market-based systems.

Therefore, Athanasoglou et al. (2008) displayed that profitability is also important for the survival of banks, since the higher their profitability, the greater their economic capacity to cope with unfavorable situations. Besides this, efficiency is also a perception that guarantees the survival of the banks and that should be explained. This concept is often used as a synonym for productivity, however, it is a relative concept. It compares what was produced, given the resources available, with what could have been produced considering the same resources.

In this context, it is necessary to understand better which factors are determinants for bank efficiency, i.e., which variables could be more relevant for the manager´s decisions to improve bank performance.

Thus, the purpose of this study is to investigate how intrinsic characteristics of banks in Eurozone countries, have an impact on bank efficiency for a period covering six consecutive years, 2011–2016. Member countries should have similar levels of economic performance, especially in the banking system, as European Union regulatory changes are designed to push the industry into the direction of a single market, especially in countries with a common currency.

In this view, the present work offers several relevant contributions to the existing literature. Firstly, the paper focuses on the banking sector, which plays a central role in the economic development and growth of a country. A profitable and efficient sector leads to more economic development. Secondly, it studies Eurozone banking, which since the financial crisis has faced major changes in terms of performance and restructuring (e.g., new capital requirements, new demands on the adequacy of directors, incentive system). Moreover, several studies have already been carried out with the aim of comparing the various economic cycles (e.g., Tsionas et al. 2015), and others helped us to identify the various moments of crisis, speculative period and deep crisis (for example, Neves et al. 2019). To that extent, we believe that our work can be considered original because it emphasizes a period not of a deep and global financial crisis, but of a sovereign debt crisis, called the eurozone crisis.

Thirdly, dual analysis is proposed, and to the best of the literature knowledge, this topic has not been studied jointly: (1) the dynamic evaluation of bank profitability uses the generalized method of moments (GMM) method (Arellano and Bond 1991; Arellano and Bover 1995; Blundell and Bond 1998), where past performance impacts present performance; (2) and the value-based data envelopment analysis (DEA) method is also used to measure banking efficiency (Gouveia et al. 2008). The GMM system provides new evidence about which bank-specific variables are important to explain banks´ profitability. After that, the value-based DEA method, considering these specifics variables, identifies which banks in the dataset are the best performers. DEA is a technique for measuring the relative efficiency of peer decision making units (DMUs) doing business under the same operating conditions and allows the consideration of multiple inputs and multiple outputs in global performance evaluation. As an efficiency measure for a given DMU, the DEA uses the maximum of weighted outputs to weighted inputs.

The information that results from this type of dual analysis can be used to help the managers to identify the gaps of inefficiency, i.e., the factors in which further improvements are needed, to set future development strategies and to identify the best targets for the inefficient DMUs. Without discharge of the importance of the traditional ratio measures, it is known that each of the ratios examines only part of the activities of the DMU under analysis, leading to insufficient information on the global performance. Several authors confirm that DEA is one of the most successful operational research techniques used in evaluating banks' performance (Fethi and Pasiouras 2010; Paradi and Zhu 2013).

Finally, the results show that management decisions, reflected in the specific characteristics of the bank, are important factors explaining profitability. Moreover, the findings highlight that if bank managers want to protect their performance, they will have to improve cost management efficiency. This study can be considered as an extension to the existing literature because it focuses on the early years after the crisis (e.g., Christopoulos et al. 2019; Wild 2016). Such exposure can be relevant for managers, regulators and potential investors. The relative comparison of bank performance across Eurozone countries enables us to identify the best practices in a way that could allow policies to be established to improve the efficiency of less efficient banks, facilitate an understanding of the impacts

of constant regulatory changes on banking operations and investigate the ability of banks to realign their business with banking operations.

The remainder of the paper is organized as follows: Section 2 surveys the relevant literature on banking profitability and reviews the hypotheses to test. Section 3 is dedicated to the data and methodological framework. The results for the dynamic evaluation are presented in Sections 4 and 5 provides some final considerations.

2. Literature Review and Hypothesis

According to Varmaz (2007) the factors that most influence the profitability of banks are market conditions regarding competition as well as service production capability. Therefore, profitability corresponds to how the company is managing its resources to create value. To measure the profitability of banks, the return on average equity (ROAE) and return on average assets (ROAA) ratios are traditionally used, because they are connected with some advantages. The ROAE provides a direct assessment of the financial return for shareholder's investment (Lee and Kim 2013) and the ROAA shows the bank's ability to generate revenue through better asset utilization (Ongore and Kusa 2013). Trujillo-Ponce (2013) argues that ROAA is perhaps the most important measure for comparing the efficiency and the operational performance of banking institutions. This is because the ROAA explains the success of the management in obtaining results with the assets that the bank holds.

The ROAE considers the contribution of all equity and off-balance sheet events, while the ROAA disregards off-balance sheet activities (Athanasoglou et al. 2008), as commitments assumed by the bank, which generate income but are not recorded in the accounts of the bank. The new challenge for bankers is focused on balance sheet management in their loan pricing discipline with strong control of operating expenses. Thus, this suggests that ROAA could be the best measure to capture bank performance.

According to extensive previous studies, the importance of factors determining the banks' performance is not new and was strengthened in the last two decades due to the fall in banking earnings, accelerated by the global financial crisis (Ghosh 2016).

These earlier studies have focused their analyses on individual country-specific studies like Athanasoglou et al. (2008); Dietrich and Wanzenried (2011); García-Herrero et al. (2009); Rumler and Waschiczek (2016), among others. Further authors already consider cross country data, for instance, Bitar et al. (2018); Dietrich and Wanzenried (2014); Nguyen (2018); Pasiouras and Kosmidou (2007); Staikouras and Wood (2004).

According to Trujillo-Ponce (2013), the determinants of bank performance could be dichotomized. First, there is a group of bank-specific determinants, resulting directly from managerial decisions, such as asset composition, capitalization, operational efficiency or size. The second group of determinants includes factors relating to the macroeconomic environment or industry specificities, such as industry concentration, economic growth, inflation, and interest rates.

In this paper, on the one hand, a model with specific characteristics of the bank, to understand which are determinant in the achievement of profitability will be considered. From there, using the value-based DEA method, it will be possible to observe how important these variables are in the definition of an efficient bank, using a cross-country comparison. Therefore, this article starts with a set of variables widely debated in the literature to estimate the bank's profitability and ends with the efficiency evaluation of banks via value-based DEA, which confirms the importance of the economic environment.

2.1. Bank-Specific Characteristic's to Determine Profitability

2.1.1. Asset Composition

The bank asset structure is an interesting bank-specific factor and the relationship with profitability is far from conclusive.

Also referred to as asset diversification, the ratio of total loans to total assets have a positive relationship in the literature, since asset diversification, e.g., hedge funds or other assets, is considered to increase profitability (Saona 2016). So, in general, loans have a positive influence on profitability, because as a bank's core business, they are a major generator of interest income (Bikker and Hu 2002).

Based on this assumption, authors, like Bourke (1989); García-Herrero et al. (2009); Saona (2016); Trujillo-Ponce (2013) refer to a positive relationship between the relative percentage of loans in the assets of a bank and its profitability.

However, other authors pointed out that ambiguous effects depending on the profitability measure are considered (Valverde and Fernández 2007; Tan et al. 2017; Trabelsi and Trad 2017), while a negative relationship between the asset structure of banks and its profitability was obtained by Bikker and Hu (2002) or Rumler and Waschiczek (2016). A large set of loans implies higher operating costs and probably the premium put on long-term interest rates (as included in the credit rate), insufficient cover for processing costs, credit losses and the cost of required capital reserves.

Consistent with this empirical evidence, the first hypothesis is stated:

Hypothesis 1. *There is a relationship between the asset bank's composition and its performance.*

2.1.2. Equity

There are reasons to believe that a better-capitalized bank should be more profitable because banks with higher capital to assets ratios are considered relatively safer to financial institutions with lower capital ratios. A bank with higher capital will have more flexibility to absorb negative shocks, so this positive impact on bank performance can be because capital acts as a safety net in the case of adverse developments (Athanasoglou et al. 2008; Beltratti and Stulz 2012). Also, a high level of capital can lead to a lower cost of debt, as to finance their assets, banks will not need as many interest-bearing funds. In other words, this relation would help the bank to finance its assets at the more favorable interest rates, increasing expected profitability and offsetting the cost of equity, considering the most expensive bank liability in terms of expected return (Garcia and Guerreiro 2016; Tran et al. 2016). García-Herrero et al. (2009) also argue that more capitalized banks have a high value, so they have incentives to remain well-capitalized and to engage in prudent lending. Following these arguments, it seems that banks with higher capital-to-assets ratios usually have a reduced need for external funding, which again has a positive effect on their profitability (Kosmidou 2008; Pasiouras and Kosmidou 2007). Thus, the empirical evidence indicates that the best performing banks are those who maintain a high level of equity concerning their assets. Consistent with these influences, a direct association between capital and profitability is expected, and the following hypothesis is established:

Hypothesis 2. *There is a positive relationship between the equity ratio of a bank and its performance.*

2.1.3. Operational Efficiency

Traditionally, the operational efficiency for the bank sector is measured by using the cost-to-income ratio (CIR), and a higher CIR reflects more cost inefficiency. To increase profitability, it is necessary to increase the efficiency of the financial institution management (Athanasoglou et al. 2008; Dietrich and Wanzenried 2011), that is, the reduction of operational costs (administrative expenses, salaries of employees, property costs) and, at the same time, to increase revenues, that could lead to a high level of bank profitability. Therefore, this ratio is usually negatively related to profitability, see, for example, Azam and Siddiqui (2012); Dietrich and Wanzenried (2011); García-Herrero et al. (2009); Garcia and Guerreiro (2016); Guru et al. (2002); Pasiouras and Kosmidou (2007), among others.

Based on this assumption, the following hypothesis is considered:

Hypothesis 3. *There is a positive association between the operational efficiency of a bank and its performance.*

2.1.4. Size

There are a wide range of studies that associate bank dimension with profitability. The economies of scale are often cited as the reason why bank size may have a positive effect on bank profits (e.g., Diamond 1984), that is, the larger a bank, the more easily it can achieve economies of scale because, having a large dimension can increase its services with the same fixed costs, thus reducing expenses (Boyd and Runkle 1993). However, a too large bank may also incur diseconomies of scale as it will have an increase in costs, such as operational, bureaucratic and marketing expenses or inertia, thus negatively affecting the bank profitability (see, for example, Athanasoglou et al. 2008; Dietrich and Wanzenried 2011; Djalilov and Piesse 2016; Kosmidou 2008). According to García-Herrero et al. (2009), the increase in the size of the bank can also make bank management difficult due to the occurrence of aggressive competitive strategies.

Therefore, empirical research on the existence of economies of scale in banking does not come to a clear conclusion. In this context, some studies reveal a positive relationship between profitability and size (Ahamed 2017; Albertazzi and Gambacorta 2009; Altunbaş et al. 2001; Dietrich and Wanzenried 2014; Kosmidou 2008[2]; Petria et al. 2015), and others reveal a negative relationship (Berger et al. 1987; Pasiouras and Kosmidou 2007). Additionally, some authors like Athanasoglou et al. (2008); Bikker and Vervliet (2017) and Goddard et al. (2004), among others, found that bank size had no statistically significant influence on bank performance.

Since the literature is unclear regarding the sign of the relationship between bank size and profitability, the overall effect needs to be investigated empirically. Therefore, the following hypothesis is proposed:

Hypothesis 4. *There is a relationship between the bank size and its performance.*

3. Data and Methodological Framework

3.1. Data

The sample comprises 94 active banks listed on the main stock exchange from 19 Eurozone Countries for the period between 2011 and 2016. An unbalanced panel was constructed with the 94 European banks whose information was available for at least five consecutive years. Thus, this sample was chosen for two reasons: (i) all active banks, listed on the main stock exchange from 19 Eurozone Countries, were included as they were considered the banks with the highest volume of total assets; (ii) a necessary condition was that banks must have complete information on the variables under study, for at least five consecutive years; this condition was fundamental for the use of panel data methodology and specifically the GMM system method. We emphasize that these banks correspond to about 20% of the total assets of eurozone banks in 2016. This is important to test for second-order serial correlation, as Arellano and Bond (1991); Arellano and Bover (1995) and Blundell and Bond (1998) stated. The test for second-order serial correlation was realized because the estimation method GMM is based on this assumption (Neves 2018). The data were collected from the Bankscope database (Bureau Van Dijk's company) and it was used to test the hypotheses established in the previous section. Regarding the variables used in the model (1), since there is no consensus about which variables best explain the bank profitability, the ROAA will be considered as the dependent variable, following, for instance, Trujillo-Ponce (2013). The banks with high competition and high operating costs from increasing regulation, and fewer opportunities to raise fees to offset these costs, include an intense balance sheet management. So, in the author's opinion, ROAA could be the best way to explain bank performance, because it is a measure which depends in a large way on the

[2] This author shows positive effects of size on Greek bank's performance only when the macroeconomic and financial structure variables are introduced in the model.

management decisions. The explanatory variables selected in this study are related to factors that are specific to banks. These variables are controlled by management and reflect the different policies and managerial decisions; consequently, they command the bank´s performance (Dietrich and Wanzenried 2014, 2011; Djalilov and Piesse 2016; Guru et al. 2002). Table 1 displays more details about the selected explanatory variables.

Table 1. Description of the explanatory variables. Bank-specific characteristics as determinants of bank return on average assets (ROAA).

Asset Composition	The ratio of net loans to total assets (NLTA) measures asset composition between both loans and asset portfolios. The bank asset composition measure follows, for instance, Guru et al. (2002) or Trujillo-Ponce (2013).
Equity	The equity to assets ratio (ETA) is included to control for the degree of financial leverage. This is a measure of capital adequacy. The higher the ratio, the lower the risk of the bank. Capital adequacy was considered, for example, by Bourke (1989); Athanasoglou et al. (2008), or Kosmidou (2008).
Cost-to Income	The cost-to income ratio (CIR) represents the total expenses over total generated revenues as a measure of operational efficiency (%). The model includes CIR following, for instance, Kosmidou (2008); Garcia and Guerreiro (2016)
Bank Size	The bank size (SIZE) is the logarithm of the number of employees; (see, for example, Sabatier 2015 or Dang et al. 2018)

3.2. Methodological Framework Using GMM System

Considering the ROAA as the dependent variable, and the independent variables defined before, the model (1) is established:

$$\text{ROAA}_{it} = \beta_0 + \beta_1\text{ROAA}_{it\text{-}1} + \beta_2 NLTA_{it} + \beta_3 ETA_{it} + \beta_4 CIR_{it} + \beta_5 SIZE_{it} + \varepsilon_{it} \quad (1)$$

where ε_{it} is the random disturbance.

The model was estimated by using the GMM panel data methodology which has two important advantages regarding cross-section analysis. Firstly, it controls individual heterogeneity, and this fact is very important because the ROAA depends on management decisions, and this circumstance could be very closely related to the specificity of each bank. Secondly, the methodology resolves the endogeneity problem between the dependent variable and some of the explanatory variables, using lagged values of the dependent variable in levels and in differences as instruments. Thus, with this methodology, there is no correlation between endogenous variables and the error term, obtaining consistent estimates (Dietrich and Wanzenried 2014).

Therefore, the model was estimated using certain instruments, following Blundell and Bond's (1998) suggestion, when deriving the system estimator used in this paper. Note that the system GMM estimator also controls for unobserved heterogeneity and the persistence of the dependent variable. The regression was performed by using a two-step dynamic panel with equations at levels, as suggested by the same authors. García-Herrero et al. (2009) also say that the GMM system for an unbalanced panel model employs all possible instruments, and thus non-significant independent variables will be suppressed in a way that results are more effective.

3.3. Methodological Framework Using Value-Based DEA Method

There are different ways to evaluate efficiency; the parametric methods assume a pre-defined functional relationship between the resources and the products. Usually, they use averages to determine what could have been produced. The non-parametric methods, among which is the data envelopment analysis (DEA) method, do not make any functional assumptions and considers that the maximum that could have been produced is obtained by observing the most productive units. The underlying idea is to compare a set of similar units and then identify those that show best practices. Although

the efficiency concept is not always accurate, in most of the cases the Pareto–Koopmans definition is usually followed. The formal definition stated by Charnes et al. (1978) says that "A unit is full efficient if and only if it is not possible to improve any input or output without worsening some of other input or output." This definition avoids the need for explicitly specifying the formal relations that are assumed to exist between inputs and outputs and there is no need to have prices or other assumptions of weights, which are supposed to reflect the relative importance of the different inputs or outputs.

It is acknowledged and confirmed by several studies that multiple criteria decision aiding (MCDA) approaches are widely used in finance (for a comprehensive review, see Zopounidis et al. 2015). The value-based DEA method developed by Gouveia et al. (2008) is a variant of the additive DEA model (Charnes et al. 1985) with oriented projections (Ali et al. 1995), in order to overcome some of its drawbacks by applying concepts from multi-attribute utility theory (MAUT). MAUT is one of the most popular analytic tools associated with the field of decision analysis (Keeney and Raiffa 1976). In the spirit of MAUT, the inputs (factors to be minimized) and outputs (factors to be maximized) are firstly converted into value functions. This transformation allows dealing with negative data, which is a difficulty in classical DEA models (Charnes, Cooper and Rhodes – CCR model and Banker, Charnes, and Cooper - BCC model).

The set of n DMUs to be evaluated is: $\{DMU_j : j = 1, \ldots, n\}$. Each DMU_j is evaluated on m factors to be minimized x_{ij} $(i = 1, \ldots, m)$ and p factors to be maximized y_{rj} $(r = 1, \ldots, p)$.

The measure of performance on criterion c is: $\{v_c(DMU_j),\ c = 1, \ldots, q,$ with $q = m + p,\ j = 1, \ldots, n\}$ based on a value function (or utility function) $v_c(.)$.

Considering that p_{cj} is the performance of DMU j in factor c, the value functions must be defined such that, for each factor c the worst p_{cj}, $j = 1, \ldots, n$, has the value 0 and the best p_{cj}, $j = 1, \ldots, n$, has the value 1, resulting in a maximization of all factors. Therefore, the value functions are defined in the range [0, 1], which overcomes the scale-dependence problem of the additive DEA model.

A preliminary phase of the value-based DEA method comprises the assessment of marginal (partial) value functions on each criterion to establish a global value function. According to the additive MAUT model, the value obtained is $V(DMU_j) = \sum_{c=1}^{q} w_c v_c(DMU_j)$, where $w_c \geq 0$, $\forall c = 1, \ldots, q$ and $\sum_{c=1}^{q} w_c = 1$ (by convention). The weights $w_1, \ldots, w_q$ considered in the aggregation are the scale coefficients of the value functions and are established such that each alternative minimizes the value difference to the best alternative (bank), according to the "min-max regret" rule.

After the preliminary phase in which the factors (to be minimized and to be maximized) are converted into value scales, the value-based DEA method can be described in two phases:

Phase 1: Compute the efficiency measure, d_k^*, for each DMU, $k = 1, \ldots, n$, and the corresponding weighting vector w_k^* by solving the linear problem (2).

Phase 2: If $d_k^* \geq 0$ then solve the "weighted additive" problem (3), using the optimal weighting vector resulting from Phase 1, w_k^*, and determine the corresponding projected point of the DMU under evaluation.

Formulation (2) considers the super-efficiency concept (Andersen and Petersen 1993), which allows the discrimination of the efficient units when assessing the k-th DMU (Gouveia et al. 2013):

$$\begin{aligned} &\min_{d_k, w} d_k \\ &s.t.\ \sum_{c=1}^{q} w_c v_c(DMU_j) - \sum_{c=1}^{q} w_c v_c(DMU_k) \leq d_k,\ j = 1, \ldots, n; j \neq k \\ &\sum_{c=1}^{q} w_c = 1 \\ &w_c \geq 0,\ \forall c = 1, \ldots, q \end{aligned} \tag{2}$$

The efficiency measure, d_k^*, for each DMU k ($k = 1, \ldots, n$) and the corresponding weighting vector are calculated by solving the linear problem (2). The optimal value of the objective function d_k^* provides the distance in terms of the difference in value for the best of all DMUs (note that the best DMU will also depend on w), excluding this from the reference set. If the score obtained in (2), d_k^*, is not positive, then the DMU k under evaluation is efficient, otherwise, it is inefficient.

In case the DMU is inefficient, Phase 2 finds an efficient target by solving the linear problem (3):

$$\begin{aligned} &\min_{\lambda,s} z_k = -\sum_{c=1}^{q} w_c^* s_c \\ &s.t. \sum_{j=1, j\neq k}^{n} \lambda_j v_c\left(DMU_j\right) - s_c = v_c(DMU_k),\ c = 1, \ldots, q \\ &\sum_{j=1, j\neq k}^{n} \lambda_j = 1 \\ &\lambda_j,\ s_c \geq 0,\ j = 1, \ldots, k-1, k+1, \ldots, n;\ c = 1, \ldots, q \end{aligned} \tag{3}$$

The variables λ_j, $j = 1, \ldots, k-1, k+1, \ldots, n$ defines a convex combination of the value score vectors associated with the $n-1$ DMUs. The set of efficient DMUs defining the convex combination with $\lambda_j > 0$ are called the "peers" of DMU k under evaluation. The convex combination corresponds to a point on the efficient frontier that is better than DMU k by a difference of value of s_c (slack) in each criterion c.

4. Results for the Dynamic Evaluation

4.1. GMM Results

In this section, the results are discussed according to the literature review and the formulated hypotheses.

Table 2 presents the main descriptive statistics (mean, standard deviation, minimum and maximum) of the variables used in this study.

Table 2. Summary of statistics.

Variables	Mean	Std. Dev.	Minimum	Maximum
ROAA	0.357	1.376	−13.41	7.401
NLTA	53.157	22.691	0.022	90.91
ETA	8.824	7.481	−3.931	99.988
CIR	65.01	19.825	14.654	287.69
SIZE	7.988	1.975	3.611	12.175

The results of the estimation model are presented using a two-step dynamic panel with equations at levels. The data used are from 19 Eurozone banks for which information is available between 2011 and 2016. The resultant unbalanced panel comprises 94 banks.

Table 3 summarizes the empirical results for the profitability measure used, ROAA.

Table 3. Estimation results of the model (1).

Variables/Tests	Coefficient	Std. Error	Z	p Value	Significance Levels
const	5.234	−0.5696	9.19	0.000	***
L1.	0.0756	0.0145	5.2	0.000	***
NLTA	−0.0011	−0.0055	−0.2	0.843	
ETA	0.0045	−0.0131	0.34	0.731	
CIR	−0.0407	−0.00344	−11.82	0	***
SIZE	−0.2683	−0.05915	−4.54	0	***
Sargan			15.052 (13)	0.3041	
Wald			222.35 (5)	0.000	
AR (1)			−2.1307	0.0331	
AR (2)			−1.3925	0.1638	

The variables are defined in Table 1. The remaining information needed to read this table is as follows: (i) Heteroscedasticity consistent asymptotic standard error in parentheses; (ii) *, **, and *** indicates significance levels at 10%, 5%, and 1% respectively; (iii) The Sargan test with a *p value* greater than 5% shows that the instruments are valid, and the values in parentheses of the test represent degrees of freedom; (iv) The Wald test has a *p value* less than 5% which means that the joint significance and the coefficients are significant distributed asymptotically as $\chi 2$ under a null hypothesis without significance, with degrees of freedom in parentheses. The table shows that there is no first or second-order correlation problem in the model see AR (1) and AR (2).

As expected, the negative and significant coefficient of the cost-to-income ratio shows that poor expenses management is one of the main contributors to poor profitability performance. This evidence corroborates Hypothesis 3 following, for example, Guru et al. (2002), Garcia and Guerreiro (2016), among others.

As we can see in the table, bank size is negatively related to profitability based on the view that the higher the number of employees, the higher the salary of the bank and, therefore, the lower its operating profitability. For example, García-Herrero et al. (2009) suggest that higher bank profitability could lead to more employees and less efficiency.

The results obtained are not surprising especially taking into account that the sample is characterized, in general, by being a civil law system. In fact, in the bank-based system, the economy is predominantly financed by banks, and in our sample period, the regulatory environment changed because the Eurozone was affected by the global financial crisis and the sovereign debt crisis. Under an ever-changing environment, and new rules of Basel III Risk Agreement, banks have to reinvent themselves to improve their profitability; therefore, in this context, it seems natural that bank management should use all the synergies taking advantage of economies of scale. For this reason, it is not surprising that the variables related to bank costs are the most significant in the model.

4.2. Value-Based DEA Results

The value-based DEA was applied for the evaluation of the 94 banks, for the time interval 2011–2016, considering that the factors to be minimized (inputs) and factors to be maximized (outputs) are the same considered in the GMM, attending to the negative and positive coefficient signals (Table 4). The ROAA is on the side of factors to be maximized because it is the assumed measure of profitability. Therefore, it is considered to be the "more-the-better" type of performance measure.

Table 4. The direction of optimization for factors.

Factors to Minimize	Factors to Maximize
x_{SIZE}: Logarithm of the number of employees	y_{ROAA}: Return on Average Assets
x_{CIR}: Cost-to-Income Ratio	y_{ETA}: Equity to Total Assets
x_{NLTA}: Net Loans to Total Assets	

Let DMU_j, $j = 1, \ldots, 94$ be observed in $t = 1, \ldots, 6$ consecutive years. Then the sample used has 6×94 DMUs (DMU_j^t). The matrices of inputs and outputs of the 564 DMUs in evaluation are $X = (x_1^1, x_2^1, \ldots, x_{94}^1, x_1^2, x_2^2, \ldots, x_{94}^2, \ldots, x_1^6, x_2^6, \ldots, x_{94}^6)$ and $Y = (y_1^1, y_2^1, \ldots, y_{94}^1, y_1^2, y_2^2, \ldots, y_{80}^2, \ldots, y_1^6, y_2^6, \ldots, y_{94}^6)$, respectively.

Considering that the value p_{cj}^t is the performance of DMU j in factor c, for the year t, the factors performances are linearly converted into values following the procedure: Firstly, two limits, M_c^L and M_c^U, are defined for each factor, such that $M_c^L < min\left\{p_{cj}^t, j = 1, \ldots, 94; t = 1, \ldots, 6\right\}$ and $M_c^U > max\left\{p_{cj}^t, j = 1, \ldots, 94; t = 1, \ldots, 6\right\}$, for each $c = 1, \ldots, 5$. Secondly, the values for each DMU are computed using:

$$v_c^t\left(DMU_j\right) = \begin{cases} \frac{p_{cj}^t - M_c^L}{M_c^U - M_c^L}, \; if\ the\ factor\ c\ is\ to\ maximize \\ \frac{M_c^U - p_{cj}^t}{M_c^U - M_c^L}, \; if\ the\ factor\ c\ is\ to\ minimize \end{cases}, \quad j = 1, \ldots, 94;\ t = 1, \ldots, 6;\ c = 1, \ldots, 5 \tag{4}$$

The M_c^L and M_c^U values of the factors to minimize and the factor to maximize that were considered for all DMUs and for the interval 2011–2016 are displayed in Table 2.

The different DEA models have been widely used for performance evaluation in different practical applications, however, it is very common to find factors that have negative or zero values. For radial measures of efficiency, as the classical models (CCR and BCC), the presence of negative data is a problematical matter. The valued-based DEA overcomes this drawback by converting the performances on each factor into a value scale. Hence after being converted into value functions, all factors are to be maximized.

Value functions could also be obtained from the DMs' preferences and this may lead to piecewise and nonlinear value functions (see, for instance, Almeida and Dias 2012; Gouveia et al. 2015, 2016; and Gouveia and Clímaco 2018).

For this study, a unifying reference set for the whole period was considered, and then the optimal value difference d_k^* was computed for each bank k, in each year, making it possible to compare all of them across years.

The statistic of the scores d^* obtained with the evaluation of DMU's efficiency across the six years, using the value-based DEA method is depicted in Table 5. Attending to the results of the problem (2), the lower the value of d^* is, the better, and if d^* is negative then the DMU under analysis is efficient. The DMUs that have $d^* = 0$ are weakly efficient and the ones that have $d^* > 0$ are inefficient (Gouveia et al. 2013).

Table 5. Score statistics.

Statistics	2011	2012	2013	2014	2015	2016
# efficient banks	4	3	3	4	3	3
Average of d^* for the efficient banks	−0.069	−0.024	−0.026	−0.01	−0.014	−0.010
Std. Dev. of d^* for the efficient banks	0.123	0.033	0.041	0.011	0.007	0.008
Average of d^* for the inefficient banks	0.089	0.086	0.081	0.08	0.08	0.085
Std. Dev. of d^* for the inefficient banks	0.046	0.046	0.044	0.036	0.039	0.038
Overall Average of d^* of all banks	0.081	0.0823	0.0774	0.0754	0.0765	0.0814
Std. Dev. of d^* of all banks	0.0609	0.0496	0.0486	0.0406	0.0421	0.0415

The years 2011 and 2014 are the ones that show more efficient banks, however they display the very different average of d^*. The year 2011 has the banks with the highest average score (more negative values of d^*) for the efficient banks, however, it also has the banks with the highest average of d^* for the inefficient banks (more positive values). The overall average of the bank scores, considering the different years, are better for 2011, 2012 and 2016 (>0.8).

There are three efficient banks for the remaining years, but the scores of the efficient banks are on average better for 2012 and 2013.

Probably these results are reflective of the financial help that banks were getting, gradually, after the global financial crisis (Gulati and Kumar 2016), and that impact the different Eurozone countries at different times (Wild 2016). Faced with serious economic difficulties in Greece, the European Union has adopted an aid plan, including loans and supervision of the European Central Bank. Our results are in line with Christopoulos et al. (2019) since they show that the PIIGS countries (Portugal, Ireland, Italy, Greece, and Spain) have a high degree of inefficiency, which is aggravated after the sovereign debt crisis since these countries pursued a fragile economic policy for the macroeconomic characteristics of these countries

The largest number of efficient banks in 2011 can be explained by the fact that these banks are German (3 banks) and French (2 banks), See Table 6. Data from the Statistical Office of the European Communities (Eurostat) show that in 2011, despite the severe sovereign debt crisis in some countries, Europe accelerates expansion through Germany and France. The two biggest heads of the European Union's economy announced quarterly and annualized growth data above all analysts' forecasts. Both countries had an increase in the Gross Domestic Product (GDP).

Table 6. The scores of the banks classified as efficient at least once in 2011–2016.

Bank	Country	d^* (2011)	d^* (2012)	d^* (2013)	d^* (2014)	d^* (2015)	d^* (2016)
Bank 1	DE	0.0008	0.0197	0.0011	**−0.0076**	0.0115	0.0125
Bank 2	GR	0.0761	0.1596	**−0.0738**	0.1144	0.0886	0.068
Bank 3	DE	**−0.005**	**−0.0013**	**−0.0025**	0.0018	0.0059	0.0018
Bank 4	IT	0.0052	**−0.0076**	0.0078	0.0006	0.0015	**−0.0083**
Bank 5	ES	0.0097	0.0155	0.0022	**−0.0019**	**−0.0074**	0.0153
Bank 6	DE	**−0.0053**	**−0.0619**	0.002	**−0.0263**	**−0.0123**	**−0.0029**
Bank 7	MT	**−0.2531**	0.0222	**−0.0018**	**−0.0023**	0.0007	**−0.0194**
Bank 8	HR	0.0537	0.0678	0.0516	0.0546	**−0.0219**	0.0394
Bank 9	AT	**−0.0122**	0.0267	0.0129	0.0318	0.0233	0.0322

Table 6 exhibits the banks that were classified as efficient at least once in 2011–2016. The negative values of efficient DMUs are highlighted in bold. We decide to designate DMUs by banks to make it easier to follow.

The best-ranked bank, in terms of annual performance, was Bank 7, a bank of Malta. This bank has the best performance value for the return on average assets and equity to assets factors in 2011, when compared to all others in this and other years. This is likely to be related to good risk management practices necessarily implemented after the crisis. However, it also has a good performance value for the number of employees, which guarantees it to be classified as efficient in the following years. This is likely to be related to the good risk management practices necessarily implemented after the crisis (Bezzina et al. 2014).

It should be noted that, besides the Bank 7, banks that are efficient more than once, are German banks. However, Bank 4, an Italian bank, appears to be efficient as often as Spain's Bank 5.

In Table 7 the results of value-based DEA Formulation (2) are presented. Each DMU chooses its best feasible weights for factors to be classified as well as possible factors relative to the set of all DMUs (banks). That is, the efficiency scores were obtained by allowing DMUs to ignore some factors from the assessment since the DMU under evaluation is free to choose the weights associated with factors (value functions) that minimize the difference of value to the "best" DMU (bank), according to the "min-max regret" rule.

Table 7. Results of value-based data envelopment analysis (DEA) (efficiency score and optimal weights) and number of times as benchmarks, for efficient banks.

Banks	d^*	w^*_{ROAA}	w^*_{ETA}	w^*_{SIZE}	w^*_{CIR}	w^*_{NLTA}	N^{er} of Times as Benchmark
Bank 7 (2011)	−0.253	0.594	0.406	0.000	0.000	0.000	289
Bank 2 (2013)	−0.074	0.213	0.000	0.000	0.787	0.000	152
Bank 6 (2012)	−0.062	0.000	0.205	0.000	0.000	0.795	9
Bank 6 (2014)	−0.026	0.107	0.000	0.457	0.038	0.398	1
Bank 8 (2015)	−0.022	0.000	0.000	0.181	0.819	0.000	234
Bank 7 (2016)	−0.019	0.131	0.000	0.242	0.341	0.287	16
Bank 6 (2015)	−0.012	0.000	0.000	0.133	0.000	0.867	0
Bank 9 (2011)	−0.012	0.000	0.000	0.871	0.129	0.000	9
Bank 4 (2016)	−0.008	0.000	0.000	0.000	0.896	0.104	195
Bank 4 (2012)	−0.008	0.000	0.000	0.089	0.204	0.708	7
Bank 1 (2014)	−0.008	0.000	0.000	0.000	0.212	0.788	6
Bank 5 (2015)	−0.007	0.212	0.161	0.043	0.000	0.584	11
Bank 6 (2011)	−0.005	0.000	0.000	0.834	0.132	0.033	3
Bank 3 (2011)	−0.005	0.414	0.000	0.000	0.039	0.547	7
Bank 6 (2016)	−0.003	0.089	0.000	0.826	0.000	0.086	0
Bank 3 (2013)	−0.003	0.000	0.000	0.095	0.011	0.894	3
Bank 7 (2014)	−0.002	0.009	0.000	0.752	0.165	0.075	0
Bank 5 (2014)	−0.002	0.073	0.000	0.194	0.234	0.500	5
Bank 7 (2013)	−0.002	0.000	0.007	0.463	0.363	0.167	1
Bank 3 (2012)	−0.001	0.000	0.124	0.004	0.099	0.773	1

Considering the banks that were classified as efficient in 2011, it could be observed that most of them disregard y_{ROAA} and y_{ETA} ($w^*_{\text{ROAA}} = 0$ and $w^*_{ETA} = 0$). In the context of the economic and financial crisis, the profitability of banks suffered a significant reduction and, in some banks, fell to negative values. This may justify the fact that banks do not consider the return on average assets to be a factor in their evaluation; they are not "good" enough in it. Most of the efficient banks chose the y_{NLTA} as a relevant factor. This factor is the one that is more often chosen for the efficiency status and only four banks disregarded it from the evaluation (Bank 7 (2011), Bank 9 (2011), Bank 2 (2013) and Bank 8 (2015)). The German banks are placed at the efficiency frontier because they are the ones with the best performances associated with the risk factor and elect it as the most prevalent.

In order to find the cases where a DMU emphasizes the pure self-evaluation, in detriment to being evaluated as an organizational unit with a balanced set of factors, it is common to use a measure which consists of recording the frequency with which this DMU appears in the peer group of other DMUs (see the last column of Table 7). The higher the number of times that a DMU belongs to the linear combination that generates the projected points of other DMUs, the more likely it will be a good performance model (Charnes et al. 1984). Thus, in the set of inefficient banks, the bank that appears most often (289 times) in the linear combination that comprises the projected point (the target) is the Bank 7 (2011). This bank is followed by Bank 8 (2015), which is the second most chosen by inefficient banks. The inefficient banks choose as peers those who form the efficient frontier, the ones that have the best practices, and those who are similar to them in the way that they want to make the smallest effort on the factors towards improvement.

The solution obtained from Formulation (3) of the value-based DEA method is a proposal of an efficiency target (projection) for each inefficient bank. To attain an efficiency status, these inefficient banks must change their value in each factor by the amount indicated by s^*. Table 8 shows the results of Phase 2 only for the first 12 inefficient banks. It is interesting to observe that in the first 12 banks classified as inefficient, 11 were already classified as efficient in other years.

Table 8. Results of value-based DEA (Phase 2) for the first 12 inefficient banks.

Banks	d^*	w^*_{ROAA}	w^*_{ETA}	w^*_{SIZE}	w^*_{CIR}	w^*_{NLTA}	s^*_{ROAA}	s^*_{ETA}	s^*_{SIZE}	s^*_{CIR}	s^*_{NLTA}
Bank 4 (2014)	0.001	0.000	0.190	0.000	0.280	0.529	0.001	0.004	0.003	0.005	0.000
Bank 7 (2015)	0.001	0.000	0.000	0.523	0.326	0.151	0.001	0.017	0.058	0.001	0.000
Bank 1 (2011)	0.001	0.000	0.000	0.000	0.347	0.653	0.001	0.013	0.020	0.344	0.002
Bank 1 (2013)	0.001	0.000	0.025	0.000	0.000	0.975	0.001	0.006	0.000	0.008	0.032
Bank 4 (2015)	0.001	0.455	0.000	0.023	0.116	0.407	0.001	0.003	0.011	0.000	0.000
Bank 3 (2014)	0.002	0.147	0.097	0.000	0.000	0.756	0.002	0.000	0.000	0.005	0.002
Bank 3 (2016)	0.002	0.000	0.000	0.035	0.145	0.820	0.002	0.005	0.015	0.000	0.012
Bank 6 (2013)	0.002	0.000	0.000	1.000	0.000	0.000	0.002	0.111	0.273	0.002	0.204
Bank 5 (2013)	0.002	0.470	0.019	0.047	0.000	0.464	0.002	0.002	0.000	0.026	0.008
Bank 4 (2011)	0.005	0.000	0.000	0.108	0.112	0.779	0.005	0.016	0.009	0.000	0.046
Bank 3 (2015)	0.006	0.095	0.000	0.025	0.102	0.778	0.006	0.004	0.004	0.000	0.000

All the banks in Table 8, being close to the efficiency frontier, need to make a small effort on the factors towards improvement. However, all need to increase the y_{ROAA}. In fact, across the sample, 457 banks need to improve on this factor, considering that the same bank that has 6 years of evaluation. The positive slacks with higher average values are the ones associated with the factor x_{CIR}, which may indicate that most important sources of inefficiency are the return on average assets and cost-to-income ratio.

Considering all the inefficient banks, the factor that most often appears with null slacks is the x_{SIZE} (186 times). However, in 564 banks, 2/3 need to improve (reduce) also in this factor to be efficient. This result is noteworthy insofar as the banks listed in the sample are also considered the largest banks in each country and throughout this article, it is possible to verify that the size of the banks is a determinant of the profitability and consequent efficiency of the banks.

In short, the post-crisis period brought the Basel III agreement, which increased regulatory costs (Anagnostopoulos and Kabeega 2019). Thus, the cost-to-income ratio contributes to the banks' inefficiency, corresponding to the adjustment that the bank had to make after the crisis, accommodating the new regulatory costs.

The bank size and the composition of their assets appear as a promoter of efficiency and profitability and this is also in line with the post-crisis period. Small banks had more financial difficulties, as a result of capital inadequacy, and a lack of financial security margin (Anagnostopoulos and Kabeega 2019). The composition of the assets also shows that in the post-crisis period, banks with fewer impairments become more efficient.

Moreover, this study shows that the number of efficient banks remains constant in the period of the sovereign debt crisis (2011–2014) and the following two years (2015–2016). This result suggest that banks restricted their funding to the economy (Kevork et al. 2018), making bank assets important for efficiency and profitability. Therefore, our results suggest that the sovereign debt crisis will have consequences in this sector until 2016 and that this will naturally condition the economy.

5. Conclusions and Further Research

Over the last two decades, several important changes occurred in the European banking industry, leading to increased competition and pressure on bank profitability.

On the whole, the findings of this work highlight that if bank managers want to protect their performance, they will have to improve cost management efficiency.

In a very difficult economic and financial environment, the challenges of banks in a bank-oriented system are enormous and include low-interest rates, intense pricing competition for commercial and mortgage loans and higher operating costs, particularly related to regulatory compliance, technology, and health care. For this reason, the use of economies of scale is important, and the management decisions and specific factors of each bank, are determining factors for bank performance and efficiency.

This work points out the factors that lead to a bank being classified as efficient change, which confirms the importance of the economic environment in a way that could affect the bank performances, aside from the bank level features.

The new European regulation has been important, but the fact that in a universe of 564 DMUs (94 banks used in the value-based DEA method observed in six consecutive years) only 20 have been considered efficient shows that there is still a long way to go.

The main limitation of this study is related to the number of banks listed by country. So, for future research it would be interesting to analyze other markets and integrate institutional and ownership factors, with very different characteristics in civil law and common law countries; to compare the determinants of efficiency in the bull and bear periods also considering different external factors such cultural and market sentiment factors.

The results obtained could help managers, investors or governments to know how to improve the efficiency of their banking sector, which is the engine of the economy for civil law countries.

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Exchange Rate Misalignment and Capital Flight from Botswana: A Cointegration Approach with Risk Thresholds

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Abstract: This study investigates the impact of exchange rate misalignment on outward capital flight in Botswana over the period 1980–2015. The study uses the autoregressive distributed lag (ARDL) approach to cointegration and the Toda and Yamamoto (1995) approach to Granger causality. Botswana's currency misalignment was caused by current account imbalances. The most important determinant of capital flight from Botswana is trade openness, which indicates that exportable commodities are misinvoiced leading to net capital outflows. Our main findings show that in the long-run, when the currency is overvalued, the volume of capital flight through trade misinvoicing declines and increasing foreign reserves does not reduce outward capital flight. However, when the currency is undervalued, the volume of capital flight through trade misinvoicing increases and foreign reserves reduce outward capital flight. Investors respond more to prospects of devaluation than to inflation. Botswana should tolerate overvaluation of the pula of only up to 5%. When the pula is overvalued beyond 5%, capital flight increases substantially. The government has to formulate trade regulations and monitor imported and exported commodities. Botswana should also implement capital controls to limit capital smuggling and maintain monetary autonomy.

Keywords: real exchange rate; exchange rate misalignment; overvaluation; undervaluation; capital flight

1. Introduction

Botswana is a small, upper middle-income economy in sub-Saharan Africa, dependent on its mining sector. Its principal export commodity is diamonds and prudent natural resource management policies have propelled its economy to grow significantly compared to other resource-rich countries. In addition, political stability is one of Botswana's key features. Nonetheless, the country faces major economic problems. First, the capital-intensive mining sector has not reduced the persistent unemployment in Botswana. Second, the country has the third highest HIV prevalence in world, which increases fiscal pressures (Deléchat and Gaertner 2008; Hillboom 2008; Limi 2006; Matlho et al. 2019). In addition, previous studies indicate an important structural problem, namely, that Botswana's currency (the pula) is overvalued (Iyke and Odhiambo 2016; Limi 2006; Pegg 2010; Taye 2012). Limi (2006) and Pegg (2010) indicate that the substantial mining revenue plays a role in this overvaluation. Lindgren and Wicklund (2018) posit that diamond prices and business confidence in Botswana have a negative correlation with the domestic exchange rate. Hence, the important issue considered in this study is the effects of exchange rate misalignment on the economy.

The extant literature shows that exchange rate overvaluation can increase capital flight, misallocate resources, abate economic efficiency and induce unfavourable downward spirals of trade and exchange rate controls (Cuddington 1986; Dornbusch 1984; Edwards 1989; Pfeffermann 1985; World Bank 1984).

This study evaluates the impact of exchange rate misalignment on capital flight from Botswana over the period 1980–2015. The country aims to attract capital inflows to develop economic sectors other than mining. Botswana is unique because unlike other developing economies, it used only the fixed exchange rate regime since 1976. There has been no exchange rate regime change and the country has experienced significant undervaluation and overvaluation of the currency. It is conceivable that such misalignment has an impact on outward capital flight in Botswana. Botswana needs capital inflows for economic diversification, therefore, it is imperative to determine the impact of misalignment on capital flight from Botswana.

This study empirically investigates the impact of exchange rate misalignment on capital flight from Botswana. The examination contributes to the literature in two important ways. First, previous studies posit that the pula is overvalued but there is no study that evaluates the impact of exchange rate misalignment on capital flight from Botswana. The present study aims to fill this gap. The results of this study are important for implementing macroeconomic policies that support capital inflows for economic diversification in Botswana. Further, the World Bank (2019) indicates that Botswana's diamond mines will be depleted by 2030. In the absence of diamonds, Botswana's economic growth will decline drastically. Correcting exchange rate misalignment is necessary for early economic diversification and sustainable economic growth without diamonds.

Second, this investigation extends Gouider and Nouira (2014) methodological approach to misalignment. Gouider and Nouira (2014) defined overvaluation and undervaluation as either positive or negative misalignment without any thresholds. The lack of thresholds in Gouider and Nouira (2014) study implies that insignificant real effective exchange rate (REER) misalignments were included in the estimations. This study uses thresholds to capture only significant REER misalignment. This approach is important for determining which level of misalignment initiates high capital flight as an early warning indicator. This will curb substantial capital outflows, which are needed desperately for economic diversification in Botswana. The use of thresholds in this study allows policymakers to take informed actions in correcting misalignment, for example devaluing the currency. The results show that Botswana should tolerate overvaluation of the pula of only up to 5%. The present study uses the autoregressive distributed lag (ARDL) bounds testing approach to cointegration and the Toda and Yamamoto (1995) approach to Granger causality to determine the relationship between economic variables. This paper is organised as follows. Section 2 reviews the literature on exchange rate misalignment and capital flight. Section 3 presents the methodology used to achieve research objectives. Section 4 presents the results of the empirical models and discussions. Section 5 summarizes the results, reviews the objectives and provides policy implications. It also identifies areas for further investigation and study limitations.

2. Literature Review

The Smithsonian Agreement formulated in 1971 necessitated that developed nations should peg their currencies to the US dollar. The Nixon Shock caused the collapse of the Bretton Woods system of fixed exchange rates among developed nations. To stimulate economic growth by stabilising the real exchange rate (RER), developing economies subsequently adopted crawling pegs and managed floating regimes. In this regard, a major concern for economies engaged in trade is RER misalignment, which has economic growth implications. Misalignment is a common occurrence by which the RER deviates from the ideal or the equilibrium exchange rate. Fixed exchange rate regimes like Botswana are generally associated with exchange rate misalignment (Chowdhury and Wheeler 2015; Dubas 2009; Ghosh et al. 2015). Pesaran et al. (2001) define exchange rate misalignment as the percentage gap between the observed exchange rate and the equilibrium real exchange rate (ERER). Deviations of the RER from the equilibrium instigated major currency crises in developing nations, such as the 1994 Mexican currency crisis, the 1997 Asian currency crises and the 1999 Brazilian financial crisis. Currencies of Asian economies were significantly misaligned before the currency crisis (Chinn 2000; Coudert et al. 2013; El-Shagi et al. 2016; Jeong et al. 2010; Kinkyo 2008).

The literature posits that overvaluation of the RER was the cause of capital flight in Latin America (Cuddington 1986). The Latin American debt crisis was a financial crisis accompanied by significant capital flight. The debate as to whether capital flight initiated the debt crisis or foreign debt caused capital flight in Latin America is ongoing. Capital flight occurs when monetary assets flow out of a country rapidly as a response to economic and political changes. It leads to loss of wealth and depreciation of the local currency. Erbe (1985) defines capital flight as total private capital outflows from developing nations. Dooley (1986) and Lessard and Williamson (1987) suggest that capital flight should be distinguished by its motivations rather than economic consequences. A challenge facing research on capital flight is its measurements, which do not capture the actual value of capital flight because capital flight can occur illegally. Illegal capital outflow is large in developing economies since they have ineffective, or no capital controls to stimulate foreign direct investment (FDI) inflows. Capital flight has significant adverse effects on economic growth, particularly in developing economies, because it reduces private and public investment. As capital leaves the domestic economy, government tax revenue declines, which reduces funding for public investments. Therefore, the government must borrow from foreign bodies at high costs. The interest rate for an investor taking assets abroad is fixed. However, the loan interest incurred by the government increases with the magnitude of the loan. Hence, capital flight creates major debt obligations, particularly in developing economies (Cuddington 1986).

According to Hermes et al. (2004), capital flight occurs owing to macroeconomic instability and manifests in multiple ways, such as budget deficits, current account deficits, overvaluation of the currency and high inflation. Overvaluation of the domestic currency is an important underlying determinant of capital flight. Expectations of depreciation are high when the currency is overvalued. Since investors aim to maximize returns and avoid welfare losses, domestic investors would be inclined to send their monetary assets abroad. The literature on exchange rate misalignment argues the Botswana pula is overvalued because of mining revenue (Limi 2006; Pegg 2010). Hence, this study aims to identify the impact of exchange rate misalignment on capital flight from Botswana as an attempt to promote FDI inflows, economic diversification and sustainable growth.

Few studies investigate the effects of exchange rate misalignment on capital flight. To determine these effects, we have to reflect on the exchange rate expectations theory developed by Hermes et al. (2004). The theory posits that an overvalued currency leads to increasing expectations of depreciation in the future. As a result, economic agents will demand more foreign goods than domestic goods, leading to inflationary pressures and loss of real income. Under such circumstances, economic agents will prefer to hold their assets abroad to avoid welfare losses, leading to capital flight. Gouider and Nouira (2014) examine the role of exchange rate misalignment on capital flight for a sample of 52 developing economies using data on the 1980–2010 period. Their results show that strong undervaluation of the domestic currency restricts capital flight, while strong overvaluation stimulates it (Gouider and Nouira 2014). Further, Sohrabji (2011) examines the link between capital flows and REER overvaluation. The author uses Edwards' (1989) model, cointegration tests and an error-correction model. The results show that capital inflows significantly contribute to exchange rate misalignment.

Botswana has no exchange rate restrictions, since it aims to boost domestic business efficiency and FDI inflows. The country attracted significant capital flows in the mining sector with moderate portfolio investments (Bank of Botswana 2016). FDI in Botswana is required for investment capital, economic diversification and promotion of inclusive growth. In 2017, Botswana experienced loss of foreign exchange reserves due to appreciation of the pula, which increases its exposure to a financial crisis (Agénor et al. 1992; Coudert et al. 2013; El-Shagi et al. 2016; Jeong et al. 2010; Kaminsky et al. 1998; Kinkyo 2008; Krugman 1979). Following Hermes et al. (2004) and Cuddington (1986), overvaluation of the pula may create expectations of depreciation thereby increasing capital outflows. The central bank conducted portfolio-rebalancing operations in 2017 to counter persistent capital outflows. As regards the literature on this issue, although capital inflow is vital to Botswana's economy, previous studies have not evaluated the impact of exchange rate misalignment on capital flight from Botswana.

3. Methodology

This section explains the methodology used to determine the relationship between exchange rate misalignment and capital flight from Botswana. It provides research hypotheses and estimation approaches as well as diagnostic measures. According to Edwards (1989), exchange rate misalignment causes severe welfare and efficiency costs owing to exchange rate and trade controls that accompany overvaluation. There is supporting evidence that REER misalignment reduces exports and deteriorates the agricultural sector (Pfeffermann 1985; World Bank 1984). A financial risk associated with exchange rate misalignment is that it generates massive capital flight, which increases social welfare costs (Cuddington 1986). Anticipations of macroeconomic instability cause high capital outflows, inducing large, rapid adjustments in interest rates and exchange rates. Further, capital flight reduces the tax base and this reduction increases budget deficits and costs of foreign borrowing (Cuddington 1986; Dornbusch 1984; Edwards 1989).

Previous studies posit that overvalued currencies generate capital flight (Cuddington 1986; Edwards 1989; Gouider and Nouira 2014; Pastor 1990). As Hermes et al. (2004) describe, overvaluation of the REER creates expectations of depreciation of the domestic currency, thereby increasing capital outflows. Currency devaluation diminishes the value of domestic assets relative to foreign assets, which encourages residents to switch to foreign assets (Cuddington 1986; Dornbusch 1984; Lessard and Williamson 1987). However, an increase in foreign exchange reserves allows the government to prevent balance of payments crises and macroeconomic crisis (Alam and Quazi 2003). As a result, investor confidence in the economy is boosted, which reduces capital outflows (Boyce 1992). Thus, the literature shows that exchange rate misalignment and capital flight affect a country's economic stability and growth. Hence, to examine these effects in relation to Botswana, this study proposes the following hypotheses:

***H*$_1$.** *Overvaluation of the pula increases capital flight in the long-run.*

***H*$_2$.** *Undervaluation of the pula decreases capital flight in the long-run.*

To determine the impact of exchange rate misalignment on capital flight, Botswana's exchange rate fundamentals should be identified first. Exchange rate fundamentals are variables that determine the REER and thus the internal and external equilibrium of the economy (Edwards 1989). Edwards (1988) proposes that exchange rate fundamentals in developing economies are terms of trade, government consumption, technological progress and capital inflows. However, further research on exchange rate misalignment shows that other macroeconomic factors, such as external debt, trade openness and capital formation are important determinants of the REER (Gouider and Nouira 2014; Hossain 2011; Pham and Delpachitra 2015; Salim and Shi 2019). Following Edwards (1988) and Hossain (2011), the relative impact of the exchange rate fundamentals for Botswana is specified as follows:

$$\begin{aligned} LNREER_t = \alpha_0 + \delta_1 LNTOT_t + \delta_2 LNGOV_t + \delta_3 GDP_t + \delta_4 FDI_t + \delta_5 AID_t \\ + \delta_6 LNOPENNESS_t + \delta_7 LNDEBT_t + \delta_8 LNCAPITAL_t + \varepsilon_t \end{aligned} \tag{1}$$

The definition of terms is as follows. *LNREER* (dependent variable) is the natural log of the REER index. *LNTOT* is the natural log of the terms of trade index. *LNGOV* is the natural log of government final consumption expenditure. *GDP* is the rate of GDP growth to measure domestic technological progress. *FDI* is FDI net capital inflows. *AID* is the real official foreign aid inflow received by Botswana. *LNOPENNESS* is the natural log of trade openness. *LNDEBT* is the natural log of Botswana's stock of external debt. *LNCAPITAL* is the natural log of the domestic gross capital formation. The epsilon ε_t represents the error term (Table S1).

To evaluate the degree of misalignment, first, the long-run exchange rate fundamentals for the Botswana economy are determined using Equation (1). Next, the Hodrick–Prescott (HP) filter is used to separate permanent and temporary components of the exchange rate fundamentals to obtain the long-run values (HP trend). Hodrick and Prescott (1997) used this technique to analyse post-war

business cycles. The filter computes the smoothed series, s of y by minimising the variance of y around s. The filter uses s to minimise the equation:

$$\sum_{t=1}^{T}(y_t - s_t)^2 + \lambda \sum_{t=2}^{T-1}((s_{t+1} - s_t) - (s_t - s_{t-1}))^2 \tag{2}$$

Consequently, the long-run exchange rate fundamentals are used to estimate the long-run *LNREER*. The fitted *LNREER* is filtered to obtain the equilibrium REER $(LNEREER)$. The smoothness of the series is determined using the parameter λ. Since this study uses annual data, the optimal value[1] for λ is 100. The next step is to calculate the degree of misalignment as follows:

$$MISREER_t = LNREER_t - LNEREER_t \tag{3}$$

The next phase is to evaluate whether misalignment of the pula was caused by unsustainable fiscal and monetary policies following Hossain (2011). The Toda and Yamamoto (1995) approach to Granger causality is applied to determine causation between the REER misalignment $(MISREER)$, cyclical components of the current account $(LNCAC)$, external debt $(LNDEBTC)$ and real GDP $(LNRGDPC)$. Excess broad money supply is captured by the variable *EMS*. The cyclical component *LNRGDPC* will be derived from the filtered series *LNRGDP*. *LNRGDP* is the natural log of real GDP. The cyclical component *LNDEBTC* will be obtained from the filtered natural log of (100 + *DEBT*) where *DEBT* is the total stock of external debt as a percentage of GDP. *EMS* is excess broad money supply defined as the difference between actual broad money supply and the predicted broad money supply. Owing to data limitations, the broad money determinants used are Botswana's real GDP $(LNRGDP)$ and the annual yield on the US government medium-term bond $\left(LNi^{US}\right)$. The cyclical component *LNCAC* will be obtained from the filtered natural log of (100 + *CA*) where *CA* is the current account balance as a percentage of GDP.

Following Gouider and Nouira (2014), this study decomposes misalignment into overvaluation $(OVER)$ and undervaluation $(UNDER)$. *OVER* will take the positive values of the misalignment, while *UNDER* will be negative misalignment. As a contribution to the literature, a 5% threshold[2] for misalignment is set to capture only significant deviations from the equilibrium real effective exchange rate (EREER). Therefore, from Equation (3), *OVER* and *UNDER* are defined as:

$$OVER_t = \begin{cases} 1 & if\ MISREER_t > 5\% \\ 0 & otherwise \end{cases} \tag{4}$$

$$UNDER_t = \begin{cases} 1 & if\ -MISREER_t < -5\% \\ 0 & otherwise \end{cases} \tag{5}$$

To determine the impact of exchange rate misalignment on capital flight from Botswana, this study will adopt the exchange rate expectations theory developed by Hermes et al. (2004). The theory posits that an overvalued currency leads to increasing expectations of depreciation in the future. Hence, economic agents will demand more foreign goods than domestic goods, leading to inflationary

[1] Estimated using EViews version 10.

[2] Zhang et al. (2019) used 25% and 50% thresholds for their early warning system while Kaminsky et al. (1998) used a 10% threshold for the signal extraction early warning system. However, these thresholds are too high to capture misalignment in this study. The 5% threshold is selected because it is optimal for detecting significant REER misalignment. When the threshold was set to 3%, 4% and 5% the results were similar with minimum disparities between the coefficients. However, an increase in overvaluation beyond the 5% threshold causes high outward capital flight. Therefore, the 5% percent threshold is also an early warning indicator for high capital flight from Botswana. The maximum threshold value accommodated by *MISREER* observations was 8%.

pressures and loss of real income. Under such circumstances, economic agents will prefer to hold their assets abroad, leading to capital flight. The principal methods used for measuring capital flight in the extant literature are the residual method, the Dooley method and the hot money approach. Hermes et al. (2004) argue that the Dooley and hot money methods provide inaccurate estimates of capital flight. This study adopts the residual method to estimate the volume of capital flight[3] from Botswana. This method evaluates capital flight by comparing sources of capital flows and their use in the economy. An advantage of this approach is that it measures all private capital outflows as capital flight (Hermes et al. 2004). Following Hermes et al. (2004), capital flight from Botswana will be estimated as follows:

$$VKF_t = \Delta ED_t + FI_t - CAD_t - \Delta FR_t \tag{6}$$

VKF is Botswana's current volume of outward capital flight (monetary value) not scaled to GDP. ΔED is the first difference of Botswana's stock of gross external debt. *FI* is the net foreign investment inflows in Botswana. *CAD* is Botswana's current account deficit and ΔFR is the first difference of the stock of official foreign reserves. Following Alam and Quazi (2003), Ndikumana and Boyce (2003) and Cheung and Qian (2010) an econometric model for capital flight based on the determinants is specified as:

$$\begin{aligned} KF_t = \alpha_0 + \delta_1 RESERVES_t + \delta_2 GDP_t + \delta_3 INF_t + \delta_4 IRD_t + \delta_5 AID_t \\ + \delta_6 LNOPENNESS_t + \delta_7 LNDEBT_t + \delta_8 LNREER_t + \varepsilon_t \end{aligned} \tag{7}$$

The definition of the variables is as follows. *KF* (dependent variable) is the volume of Botswana's outward capital flight[4] as a percentage of GDP. Note that this variable is different from *VKF*, which is the monetary value of Botswana's outward capital flight. The variable *KF* is better than *VKF* because it facilitates tracking of the dynamics of capital flight from the Botswana economy. The regressors are defined as follows. *RESERVES* is the volume of reserves per GDP. *GDP* is the real GDP growth rate. *INF* is the domestic inflation rate. *IRD* is the real interest rate differential[5] between Botswana and South Africa due to proximity and economic linkages between the two countries (Kganetsano 2007).[6] *AID* is the real foreign aid inflow. *LNOPENNESS* is the natural log of trade openness. *LNDEBT* is the natural log of external debt. *LNREER* is natural log of the REER index for Botswana. The epsilon ε_t represents the error term.

Equation (7) does not directly assess the impact of REER misalignment, which is the focus of this investigation. To determine the effects of misalignment on capital flight, *LNREER* in Equation (7) is substituted with overvaluation $(OVER)$ and undervaluation $(UNDER)$ dummies as follows:

$$\begin{aligned} KF_t = \alpha_0 + \delta_1 RESERVES_t + \delta_2 GDP_t + \delta_3 INF_t + \delta_4 IRD_t + \delta_5 AID_t \\ + \delta_6 LNOPENNESS_t + \delta_7 LNDEBT_t + \delta_8 OVER_t + \varepsilon_t \end{aligned} \tag{8}$$

$$\begin{aligned} KF_t = \alpha_0 + \delta_1 RESERVES_t + \delta_2 GDP_t + \delta_3 INF_t + \delta_4 IRD_t + \delta_5 AID_t \\ + \delta_6 LNOPENNESS_t + \delta_7 LNDEBT_t + \delta_8 UNDER_t + \varepsilon_t \end{aligned} \tag{9}$$

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3 Capital flight can be either massive capital leaving a particular country to other nations (outward capital flight) or massive capital from other nations entering the domestic economy (inward capital flight). This study evaluates the magnitude of capital flight from Botswana to other economies.

4 KF was calculated as $\left(\frac{VKF_t}{GDP_t}\right)$% where *VKF* is the volume of capital flight measured using the residual method and GDP is Botswana's total GDP.

5 In this study, *IRD* is the difference between Botswana and South Africa's real interest rate. An increase in *IRD* is expected to reduce capital flight ($\delta_4 < 0$). However, if *IRD* is taken as the difference between South Africa and Botswana's real interest rate, an increase in *IRD* will encourage capital flight ($\delta_4 > 0$).

6 Kganetsano (2007) argue that macroeconomic changes in South Africa are likely to affect Botswana, given the large size of the South African economy and the volume of its exports to Botswana.

3.1. Time Series Properties and Estimators

The long-run relationship between variables in levels can be evaluated using the Engle–Granger two-step residual based procedure (Engle and Granger 1987) and Johansen's system-based reduced rank regression approach (Johansen 1988; Johansen and Juselius 1990). A disadvantage of the Engle and Granger (1987) approach is the small sample bias arising from the exclusion of short-run dynamics (Alam and Quazi 2003). The procedures developed by Johansen (1988) and Phillips and Hansen (1990) require that the variables involved should be $I(1)$. However, the ARDL bounds testing procedure developed by Pesaran et al. (2001) applies whether the regressors are $I(0)$, purely $I(1)$ or integrated of different orders. Hence, this study adopts the ARDL bounds testing procedure to examine REER misalignment and capital flight from Botswana (Equations (1), (8) and (9)). The bounds testing procedure is advantageous since it can be executed even if the explanatory variables are endogenous. The approach is also suitable for smaller samples. To perform the bounds test, the following steps are followed. First, we determine the stationarity of the variables. Then, the optimal lag for the model is evaluated using the Schwarz–Bayesian information criterion (SBIC). The long-run relationship between the variables in levels is evaluated using the bounds test. Following Pesaran et al. (2001), the error correction models for this study are represented as:

$$\begin{aligned}\Delta LNREER_t = \beta_0 \quad & + \sum_{i=1}^{n1} \beta_{1i}\Delta LNREER_{t-i} + \sum_{i=0}^{n2} \beta_{2i}\Delta LNTOT_{t-i} + \sum_{i=0}^{n3} \beta_{3i}\Delta LNGOV_{t-i} \\ & + \sum_{i=0}^{n4} \beta_{4i}\Delta GDP_{t-i} + \sum_{i=0}^{n5} \beta_{5i}\Delta FDI_{t-i} + \sum_{i=0}^{n6} \beta_{6i}\Delta AID_{t-i} \\ & + \sum_{i=0}^{n7} \beta_{7i}\Delta LNOPENNESS_{t-i} + \sum_{i=0}^{n8} \beta_{8i}\Delta LNDEBT_{t-i} \\ & + \sum_{i=0}^{n9} \beta_{9i}\Delta LNCAPITAL_{t-i} + \delta_0 LNREER_{t-1} + \delta_1 LNTOT_{t-1} \\ & + \delta_2 LNGOV_{t-1} + \delta_3 GDP_{t-1} + \delta_4 FDI_{t-1} + \delta_5 AID_{t-1} \\ & + \delta_6 LNOPENNESS_{t-1} + \delta_7 LNDEBT_{t-1} + \delta_8 LNCAPITAL_{t-1} + \mu_t\end{aligned} \tag{10}$$

$$\begin{aligned}\Delta KF_t = \beta_0 + \sum_{i=1}^{n1} \quad & \beta_{1i}\Delta KF_{t-i} + \sum_{i=1}^{n2} \beta_{2i}\Delta RESERVES_{t-i} + \sum_{i=0}^{n3} \beta_{3i}\Delta GDP_{t-i} \\ & + \sum_{i=0}^{n4} \beta_{4i}\Delta INF_{t-i} + \sum_{i=0}^{n5} \beta_{5i}\Delta IRD_{t-i} + \sum_{i=0}^{n6} \beta_{6i}\Delta AID_{t-i} \\ & + \sum_{i=0}^{n7} \beta_{7i}\Delta LNOPENNESS_{t-i} + \sum_{i=0}^{n8} \beta_{8i}\Delta LNDEBT_{t-i} \\ & + \sum_{i=0}^{n9} \beta_{9i}\Delta OVER_{t-i} + \delta_0 KF_{t-1} + \delta_1 RESERVES_{t-1} + \delta_2 GDP_{t-1} \\ & + \delta_3 INF_{t-1} + \delta_4 IRD_{t-1} + \delta_5 AID_{t-1} + \delta_6 LNOPENNESS_{t-1} \\ & + \delta_7 LNDEBT_{t-1} + \delta_8 OVER_{t-1} + \mu_t\end{aligned} \tag{11}$$

$$\begin{aligned}\Delta KF_t = \beta_0 + \sum_{i=1}^{n1} & \beta_{1i}\Delta KF_{t-i} + \sum_{i=1}^{n2}\beta_{2i}\Delta RESERVES_{t-i} + \sum_{i=0}^{n3}\beta_{3i}\Delta GDP_{t-i} \\ & + \sum_{i=0}^{n4}\beta_{4i}\Delta INF_{t-i} + \sum_{i=0}^{n5}\beta_{5i}\Delta IRD_{t-i} + \sum_{i=0}^{n6}\beta_{6i}\Delta AID_{t-i} \\ & + \sum_{i=0}^{n7}\beta_{7i}\Delta LNOPENNESS_{t-i} + \sum_{i=0}^{n8}\beta_{8i}\Delta LNDEBT_{t-i} \\ & + \sum_{i=0}^{n9}\beta_{9i}\Delta UNDER_{t-i} + \delta_0 KF_{t-1} + \delta_1 RESERVES_{t-1} + \delta_2 GDP_{t-1} \\ & + \delta_3 INF_{t-1} + \delta_4 IRD_{t-1} + \delta_5 AID_{t-1} + \delta_6 LNOPENNESS_{t-1} \\ & + \delta_7 LNDEBT_{t-1} + \delta_8 UNDER_{t-1} + \mu_t\end{aligned} \tag{12}$$

The definition of terms is as follows. Δ is the first difference operator. β_0 is the regression constant while μ_t represents the white noise error term. $\delta_0 - \delta_7$ indicate the long-run coefficients while $\beta_1 - \beta_8$ represent the error correction short-run dynamics. The error-correction models for the above equations after affirming the long-run relationship between the variables is specified as follows:

$$\begin{aligned}\Delta LNREER_t = \beta_0 & + \sum_{i=1}^{n1}\beta_{1i}\Delta LNREER_{t-i} + \sum_{i=0}^{n2}\beta_{2i}\Delta LNTOT_{t-i} + \sum_{i=0}^{n3}\beta_{3i}\Delta LNGOV_{t-i} \\ & + \sum_{i=0}^{n4}\beta_{4i}\Delta GDP_{t-i} + \sum_{i=0}^{n5}\beta_{5i}\Delta FDI_{t-i} + \sum_{i=0}^{n6}\beta_{6i}\Delta AID_{t-i} \\ & + \sum_{i=0}^{n7}\beta_{7i}\Delta LNOPENNESS_{t-i} + \sum_{i=0}^{n8}\beta_{8i}\Delta LNDEBT_{t-i} \\ & + \sum_{i=0}^{n9}\beta_{9i}\Delta LNCAPITAL_{t-i} + \theta ecm_{t-1} + \mu_t\end{aligned} \tag{13}$$

$$\begin{aligned}\Delta KF_t = \beta_0 + \sum_{i=1}^{n1} & \beta_{1i}\Delta KF_{t-i} + \sum_{i=1}^{n2}\beta_{2i}\Delta RESERVES_{t-i} + \sum_{i=0}^{n3}\beta_{3i}\Delta GDP_{t-i} \\ & + \sum_{i=0}^{n4}\beta_{4i}\Delta INF_{t-i} + \sum_{i=0}^{n5}\beta_{5i}\Delta IRD_{t-i} + \sum_{i=0}^{n6}\beta_{6i}\Delta AID_{t-i} \\ & + \sum_{i=0}^{n7}\beta_{7i}\Delta LNOPENNESS_{t-i} + \sum_{i=0}^{n8}\beta_{8i}\Delta LNDEBT_{t-i} \\ & + \sum_{i=0}^{n9}\beta_{9i}\Delta OVER_{t-i} + \theta ecm_{t-1} + \mu_t\end{aligned} \tag{14}$$

$$\begin{aligned}\Delta KF_t = \beta_0 + \sum_{i=1}^{n1} & \beta_{1i}\Delta KF_{t-i} + \sum_{i=1}^{n2}\beta_{2i}\Delta RESERVES_{t-i} + \sum_{i=0}^{n3}\beta_{3i}\Delta GDP_{t-i} \\ & + \sum_{i=0}^{n4}\beta_{4i}\Delta INF_{t-i} + \sum_{i=0}^{n5}\beta_{5i}\Delta IRD_{t-i} + \sum_{i=0}^{n6}\beta_{6i}\Delta AID_{t-i} \\ & + \sum_{i=0}^{n7}\beta_{7i}\Delta LNOPENNESS_{t-i} + \sum_{i=0}^{n8}\beta_{8i}\Delta LNDEBT_{t-i} \\ & + \sum_{i=0}^{n9}\beta_{9i}\Delta UNDER_{t-i} + \theta ecm_{t-1} + \mu_t\end{aligned} \tag{15}$$

where the term ecm_{t-1} is the error-correction term and θ is its coefficient. The term ecm_{t-1} represents the speed of convergence to the equilibrium level if there is a disturbance in the system.

This study further uses the Toda and Yamamoto (1995) approach to Granger causality to investigate the causal relationship among the variables. The ordinary Granger causality test is not suitable for this investigation since the variables under investigation are not all $I(1)$. Further, Wolde-Rufael (2005) argue that the F-statistic in Granger causality may be invalid because the test lacks a standard distribution in cases where the times series is cointegrated. An advantage of the Toda and Yamamoto (1995) approach is its applicability whether a series is $I(0)$, $I(1)$, $I(2)$, non-cointegrated or cointegrated of different

arbitrary orders. The test also uses a modified Wald test and a standard autoregressive model in levels form to reduce the likelihood of mistakenly identifying the order of the series (Mavrotas and Kelly 2001). For estimation purposes, the vector autoregression (VAR) system for *MISREER* and the causes of misalignment is represented as:

$$MISREER_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} MISREER_{t-i} + \sum_{j=k+1}^{d_{max}} \alpha_{2j} MISREER_{t-j} + \sum_{i=1}^{k} \phi_{1i} X_{t-i} + \sum_{j=k+1}^{d_{max}} \phi_{2j} X_{t-j} + \lambda_{it} \quad (16)$$

$$X_t = \alpha_0 + \sum_{i=1}^{k} \beta_{1i} X_{t-i} + \sum_{j=k+1}^{d_{max}} \beta_{2j} X_{t-j} + \sum_{i=1}^{k} \delta_{1i} MISREER_{t-i} + \sum_{j=k+1}^{d_{max}} \alpha_{2j} MISREER_{t-j} + \lambda_{2t} \quad (17)$$

where X_t is any of the potential causes of misalignment $(LNCAC,\ LNDEBTC,\ EMS$ and $LNRGDPC)$. The VAR system represents the bivariate relationship between *MISREER* and each potential cause. The causal links examined are as follows: $MISREER - LNCAC$; $MISREER - LNDEBT$; $MISREER - EMS$ and $MISREER - LNGDPC$. The highest order of integration is denoted by d_{max}. Likewise, the VAR system for *KF* and its causes, Y_t is represented as:

$$KF_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} KF_{t-i} + \sum_{j=k+1}^{d_{max}} \alpha_{2j} KF_{t-j} + \sum_{i=1}^{k} \phi_{1i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \phi_{2j} Y_{t-j} + \lambda_{it} \quad (18)$$

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \beta_{1i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \beta_{2j} Y_{t-j} + \sum_{i=1}^{k} \delta_{1i} KF_{t-i} + \sum_{j=k+1}^{d_{max}} \alpha_{2j} KF_{t-j} + \lambda_{2t} \quad (19)$$

where Y_t is any of the determinants of KF. The VAR system represents the bivariate relationship between *KF* and each potential cause. The bivariate causal links examined are as follows:

$$KF - RESERVES;\ KF - GDP;\ KF - INF;\ KF - IRD;\ KF - AID;\ KF - LNOPENNESS;\ KF - LNDEBT;\ KF - OVER \text{ and } KF - UNDER.$$

3.2. Data Diagnostics

This investigation uses annual data (time series) for the Botswana economy for the period 1980–2015. The data sources are the International Financial Statistics (IFS), World Development Indicators (WDI) and the Federal Reserve Economic Data (FRED). The study adopts the ARDL bounds testing approach, which is applicable whether all the regressors are $I(0)$ or $I(1)$ or a mixture of both. However, the procedure is not valid if any of the variables under examination is $I(2)$. This investigation used the generalised least squares transformed Dickey–Fuller (DF-GLS) test and the augmented Dickey–Fuller (ADF) unit root test to examine stationarity. An advantage of the DF-GLS procedure is that it has high power even when the root of the times series is closer to unity (Elliot et al. 1996). The results of the tests showed that the sample is a mixture of $I(0)$ and $I(1)$ series. Multicollinearity was assessed using the variance inflation factor (VIF) in this study. As a rule of thumb, VIFs greater than 10 signal a serious multicollinearity problem while VIFs between 5 and 10 signal a less serious problem of multicollinearity (Pedace 2013). The VIFs for the variables in this investigation are less than 6, which is acceptable for further analysis.

4. Results

This section reports and discusses empirical findings on exchange rate misalignment in Botswana. First, it investigates the determinants of Botswana's REER using the ARDL approach to cointegration. Next, based on the exchange rate fundamentals, the EREER is estimated to evaluate the degree of misalignment. Lastly, the Toda and Yamamoto (1995) approach to Granger causality is used to investigate causal relations between REER misalignment and its potential causes. Granger (1981), Engle and Granger (1987) and Johansen (1988) pioneered the use of cointegration for time series analysis. Following Engle and Granger (1987), a series without a deterministic component but with a

stationary autoregressive moving average after differencing d times is integrated of order d, $[x_t \sim I(d)]$. The properties of $I(0)$ and $I(1)$ series differ based on their responsiveness to innovations. If $x_t \sim I(0)$, its variance is finite and innovations have a short-term effect on the magnitude of x_t. In contrast, an innovation has a long-term effect on the value of an $I(1)$ series (Engle and Granger 1987). The procedure followed for the ARDL bounds cointegration approach is as follows. First, the variables were subjected to stationarity tests. The results show that only *GDP* is $I(0)$ while other variables (*LNREER*, *LNTOT*, *LNGOV*, *FDI*, *AID*, *LNOPENNESS*, *LNDEBT* and *LNCAPITAL*) are $I(1)$. Next, the optimal lag length of the specifications is determined using the SBIC. The SBIC is used to determine the optimal lag length since it is more reliable for optimal model selection than the Akaike information criterion (AIC) (Pesaran and Shin 1999). The long-run levels relationships for different specifications are evaluated using the *F*-test. Subsequently, the coefficients of the variables are estimated with diagnostic tests.

The benchmark for determining a long-run relationship between the dependent variable and independent variables is the *F*-test. The optimal lag established for the ARDL model using the SBIC is zero when *LNREER* is the dependent variable. The null hypothesis of no cointegration is $H_0 : \delta_1 = \delta_2 = \cdots \delta_P = 0$ against the alternative $H_1 : \delta_1 \neq \delta_2 \neq \cdots \delta_P \neq 0$. The criterion for the long-run equilibrium relationship is based on the lower and upper bound critical values proposed by Pesaran et al. (2001). Following Pesaran et al. (2001), we reject the null of no long-run equilibrium relationship if the computed *F*-statistic is higher than the upper bound critical values. However, if the *F*-statistic is less than the lower bounds, we fail to reject the null of no long-run equilibrium relationship. The test is inconclusive if the *F*-statistic falls between the lower and upper bounds.

Banerjee et al. (1998) suggest that a negative and significant error-correction term signals a long-run relationship. The *F*-test for the parameter that $\delta_1 = \delta_2 = \cdots \delta_P = 0$ in the specification with *LNREER* as the dependent variable is expressed as $F(LNREER|X_1, X_2, \cdots X_P)$ where X_1 to X_P are the determinants of the REER. The procedure is repeated by interchanging the dependent variable with the regressors. The order of the variables when *LNREER* is an independent variable is $F(X_1|LNREER, X_2, \cdots X_P)$. Following Pesaran et al. (2001) we determine the *F*-test by including a restricted constant (RC); unrestricted constant (UC) and unrestricted constant with unrestricted trend (UC + UT) in the specifications. This is important because it helps to determine the sensitivity of the long-run equilibrium relationship to a deterministic trend. When a specification includes RC, it indicates the dynamics of the long-run equilibrium relationship when the intercept is restricted with no linear trend. When a specification includes UC it shows the dynamics of the relationship when an unrestricted constant with no trend is included in the specification. Consequently, when a specification includes UC + UT it reveals the relationship between the variables when there is an unrestricted constant with unrestricted trend in the model specification. Since $F(LNREER|X_1, X_2, \cdots X_P)$ with trend and intercept (Table 1) is greater than the upper limit of the critical bound (3.23 > 3.14), the null hypothesis of no long-run equilibrium relationship[7] is rejected at the 10% level. In addition, when the test is conducted with restricted and unrestricted constants, the null of no long-run equilibrium relationship is rejected at the 5% level. Further, when *LNREER* is switched to a regressor position, the computed *F*-statistic for the majority of the determinants of the REER is greater than the upper bound critical values indicating a long-run equilibrium relationship. The presence of a long-run equilibrium relationship indicates that the regressors are not long-run forcing variables[8] (Pesaran et al. 2001). Table 1 presents the results of the *F*-test.

[7] For the exchange rate fundamentals, the value of the regressors k was greater than 7, therefore only Pesaran et al. (2001) critical values were followed.

[8] A variable x_t is long-run forcing if there is no feedback from the long-run equilibrium relationship on the change of x_t. Consequently, there will be no information on the marginal process for x_t about the parameters of the relationship (Pesaran et al. 2001).

Table 1. Results of the F-test for the long-run relationship between the real effective exchange rate (LNREER) and its determinants.

Model Specification (k = 8)	Optimal Lag	RC	UC	UC + UT
F(LNREER|LNTOT, LNGOV, GDP, FDI, AID, LNOPENNESS, LNDEBT, LNCAPITAL)	0	3.2037 **	3.5175 **	3.2349 *
F(LNTOT|LNREER, LNGOV, GDP, FDI, AID, LNOPENNESS, LNDEBT, LNCAPITAL)	1	6.4683 ***	7.1756 ***	6.7281 ***
F(LNGOV|LNREER, LNTOT, GDP, FDI, AID, LNOPENNESS, LNDEBT, LNCAPITAL)	1	3.9829 ***	4.7406 ***	4.3554 **
F(GDP|LNREER, LNTOT, LNGOV, FDI, AID, LNOPENNESS, LNDEBT, LNCAPITAL)	0	6.9034 ***	7.6376 ***	7.1384 ***
F(FDI|LNREER, LNTOT, LNGOV, GDP, AID, LNOPENNESS, LNDEBT, LNCAPITAL)	2	15.3922 ***	16.8090 ***	15.8756 ***
F(AID|LNREER, LNTOT, LNGOV, GDP, FDI, LNOPENNESS, LNDEBT, LNCAPITAL)	2	7.7685 ***	8.1055 ***	11.1441 ***
F(LNOPENNESS|LNREER, LNTOT, LNGOV, GDP, FDI, AID, LNDEBT, LNCAPITAL)	1	6.4728 ***	7.1814 ***	6.8454 ***
F(LNDEBT|LNREER, LNTOT, LNGOV, GDP, FDI, LNOPENNESS, AID, LNCAPITAL)	2	4.4928 ***	4.9825 ***	8.0778 ***
F(LNCAPITAL|LNREER, LNTOT, LNGOV, GDP, FDI, AID, LNOPENNESS, LNDEBT)	1	1.3175	1.4493	1.5992

Notes: The reported values are F-statistics. k is the number of regressors. SBIC optimal lag. RC = restricted constant; UC = unrestricted constant; UC + UT = unrestricted constant with unrestricted trend. The critical values for the F-statistic with RC are {1.85, 2.11, 2.62} and {2.85, 3.15, 3.77} at the 10%, 5%, and 1% levels, respectively. The critical values for the F-statistic with UC are {1.95, 2.22, 2.79} and {3.06, 3.39, 4.1} at the 10%, 5%, and 1% levels, respectively. The critical values for the F-statistic with UC + UT are {2.26, 2.55, 3.15} and {3.14, 3.68, 4.43} at the 10%, 5%, and 1% levels, respectively. *, ** and *** indicate significance at 10%, 5%, and 1%, respectively.

The next phase of the ARDL cointegration approach is to estimate the coefficients of the exchange rate fundamentals. The ARDL technique estimates $(p+1)^k$ number of regressions for the optimal lag length for each variable. The term p is the maximum number of lags and k here is the number of variables in the equation. The optimal SBIC lag length is zero while that for AIC is one. Since a small lag length provides better results, the optimal lag used was zero. AIC selected the same model as SBIC (1, 0, 0, 0, 0, 0, 0, 1, 0). The estimated error-correction model is robust since the short-run coefficients were significant. The diagnostic tests did not indicate autocorrelation, endogeneity, non-normality of the residuals or heteroskedasticity. Further, the CUSUM plots were within the 5% boundaries, indicating no systematic change of the estimated coefficients. To obtain a parsimonious model, the Wald test was used to test for the significance of the coefficients of the unrestricted model. The variables *LNGOV* and *FDI* were deleted and the restricted model was estimated with the remaining variables. Tables 2 and 3 presents the results of the restricted model.

Table 2. Long-run coefficients of the determinants of LNREER (restricted model).

Model: SBIC-ARDL (1, 0, 0, 0, 0, 0, 0, 1, 0)		
Regressor	**Long-Run Coefficient**	***t*-Statistic (*p*-Value)**
Constant	5.1731 ***	7.1801 (0.0000)
LNTOT	−0.3551 ***	−3.9642 (0.0004)
GDP	−0.0038 *	−1.7363 (0.0931)
AID	−0.0193 ***	−5.4407 (0.0000)
LNOPENNESS	0.2374 **	2.1781 (0.0377)
LNDEBT	−0.0553 ***	−2.8405 (0.0082)
LNCAPITAL	0.0462	1.1897 (0.2438)
The Wald test for the hypothesis:	χ^2 (p-value)	
H_0: Coefficient on LNTOT = 0	$\chi^2_{(1)} = 15.7152$ (0.0001) **	
H_0: Coefficient on GDP = 0	$\chi^2_{(1)} = 3.0146$ (0.0825)	
H_0: Coefficient on AID = 0	$\chi^2_{(1)} = 29.6016$ (0.0000) **	
H_0: Coefficient on LNOPENNESS = 0	$\chi^2_{(1)} = 4.7440$ (0.0294) **	
H_0: Coefficient on LNDEBT = 0	$\chi^2_{(1)} = 8.0683$ (0.0045) **	
H_0: Coefficient on LNCAPITAL = 0	$\chi^2_{(1)} = 1.4154$ (0.2342)	

Notes: χ^2 is the Chi-squared test statistic. The significance level for the Wald test is 5%. *, ** and *** indicate significance at 10%, 5%, and 1%, respectively.

This section discusses the results of the restricted model (Table 2). The coefficient for terms of trade $(LNTOT)$ is statistically significant with a negative sign (−0.3551), which indicates that improvements in terms of trade terms increases the demand for foreign goods, resulting in REER depreciation. This finding is not consistent with that of Hinkle and Montiel (1999), who argue that improvements in terms of trade appreciate the REER for imports by increasing the demand for non-tradables. In the case of Botswana, an improvement in terms of trade reflects a higher demand for mineral exports. The revenue generated is used to purchase more imports (food, fuel and machinery), typically from South Africa.[9] Approximately 80% of Botswana's imports originate from South Africa. This causes a high demand for the foreign currency, resulting in REER depreciation. The coefficient for *GDP* is negative (−0.0038) and not significantly different from zero, which signals low technological progress in Botswana and a minor impact on the REER. The negative coefficient is not consistent with the Balassa–Samuelson

[9] According to the International Monetary Fund (2007), South Africa's competitive advantage overshadows Botswana's competitive advantage, given the large domestic market and abundant labour supply in South Africa. Consequently, the International Monetary Fund (2007) recommends that Botswana should import from South Africa rather than produce goods domestically.

effect, which stipulates that a high rate of technological progress will cause an equilibrium REER appreciation (Balassa 1964; Gouider and Nouira 2014; Samuelson 1964). The coefficient is negative since the manufacturing sector in Botswana is small and unable to meet technological demands of the large mining sector. Attempts to diversify the economy have been unsuccessful because the manufacturing and agriculture sectors have not grown significantly. The manufacturing sector contributes approximately 6% to GDP while the mining sector contributes nearly 25%. Machinery and equipment are imported from other countries and less is spent on domestic non-tradable goods. The demand for foreign currency causes the depreciation of the pula.

Table 3. Error-correction model (restricted model).

Model: SBIC-ARDL (1, 0, 0, 0, 0, 0, 0, 1, 0)		
Regressor	**Short-Run Coefficient**	***t*-Statistic (*p*-Value)**
Constant	−0.0021	−0.3118 (0.7576)
ΔLNTOT	−0.2154 **	−2.0713 (0.0480)
ΔGDP	−0.0031 *	−1.8999 (0.0682)
ΔAID	−0.0192 ***	−3.7559 (0.0008)
ΔLNOPENNESS	0.2167	1.6919 (0.1022)
ΔLNDEBT	−0.0673 **	−2.4281 (0.0221)
ΔLNCAPITAL	0.0258	0.6765 (0.5045)
ecm_{t-1}	−0.6869 ***	−3.8045 (0.0007)
The Wald test for the hypothesis:	χ^2 (*p*-value)	
H_0: Coefficient on ΔLNTOT = 0	$\chi^2_{(1)} = 4.2903$ (0.0383) **	
H_0: Coefficient on ΔGDP = 0	$\chi^2_{(1)} = 3.6098$ (0.0574)	
H_0: Coefficient on ΔAID = 0	$\chi^2_{(1)} = 14.1070$ (0.0002) **	
H_0: Coefficient on ΔLNOPENNESS = 0	$\chi^2_{(1)} = 2.8624$ (0.0907)	
H_0: Coefficient on ΔLNDEBT = 0	$\chi^2_{(1)} = 5.8954$ (0.0152) **	
H_0: Coefficient on ΔLNCAPITAL = 0	$\chi^2_{(1)} = 0.4576$ (0.4987)	
H_0: Coefficient on $ecm_{t-1} = 0$	$\chi^2_{(1)} = 14.4740$ (0.0001) **	
R^2	0.5124	
Adjusted R^2	0.3860	
Standard error of the regression	0.0386	
Observations	35	

Notes: χ^2 is the Chi-squared test statistic. The significance level for the Wald test is 5%. *, ** and *** indicate significance at 10%, 5%, and 1%, respectively.

The coefficient for *AID* inflows is negative and statistically significant (−0.0193) indicating that *AID* received increases the demand for importable commodities relative to domestic goods, which depreciates the REER. This result deviates from the findings of Alam and Quazi (2003), who argued that the supply of foreign aid induces currency appreciation. This result can be explained by the rapid development of the mining sector in Botswana because aid received was used to purchase mining machinery and equipment abroad. The government also solicited foreign expertise to develop physical and social infrastructure. Therefore, less aid was spent on the small non-tradable goods market. This results in the depreciation of the REER. The coefficient for *LNOPENNESS* is positive and statistically significant (0.2374), which signals that removing trade barriers results in a higher demand for domestic goods, including non-tradables, leading to REER appreciation. This result is not in line with the theory that trade liberalisation reduces the demand for non-tradables goods, which depreciates the REER (Gouider and Nouira 2014). The positive coefficient can be explained by Botswana's membership of the Southern African Customs Union (SACU)[10]. Other member states are Lesotho, Namibia, South

[10] SACU was formed in 1910 to promote cross-border movement of goods produced by the member states without import tariffs or import quotas. Other goals of the organisation include promotion of regional integration, poverty reduction and

Africa and Swaziland. The SACU agreement is based on the promotion of free movement of goods between the territories of the member economies. Trade liberalisation increases the external demand of Botswana's goods. The public in Botswana will subsequently increase their expenditure on the non-tradable commodities, resulting in REER appreciation. The variable *LNDEBT* has a negative and significant coefficient (−0.0553), signifying that a depreciating pula is necessary for financing high external debt. The result is consistent with that of Hossain (2011), who found that an increase in foreign debt in Bangladesh required depreciation of the taka for debt financing.

The variable *LNCAPITAL* holds a positive coefficient (0.0462), which signals that a high level of capital accumulation in Botswana increases expenditure on non-tradable goods, which appreciates the REER. This result is inconsistent with the findings of Pham and Delpachitra (2015), who argue that capital stock and investment cause a depreciation of the REER. Improvements in accumulated capital are more likely to increase productivity. The positive relationship can be explained by programmes introduced by the Botswana National Productivity Centre, which encourage productivity and sustainable performance. The Enterprise Support Programme and the Public Service Programme were established to improve performance and productivity in the private and public sectors. The central bank also encourages sustained improvements in productivity, to reduce inflation in Botswana. The acquisition of capital improves productivity, which results in a higher supply and consumption of non-tradable commodities. This eventually leads to REER appreciation.

The signs of the variables in the error-correction model are consistent with those of the long-run coefficients. The sign and the magnitude of the error-correction term (ecm_{t-1}) is important for evaluating the short-term adjustment process. A positive value of ecm_{t-1} will cause *LNREER* to diverge from its long-run equilibrium path in relation to exogenous-forcing variables. The coefficient for the error-correction term is −0.6869 (Table 3) and is significant at the 1% level, which suggests that ecm_{t-1} tends to cause *LNREER* to converge monotonically to its long-run equilibrium path at a speed of 68.69% annually. The negative and significant error-correction term further validates the long-run equilibrium relationship between *LNREER* and its associated determinants.

Based on the long-run coefficients of the restricted model (Table 2), Botswana's exchange rate fundamentals are $LNTOT, GDP$, AID, $LNOPENNESS$ and $LNDEBT$. The long-run values of the exchange rate fundamentals and the EREER were obtained using the HP filter. The pula seems to have experienced misalignment, calculated by the deviation of *LNREER* from *LNEREER*. Figure 1 shows the degree of misalignment.

The two types of exchange rate misalignment are macroeconomic-induced misalignment and structural misalignment. In theory, the former is prompted by inconsistent fiscal and monetary policy. In contrast, structural misalignment arises when exchange rate fundamentals are not reflected into changes of the REER. In developing economies such as Botswana, it is common for exchange rate misalignment to occur owing to inconsistent fiscal and monetary policies. This section evaluates whether misalignment of the pula was caused by unsustainable fiscal and monetary policies. The Toda and Yamamoto (1995) approach to Granger causality is applied to determine causation between REER misalignment $(MISREER)$, cyclical component of the current account $(LNCAC)$, cyclical component of external debt $(LNDEBTC)$, cyclical component of real GDP $(LNRGDPC)$ and excess broad money supply (EMS). The ADF test indicates that only $LNDEBTC$ is $I(0)$ while $LNCAC$, $MISREER$, EMS and $LNRGDPC$ are $I(1)$. Following Wolde-Rufael (2005), the procedure is to augment the correct VAR order k, by the highest order of integration (d_{max}). The next step is to estimate a $(k + d_{max})th$ order of the VAR. Serial correlation of the residuals was evaluated using the Breusch–Godfrey serial correlation LM test. The null hypothesis of no serial correlation was not rejected for all the tests. The data span is from 1980 to 2015 for all series. Table 4 presents the results of the causality test.

stable democratic governments. Botswana is also a member of SADC, which promotes socioeconomic cooperation and political stability.

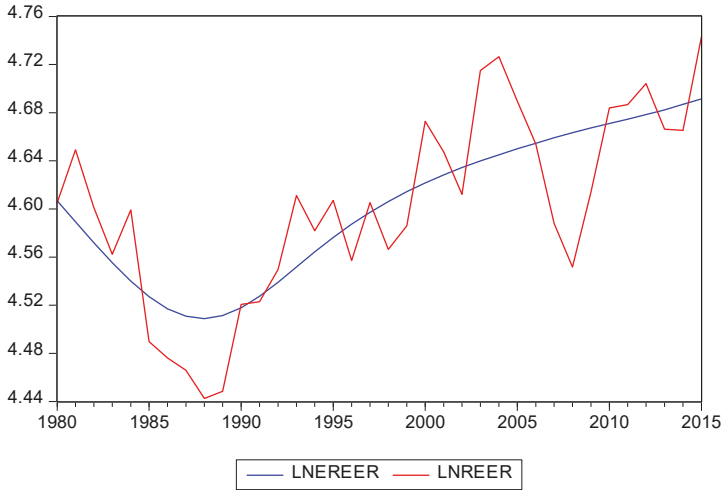

Figure 1. Botswana pula misalignment (1980–2015).

Table 4. Causality between MISREER and its potential causes.

Hypothesis	χ^2	*p*-Value	Causality
LNCAC does not Granger-cause MISREER	7.6138	0.0222 **	LNCAC → MISREER
MISREER does not Granger-cause LNCAC	6.4705	0.0393 **	LNCAC ← MISREER
LNDEBTC does not Granger-cause MISREER	0.6962	0.7060	No
MISREER does not Granger-cause LNDEBTC	0.2162	0.8991	No
EMS does not Granger-cause MISREER	0.2431	0.8856	No
MISREER does not Granger-cause EMS	0.7286	0.6947	No
LNRGDPC does not Granger-cause MISREER	2.7267	0.2558	No
MISREER does not Granger-cause LNRGDPC	1.1045	0.5757	No

Notes: The HP filter was used to generate the cyclical component of the series. χ^2 is the Chi-square statistic; → is the direction of causality when rejecting the null hypothesis of no causality. 'No' indicates that the null of no causality cannot be rejected. ** indicates significance at 5%.

Drawing from the results of the causality test, Botswana's REER misalignment is caused by the cyclical component of the current account. This indicates that REER misalignment is caused by current account imbalances. Further, REER misalignment had a significant influence on Botswana's current account balance as shown by the reverse causality effect from REER misalignment to the cyclical component of the current account. There is no evidence of causality between REER misalignment and external debt and REER misalignment and excess broad money supply. This finding signals that exchange rate misalignment in Botswana was not caused by inconsistent fiscal and monetary policies. In addition, there was no evidence of causality between misalignment and the cyclical component of real GDP, revealing that REER misalignment had no significant impact on economic growth in Botswana.

4.1. The Causes of Capital Flight from Botswana

Before examining the impact of REER misalignment on capital flight, we have to determine the causes of capital flight from Botswana. Botswana experienced a high level of capital flight between the years 1980 and 1985 (see Figure A1 in the Appendix A). In 1980, capital flight amounted to 24.75% of GDP. The magnitude of capital flight declined to 2.05% of GDP in 1985. Between 1986 and 2000, Botswana experienced inward capital flight, which indicates the rapid development of the mining sector. In 2007, Botswana experienced inward capital flight of 16.35%, which declined drastically to

0.89% as outward capital flight in 2008. This marks the period of the 2007−2008 Global Financial Crisis as investors were seeking higher returns for their monetary assets in other economies. The general trend is that from 2012 to 2015, Botswana experienced increasing inward capital flight amounting to 6.34% of GDP in 2015. This may be attributed to the Sectoral Development and Business Linkages Unit developed in 2011, which was designed to attract FDI and promote skills transfer as part of the Economic Diversification Drive. On average, Botswana experienced inward capital flight over the period 1980−2015.

The general to specific approach is used to identify determinants of capital flight. Trade openness ($LNOPENNESS$) and the level of foreign reserves ($RESERVES$) are found to be the determinants of Botswana's capital flight. The other variables (GDP, INF, IRD, AID and $LNDEBT$) are redundant and have no explanatory power on capital flight from Botswana. The results of the stationarity tests show that the variable $RESERVES$ is $I(0)$ while KF and $LNOPENNESS$ are $I(1)$. The F-test as described by Pesaran et al. (2001) is used for determining a long-run relationship for the variables KF, $LNOPENNESS$ and $RESERVES$. The optimal lag established for the ARDL model using the SBIC is zero when KF is the dependent variable. The null hypothesis of no long-run equilibrium relationship is $H_0 : \delta_1 = \delta_2 = \delta_3 = 0$ whereas the alternative is $H_1 : \delta_1 \neq \delta_2 \neq \delta_3 \neq 0$. The F-test for the restriction that $\delta_1 = \delta_2 = \delta_3 = 0$ when KF is the dependent variable is expressed as $F(KF|LNOPENNESS, RESERVES)$. The process is repeated by interchanging the dependent variable with the regressors. The F-statistic for $F(KF|LNOPENNESS, RESERVES)$ with trend and intercept is greater than the upper limit of the critical bound ($22.23 > 7.52$). Consequently, the null hypothesis of no long-run equilibrium relationship is rejected at the 1% significance level. The test is also executed with constants only and the null of no long-run equilibrium relationship is still rejected at the 1% significance level. The null hypothesis of no long-run equilibrium relationship is rejected at the 5% level when $RESERVES$ is a dependent variable in all regressions. However, the variable $LNOPENNESS$ indicated no evidence of a long-run equilibrium relationship with other variables when it is a dependent variable.

The next procedure is to estimate the short-run and long-run coefficients for KF, $LNOPENNESS$ and $RESERVES$. The optimal lag length for SBIC and AIC is zero when KF is the dependent variable. AIC selected the same model as SBIC (1, 0, 1). Table 5 presents the results of the estimated coefficients.

The estimated error-correction model is robust since the short-run coefficients are significant. The diagnostic tests do not signal autocorrelation, endogeneity, non-normality of the residuals or heteroskedasticity. The estimated model is stable because the CUSUM plots suggested no systematic changes in the estimated coefficients. The coefficient for $LNOPENNESS$ is positive and significant (62.3474), which signals that trade liberalisation increases the volume of outward capital flight. The coefficient suggests that the reported value of Botswana's exports is understated, leading to net capital outflows through trade. According to Global Financial Integrity (Global Financial Integrity 2015), Botswana lost approximately 13 billion US dollars through trade misinvoicing in 2004–2013. The estimated value of Botswana's under-invoiced exports is approximately 9 billion US dollars against 4 billion US dollars for over-invoiced exports during 2004–2013 (Global Financial Integrity 2015). In the case of imports, the disparity was small, which indicates that the economy experiences net capital outflows through trade. Ajayi and Ndikumana (2015) posit that trade misinvoicing occurs by understating the quantity of goods or prices. The seller sends the difference between the actual earnings and the understated values to foreign accounts. The results are consistent with those of Cheung and Qian (2010), who argue that increasing trade openness allows economic agents to falsify trade prices in China, resulting in a rise in capital flight.

Table 5. Coefficients of the determinants of capital flight (KF).

Model: SBIC-ARDL (1, 0, 1)		
Regressor	**Long-Run Coefficient**	***t*-Statistic (*p*-Value)**
Constant	−283.4200 ***	−4.1406 (0.0002)
LNOPENNESS	62.3474 ***	4.1962 (0.0002)
RESERVES	−0.7727 ***	−5.0693 (0.0000)
The Wald test for the hypothesis:	χ^2 (*p*-value)	
H_0: Coefficient on LNOPENNESS = 0	$\chi^2_{(1)}$ = 17.6084 (0.0000) **	
H_0: Coefficient on RESERVES = 0	$\chi^2_{(1)}$ = 25.7000 (0.0000) **	
Error-Correction Model		
Regressor	**Short-Run Coefficient**	***t*-Statistic (*p*-Value)**
Constant	−0.9393	−0.7753 (0.4445)
ΔLNOPENNESS	9.9306	0.5315 (0.5991)
ΔRESERVES	0.5243 ***	5.5751 (0.0000)
$\Delta RESERVES_{t-1}$	−0.6448 ***	−6.7326 (0.0000)
ecm_{t-1}	−0.4705 ***	−3.3708 (0.0021)
The Wald test for the hypothesis:	χ^2 (*p*-value)	
H_0: Coefficient on ΔLNOPENNESS = 0	$\chi^2_{(1)}$ = 0.2825 (0.5951)	
H_0: Coefficient on ΔRESERVES = 0	$\chi^2_{(1)}$ = 31.0817 (0.0000) **	
H_0: Coefficient on $\Delta RESERVES_{t-1}$ = 0	$\chi^2_{(1)}$ = 45.3285 (0.0000) **	
H_0: Coefficient on ecm_{t-1} = 0	$\chi^2_{(1)}$ = 11.3623 (0.0007) **	
R^2	0.8550	
Adjusted R^2	0.8350	
Standard error of the regression	7.0378	
Observations	34	
Additional Diagnostics		
BG LM test for serial correlation	F (1, 28) = 0.9245	
BPG test for heteroskedasticity	F (4, 29) = 0.5875	
Ramsey RESET	F (1, 28) = 0.1716	
Normality test	JB (1.3224) = 0.5162	
Stable	Yes	

Notes: χ^2 is the Chi-squared test statistic. BG LM = Breusch–Godfrey serial correlation LM test. BPG = Breusch–Pagan–Godfrey test. *JB* = Jacque–Bera statistic. The significance level for the Wald test and other diagnostic tests is 5%. ** and *** indicate significance at 5%, and 1%, respectively.

The coefficient for *RESERVES* is negative and statistically significant (−0.7727) indicating that a high level of foreign reserves[11] reduces outward capital flight. An increase in reserves indicates that the central bank can intervene in the foreign exchange market to stabilise the local currency's exchange rate, which reduces capital outflows. In addition, a high level of reserves indicates that the government can finance current account deficits by selling foreign currency in the foreign exchange market. This finding is consistent with that of Boyce (1992), who asserts that a higher level of reserves indicates a lower probability of a balance of payments crisis,[12] which reduces capital flight. The results of the error-correction model show that only Δ*LNOPENNESS* was not significant in the short-run. The coefficient for Δ*LNOPENNESS* is positive with a lesser impact (9.9306) than the long-run coefficient (62.3474). This shows that trade misinvoicing is a process that intensifies over time. The value for the error-correction term (ecm_{t-1} = −0.4705) is significant at the 1% level, which indicates a speed of convergence to equilibrium at 47.05% per annum. The statistical significance and the negative

[11] In addition to the pula, Botswana's foreign reserves are held in the form of US dollars and the SDR. Bank of Botswana (2017) is responsible for the management of foreign reserves to ensure liquidity and return on reserve assets.

[12] In early warning systems, a sharp decline in foreign reserves is an indicator of an imminent crisis (see Kaminsky et al. 1998).

sign of the error-correction term confirm the presence of a long-run equilibrium relationship between *KF*, *LNOPENNESS* and *RESERVES*.

The previous section indicated that trade openness and the level of foreign reserves are the determinants of capital flight from Botswana. The aim of the following sections is to examine the effects of exchange rate misalignment on capital flight by including dummy variables for overvaluation and undervaluation in the specification.

4.1.1. The Impact of Overvaluation on Capital Flight

The null of the first hypothesis (H_1) proposed that overvaluation of the Botswana pula increases capital flight in the long-run. In this study, a 5% threshold for positive misalignment was used to create the overvaluation dummy variable $(OVER)$. The variable is included in the regression to determine its effect on capital flight and other regressors. The *F*-test is used to determine a long-run relationship between *KF*, *OVER*, *LNOPENNESS* and *RESERVES*. The optimal lag established for the ARDL model using the SBIC is zero when *KF* is the dependent variable. The computed *F*-statistic when *KF* is the dependent variable with trend and intercept is greater than the upper limit of the critical bound (16.10 > 6.36). The null hypothesis of no long-run equilibrium relationship is rejected at the 1% significance level. The test is performed again with constants only and the null of no long-run equilibrium relationship is still rejected at the 1% significance level. The null hypothesis of no long-run equilibrium relationship is rejected at the 1% significance level when *OVER* is a dependent variable in all cases. However, when the variables *LNOPENNESS* and *RESERVES* are dependent variables, the null hypothesis of no long-run equilibrium relationship is not rejected in all cases. The optimal lag length for SBIC and AIC is zero when *KF* is the dependent variable. AIC selected the same model as SBIC (1, 0, 0, 1). Table 6 presents the results of the estimated regression coefficients.

The estimated error-correction model above shows no challenges of endogeneity, non-normality of the residuals or heteroskedasticity. The estimated coefficients for the model are systematically stable. The coefficient for *OVER* is positive (8.0067), indicating that an overvalued currency leads to increasing expectations of depreciation in the future resulting in substantial capital outflows[13]. Consequently, we fail to reject the null of H_1. The results are consistent with those of Cuddington (1986), who shows that overvaluation of the Argentine Peso increased the probability of a major devaluation and was the cause of capital flight in 1980–1982. The coefficient for *LNOPENNESS* is positive and significant (49.3755) at the 5% significance level. This signals that when the currency is overvalued, trade liberalisation increases the volume of outward capital flight through exportable commodities. This finding is consistent with that of Cheung and Qian (2010).

The coefficient for *RESERVES* is positive (0.2439), indicating that increasing the level of foreign reserves when the currency is overvalued does not reduce outward capital flight. This result is not consistent with that of Boyce (1992), who argues that a higher level of reserves reduces capital flight. This finding can be explained by Botswana's history of devaluation of the pula for competitiveness of exports. The pula was devalued seven times between 1980 and 2005. The highest devaluation was 15% in 1985 and 12% in 2005. Investors may expect a larger depreciation of the pula, leading to high capital outflows. The fear of welfare losses from devaluation may be too high such that increasing foreign reserves does not deter investors from sending their assets abroad.

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[13] At the 3% threshold, the coefficient for *OVER* is 8.7746. The coefficient for *OVER* is 8.0067 at the 4% and 5% thresholds. When the threshold is 6%, 7%, and 8% the coefficient for *OVER* is three times greater (24.0354, 24.0354, and 24.2009) than the coefficient at the 5% threshold. This shows that the higher the overvaluation, the higher the expectations of devaluation resulting in large capital flight. Policymakers should tolerate overvaluation only up to 5%. The coefficient for *LNOPENNESS* increases from 49.4755 at the 5% level to 57.5182 at the 6% and 7% thresholds. There was less variation in the coefficients of *RESERVES* when the threshold was altered.

Table 6. Estimated coefficients of the overvaluation dummy (OVER) and other determinants of KF.

Model: SBIC-ARDL (1, 0, 0, 1)		
Regressor	**Long-Run Coefficient**	***t*-Statistic (*p*-Value)**
Constant	−232.1514 **	2.5855 (0.0145)
OVER	8.0067	1.2929 (0.2053)
LNOPENNESS	49.3755 **	2.5362 (0.0163)
RESERVES	0.2439	1.1604 (0.2545)
The Wald test for the hypothesis:	χ^2 (*p*-value)	
H_0: Coefficient on OVER = 0	$\chi^2_{(1)} = 1.6715$ (0.1961)	
H_0: Coefficient on LNOPENNESS = 0	$\chi^2_{(1)} = 6.4321$ (0.0112) **	
H_0: Coefficient on RESERVES = 0	$\chi^2_{(1)} = 1.3465$ (0.2549)	
Error-Correction Model		
Regressor	**Short-Run Coefficient**	***t*-Statistic (*p*-Value)**
Constant	−0.5780	−0.3316 (0.7425)
ΔOVER	4.4302	1.3719 (0.1803)
ΔLNOPENNESS	27.7653	0.9965 (0.3270)
ΔRESERVES	0.7909 ***	6.1610 (0.0000)
ecm_{t-1}	−0.6547 ***	−4.6701 (0.0001)
The Wald test for the hypothesis:	χ^2 (*p*-value)	
H_0: Coefficient on ΔOVER = 0	$\chi^2_{(1)} = 1.8822$ (0.1701)	
H_0: Coefficient on ΔLNOPENNESS = 0	$\chi^2_{(1)} = 0.9931$ (0.3190)	
H_0: Coefficient on ΔRESERVES = 0	$\chi^2_{(1)} = 37.9577$ (0.0000) **	
H_0: Coefficient on $ecm_{t-1} = 0$	$\chi^2_{(1)} = 21.8099$ (0.0000) **	
R^2	0.6804	
Adjusted R^2	0.6378	
Standard error of the regression	10.2731	
Observations	35	
Additional Diagnostics		
BG LM test for serial correlation	F (1, 31) = 0.0896	
BPG test for heteroskedasticity	F (3, 32) = 0.0534	
Ramsey RESET	F (1, 31) = 0.2794	
Normality test	JB (0.0224) = 0.9889	
Stable	Yes	

Notes: χ^2 is the Chi-squared test statistic. BG LM = Breusch–Godfrey serial correlation LM test. BPG = Breusch–Pagan–Godfrey test. *JB* = Jacque–Bera statistic. The significance level for the Wald test and other diagnostic tests is 5%. ** and *** indicate significance at 5%, and 1%, respectively.

The results of the error-correction model show that only $\Delta RESERVES$ was significant in the short-run. The coefficient for $\Delta LNOPENNESS$ is positive with a lower impact (27.7653) than the long-run coefficient (49.3755). This is because in the long-run, economic agents involved in trade misinvoicing have more experience, leading to higher capital outflows than in the short-run. In the short-run, *OVER* still bears a positive sign (4.4302), indicating that overvaluation increases capital flight. The value for the error-correction term ($ecm_{t-1} = -0.6547$) is significant at the 1% significance level, which signals a speed of convergence to equilibrium at 65.47% annually. The statistical significance and the negative sign of the error-correction term further confirm the presence of a long-run equilibrium relationship between *KF*, *OVER*, *LNOPENNESS* and *RESERVES*.

4.1.2. The Impact of Undervaluation on Capital Flight

The null of the second hypothesis (H_2) proposed that undervaluation of the Botswana pula decreases capital flight in the long-run. Similar to the procedure followed to determine overvaluation, a 5% threshold is used to create the undervaluation dummy variable (*UNDER*). The *F*-test is used to determine a long-run relationship between *KF*, *UNDER*, *LNOPENNESS* and *RESERVES*. The

optimal lag established for the ARDL model using the SBIC is zero when *KF* is the dependent variable. The computed *F*-statistic when *KF* is the dependent variable with trend and intercept is greater than the upper limit of the critical bound (25.38 > 6.36). The null hypothesis of no long-run equilibrium relationship is rejected at the 1% significance level. When the variable *UNDER* is a dependent variable, the null hypothesis of no long-run equilibrium relationship is rejected at the 5% level in all regressions (RC, UC and UC + UT). However, when *LNOPENNESS* and *RESERVES* are dependent variables, the null of no long-run equilibrium relationship is not rejected. The optimal lag length for SBIC and AIC is zero when *KF* is the dependent variable. Table 7 presents the results of the estimated regression coefficients.

Table 7. Estimated coefficients of the undervaluation dummy (UNDER) and other determinants of KF.

Model: SBIC-ARDL (1, 0, 0, 1)		
Regressor	**Long-Run Coefficient**	***t*-Statistic (*p*-Value)**
Constant	−291.5128 ***	−4.1595 (0.0002)
UNDER	3.8561	0.6723 (0.5064)
LNOPENNESS	64.0550 ***	4.2140 (0.0002)
RESERVES	−0.8190 ***	−4.8613 (0.0000)
The Wald test for the hypothesis:	χ^2 (*p*-value)	
H_0: Coefficient on UNDER = 0	$\chi^2_{(1)}$ = 0.4519 (0.5014)	
H_0: Coefficient on LNOPENNESS = 0	$\chi^2_{(1)}$ = 17.7577 (0.0000) **	
H_0: Coefficient on RESERVES = 0	$\chi^2_{(1)}$ = 23.6320 (0.0000) **	
Error-Correction Model		
Regressor	**Short-Run Coefficient**	***t*-Statistic (*p*-Value)**
Constant	−0.9235	−0.7760 (0.4443)
ΔUNDER	0.3369	0.0950 (0.9250)
ΔLNOPENNESS	12.3948	0.6706 (0.5079)
ΔRESERVES	0.5214 ***	5.6507 (0.0000)
$\Delta RESERVES_{t-1}$	−0.6333 ***	−6.6013 (0.0000)
ecm_{t-1}	−0.5149 ***	−3.7165 (0.0009)
The Wald test for the hypothesis:	χ^2 (*p*-value)	
H_0: Coefficient on ΔUNDER = 0	$\chi^2_{(1)}$ = 0.0090 (0.9243)	
H_0: Coefficient on ΔLNOPENNESS = 0	$\chi^2_{(1)}$ = 0.4498 (0.5024)	
H_0: Coefficient on ΔRESERVES = 0	$\chi^2_{(1)}$ = 31.9303 (0.0000) **	
H_0: Coefficient on $\Delta RESERVES_{t-1}$ = 0	$\chi^2_{(1)}$ = 43.5768 (0.0000) **	
H_0: Coefficient on ecm_{t-1} = 0	$\chi^2_{(1)}$ = 13.8124 (0.0003) **	
R^2	0.8649	
Adjusted R^2	0.8408	
Standard error of the regression	6.9135	
Observations	34	
Additional Diagnostics		
BG LM test for serial correlation	*F* (1, 30) = 0.0770	
BPG test for heteroskedasticity	*F* (3, 31) = 0.7388	
Ramsey RESET	*F* (1, 30) = 0.4577	
Normality test	*JB* (3.2014) = 0.2018	
Stable	Yes	

Notes: χ^2 is the Chi-squared test statistic. BG LM = Breusch–Godfrey serial correlation LM test. BPG = Breusch–Pagan–Godfrey test. *JB* = Jacque–Bera statistic. The significance level for the Wald test and other diagnostic tests is 5%. ** and *** indicate significance at 5%, and 1%, respectively.

The estimated error-correction model (Table 7) shows no problems of serial correlation, endogeneity, non-normality of the residuals or heteroskedasticity. The model is systematically stable as its CUSUM plots were within the 5% boundaries. The coefficient for *UNDER* is positive (3.8561), indicating that an undervalued currency increases outward capital flight. Consequently, we reject the null hypothesis of

H_2. The results are not consistent with the findings of Gouider and Nouira (2014), who argue that undervaluation has no effect on capital flight. This disparity can be explained by the methodology Gouider and Nouira (2014) used. The duo did not use any threshold for determining undervaluation. Undervaluation was assumed as cases where the calculated value for misalignment was negative. Therefore, the study included redundant observations in the analysis that may not qualify to be undervaluation. In the present study, a 5% threshold is used to capture only significant cases of undervaluation[14]. The results agree partially with those of Gouider and Nouira (2014) because the Chi-square statistic *p*-value (p = 0.5014) for the variable *UNDER* indicates that undervaluation is a minor determinant of capital flight. Therefore, for a restricted model, the variable *UNDER* can be deleted.

The coefficient for *LNOPENNESS* is positive and significant (64.0550) at the 5% significance level. This signals that when the currency is undervalued, removing trade barriers increases the volume of outward capital flight through exportable commodities. The coefficient for *LNOPENNESS* when the currency is undervalued is greater than when the currency is overvalued (64.0550 > 49.3755). This can be explained by an increase in the volume of exports when the currency is undervalued (Vo et al. 2019; Thuy and Thuy 2019). An undervalued currency raises competitiveness of exports, which allows more goods to be misinvoiced and results in high capital flight. However, when the currency is overvalued, the demand for exports is low. Consequently, there will be less trade misinvoicing and low capital flight. The coefficient for *RESERVES* is negative (−0.8190), which indicates that an increase in the level of foreign reserves when the currency is undervalued reduces outward capital flight. This finding is consistent with economic theory that a higher level of reserves reduces capital flight (Boyce 1992).

The results of the error-correction model show that only $\Delta RESERVES$ and its lag were significant in the short-run. The coefficient for $\Delta LNOPENNESS$ is positive with a lower impact (12.3948) than the long-run coefficient (64.0550). In the short-run, the coefficient for *UNDER* still bears a positive sign (0.3369), indicating that undervaluation induces capital flight. The value for the error-correction term ($ecm_{t-1} = -0.5149$) is significant at the 1% level, which signals a speed of convergence to equilibrium at 51.49% annually. The significant and negative error-correction term confirms a long-run equilibrium relationship between the variables *KF*, *UNDER*, *LNOPENNESS* and *RESERVES*. The results of the *F*-test indicated a long-run relationship[15] when *KF* is a dependent variable. The Gregory–Hansen cointegration test was used to account for structural breaks in the relationship between the variables. The results of the Gregory–Hansen cointegration test reject the null hypothesis of no cointegration when *KF* is the dependent variable which confirms the long-run relation between *KF* and the regressors.

The results of the ARDL bounds test show that a long-run equilibrium relationship exists between capital flight and its determinants. The estimated coefficients of the ARDL models do not indicate causality between the variables. Therefore, the Toda and Yamamoto (1995) approach to Granger causality is applied to determine causation between *KF*, *OVER*, *UNDER*, *LNOPENNESS* and *RESERVES*. Table 8 presents the results of the causality test.

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[14] At the 3% threshold, the coefficient for *UNDER* is 3.3463. The coefficient is 4.0487 at the 4% threshold. The coefficient increases to 12.4325 at the 8% threshold level. There was less variation in the coefficients of *LNOPENNESS* and *RESERVES* when the threshold was altered.

[15] Narayan (2005) critical values were further used to determine the long-run equilibrium relationship between KF and the regressors (unrestricted constant without the time trend). The computed *F*-statistic for *F*(KF|LNOPENNESS, RESERVES) is 5.1459 which is significant at the 5% level. The computed *F*-statistic for *F*(KF|OVER, LNOPENNESS, RESERVES) is 14.0664 which is significant at the 1% level. The computed *F*-statistic for *F*(KF|UNDER, LNOPENNESS, RESERVES) is 5.9052 which is significant at the 5% level.

Table 8. Causality between KF, OVER, UNDER and RESERVES.

Hypothesis	χ^2	*p*-Value	Causality
OVER does not Granger-cause KF	4.2343	0.0396 **	OVER → KF
KF does not Granger-cause OVER	0.2481	0.6184	No
RESERVES does not Granger-cause KF	28.5347	0.0000 ***	RESERVES → KF
KF does not Granger-cause RESERVES	0.3219	0.5705	No
LNOPENNESS does not Granger-cause KF	0.5755	0.7500	No
KF does not Granger-cause LNOPENNESS	6.4861	0.0390 **	KF → LNOPENNESS
UNDER does not Granger-cause KF	1.4348	0.4880	No
KF does not Granger-cause UNDER	0.3613	0.8347	No

Notes: χ^2 is the Chi-square statistic; → is the direction of causality when rejecting the null hypothesis of no causality. 'No' indicates that the null of no causality cannot be rejected. ** and *** indicate significance at 5%, and 1%, respectively.

The causality effect from overvaluation to capital flight supports the exchange rate expectations theory, which posits that overvaluation of the currency increases expectations of devaluation, leading to capital flight. In addition, the causality effect from foreign reserves to capital flight indicates that a decline in foreign reserves increases doubts about the ability of the government to solve economic problems, leading to capital flight. The results of the causality test show that undervaluation does not cause capital flight from Botswana. The lack of a causal relationship implies that when the currency is undervalued, investors are less likely to move their assets to foreign countries despite the rising inflation. Investors respond more to prospects of devaluation than to inflation. The causal relationship from capital flight to trade openness implies that capital leaving Botswana is used for importing more of Botswana's goods. Since trade openness is a major conduit for capital flight from Botswana, the causal relationship implies a habit formation effect as economic agents gain more experience with trade misinvoicing.

5. Conclusions

To the best of the authors' knowledge, this study is the first contribution to the literature that evaluates the impact of exchange rate misalignment on capital flight from Botswana. The principal aim of this study was to determine the impact of exchange rate misalignment on capital flight from Botswana over the period 1980–2015. The examination contributes to the literature in two important ways. First, previous studies posit that the pula is overvalued but there is no study that evaluates the impact of exchange rate misalignment on capital flight from Botswana. The present study filled this gap. The results of this study are important for implementing macroeconomic policies that support capital inflows for economic diversification in Botswana. Further, the World Bank (2019) indicates that Botswana's diamond mines will be depleted by 2030. In the absence of diamonds, Botswana's economic growth will decline drastically. Correcting exchange rate misalignment is necessary for early economic diversification and sustainable economic growth without diamonds. The results show that on average, Botswana experienced inward capital flight during 1980–2015. The most important determinant of capital flight from Botswana is trade openness, which indicates that exportable commodities are falsely invoiced, leading to net capital outflows. Overvaluation of the currency increased capital flight in the long-run since it increases expectations of devaluation. The Toda and Yamamoto (1995) causality test support the ARDL estimates that overvaluation and declining foreign reserves cause outward capital flight. There was no causality between undervaluation and capital flight, which suggests that undervaluation is a minor determinant of capital flight from Botswana. In summary, the results posit that in the long-run, when the currency is overvalued, the volume of capital flight through trade misinvoicing declines and increasing foreign reserves does not reduce capital flight. However, when the currency is undervalued, the volume of capital flight through trade misinvoicing increases and foreign reserves reduce outward capital flight.

The findings of this study would be vital for the implementation of macroeconomic policies in Botswana. The results of this study indicate that the major conduit of capital flight from Botswana is misinvoicing of exports. The government has to formulate trade regulations and monitor imported and exported commodities. This process will involve trading partner economies by promoting transparency in international trade. The SACU and SADC units should be involved in the process since they promote free trade and economic cooperation. Ajayi and Ndikumana (2015) suggest that trading partners should share invoice data, because this will help identify disparities in prices and quantities of goods between both sides of the trade transaction. Botswana should implement capital controls to limit capital smuggling and maintain monetary autonomy. Botswana has no capital controls to promote business efficiency and FDI inflows. However, the country experienced 14–21% of total trade as illicit financial outflows during 2005–2014 (Global Financial Integrity 2017). Capital controls can be implemented by increasing transaction costs and promoting regulation of the financial sector (Ajayi and Ndikumana 2015). In addition, the lack of capital controls interferes with macroeconomic policies implemented. The country should maintain stable reserves to support the currency in the case of a financial crisis. This study has some limitations. First, the lack of data for the Botswana economy restricted the choice of estimators. The nonlinear smooth transition model (STR) is a viable alternative to ARDL but it required quarterly data, which for Botswana is not available. Capital flight and REER misalignment are a concern in developing countries like Botswana. However, developing countries often lack sufficient data for meaningful results. In future, developing countries can be grouped together in a panel framework to obtain sufficient observations.

Supplementary Materials: The following are available online at http://www.mdpi.com/1911-8074/12/2/101/s1, Figure S1. Plots of CUSUM and CUSUM of squares (LNREER and fundamentals). Figure S2. Plots of CUSUM and CUSUM of squares (KF, LNOPENNESS, RESERVES). Figure S3. Plots of CUSUM and CUSUM of squares (KF, OVER, LNOPENNESS, RESERVES). Figure S4. Plots of CUSUM and CUSUM of squares (KF, UNDER, LNOPENNESS, RESERVES). Table S1. List of variables and data sources.

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Appendix A

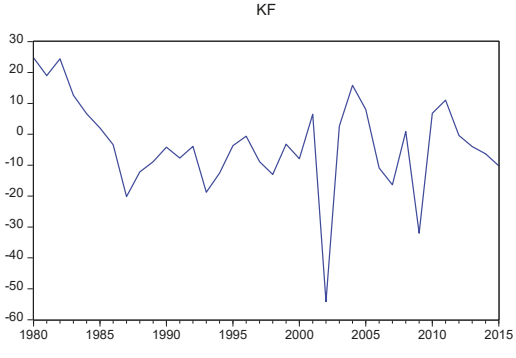

Figure A1. Botswana's outward capital flight (KF). Positive values indicate resources leaving Botswana to other economies and less preference for domestic assets (outward capital flight). Negative values signal inward capital flight and less preference for foreign assets.

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The Impact of Corporate Diversification and Financial Structure on Firm Performance: Evidence from South Asian Countries

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Abstract: We examined the impact of corporate diversification and financial structure on the firms' financial performance. We collected data from 520 manufacturing firms from Pakistan, India, Sri Lanka, and Bangladesh. We used panel data of 14 years from 2004–2017 to analyze the results. We applied a two-step dynamic panel approach to analyze the hypotheses. We found that product diversification and geographic diversification significantly affected the firms' financial performance. We further found that dividend policy and capital structure had a significant impact on the firm's financial performance.

Keywords: corporate diversification; financial structure; corporate governance; audit quality; firm financial performance

1. Introduction

Managers tend to diversify their business to get more benefits from the current market with minimum risk. Globalization provides an opportunity to expand their business across the border for profit maximization. Thus, corporate diversification strategy becomes important for the expansion and growth of firms in competitive and dynamic environments. The objective of corporate diversification is to increase profitability, market share, debt capacity, growth opportunity, risk reduction, and the need to use human and financial resources efficiently (Afza et al. 2008). Changes in economic or industrial conditions force management to diversify their business (Phung and Mishra 2016). Diversification also helps firms to explore different markets (Gomes and Livdan 2004).

When firms go for diversification, they need extra capital. According to Lewellen (1971), diversified firms need more debt financing than non-diversified firms. The effective financial structure maximizes the value for shareholders. There are three types of financial structure in finance theory: investing, financing, and dividend policies (Zulkafli et al. 2015). Corporate governance plays an important role to improve the firms' financial performance (Yermack 1996; Erickson et al. 2005). We take corporate governance into consideration and how corporate governance affects the firms' financial performance. Claessens and Yurtoglu (2013) explain that a good governance system is beneficial for the firms through better access to finance, good financial performance, and more desirable treatment of stakeholders.

In this complex world, survival of the manufacturing industry becomes more challenging. Given the complex, globalized, and challenging environment, there is a need for survival and better financial performance of the manufacturing sector. Therefore, this sector has to diversify its businesses into different products and different markets. However, the corporate diversification, financial structure (investment, financing, and dividend policies), and corporate governance are the

important factors to enhance the firms' financial performance. We find that product diversification, geographic diversification, and financial structure significantly affect the firms' financial performance. The outputs of our study suggest that financial policies are important determinants of firms' financial performance. In addition, our findings are beneficial for firms in emerging markets engaging in diversification operations.

There are five sections of the study. We discuss the introduction in Section 1 followed by literature in Section 2. The methodology is explained in Section 3. Section 4 deals with the empirical analysis and we conclude our study in Section 5.

2. Review of Literature

A corporate diversification strategy deals with business expansion and profit maximization of a firm. The modern portfolio theory of Markowitz (1952) states that diversification in various investment projects leads to minimize risk and maximize expected return. In agency theory, the literature shows that managers work for their personal benefits at the expense of shareholders by using diversification strategies (Jensen and Meckling 1976; Denis et al. 1997). Lins and Servaes (2002) explain that the utilization of internal capital is an attraction for diversification due to imperfection in the external capital market. The concept explains a positive relationship between corporate diversification and firms' value because a firm has informational advantages in raising capital and it can avoid the costs of external financing, which is greater than the cost of internal financing.

To meet challenges and survive in the markets, firms make diversification decisions. Management of the firms decide whether to go for related or unrelated diversification. If firms opt for related diversification, that provides good output and reduces total risk. However, if management goes for unrelated diversification, it may have a negative impact on firm value. Corporate diversification strategy helps firms to expand business activities and get maximum profit (Phung and Mishra 2016). According to Pandya and Rao (1998), diversified firms perform better on risk and return basis. According to Phung and Mishra (2016), there is a negative impact of diversification on financial performance. This negative impact is due to a weak and inefficient corporate governance system, which motivates firms to diversify and ultimately negatively affects the firms' financial performance. Furthermore, inefficient diversification strategy negatively affects the firms' financial performance (Berger and Ofek 1995). The literature states that diversification is important and has the potential to increase the firms' financial performance. Therefore, the impact of diversification on the firms' financial performance depends on its effective management.

Hypothesis 1 (H1). *Corporate diversification positively affects the firm's financial performance.*

When firms make diversification decisions, financial structure is an important factor which affects the firms' financial performance. Zulkafli et al. (2015) consider financing, investment, and dividend policies as corporate financial structure. Proper management of financial decisions (investment, financing, working capital, and dividend policy) is essential for the firms' financial performance (Butt et al. 2010). However, we investigate the impact of capital structure on the firms' financial performance. Based on some assumptions, Modigliani and Miller (1958) state that capital structure does not affect the firm's value. Later, Modigliani and Miller (1963) suggest that with an increase in taxes and deductible interest expenses, a firm prefers debt financing instead of equity financing. It shows that they have a different opinion when they consider the effects of tax shield and capital market imperfection. They revise their arguments and explain that capital structure affects the value of the firm due to the cost of debt. Myers and Majluf (1984); Myers (1984) explain Pecking Order Theory when a firm opts for internal rather than external sources of financing. Equity and debt financing bear the capital cost; therefore, it is not a cheap source of financing. A firm opts debt financing as it bears less cost as compared to equity financing. Dividend payments also give information to shareholders about firms' financial performance. This is among the major financial decisions that top management takes (Baker

et al. 2001). The business activities and growth depend on the financial structure of a firm. Firms need to make an investment decision with great care as this demands the estimation of the value of certain projects based on timing, size, and estimation of the cash flow of the future.

Butt et al. (2010) suggest that capital structure and dividend payments are important elements of firm growth and they find the positive impact of capital structure on the firms' financial performance. Safieddine and Titman (1999) state a positive impact of debt financing on the firms' financial performance. According to Gleason et al. (2000), capital structure and firms' financial performance have a negative relationship. Yat Hung et al. (2002); Salim and Yadav (2012) find a negative impact of capital structure on the firms' financial performance because the increase in leverage enhances the chances of bankruptcy cost which in turn decreases financial performance. Firms face financing obstacles, which slow down the firms' growth (Beck and Demirguc-Kunt 2006). The negative impact of capital structure on the firms' financial performance confirms the Pecking Order Theory of Myers and Majluf (1984) which explains that when firms go for more debt financing, they earn less profit. Literature leads us to think that the relationship between capital structure and firms' financial performance and shareholders' wealth is still present. The firms should generate optimal capital structure in order to maximize wealth for shareholders.

Hypothesis 2 (H2). *Capital structure negatively affects the firm's financial performance.*

Does the dividend payment policy affect the value of a firm? There are different views in the literature about dividend policy and the value of a firm. Literature states that when firms buy back their stock, it gives a signal about undervaluation of stock prices of firms. This ultimately positively influences the firms' return because it creates wealth for stockholders along with an increase in share prices. The bird in hand theory of Gordon (1963) and the dividend growth model of Walter (1963) explain the relevance of dividend payment and further explain that dividend payment affects the value of the firms. Butt et al. (2010); Ali et al. (2015) find that dividend policy positively affects the firm's financial performance. Hunjra (2018) proves a significant role of dividend payments towards the firm's financial performance and support the relevancy school of thought. The concepts describe that dividend is less risky as compared to capital gain. Therefore, investors prefer dividend instead of receiving capital gain. This means that dividend payments increase the value of the firm. Titman et al. (2004); Cooper et al. (2008) state that dividend payment has a negative impact on firms' financial performance.

Hypothesis 3 (H3). *Dividend policy positively affects the firm's financial performance.*

Investment decision-making is another important component of the financial structure of the firm. The purpose of every investment is to earn the profit. Thus, investment decision-making directly affects the firms' financial performance. Miller and Modigliani (1961) present irrelevance proposition of dividend and explain that dividend payment does not affect the value of the firms rather investment decision affects the firm's value. Chen and Ho (1997); Chung et al. (1998); Jiang et al. (2006) show a positive impact of investment plans on the firm's financial performance. Titman et al. (2004) and Cooper et al. (2008) state investment decision has a negative impact on financial performance. The firms having an investment in fixed assets are less likely to have liquid assets. Therefore, firms having more liquid assets are likely to capitalize on long-term investment opportunities.

Hypothesis 4 (H4). *Investment policy positively affects the firm's financial performance.*

We have incorporated a set of control variables in our study (i.e., corporate governance, firm age, and firm size and growth). Firms can generate more capital for investment and improve their financial performance by applying good corporate governance practices. In a competitive environment, effective corporate governance is important for economic development (Boubaker and Nguyen 2015).

Jensen and Meckling (1976) present agency theory which explains that in a corporate governance system, managers work for their self-interest instead of owners' interest which results in inefficient allocation of resources and a decrease in financial performance. Due to availing personal benefits, management makes a decision like diversification. The theory supports the fact that agency conflicts negatively affects the firms' financial performance. Corporate governance minimizes the agency problem as individual and institutional investors prefer firms which are well governed. On the contrary, Stewardship theory explains that managers focus only on the collective wellbeing of the firms regardless of the self-interest of the managers (Donaldson and Davis 1991). Therefore, this theory suggests that firms can increase their financial performance if the top-level management possesses more power and they develop trust in running business affairs.

The literature explains the impact of corporate governance on firm's financial performance. Board of directors is a fundamental element of a firm's corporate governance structure (Black et al. 2009). Yermack (1996) finds a negative impact of board size on the financial performance of large firms in USA. Mak and Kusnadi (2005) find a negative impact of board size on firms' financial performance. Kiel and Nicholson (2003); Dar et al. (2011) find a positive impact of board size on the firm's financial performance. The literature states that board size is an important element of a good corporate governance practice. Bhagat and Bolton (2008); Ehikioya (2009) reveal a negative and significant relationship between CEO duality and firm's financial performance. The positive relationships between corporate governance mechanisms and financial performance show efficient management of corporate governance system. The negative relationship validates Agency Theory and indicates the situations where management performs for their own best interest with the investment of owners.

The auditor's full independent opinion after audit leads to audit quality (DeAngelo 1981). An audit committee performs an important and monitoring part to ensure the quality of the firm's accountability and financial statements (Carcello and Neal 2003). Resource dependence theory suggests that the large size of the audit committee can bring good resources into the firm like experience and skills. This shows the effectiveness of audit work while monitoring the operations of management that improves the firms' financial performance (Pearce and Zahra 1992). External audit quality in terms of big audit firms is also an important element of the audit committee. DeAngelo (1981) argues that the big four firms provide better audit quality which enhances the firms' financial performance. Bauer et al. (2009) find a positive impact of large audit committee size on the firms' financial performance. The frequency of audit committee meetings ensures the activeness of the audit committee, which improves the financial performance of the firms. Vafeas (1999); Xie et al. (2003) find the frequency of audit committee meetings has a positive impact on firms' financial performance. Considering the above studies, we take an audit committee and audit quality in our study to check their impact on the firms' financial performance as they enhance the quality of financial reporting and financial performance.

Large board size enhances the utilization of the firm's useful resources (Boubaker and Nguyen 2012). Hence, large firms have more opportunities to gain economies of scale and economies of scope. Firm size has a positive impact on the firm's financial performance (Titman and Wessels 1988; Frank and Goyal 2003; Hunjra et al. 2014). It is argued that firms with large size faceless financial distress and generate more profit (Titman and Wessels 1988). The firms' financial performance also depends on growth opportunities and the firms' age. Firm age is important in a way that it explains about the experience of the firm in its operations. Muritala (2012); Hunjra et al. (2014); Lazar (2016) find that firm growth and firm age have a positive impact on firms' financial performance. The positive impact of growth indicates the opportunities for the firms to expand business and earn more profit. Pervan et al. (2017) present a theoretical discussion about the positive and negative impact of age on financial performance. Firms with old age have more abilities, experience, good technology, skilled labor, and learning environment, which help them to increase financial performance. On the contrary, older firms face the situation where there is a reduction in flexibility and ability to make immediate changes and take quick decisions. With the increase in age, firms also avoid taking the risk.

3. Methodology

3.1. Data

We use panel data for the period of 2004 to 2017. We collect the data from the financial statements of the manufacturing industry firms listed on Pakistan Stock Exchange (PSX), Bombay Stock Exchange (BSE), Colombo Stock Exchange (CSE) and Dhaka Stock Exchange (DSE) for the countries Pakistan, India, Sri-Lanka and Bangladesh respectively. For analysis, we use the data of 520 firms from manufacturing sector because this sector is positively opting the diversification strategy that needs management of operations and financial activities. Table 1 describes number of firms of selected countries. We follow Campa and Kedia (2002) for the selection of sample in our study while considering the product diversification. We categorize firms as diversified when they produce more than one products, whereas we categorize firms as specialized when they produce single product. In addition, out of overall 520 sample firms, we classify 415 firms as diversified while 105 firms as single product firms.

Table 1. Categories of the Firms.

Countries	Diversified Firms	Single Product Firms	Total
Pakistan	225	38	263
India	87	30	117
Sri Lanka	74	21	95
Bangladesh	29	16	45
Total	415	105	520

3.2. Statistics

We use both accounting measures like Return on Assets (ROA) and Return on Equity (ROE) and market measures that is Tobin's Q (TQ) of profitability. We classify the firms producing a single product as specialized with a value of 0 and firms producing more than one product as diversified firms with a value of 1. Afza et al. (2008) apply the same criteria to measure product diversification. The proxy for geographic diversification is the proportion of foreign sales to total sales. Schmid and Walter (2012) also use this proxy in their study. We measure capital structure as a ratio of total debts to total assets of the firm. Bhaduri (2002) uses the same measure of capital structure. We calculate dividend per share as the proxy of dividend policy. Oloidi and Adeyeye (2014) use the same proxy in their study. We use the proxy for investment policy as a change in investment in fixed assets. Aivazian et al. (2005) apply this measure of investment in their study.

We measure board size as a number of board members. Bhagat and Bolton (2008) use this proxy in their research. For CEO duality, we use value 1 if the CEO is also a director of the firm, otherwise, it is 0 (Bhagat and Bolton 2008). Audit quality characteristics include audit quality, audit committee size and audit committee activity. We take value 1 if the firm is audited by big four audit firms, otherwise, 0 followed the approach of Francis and Yu (2009). We measure audit committee size as a total number of members in audit committee (Azim 2012). We calculate the audit committee activity as the frequency of audit committee meetings in a financial year (Xie et al. 2003). We calculate the firms' size as the natural log of total assets. In our study, we measure growth as the percentage change in sales. Further, we measure the firms' age as the difference between the year in which a firm starts and the year in which it exists in the sample. Hunjra et al. (2014); Muritala (2012) apply similar calculations of size, growth and age for analysis. The description of variables is given in Table 2.

Table 2. Tabular summary of definitions of variables.

Study Issue	Variable/s	Symbols	Definition/Calculation	Reference/s
Firms' Financial Performance	Return on Assets	ROA	Net income Available to Common Shareholders/Book value of assets	Afza et al. (2008); Iqbal et al. (2012)
	Return on Equity	ROE	Net income/Shareholders equity	Afza et al. (2008); Iqbal et al. (2012)
	Tobin's Q	TQ	The market value of equity plus book value of liabilities divided by book value of Assets	Wernerfelt (1997); Afza et al. (2008)
Corporate Diversification	Product Diversification	PD	Value 1, if a firm operates in more than one product, otherwise 0.	Afza et al. (2008)
	Geographic Diversification	GD	Foreign sales divided by Total sales.	Schmid and Walter (2012)
Financial Structure	Investment Policy	IP	Change in Investment in Fixed Assets	Aivazian et al. (2005)
	Capital Structure/Financing Policy	CS	Total debts divided by total assets	Bhaduri (2002)
	Dividend per share	DP	Total dividends paid out in a year/outstanding common shares	Oloidi and Adeyeye (2014)
Corporate Governance and Audit Quality Characteristics as Control Variables	Board Size	BSIZE	Number of Members in Board	Bhagat and Bolton (2008)
	CEO duality	CEOD	Value 1 if the CEO also acts as chairman of the board, otherwise 0.	Bhagat and Bolton (2008)
	Audit quality	AQ	Value 1, if the firms get their accounts audited with big four audit professionals (Deloittee Touche Tohmatsu, PwC, Ernst & Young and KPMG), otherwise 0.	Francis and Yu (2009)
	Audit Committee Size	ACSIZE	Total number of members in the audit committee	Azim (2012)
	Audit Committee Activity	ACA	The frequency of audit committee meetings in a financial year.	Xie et al. (2003)
Other Control Variables	Size	SIZE	Natural Log of Total Assets	Hunjra et al. (2014)
	Growth	GRTH	Percentage change in sales	Muritala (2012);
	Age	AGE	Difference between the year in which the firm starts and the year in which the firm exists in the sample	Muritala (2012); Hunjra et al. (2014)

We use the following equations to analyze the results:

$$ROA_{i,t} = \alpha_{i,t} + \beta_1 PD_{i,t} + \beta_2 GD_{i,t} + \beta_3 CS_{i,t} + \beta_4 DP_{i,t} + \beta_5 IP_{i,t} + \beta_6 BSIZE_{i,t} + \beta_7 CEOD_{i,t} + \beta_8 AQ_{i,t} + \beta_9 ACSIZE_{i,t} + \beta_{10} ACA_{i,t} + \beta_{11} AGE_{i,t} + \beta_{12} GRTH_{i,t} + \beta_{13} SIZE_{i,t} + \varepsilon_{i,t}, \quad (1)$$

$$ROE_{i,t} = \alpha_{i,t} + \beta_1 PD_{i,t} + \beta_2 GD_{i,t} + \beta_3 CS_{i,t} + \beta_4 DP_{i,t} + \beta_5 IP_{i,t} + \beta_6 BSIZE_{i,t} + \beta_7 CEOD_{i,t} + \beta_8 AQ_{i,t} + \beta_9 ACSIZE_{i,t} + \beta_{10} ACA_{i,t} + \beta_{11} AGE_{i,t} + \beta_{12} GRTH_{i,t} + \beta_{13} SIZE_{i,t} + \varepsilon_{i,t}, \quad (2)$$

$$TQ_{i,t} = \alpha_{i,t} + \beta_1 PD_{i,t} + \beta_2 GD_{i,t} + \beta_3 CS_{i,t} + \beta_4 DP_{i,t} + \beta_5 IP_{i,t} + \beta_6 BSIZE_{i,t} + \beta_7 CEOD_{i,t} + \beta_8 AQ_{i,t} + \beta_9 ACSIZE_{i,t} + \beta_{10} ACA_{i,t} + \beta_{11} AGE_{i,t} + \beta_{12} GRTH_{i,t} + \beta_{13} SIZE_{i,t} + \varepsilon_{i,t}. \quad (3)$$

We use descriptive statistics to check the normality of data and correlation is used to check the multicollinearity. We apply the Generalized Method of Moments (GMM), as this method performs consistent parameter estimation for the small time period and for a large cross-section. The GMM estimators enable asymptotically efficient inferences employing a relatively minimal set of assumptions (Arellano and Bond 1991; Blundell and Bond 1998). We deal with the unobserved heterogeneity by applying a fixed effect or by taking the first or second difference. The ability of first or second difference to remove the unobserved heterogeneity is developed for two-step dynamic panel data models. Furthermore, these models contain one or more lagged dependent variables and allow modeling of a partial adjustment mechanism.

4. Empirical Analysis

In Table 3, the mean value of financial performance represents the same trend and we find a lesser variation in values of financial performance measures which proves there is no outlier in our data. We further find that most of the firms are producing more than one product. In this competitive environment, it is necessary for manufacturing firms to expand their business for their survival. The firms do not pay a regular dividend to their investors as well as the average per share dividend is also very low. Results also indicate that this sector relies more on debt financing as compared to equity financing. In addition, an increase in debt structure results in the lowest return on assets. Therefore, opting for the diversification strategy, this sector needs to take a risk by increasing debt financing which helps to increase value. This sector is also growing in terms of fixed asset investments. Corporate governance is still at a growing stage in South Asian countries. The audit committee meets four times in a year. In addition, the average number of members of an audit committee are three. We find that more than one-third of the firms get their accounts audited with the big four audit firms. The average board size is around eight members and that shows a weak governance system. We further found that a lesser percentage of CEOs are acting as chairperson of the board. Sales growth shows a growing trend in the sales volume of this sector. Table 4 represents the correlation values to check the multicollinearity.

Table 3. Descriptive Statistics.

	Pakistan		India		Sri Lanka		Bangladesh		Overall	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
ROA	0.039	0.124	0.051	0.197	0.079	0.191	0.087	0.106	0.051	0.155
ROE	0.138	0.385	0.177	0.458	0.137	0.334	0.190	0.383	0.150	0.396
TQ	1.224	0.978	0.712	0.465	0.575	0.359	0.537	0.276	0.962	0.831
PD	0.835	0.371	0.747	0.435	0.770	0.421	0.656	0.476	0.794	0.405
GD	0.155	0.258	0.124	0.233	0.079	0.239	0.128	0.310	0.135	0.255
CS	0.587	0.286	0.566	0.243	0.442	0.229	0.434	0.217	0.550	0.271
DP	4.930	20.215	0.007	0.039	0.105	0.823	0.208	1.565	2.760	15.232
IP	0.137	0.503	0.154	0.556	0.146	0.598	0.184	0.728	0.145	0.547
BSIZE	7.854	1.345	8.234	3.340	8.159	2.524	8.274	2.566	8.014	2.230
CEOD	0.282	0.450	0.550	0.498	0.137	0.344	0.081	0.273	0.307	0.461
AQ	0.460	0.498	0.082	0.275	0.843	0.364	0.065	0.246	0.409	0.492
ACSIZE	3.243	0.597	3.531	1.339	2.843	0.779	3.780	1.191	3.280	0.921
ACA	4.169	0.599	4.191	1.614	4.093	1.439	4.215	1.285	4.165	1.104
AGE	34.445	18.860	38.245	28.112	47.449	36.822	28.481	23.069	36.960	25.434
GRTH	0.164	0.690	0.163	0.455	0.146	2.068	0.238	0.986	0.169	1.065
SIZE	21.764	1.557	15.519	1.553	14.917	1.520	16.028	1.683	18.914	3.545

Note: ROA is Return on Assets, ROE is Return of Equity, TQ is the Market Return, PD is Product Diversification, GD is Geographic Diversification, CS is Capital Structure, DP is Dividend Policy, IP is Investment Policy, ACA is Audit Committee Activity, ACSIZE is Audit Committee Size, AQ is Audit Quality, BSIZE is Board Size, CEOD is CEO Duality, AGE is Years of Activity of the Firm, GRTH is Sales Growth, SIZE is the Natural Log of Total Assets.

Table 5 explains the hypotheses testing through two-step dynamic panel regression. We categorize corporate diversification into two parts; product diversification and geographic diversification; therefore, we run three models for each one of the dependent variable in the analyses. In the first model, we analyze the impact of independent variables on firms' financial performance with product diversification. In the second model, we investigate the impact of independent variables on firms' financial performance with geographic diversification, whereas, in the third model, we run the analysis with product diversification as well as geographic diversification. We find that product diversification has a significant and positive impact on Return on Equity and Tobin's Q while it only has an insignificant impact on Return on Assets in the third model. An insignificant relationship suggests that highly diversified firms may not attract shareholders. Adamu et al. (2011) explain that if firms want to enhance financial performance, they should adopt a focused strategy. We find that geographic diversification has a significant and positive impact on Return on Assets, whereas it has a significant and negative impact on Tobin's Q. In addition, geographic diversification has an insignificant impact on ROE. The insignificant impact of corporate diversification is due to the reason that revenues from diversification are offset by extra expenses with respect to diversification (Hengartner 2006).

Varying results of diversification strategy justify the inefficient utilization of resources (Gao and Chou 2015). The reason for the negative impact of geographic diversification on Tobin's Q is that an inefficient corporate governance system induces managers to expand their business for personal benefits that have a negative impact on the firms' financial performance (Phung and Mishra 2016). This reason is in line with the Agency Theory of Jensen and Meckling (1976). We find that dividend policy significantly influences the firms' financial performance, which is according to the Bird in Hand Theory of Gordon (1963). The theory explains that dividend policy affects the firm's value. We find that dividend policy has a significant and positive impact on Return on Assets, whereas, it has a significant and negative impact on Tobin's Q. Negative impact shows that dividend payments reduce retained earnings of the firms. Further, dividend policy has an insignificant impact on Return on Equity in second and third models. The positive impact of dividend policy on financial performance is similar to the results of Butt et al. (2010) and Ali et al. (2015).

Table 4. Correlation Analysis.

	ROA	ROE	TQ	PD	GD	CS	DP	IP	BSIZE	CEOD	AQ	ACSIZE	ACA	AGE	GRTH	SIZE
ROA	1															
ROE	0.325	1														
TQ	0.052	0.102	1													
PD	−0.010	0.019	0.074	1												
GD	0.007	−0.009	−0.076	0.030	1											
CS	−0.147	−0.017	0.092	0.017	0.034	1										
DP	0.132	0.125	0.317	0.066	−0.025	−0.009	1									
IP	0.039	−0.010	0.008	0.008	−0.013	−0.002	0.009	1								
BSIZE	0.053	0.019	0.031	−0.083	−0.057	−0.042	0.028	0.051	1							
CEOD	−0.116	0.000	−0.017	0.018	0.057	0.125	−0.033	−0.019	0.062	1						
AQ	0.172	0.028	0.157	0.039	−0.079	−0.170	0.162	0.027	0.111	−0.261	1					
ACSIZE	0.053	0.017	0.062	−0.024	−0.010	−0.046	0.050	0.047	0.508	0.074	0.009	1				
ACA	−0.048	−0.001	0.005	0.014	0.024	0.000	0.003	0.042	0.359	0.110	0.050	0.366	1			
AGE	0.051	−0.016	−0.010	−0.017	−0.031	−0.104	0.058	0.011	0.125	−0.015	0.127	0.099	−0.026	1		
GRTH	0.035	0.007	−0.008	−0.030	−0.013	−0.018	−0.005	0.033	−0.006	−0.017	0.006	0.011	−0.010	0.026	1	
SIZE	−0.046	−0.010	0.341	0.092	0.101	0.156	0.201	0.021	0.043	−0.070	0.179	0.069	0.069	−0.045	0.015	1

Note: ROA is Return on Assets, ROE is Return of Equity, TQ is the Market Return, PD is Product Diversification, GD is Geographic Diversification, CS is Capital Structure, DP is Dividend Policy, IP is Investment Policy, ACA is Audit Committee Activity, ACSIZE is Audit Committee Size, AQ is Audit Quality, BSIZE is Board Size, CEOD is CEO Duality, AGE is Years of Activity of the Firm, GRTH is Sales Growth, SIZE is Natural Log of Total Assets.

Table 5. Two-step System Dynamic Panel Regression (Overall Sample).

	Dependent Variable (ROA)			Dependent Variable (ROE)			Dependent Variable (TQ)		
L1.	0.241 *** (0.000)	0.243 *** (0.000)	0.244 *** (0.000)	0.163 *** (0.000)	0.165 *** (0.000)	0.165 *** (0.000)	0.393 *** (0.000)	0.391 *** (0.000)	0.390 *** (0.000)
L2.	0.143 *** (0.000)	0.133 *** (0.000)	0.134 *** (0.000)	0.039 *** (0.000)	0.042 *** (0.000)	0.044 *** (0.000)	−0.047 *** (0.000)	−0.047 *** (0.000)	−0.049 *** (0.000)
PD	0.026 * (0.085)	–	0.017 (0.264)	0.124 *** (0.005)	–	0.091 ** (0.033)	0.184 *** (0.001)	–	0.207 *** (0.000)
GD	–	0.030 *** (0.003)	0.026 *** (0.008)	–	0.066 (0.103)	0.056 (0.157)	–	−0.086 *** (0.003)	−0.103 *** (0.001)
CS	−0.040 *** (0.000)	−0.044 *** (0.000)	−0.043 *** (0.000)	−0.040 (0.252)	−0.060 * (0.090)	−0.060 * (0.089)	0.292 *** (0.000)	0.274 *** (0.000)	0.277 *** (0.000)
DP	0.0002 *** (0.007)	0.0002 *** (0.004)	0.0002 *** (0.004)	−0.001 * (0.065)	0.000 (0.147)	−0.000 (0.136)	−0.001 *** (0.008)	−0.001 ** (0.010)	−0.001 *** (0.007)
IP	0.000 (0.861)	−0.001 (0.620)	−0.002 (0.493)	−0.001 (0.878)	−0.001 (0.828)	−0.003 (0.687)	−0.007 (0.189)	−0.011 ** (0.037)	−0.010 * (0.054)
BSIZE	0.000 (0.978)	0.000 (0.834)	0.000 (0.810)	−0.001 (0.858)	0.001 (0.799)	0.001 (0.881)	0.005 (0.250)	0.004 (0.389)	0.005 (0.313)
CEOD	0.007 (0.230)	0.004 (0.473)	0.005 (0.436)	0.012 (0.566)	0.002 (0.939)	0.006 (0.779)	−0.040 * (0.071)	−0.030 (0.191)	−0.036 (0.110)
AQ	0.006 (0.322)	0.004 (0.481)	0.004 (0.493)	−0.010 (0.653)	−0.001 (0.960)	−0.009 (0.686)	0.171 *** (0.000)	0.166 *** (0.000)	0.162 *** (0.000)
ACSIZE	0.005 ** (0.049)	0.002 (0.285)	0.003 (0.243)	0.008 (0.458)	−0.003 (0.801)	−0.003 (0.823)	0.033 *** (0.002)	0.033 *** (0.001)	0.034 *** (0.001)
ACA	0.000 (0.835)	−0.001 (0.526)	−0.001 (0.533)	0.004 (0.377)	0.005 (0.336)	0.006 (0.249)	0.001 (0.807)	0.002 (0.680)	0.001 (0.810)
AGE	−0.002 *** (0.000)	−0.003 *** (0.000)	−0.003 *** (0.000)	−0.006 *** (0.000)	−0.005 *** (0.000)	−0.005 *** (0.001)	−0.011 *** (0.000)	−0.011 *** (0.000)	−0.011 *** (0.000)
GRTH	0.008 ** (0.024)	0.008 ** (0.024)	0.007 ** (0.028)	0.014 (0.107)	0.016 * (0.052)	0.015 * (0.064)	0.000 (0.980)	0.000 (0.948)	0.000 (0.999)
SIZE	−0.018 *** (0.000)	−0.014 *** (0.000)	−0.013 *** (0.000)	0.008 (0.463)	−0.003 (0.730)	−0.004 (0.679)	0.060 *** (0.000)	0.066 *** (0.000)	0.063 *** (0.000)
C	0.436 *** (0.000)	0.407 *** (0.000)	0.386 *** (0.000)	0.041 (0.827)	0.357 ** (0.030)	0.283 * (0.097)	−0.676 *** (0.000)	−0.624 *** (0.001)	−0.715 *** (0.000)

Note: ***, ** and * represent levels of significant at 1%, 5% and 10%. *p*-values are shown in parentheses. ROA is Return on Assets, ROE is Return of Equity, TQ is the Market Return, PD is Product Diversification, GD is Geographic Diversification, CS is Capital Structure, DP is Dividend Policy, IP is Investment Policy, ACA is Audit Committee Activity, ACSIZE is Audit Committee Size, AQ is Audit Quality, BSIZE is Board Size, CEOD is CEO Duality, AGE is Years of Activity of the Firm, GRTH is Sales Growth, SIZE is the Natural Log of Total Assets.

The reason for the insignificant impact of dividend on financial performance variables is that manufacturing firms do not follow a regular pattern of dividend payments. Capital structure has a significant and negative impact on Return on Assets while it has a significant and positive impact on Tobin's Q. In addition, capital structure has a significant and negative impact on Return on Equity in the first and third models. Investment policy shows an insignificant impact on Return on Assets and Return on Equity while it has a significant and negative impact on Tobin's Q in the second and third models. The insignificant impact of investment policy is similar to the results of Kotšina and Hazak (2012). The reason for the insignificant impact is that firms fix the new selling prices of their goods by considering the changes in variable expenses and ignoring fixed expenses. There is also a general phenomenon that firms produce their products in large volume. As a result, there is a decrease in the unit cost of production. Due to this, any change in investment does not affect financial performance.

The analysis shows mixed results regarding the impact of corporate governance and audit quality on firms' financial performance. This is due to the weak and inefficient governance system in South Asian countries. The board size has an insignificant impact on firms' financial performance. The insignificant results of board size are similar to the results of Hunjra et al. (2016). We find that CEO duality has insignificance but a negative impact on financial performance. We find that the audit committee size has significance and a positive impact on Tobin's Q in the second and third model only. Positive effects of audit committee size on financial performance follow the Resource

Dependence Theory that states a positive relationship between audit committee size and the firms' financial performance (Pearce and Zahra 1992). Audit committee activity has an insignificant impact on the firms' financial performance. Reasons for the inconsistent and insignificant impact of audit committee activity and audit committee size are the very small variation in audit committee activity and audit committee size of the firms that do not affect financial performance. We find that audit quality has significance and positive impact on Tobin's Q only. For the other two measures of financial performance, audit quality has an insignificant impact. The reason for varying results is that each one of the selected countries has a different quality of audit professionals.

Tables 6 and 7 deal with the analysis of an individual country. It states that product diversification has a significant and positive impact on all measures of financial performance for Pakistan and that shows improvement in product development of firms in Pakistan. The positive effects also follow Markowitz (1952) portfolio theory which explains that firms can reduce risk and increase output if they diversify their resources. In addition, product diversification significantly but negatively affects the financial performance of the firms in India which shows agency issues are more prevailing in firms as well as underutilization of assets of the firms. For Sri Lanka and Bangladesh, product diversification shows mixed and inconsistent outputs but the general trend shows that product diversification has a significant impact on financial performance. Geographic diversification has a significant impact on financial performance for the firms of all individual countries of our study. Generally, the impact is positive which shows improvement in product quality and more acceptability in foreign markets. Furthermore, the impact is negative when we measure financial performance as Return on Equity. The reason for the negative impact of geographic diversification on financial performance is that multinational firms have inefficient innovation as compared to domestic firms and this low level of innovation explains adverse effect of geographic diversification on financial performance (Gao and Chou 2015).

There are inconsistent results with respect to dividend policy and capital structure for all selected countries. This is because the stock market is not efficient and the debt market is also in developing phase in these countries. There is inconsistent pattern of paying the dividend as well as generating long-term loans. Firms mostly rely on bank loans. Therefore, the capital structure of firms in Pakistani and Sri Lanka shows significant impact on the firms' financial performance, but the impact is negative. The negative impact of capital structure on the firms' financial performance is in line with the results of Vatavu (2015). The capital structure of Indian firms has a significant impact on all measures of financial performance. The results show that firms in India implement capital structure decisions properly. For Bangladesh, the impact of capital structure on firm's financial performance is significant and positive that shows a development of the loan market in Bangladesh.

Investment policy shows mixed results in all selected countries. For Pakistani firms, investment policy has a significant and negative impact on Return on Assets, but the impact is significant and positive on Tobin's Q. For Indian firms, investment policy has a significant and positive impact on Return on Assets, while it has a significant and negative impact on Tobin's Q. The investment decision is a significant determinant of financial performance for Sri Lanka, but the impact is negative on Return on Equity. For firms in Bangladesh, investment policy has a significant and positive impact on Tobin's Q. For the other two measures of financial performance, investment policy has varying outputs for each one of the models of the analysis. The negative impact of CEO duality follows Resource Dependence Theory, which explains the lack of concentration. In general, corporate governance and audit quality mechanisms show mixed findings. We can link these findings with Institutional Theory, which argues that firms might follow regulations or practices of corporate governance in order to increase financial performance. The insignificant effects of corporate governance variables are similar to the results of Chen et al. (2008) and Dar et al. (2011).

Table 6. Two-step System Dynamic Panel Regression (Pakistan and India).

	Pakistan									India								
	Dependent Variable (ROA)			Dependent Variable (ROE)			Dependent Variable (TQ)			Dependent Variable (ROA)			Dependent Variable (ROE)			Dependent Variable (TQ)		
L1.	0.223 ***	0.224 ***	0.223 ***	0.098 ***	0.103 ***	0.099 ***	0.340 ***	0.338 ***	0.338 ***	0.293 ***	0.290 ***	0.291 ***	0.145 ***	0.143 ***	0.144 ***	0.616 ***	0.617 ***	0.616 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L2.	0.119 ***	0.118 ***	0.119 ***	0.050 ***	0.056 ***	0.049 ***	−0.074 ***	−0.073 ***	−0.076 ***	0.229 ***	0.229 ***	0.229 ***	0.057 ***	0.057 ***	0.058 ***	−0.159 ***	−0.164 ***	−0.163 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
PD	0.026 **	–	0.022 *	0.144 ***	–	0.121 ***	0.318 ***	–	0.384 ***	−0.031 ***	–	−0.032 ***	−0.086 ***	–	−0.078 ***	−0.009	–	−0.011*
	(0.020)		(0.053)	(0.000)		(0.001)	(0.001)		(0.000)	(0.000)		(0.000)	(0.003)		(0.004)	(0.181)		(0.086)
GD	–	0.027 ***	0.024 ***	–	0.168 ***	0.151 ***	–	−0.185 ***	−0.246 ***	–	0.006 ***	0.008 ***	–	−0.017 ***	−0.019 ***	–	−0.025 ***	−0.027 ***
		(0.003)	(0.007)		(0.000)	(0.000)		(0.000)	(0.000)		(0.003)	(0.000)		(0.000)	(0.000)		(0.006)	(0.004)
CS	−0.087 ***	−0.089 ***	−0.089 ***	−0.079 ***	−0.073 ***	−0.074 ***	−0.071 *	−0.096 **	−0.086 **	0.020 ***	0.020 ***	0.021 ***	−0.343 ***	−0.353 ***	−0.350 ***	0.522 ***	0.518 ***	0.520 ***
	(0.000)	(0.000)	(0.000)	(0.003)	(0.007)	(0.006)	(0.069)	(0.010)	(0.027)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DP	0.0004 ***	0.0004 ***	0.0004 ***	0.000	0.000	0.000	0.000	0.000	0.000	0.319 ***	0.320 ***	0.321 ***	0.564 ***	0.541 ***	0.550 ***	0.408 ***	0.432 ***	0.447 ***
	(0.000)	(0.000)	(0.000)	(0.272)	(0.294)	(0.362)	(0.212)	(0.140)	(0.353)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IP	−0.005 ***	−0.005 ***	−0.005 ***	−0.012 *	−0.007	−0.009	0.037 ***	0.030 ***	0.034 ***	0.020 ***	0.021 ***	0.021 ***	0.004	0.001	0.001	−0.041 ***	−0.040 ***	−0.041 ***
	(0.008)	(0.002)	(0.002)	(0.070)	(0.347)	(0.194)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.119)	(0.693)	(0.584)	(0.000)	(0.000)	(0.000)
BSIZE	−0.002	−0.002	−0.002	0.004	0.005	0.006	0.026 *	0.024 *	0.025 *	0.003 ***	0.003 ***	0.003 ***	0.003 **	0.002 *	0.003 *	0.025 ***	0.024 ***	0.025 ***
	(0.186)	(0.124)	(0.175)	(0.542)	(0.426)	(0.329)	(0.071)	(0.089)	(0.080)	(0.000)	(0.000)	(0.000)	(0.020)	(0.070)	(0.050)	(0.000)	(0.000)	(0.000)
CEOD	−0.004	−0.005	−0.005	−0.012	−0.009	−0.015	−0.188 ***	−0.183 ***	−0.177 ***	−0.059 ***	−0.061 ***	−0.063 ***	0.042 ***	0.052 ***	0.048 ***	−0.153 ***	−0.159 ***	−0.160 ***
	(0.456)	(0.441)	(0.412)	(0.491)	(0.616)	(0.446)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
AQ	−0.002	−0.001	−0.002	−0.137 ***	−0.130 ***	−0.131 ***	0.566 ***	0.561 ***	0.545 ***	−0.006 ***	−0.009	−0.008	−0.027 *	−0.025 *	−0.023	0.661 ***	0.654 ***	0.667 ***
	(0.706)	(0.845)	(0.742)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.244)	(0.254)	(0.057)	(0.067)	(0.112)	(0.000)	(0.000)	(0.000)
ACSIZE	0.012 ***	0.012 ***	0.012 ***	0.035**	0.029**	0.032**	0.209 ***	0.204 ***	0.208 ***	0.014 ***	0.013 ***	0.013 ***	−0.015 ***	−0.015 ***	−0.015 ***	−0.007 *	−0.006 *	−0.006
	(0.000)	(0.000)	(0.000)	(0.018)	(0.049)	(0.035)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.057)	(0.097)	(0.114)
ACA	−0.00 *	−0.005 *	−0.005*	0.004	0.001	0.001	−0.001	0.004	0.002	−0.011 ***	−0.011 ***	−0.011 ***	0.009 ***	0.010 ***	0.009 ***	0.023 ***	0.024 ***	0.024 ***
	(0.073)	(0.054)	(0.062)	(0.482)	(0.835)	(0.884)	(0.926)	(0.780)	(0.876)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
AGE	−0.003 ***	−0.003 ***	−0.003 ***	−0.002 *	0.000	−0.001	0.022 ***	0.020 ***	0.022 ***	−0.001 ***	−0.001 ***	−0.001 ***	−0.007 ***	−0.008 ***	−0.007 ***	−0.012 ***	−0.012 ***	−0.012 ***
	(0.000)	(0.000)	(0.000)	(0.051)	(0.879)	(0.422)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GRTH	0.019 ***	0.019 ***	0.019 ***	0.028 ***	0.030 ***	0.029 ***	0.014 **	0.015 ***	0.016 ***	0.022 ***	0.021 ***	0.022 ***	0.075 ***	0.072 ***	0.073 ***	−0.043 ***	−0.043 ***	−0.042 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.022)	(0.006)	(0.009)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
SIZE	0.019 ***	0.018 ***	0.017 ***	−0.003	−0.008	−0.007	−0.450 ***	−0.430 ***	−0.444 ***	−0.051 ***	−0.050 ***	−0.051 ***	−0.090 ***	−0.086 ***	−0.087 ***	0.184 ***	0.184 ***	0.184 ***
	(0.000)	(0.000)	(0.000)	(0.808)	(0.548)	(0.624)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
C	−0.255 ***	−0.223 ***	−0.234 ***	0.070	0.230	0.120	8.561 ***	8.515 ***	8.410 ***	0.871 ***	0.848 ***	0.875 ***	2.025 ***	1.922 ***	1.989 ***	−2.569 ***	−2.592 ***	−2.583 ***
	(0.000)	(0.000)	(0.000)	(0.781)	(0.380)	(0.656)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: ***, **, and * represents levels of significant at 1%, 5%, and 10%. *p*-values are shown in parentheses.

Table 7. Two-step System Dynamic Panel Regression (Sri Lanka and Bangladesh).

	Sri Lanka									Bangladesh								
	Dependent Variable (ROA)			Dependent Variable (ROE)			Dependent Variable (TQ)			Dependent Variable (ROA)			Dependent Variable (ROE)			Dependent Variable (TQ)		
L1.	0.430 ***	0.400 ***	0.393 ***	0.084 ***	0.106 ***	0.112 ***	0.390 ***	0.391 ***	0.402 ***	0.122 ***	0.103 ***	0.094 **	0.124 ***	0.073 ***	0.088 ***	0.466 ***	0.507 ***	0.479 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.021)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L2.	0.370 ***	0.277 ***	0.274 ***	0.056 ***	0.001	0.011 ***	−0.144 ***	−0.122 ***	−0.146 ***	0.170 ***	0.132 ***	0.163 ***	−0.229 ***	−0.203 ***	−0.189 ***	−0.134 ***	−0.147 ***	−0.102 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.317)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)
PD	−0.006	–	−0.073 ***	0.599 ***	–	0.224 ***	−0.292 ***	–	−0.312 ***	0.204 ***	–	0.209 ***	1.505 ***	–	1.471 ***	0.063	–	−0.157
	(0.362)		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.482)		(0.130)
GD	–	0.217 ***	0.201 ***	–	−0.575 ***	−0.508 ***	–	0.018 *	−0.005	–	0.018 ***	0.017 ***	–	−0.187 ***	−0.152 ***	–	0.035 ***	0.031 **
		(0.000)	(0.000)		(0.000)	(0.000)		(0.061)	(0.498)		(0.003)	(0.007)		(0.000)	(0.000)		(0.006)	(0.011)
CS	−0.201 ***	−0.201 ***	−0.196 ***	−0.493 ***	−0.477 ***	−0.473 ***	0.989 ***	0.972 ***	0.989 ***	0.027 **	0.005	0.030 **	1.021 ***	0.599 ***	0.519 ***	0.492 ***	0.479 ***	0.508 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.019)	(0.544)	(0.025)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DP	−0.003 ***	−0.003 ***	−0.003 ***	0.029 ***	0.020 ***	0.019 ***	−0.007 ***	−0.001 ***	−0.007 ***	−0.001	0.001	0.000	−0.018 ***	−0.023 ***	−0.019 ***	−0.021 ***	−0.017 ***	−0.016 ***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.220)	(0.281)	(0.935)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IP	0.049 ***	0.053 ***	0.053 ***	−0.066 ***	−0.075 ***	−0.075 ***	−0.004 ***	0.004 ***	−0.006 ***	−0.002	−0.004 *	−0.002	0.009	−0.027 ***	−0.018 **	0.030 ***	0.035 ***	0.029 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.498)	(0.070)	(0.234)	(0.111)	(0.000)	(0.026)	(0.000)	(0.000)	(0.000)
BSIZE	0.001	0.005 ***	0.004 ***	−0.028 ***	−0.021 ***	−0.020 ***	0.008 ***	0.010 ***	0.007 ***	0.002 *	0.004	0.005 ***	0.046 ***	−0.030 ***	0.011 **	−0.001	0.005	−0.007
	(0.161)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.099)	(0.008)	(0.002)	(0.000)	(0.000)	(0.031)	(0.832)	(0.436)	(0.242)
CEOD	−0.001	0.050 ***	0.051 ***	−0.064 ***	−0.068 ***	−0.064 ***	0.101 ***	0.103 ***	0.094 ***	−0.034 **	−0.014	−0.030 **	−0.192 ***	−0.190 ***	−0.192 ***	0.029	0.175 **	0.126
	(0.848)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.014)	(0.269)	(0.048)	(0.000)	(0.000)	(0.000)	(0.490)	(0.024)	(0.130)
AQ	0.036 ***	−0.173 ***	−0.177 ***	0.483 ***	0.429 ***	0.366 ***	−0.193 ***	−0.270 ***	−0.178 ***	0.047 ***	0.040 ***	0.044 ***	−0.024	−0.003	0.047	−0.033	−0.018	0.001
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.661)	(0.918)	(0.376)	(0.569)	(0.188)	(0.943)
ACSIZE	0.013 ***	0.029 ***	0.033 ***	−0.134 ***	−0.130 ***	−0.134 ***	0.004	−0.016 ***	0.003	0.019 ***	0.020 ***	0.022 ***	0.084 ***	0.036 ***	0.072 ***	−0.009	−0.004	−0.017 **
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.481)	(0.000)	(0.624)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.331)	(0.526)	(0.021)
ACA	−0.004 ***	−0.006 ***	−0.005 ***	0.017 ***	0.001	0.005 **	0.001	0.001	0.000	−0.006 ***	−0.005 ***	−0.005 *	−0.012	0.066 ***	0.033 **	−0.022 ***	−0.030 ***	−0.028 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.675)	(0.018)	(0.221)	(0.324)	(0.837)	(0.008)	(0.006)	(0.093)	(0.471)	(0.000)	(0.022)	(0.000)	(0.000)	(0.000)
AGE	−0.013 ***	−0.010 ***	−0.009 ***	0.006 ***	0.005 ***	0.006 ***	0.011 ***	0.012 ***	0.011 ***	−0.003 ***	−0.0005 *	−0.002 ***	−0.032 ***	−0.023 ***	−0.039 ***	0.000	0.004 ***	0.004 **
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.074)	(0.002)	(0.000)	(0.000)	(0.000)	(0.925)	(0.000)	(0.017)
GRTH	0.003 ***	0.004 ***	0.004 ***	0.002 ***	0.004	0.005	0.004 ***	0.003 ***	0.003 ***	0.012 ***	0.009 ***	0.020 ***	0.047 ***	−0.037 ***	0.021 ***	0.003	−0.003	−0.007
	(0.000)	(0.003)	(0.006)	(0.628)	(0.226)	(0.220)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.519)	(0.276)	(0.106)
SIZE	0.019 ***	−0.025 ***	−0.026 ***	−0.140 ***	−0.161 ***	−0.160 ***	−0.019 ***	−0.035 ***	−0.016 ***	0.004	−0.022 ***	−0.008	0.139 ***	0.130 ***	0.094 ***	−0.019 **	−0.018 **	−0.026 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.475)	(0.000)	(0.189)	(0.000)	(0.000)	(0.001)	(0.044)	(0.047)	(0.001)
C	0.386 ***	0.966 ***	1.027 ***	1.834 ***	2.726 ***	2.536 ***	0.025	0.124 ***	0.030	−0.149 *	0.325 ***	−0.030	−3.231 ***	−1.610 ***	−1.782 ***	0.528 ***	0.398 **	0.734 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.533)	(0.000)	(0.553)	(0.071)	(0.000)	(0.747)	(0.000)	(0.000)	(0.000)	(0.004)	(0.037)	(0.000)

Note: ***, **, and * represents levels of significant at 1%, 5%, and 10%. *p*-values are shown in parentheses.

Control variables show that firm age has a significant and negative effect on firms' financial performance. It shows that when firms get older, they start losing concentration of managing their assets, hence they start devastating their financial performance. Results show that in general, firm growth has a significant and positive impact on financial performance. Firm size has a negative and significant and negative relationship with Return on Assets but it has a significant and positive impact on Tobin's Q. Further, size has an insignificant impact on Return on Equity. Negative and insignificant impact of size shows that manufacturing firms of South Asian countries fail to utilize economies of scale, and they do not meet market requirements of economic efficiency. In a separate analysis of each country, control variables show varying findings but in the majority of the analyses, it shows significant outputs. However, the use of different measures of financial performance and three models for each one of the financial performance measure in our study reconciles the varying outputs.

5. Conclusions

The manufacturing sector plays a substantial role in the economic development of a country. This sector is opting for diversification strategies for growth and survival in a competitive business environment. The objective of our study is to analyze the impact of corporate diversification and financial structure on the financial performance of the manufacturing firms of South Asian Countries. Financial structure describes financing, dividend, and investment policies. We categorized corporate diversification as product and geographic diversification. Therefore, we ran three models for each one of the independent variable; two separate models for product diversification and geographic diversification and one overall model for both. Although some results relating to product diversification and geographic diversification follow Agency Theory, where managers prefer diversification strategy for their personal benefits, which adversely affects financial performance but still we found mixed output. The varying results are the reasons of different circumstance and economic condition of the respective countries. We found dividend policy is a determinant of financial performance of the firms. Investment plans show a general trend of insignificant impact on the firms' financial performance. Corporate governance and audit quality characteristics on the firm's financial performance revealed varying outputs in our study.

Based on the results, we drew several policy implications including that the manufacturing sector needs to apply efficient financial structure to improve its financial performance. In general, our results suggest that diversification improves firms' financial performance but still there is a need of proper management of diversification decisions as excessive diversification can lead to a decrease in firms' financial performance. There is a need to efficiently utilize the firms' resources to apply proper diversification strategies. The capital structure showed significant impact on firms' financial performance which suggests that there is need for an efficient mix of debt and equity in order to decrease the capital cost, which can increase the profitability, and value of the firms. We suggested firms follow a proper dividend policy to attract investors. In addition, effective management of corporate diversification with good corporate governance and proper implication of financial structure can improve the financial performance of manufacturing firms.

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Determinants and Impacts of Financial Literacy in Cambodia and Viet Nam

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Abstract: Our paper extends the literature on the determinants and impacts of financial literacy by conducting the OECD/INFE survey in two relatively low-income Asian economies—Cambodia and Viet Nam—and analyzing the determinants of financial literacy and the effects of financial literacy on savings and financial inclusion. Generally, our study corroborates the findings of studies of other countries, but uncovers some differences as well. The main determinants of financial literacy are found to be educational level, income, age, and occupational status. Both financial literacy and general education levels are found to be positively and significantly related to savings behavior and financial inclusion, and these results generally hold even when correcting for possible endogeneity of financial literacy.

Keywords: financial literacy; financial inclusion; household saving; Cambodia; Viet Nam

1. Introduction

Financial literacy is becoming increasingly recognized as an important policy objective in many countries (OECD/INFE 2015b). This reflects the increasing need for individuals to manage their own retirement savings and pensions, resulting mainly from the trend of switching to defined-contribution from defined-benefit pension plans, as well as developments in financial technology (fintech) which require greater sophistication on the part of users. However, surveys consistently show that the level of financial literacy is relatively low even in advanced economies (OECD/INFE 2016). This points to the need to develop strategies for financial education to improve financial literacy. At their summit in Los Cabos in 2012, G20 leaders endorsed the High-Level Principles on National Strategies for Financial Education developed by the Organization for Economic Cooperation and Development International Network on Financial Education (OECD/INFE), thereby acknowledging the importance of coordinated policy approaches to financial education (Group of Twenty (G20) (2012)).

Survey data on financial literacy can provide information on the levels of financial literacy of various groups within a country, and thereby indicate which groups have the greatest needs for financial education. Ideally, the survey should be carried out repeatedly to identify where policies have led to improvement of what more needs to be done. Use of a standardized survey instrument also makes it possible to make cross-country comparisons of key measures of financial literacy and related variables.

In order to accomplish this, the OECD/INFE developed a standard survey for gathering information on financial literacy and financial inclusion, the latest version of which is described in OECD/INFE (2015c). OECD/INFE (2016) and OECD/INFE (2017) provides summaries of the results of these surveys for over 30 countries. However, this list includes only five Asian economies—Hong Kong, China; India, the Republic of Korea; Malaysia; and Thailand—and most of these have relatively high incomes. Our study of adult financial literacy in Cambodia and Viet Nam breaks new ground in two ways: (i) It marks the first implementation of the OECD/INFE survey in the so-called CLMV

countries (Cambodia, Lao PDR, Myanmar, and Viet Nam); and (ii) Cambodia and Viet Nam have considerably lower levels of per capita income than do most of the other countries previously surveyed. In 2015, nominal per capita GDP in Cambodia was $1144, while in Viet Nam it was $2088, compared to $3754 for Georgia and $3954 for Albania, the lowest among countries previously sampled (IMF World Economic Outlook database).

In the survey form, financial literacy is divided into three related aspects: financial knowledge, financial behavior, and attitudes toward longer-term financial planning. This is consistent with OECD/INFE (2016, p. 47), which defines financial literacy as " ... [a] combination of awareness, knowledge, skill, attitude, and behavior necessary to make sound financial decisions and ultimately achieve individual financial well-being." In other words, the OECD/INFE concept of financial literacy is multidimensional, reflecting not only knowledge, but also skills, attitudes, and actual behavior.

Financial knowledge is information and concepts which help individuals to compare financial products and services and make appropriate, well-informed financial decisions. A basic knowledge of financial concepts, and the ability to apply numerical skills to financial issues enable consumers to manage their financial affairs and respond appropriately to news and events that may have implications for their financial situation. Financial knowledge can be measured either objectively (through survey questions) or subjectively; i.e., by asking respondents to rate their own knowledge compared with that of their peers.

Financial behavior (or financial "savvy") refers to financial decisions and actions. Some types of behavior, such as delaying bill payments, not planning for future expenditures, or choosing financial products without researching the market, may adversely effect on an individual's financial situation and well-being. Financial behavior may thus differ from financial knowledge, and it is important to how financial knowledge can affect financial behavior.

Financial attitudes regarding longer-term financial planning include aspects such as individuals' time preference and willingness to make planned savings. For example, one survey question asks about preferences for the short term through "living for today" and spending money. Such preferences are likely to promote behaviors that could lead to reduced financial resilience and well-being.

This paper is organized as follows. Section 2 briefly discusses the literature on determinants of financial literacy and its effects. The data collection and empirical approach is presented in Section 3. Sections 4 and 5 present the descriptive analyses and empirical results, followed by conclusions and policy implications in Section 6.

2. Literature Survey

The literature on financial literacy focuses on two main areas: (i) the determinants of financial literacy, including age, gender, level of education, and occupation; and (ii) the effects of financial literacy on financial behavior, including saving, use of credit, and preparation for retirement.

One of the earliest to develop quantifiable measures of financial literacy was that of the Jump$tart Coalition for Personal Financial Literacy program for high school and college students in the US in 1997 described in Mandell (2009). Lusardi and Mitchell (2006) added a set of financial literacy questions to the 2004 Health and Retirement Study (HRS), a survey of US households aged 50 and older, which have served as a model for later surveys. The three core questions in the original survey were aimed at identifying respondents' understanding of some key financial concepts: compound interest, real rates of return, and risk diversification. Later surveys, including the OECD/INFE survey, extended the financial knowledge questions but also added questions about financial attitudes, financial behavior, and financial experience. The methodology for calculating scores from the OECD/INFE survey responses is described below in Section 3.2.

Lusardi and Mitchell (2014) provide an extensive review of the literature on factors related to financial literacy. Financial literacy scores tend to follow a hump-shaped pattern with respect to age, first rising and then declining in old age. However, elderly persons' confidence in their financial literacy shows no similar decline, suggesting a perceptual gap. Women generally score lower than

men in financial literacy, although this seems to vary a lot by country and culture. On the other hand, women tend to be more willing to admit not knowing an answer than men are. Higher levels of education and parents' education are positively correlated with financial literacy. These findings were generally confirmed in the analysis of the results of the OECD/INFE survey in the above-mentioned sample of 30 countries in OECD/INFE (2016).

A key question for policy is whether financial education programs can improve financial literacy. A large number of studies have been conducted, but the results are inconclusive. The results depend on many specific aspects of the programs, including course content, knowledge of the teachers, etc. Fernandes et al. (2014) perform a meta-analysis of 188 studies and find that financial education has a significant but very small effect of only 0.1% on related economic behaviors. Lusardi and Mitchell (2014) cite Walstad et al. (2010) as an example of a careful study that found significant impacts from a financial literacy study program. In their survey, Hastings et al. (2013, p. 359) argue that the evidence on the effectiveness of financial education programs on financial literacy is " . . . at best contradictory."

Many papers attempt to link measures of financial literacy with other economic and financial behaviors, going back to Bernheim (1995, 1998) in the US. Hilgert et al. (2003) found a strong correlation between financial literacy and daily financial management skills, while other studies found that the more numerate and financially literate are more likely to participate in financial markets, invest in stocks, and make precautionary savings (Christelis et al. 2010; van Rooij et al. 2011; de Bassa Scheresberg 2013). The more financially savvy are also more likely to undertake retirement planning, and those who make financial plans also tend to accumulate more wealth (Lusardi and Mitchell 2011). Mahdzan and Tabiani (2013) find similar evidence in Malaysia.

In terms of household borrowing, Moore (2003) found that those with lower financial literacy are more likely to have more expensive mortgages. Campbell (2006) showed that those with lower income and less education were less likely to refinance their mortgages during periods of falling interest rates. Stango and Zinman (2009) found that those who could not correctly calculate interest rates generally borrowed more and accumulated less wealth.

3. Data and Methodology

3.1. Data Collection

We used the harmonized OECD/INFE questionnaire of adult financial literacy (OECD/INFE 2015c) to ensure comparability with studies of other countries. The questionnaire includes questions about individual information (such as gender, age, income, occupation, and other sociodemographic information) and questions about financial literacy and financial inclusion. ADBI translated the OECD/INFE questionnaire into Khmer and Vietnamese and conducted cross-checks with Cambodian and Vietnamese teams from Indochina Research Ltd. to ensure the correctness of the translation.

The surveys were conducted by Indochina Research Ltd. under the direction of the Asian Development Bank Institute. Data collection was conducted in October and November 2016. Multilevel stratification was used. Cambodia was divided into five geographical regions (including Phnom Penh, Coastal, Plain, Mountain, Plateau and Mountain, and Tonle Sap) and Viet Nam into six geographical regions (including Northern Highland and Midland, Red River Delta, Northern and Coastal Central, Central Highland, South East, and Mekong River Delta). For Cambodia, we selected Phnom Penh plus two randomly chosen provinces from each of the other four regions. For Viet Nam, we selected Ha Noi (the capital city) and Ho Chi Minh City (the economic hub), plus two provinces each in the Red River Delta and South East areas, and three provinces in other regions. In each province, the provincial city was selected to represent the urban population while we randomly selected one rural district (in Cambodia) or one or two rural districts (in Viet Nam) for the rural sample. In each district, we randomly selected the communes and individual households based on simple sampling procedures. In Cambodia, there were 1035 respondents from nine cities/provinces, and in Viet Nam, there were 1000 respondents from 18 cities/provinces. Details of the sample distribution are given in Appendix A.

3.2. Construction of Financial Literacy Scores

In this paper, we follow the methodology in OECD/INFE (2015a) to calculate scores for the various indicators of financial literacy and financial inclusion. The score for financial knowledge is calculated from responses to seven questions reflecting the subject's understanding of basic knowledge (or awareness) of finance such as calculation of interest rates and compound interest rates, risk and return evaluation, the effect of inflation, and the benefits of financial diversification. This indicator ranges between 0 and 7 based on the number of correct answers. The financial behavior score is calculated from nine questions relating to household budgeting, saving, considered purchases, bill payments, care about financial affairs, long-term financial goals, and borrowing, and ranges between 0 and 9. The score for financial attitude measures the respondent's responses to five questions about about money, saving, and spending, and ranges from 1 to 5. A higher score represents more conservative and considered behavior. The overall score for financial literacy is the sum of three scores, and hence takes values between 1 and 21. The score for financial inclusion is calculated from seven indicators, including holdings of payment products, savings, insurance, credit products, product choice, and family financial support in case of emergency, and ranges from 0 to 7.

For ease of interpretation, we converted all indicator scores into z-score values:

$$score_z = \frac{(score - \overline{score})}{score_{sd}}$$

where $score_z$ is the converted z-score, $\overline{score}$ is the mean score, and $score_{sd}$ is the standard deviation of the score.

3.3. Methodology

In this paper, we estimate the following equations for indices related to financial literacy:

$$FL_i = \alpha_0 + \alpha_1 Income_i + X_i\alpha_2 + \epsilon_i \tag{1}$$

where FL_i alternatively indicates the financial literacy, financial knowledge, financial behavior, and financial attitude score of individual i; $Income_i$ is the natural logarithm of individual i's household income; X_i is a vector of control variables; and ϵ_i is the identically and independently distributed (i.i.d.) error term. The control variables include individual age, education level, gender, occupation, rural versus urban residence, and province. With regards to age, we divide the sample into three age groups: those under 30 years old, those over 30 years old but under 60 years old, and those over 60 years old. We use the group of over-60-years-old individuals as the base group. For educational level, we combine the categories into three groups: (i) those with some primary education or who have completed primary school (called the "some primary education" group)[1]; (ii) those with some secondary education or who have completed secondary school (called the "some secondary education" group); and (iii) those with at least some technical education or university-level education (called the "tertiary education" group). The last group is used as the base group. With regards to occupations, we combine those who are apprentices, unemployed workers (including voluntarily unemployed people), retired and disabled people, and students into one group of nonworking people and use this as the base group in this study. The remaining groups are self-employed people, salaried employees, and housewives.[2]

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1 None of the respondents has no primary education in either country.

2 Housewives may also be viewed as nonworking people, but we still keep them as a separate group because they may play an important role in managing household finance.

3.3.1. Effects of Financial Literacy on Saving Behavior

To quantify the effect of financial literacy on saving behavior, the following equation is estimated:

$$Save_i = \beta_0 + \beta_1 FL_i + \beta_2 Income_i + X_i\beta_3 + \eta_i \quad (2)$$

where $Save_i$ is a dummy variable, taking the value of one if the individual has any types of saving products and zero otherwise.[3] FL_i is the financial literacy score, and β_1 measures the effects of financial literacy on saving behavior. Other variables are defined the same as in Equation (1) and η_i is the i.i.d. error term.

3.3.2. Effect of Financial Literacy on Financial Inclusion

To quantify the effect of financial literacy on financial inclusion, the following equation is estimated:

$$FI_i = \gamma_0 + \gamma_1 FL_i + \gamma_2 Income_i + X_i\gamma_3 + \omega_i \quad (3)$$

where FI_i is the financial inclusion score, FL_i is the financial literacy score, and γ_1 measures the effects of financial literacy on saving behavior. Other variables are defined the same as in Equation (1) and ω_i is the i.i.d. error term.

4. Descriptive Statistics[4]

Table 1 presents the average values of the scores of financial literacy and financial inclusion in Cambodia and Viet Nam, including breakdowns by various categories. In both countries, the level of financial literacy is rather low, with that of Cambodia being the lower of the two. The financial literacy scores are only 11.8 and 12.5 in Cambodia and Viet Nam, respectively, out of a total possible score of 21. These scores are much lower than the 30-country average score of 13.3 and those of some other developing Asian economies such as Thailand (12.8) and Malaysia (12.3) (OECD/INFE 2016).

Of greater concern, perhaps, is the fact that the share of respondents who answered correctly five out of seven financial knowledge questions, which is considered to be the minimum target level, was very low. Based on our samples, only 17.0% of people in Cambodia and 36% of people in Viet Nam answered correctly five or more questions. On average, this figure is 62% for the OECD countries surveyed, and 56% for the full sample of 30 countries surveyed (OECD/INFE 2016). Again, however, this gap can be attributed to the low level of income in these two countries.

These average financial literacy scores are quite consistent with individuals' self-assessment of overall knowledge about financial matters compared with other adults in each country (Figure 1). Only about 12–14% of Cambodian and Vietnamese respondents considered themselves to have a better understanding of overall knowledge about financial matters than other adults. This is consistent with the results for other countries with relatively low financial literacy scores. About 63% in Cambodia and 59% in Viet Nam self-assessed that they have the same level as other adults.

[3] The score for savings behavior in this section is identified through questions on whether the respondents hold any types of saving accounts or participate in saving clubs or not (the so-called "formal way to save"). Savings, however, could take many other forms, such as holding cash at home, or in a wallet, building up a balance in a bank account, giving money to a family member to save, buying gold, property, or livestock, etc. We also present the estimation results using a broader definition of savings (i.e., it takes the value of one if an individual either saves in formal ways or informal ways, and zero otherwise) in Appendix D.

[4] In this section and the empirical results section, we use a weighted sample. In Viet Nam, weights are calculated based on the rural-urban population distribution and economic conditions (measured by income per capita) to correct for the underrepresentation of the top 40% income groups and slight underrepresentation of the urban population in our sample (especially in the South East region). In Cambodia, weights are calculated based on economic conditions (measured by income per capita). Please refer to Appendix B for details.

Table 1. Financial literacy and financial inclusion scores in Cambodia and Viet Nam.

	All	Urban Residents	Rural Residents	Women	Men	Aged under 30	Aged from 30–60	Aged over 60	People with Some Tertiary Education	People with Some Secondary Education	People with Some Primary Education and Lower	Below Median	Above Median
Cambodia													
Financial knowledge	3.52	3.52	3.52	3.57	3.47	3.61	3.50	3.24	4.62	3.64	3.35	3.37	3.68
% knowledgeable people	17%	23%	15%	19%	16%	18%	18%	13%	57%	21%	11%	13%	22%
Financial "savvy" behavior	5.49	5.57	5.45	5.35	5.61	5.39	5.66	5.05	5.50	5.61	5.40	5.31	5.67
Financial attitude	2.80	2.95	2.74	2.83	2.76	2.84	2.77	2.75	2.92	2.81	2.77	2.71	2.88
Financial literacy	11.80	12.03	11.71	11.74	11.85	11.84	11.93	11.03	13.04	12.06	11.52	11.40	12.24
Financial inclusion	1.85	2.05	1.77	1.88	1.88	1.78	2.03	1.26	2.51	2.04	1.63	1.63	2.1
Vietnam													
Financial knowledge	3.96	4.35	3.73	3.89	4.05	4.06	3.94	3.52	4.15	4.15	3.66	3.90	3.99
% knowledgeable people	36%	47%	29%	35%	36%	39%	34%	26%	43%	40%	27%	34%	36%
Financial "savvy" behavior	5.70	6.22	5.38	5.88	5.50	5.44	5.83	5.64	6.39	5.68	5.27	4.93	5.96
Financial attitude	3.00	3.03	2.98	3.04	2.95	2.91	3.04	2.90	3.06	3.00	2.96	2.97	3.01
Financial literacy	12.67	13.60	12.08	12.80	12.50	12.42	12.81	12.06	13.60	12.82	11.88	11.80	12.95
Financial inclusion	2.55	2.82	2.38	2.42	2.70	2.50	2.58	2.41	3.43	2.45	2.02	2.21	2.66

Note: Knowledgeable refers to those answering at least 5 out of 7 questions on financial knowledge correctly. A weighted sample is used to draw this figure. Source: Authors' compilation from survey data.

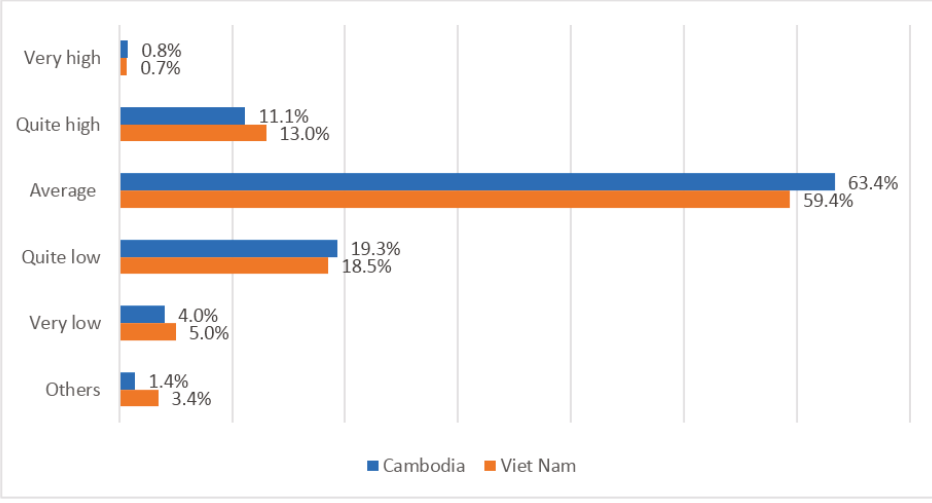

Figure 1. Self-assessment of overall knowledge about financial matters in Cambodia and Viet Nam. Note: A weighted sample is used to draw this figure. Source: Authors' compilation from survey data.

Financial literacy varies by population group in both Cambodia and Viet Nam (Table 1). In both countries, younger, urban, more educated, and higher-income respondents have higher financial literacy scores. While female Cambodians have slightly lower financial literacy scores than male Cambodians (11.74 vs. 11.85), female Vietnamese have higher financial literacy scores than their male counterparts (12.80 vs. 12.50).

For all subcomponents of the financial literacy score, younger, more educated and higher income groups of population have higher scores than older, less educated and poorer ones in both Cambodia and Viet Nam. Cambodian women have higher financial knowledge and financial attitude scores, and lower financial behavior score than their male counterparts, but in Viet Nam, women have lower financial knowledge scores and higher financial behavior, and financial attitude scores than men. Similarly, the differences in financial literacy score between Cambodian rural and urban residents are mostly due to differences in financial behavior and financial attitude score while differences in scores of all three sub-components between rural and urban residents add up to the rather large gaps in urban and rural financial literacy scores in Viet Nam.

Figure 2 documents the saving behavior of Cambodian and Vietnamese in our sample. The proportion of respondents who do not have saving products is rather low in both Cambodia (16.0%) and Viet Nam (25.7%). The saving forms that most of respondents in our sample use are informal (such as keeping money at home, asking friends, relatives, or other family members to keep money for them). More than 80% of Cambodian and 64% of Vietnamese use this form of saving. The proportion of respondents who save in formal financial institutions or buy saving products (i.e., formal saving forms) is rather low, however. A relatively small share of respondents (10.1% in Cambodia and 16.2% in Viet Nam) have both formal and informal savings.

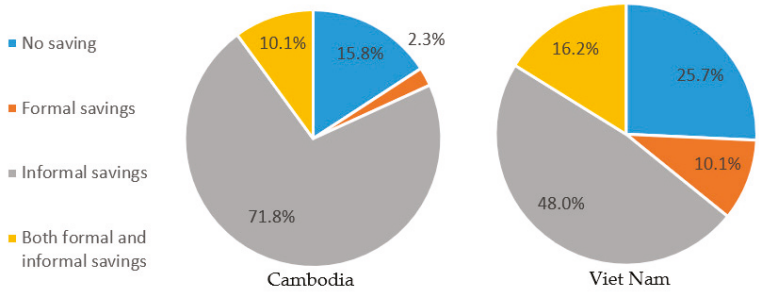

Figure 2. Proportion of individuals using different saving forms. Note: A weighted sample is used to draw this figure (see Appendix B). Source: Authors' compilation from survey data.

Table 2 presents the descriptive statistics of explanatory variables included in the econometric models (both unweighted and weighted samples). The average monthly household income is USD 310.0 in Cambodia and USD 420 in Viet Nam.[5] In the Cambodian sample, 53% have only some primary education, 43% have some secondary education, while only 4.1% have some tertiary education. Although more than a quarter of the Vietnamese sample have some tertiary education, which is much higher than the Cambodian sample, the group with some secondary education accounts for the largest proportion, at 41%. The age distribution is also slightly different. While people aged over 60 account for more than 11% of the Cambodian sample, they make up only about 3% of the Vietnamese sample. With regards to occupation, while 52% of the Cambodian sample are self-employed, this figure is only 22% in the Viet Nam sample. Salaried employees account for one-third of the Vietnamese sample, which is much higher than the Cambodian figure (16%). About 70% of Cambodian respondents live in rural areas while this figure is about 61% in Viet Nam. Due to the rather large differences in the Cambodian and Vietnamese samples, in this paper, we estimate the determinants of financial literacy and the impacts of financial literacy on financial inclusion and the savings decision separately for each country. However, we also provide results for the pooled sample in Appendix D.

Table 2. Descriptive statistics of explanatory variables.

Explanatory Variable	Cambodia	Viet Nam
	Weighted Sample	
Monthly household income (in USD, mean and stand. dev.)	311.0 (193.1)	414.4 (264.0)
With some primary education	52.8%	34.1%
With some secondary education	43.2%	40.7%
With at least some tertiary education	4.1%	25.2%
Aged under 30 (%)	40.1%	31.0%
Aged from 30 to 60 (%)	48.9%	66.0%
Aged over 60 (%)	11.1%	3.0%
Being a male (%)	52.3%	46.3%
Self-employed (%)	54.8%	21.5%
Salaried employee (%)	16.4%	32.8%
Housewife (%)	16.0%	15.0%
Living in rural area	72.0%	61.4%

Note: Share of total respondents except where noted. Source: Authors.

[5] In this paper, we use household income as the independent variable since it is expected to be more related to household financial matters than individual income.

5. Econometric Results

In this section, we estimate the determinants of financial literacy, and the effects of financial literacy on the savings decision and financial inclusion in Cambodia and Viet Nam.

5.1. Determinants of Financial Literacy

Table 3 shows ordinary least squares (OLS) regressions for the overall financial literacy score of Cambodia (columns 1 and 2) and Viet Nam (columns 3 and 4). Columns 2 and 4 include household income as an explanatory variable. The results indicate that, in both Cambodia and Viet Nam, people with higher education have higher scores of financial literacy. For example, in Cambodia, those with only some primary education or some secondary education have a lower financial literacy score than those with some tertiary education by 0.63 or 0.37 percentage points, respectively. This corroborates the results of many other studies which used a variety of methods for calculating financial literacy scores, including Bucher-Koenen and Lusardi (2011), OECD/INFE (2016), and Murendo and Mutsonziwa (2017). The coefficients on education level are slightly smaller in absolute terms in Viet Nam than in Cambodia, but still highly significant. It should be noted that the R-squared is significantly lower for Cambodia than for Viet Nam in all of the regressions.

Table 3. Determinants of financial literacy score in Cambodia and Viet Nam.

	(1)	(2)	(3)	(4)
	Cambodia		Viet Nam	
Income		0.333 ***		0.224 ***
		[0.055]		[0.064]
With some primary education	−0.810 ***	−0.629 ***	−0.525 ***	−0.460 ***
	[0.179]	[0.172]	[0.100]	[0.100]
With some secondary education	−0.496 ***	−0.370 **	−0.202 **	−0.166 **
	[0.168]	[0.160]	[0.083]	[0.084]
Aged under 30	0.189	0.196*	−0.141	−0.147
	[0.121]	[0.118]	[0.153]	[0.150]
Aged from 30 to 60	0.254 **	0.269 **	−0.017	−0.068
	[0.114]	[0.110]	[0.148]	[0.144]
Male	0.085	0.074	−0.043	−0.046
	[0.069]	[0.068]	[0.067]	[0.066]
Self-employed	0.526 ***	0.457 ***	0.231 **	0.202 **
	[0.112]	[0.111]	[0.093]	[0.092]
Salaried employee	0.452 ***	0.358 ***	0.120	0.120
	[0.122]	[0.120]	[0.086]	[0.084]
Housewife	0.407 ***	0.401 ***	0.151	0.130
	[0.135]	[0.131]	[0.125]	[0.120]
Living in rural area	−0.110	−0.120	−0.367 ***	−0.288 ***
	[0.084]	[0.083]	[0.072]	[0.072]
Intercept	0.375	−1.553 ***	−0.056	−3.608 ***
	[0.281]	[0.418]	[0.344]	[1.014]
No. of observations	1035	1035	1000	1000
R square	0.0979	0.135	0.3325	0.3466

Note: Figures in brackets are standard deviations. ***, **, and * denote coefficients significant at the 1%, 5%, and 10% statistical levels, respectively. The dependent variable is the financial literacy z-score. Province dummies are included in all estimates. The weighted sample is used in all estimations. Source: Authors' estimates.

The coefficient on income is statistically significant at the 1% level, suggesting that a higher income is associated with a higher financial literacy score. This relationship holds even when some indicators that determine the individual income such as education and occupation have been controlled for.

It is surprising that the coefficients of the two age categories are not statistically significant for Viet Nam, suggesting that the individual age is not correlated with financial literacy, although the 30–60 age group shows a significantly higher level in Cambodia.[6] This result is different from some previous literature such as Jappelli and Padula (2013) and OECD/INFE (2016). The correlation between age and financial literacy may be captured by the education variables. This could be due to the fact that both Viet Nam and Cambodia are developing economies, and thus the older generation has lower education levels than the younger generation. The coefficient for males is not significant, which shows that there is not much difference in financial literacy between women and men in Cambodia and Viet Nam. This is also different from results in other studies, where men typically score higher (Lusardi and Mitchell 2014).

The results also indicate that occupational status correlates with financial literacy. In Cambodia, the self-employed, salaried workers, and housewives have significantly higher financial literacy scores than the base group (the unemployed, retired people, students). In Viet Nam, the self-employed workers have higher financial literacy scores than the base group, while the salaried workers' and housewives' scores are not statistically, significantly different from the base group. Rural residents in Viet Nam have lower financial literacy scores than their urban counterparts, as expected, but no difference in financial literacy scores between rural and urban areas is observed in Cambodia.

Table 4 presents the regression results for the determinants of the three subcomponents of the financial literacy score: financial knowledge (columns 1 and 2), financial behavior (columns 3 and 4), and financial attitude (columns 5 and 6). We find that correlations between the covariates and each of the financial literacy subcomponents vary. For the Cambodian sample, only education level and income are significantly associated with financial knowledge. For the case of Viet Nam, income, education level, and occupation are not significantly correlated with financial knowledge. Unlike the case of Cambodia, in Viet Nam men have significantly higher financial knowledge scores than do women.[7] Rural residents also have lower financial knowledge scores than urban residents. With regards to the determinants of financial behavior, the estimation results for both Cambodian and Vietnamese samples suggest that higher financial knowledge is positively associated with savvier financial behavior, and this relationship is statistically significant at the 1% level. In both countries, individuals with a higher household income show savvier behavior than those with a lower income. Higher education is only significantly correlated with higher financial behavior scores in the Vietnamese sample. Cambodian respondents who are from 30 to 60 years old and male are likely to have higher financial behavior scores, but at only the 10% level of significance. Meanwhile, in Viet Nam, the respondents aged under 30 are less savvy than those aged over 60, and those aged from 30 to 60 are not significantly different from those aged over 60 in terms of "savvy" financial behavior. Unlike the Cambodian sample, male respondents in the Vietnamese sample are less savvy than female respondents at the 1% level. In Cambodia, those who are either self-employed, salaried employees, or housewives are savvier than those in the base groups (i.e., the unemployed, retired people, and students). But among the Vietnamese, only the self-employed are more likely to be savvy in their financial behavior than individuals in other occupations.

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[6] In Viet Nam, those who are aged 30 or over but under 60 tend to save slightly more than the other two age groups when those two groups are combined into the base group in our estimation. But this relationship is significant only at the 10% level (results upon request).

[7] However, the magnitude is only about half of that of the average coefficient for males (0.32) in the OECD's 30-country sample (OECD/INFE 2016).

Table 4. Determinants of financial knowledge, financial behavior and financial attitude scores in Cambodia and Viet Nam.

Dependent Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Cambodia	Viet Nam	Cambodia	Viet Nam	Cambodia	Viet Nam
	Financial Knowledge Score		Financial Behavior Score		Financial Attitude Score	
Financial knowledge			0.185 ***	0.165 ***	−0.044	0.027
			[0.031]	[0.035]	[0.033]	[0.036]
Income	0.204 ***	−0.038	0.191 ***	0.389 ***	0.186 ***	−0.022
	[0.057]	[0.075]	[0.053]	[0.061]	[0.057]	[0.073]
With some primary education	−1.067 ***	−0.180	0.043	−0.424 ***	0.069	−0.190
	[0.170]	[0.122]	[0.168]	[0.100]	[0.175]	[0.121]
With some secondary education	−0.851 ***	0.038	0.164	−0.224 ***	0.087	−0.119
	[0.158]	[0.096]	[0.160]	[0.082]	[0.169]	[0.091]
Aged under 30	0.075	0.234	0.134	−0.456 **	0.094	0.018
	[0.113]	[0.150]	[0.112]	[0.220]	[0.108]	[0.176]
Aged from 30 to 60	0.111	0.187	0.196 *	−0.367 *	0.018	0.155
	[0.107]	[0.140]	[0.106]	[0.217]	[0.104]	[0.169]
Being a male	−0.016	0.158 **	0.126 *	−0.237 ***	−0.098	0.029
	[0.069]	[0.071]	[0.065]	[0.066]	[0.067]	[0.079]
Self-employed	0.149	0.085	0.411 ***	0.163 *	0.132	0.115
	[0.116]	[0.096]	[0.105]	[0.091]	[0.098]	[0.095]
Salaried employee	0.083	0.122	0.267 **	0.092	0.265 **	−0.046
	[0.135]	[0.092]	[0.117]	[0.079]	[0.113]	[0.095]
Housewife	0.019	0.002	0.514 ***	−0.049	0.154	0.448 ***
	[0.140]	[0.113]	[0.117]	[0.113]	[0.117]	[0.151]
Living in rural area	−0.053	−0.394 ***	−0.079	−0.086	−0.045	0.047
	[0.079]	[0.081]	[0.083]	[0.071]	[0.093]	[0.082]
Intercept	−0.014	0.720	−1.591 ***	−5.482 ***	−1.095 ***	−0.369
	[0.443]	[1.213]	[0.407]	[0.990]	[0.421]	[1.195]
N	1035	1000	1035	1000	1035	1000
R-squared	0.087	0.2587	0.193	0.3666	0.0847	0.2372

Note: Figures in brackets are standard deviations. ***, ** and * denote coefficients significant at the 1%, 5%, and 10% statistical levels, respectively. The dependent variable is the financial behavior score converted to a z-score. Province dummies are included in all estimates. The weighted sample is used in all estimations. Source: Authors' estimates.

The results in columns 5 and 6 show that very few covariates are correlated with financial attitude. In Cambodia, higher-income and salaried employees tend to have more conservative views on money, saving, and consumption, while this is only the case for housewives in Viet Nam. Financial knowledge is not significantly associated with financial attitude in Cambodia, and has only a weak (and not statistically significant) correlation among the Vietnamese.

5.2. Effect of Financial Literacy on Savings Behavior

Table 5 presents the regression results for the relation between financial literacy and savings behavior.[8] Since our saving behavior variable is binary, we estimate the savings behavior equation using both linear probability and probit estimators. The linear probability regression results are reported in columns 1 and 2 (for Cambodia) and columns 4 and 5 (for Viet Nam) while columns 3 and 6 display the results (marginal effects) from probit estimators for each country, respectively. In both countries, financial literacy has a positive and statistically significant correlation with positive savings behavior, regardless of the estimators used. Moreover, the coefficients on financial literacy are quite similar in all estimates. A one standard deviation increase in the financial literacy score is associated with an increased probability of some savings by around 7 percentage points in Cambodia and 10 percentage points in Viet Nam. A higher income is also positively associated with the probability of saving in Cambodia, but not in Viet Nam. With regards to education, those with some primary education (in both Cambodia and Viet Nam) and some secondary education (in Viet Nam and,

[8] As mentioned in Section 3, please refer to Appendix D for the estimation results in which a broader definition of savings is adopted.

to some extent, in Cambodia) tend to have a lower probability of saving than those with some tertiary education (the base group). While age is not correlated with the probability of saving in Cambodia, in Viet Nam, individuals under 60 years old also tend to have a lower probability of saving than those over 60. There is no difference in savings probability between men and women in Viet Nam, but there is a weak (and positive) correlation between being a male and saving in Cambodia. This tendency is also reflected in the negative coefficient for being a housewife; i.e., housewives save less than other occupational groups.

Table 5. Financial literacy and saving behavior in Cambodia and Viet Nam.

	(1)	(2)	(3)	(4)	(5)	(6)
		Cambodia			Viet Nam	
Financial literacy		0.072 ***	0.069 ***		0.099 ***	0.106 ***
		[0.012]	[0.011]		[0.018]	[0.018]
Income	0.063 ***	0.039 **	0.045 **	0.068**	0.046	0.047
	[0.017]	[0.017]	[0.018]	[0.033]	[0.032]	[0.031]
With some primary education	−0.220 ***	−0.174 **	−0.103 **	−0.183 ***	−0.137 **	−0.120 **
	[0.075]	[0.071]	[0.042]	[0.053]	[0.054]	[0.049]
With some secondary education	−0.143 *	−0.117 *	−0.051	−0.140 ***	−0.124 **	−0.103 **
	[0.074]	[0.071]	[0.039]	[0.048]	[0.048]	[0.041]
Aged under 30	−0.056	−0.070 **	−0.049	−0.264**	−0.249 ***	−0.238 ***
	[0.035]	[0.034]	[0.037]	[0.103]	[0.095]	[0.080]
Aged from 30 to 60	0.013	−0.006	0.008	−0.175*	−0.168 *	−0.151 **
	[0.032]	[0.031]	[0.034]	[0.103]	[0.095]	[0.077]
Being a male	0.043 **	0.038 *	0.033 *	−0.029	−0.025	−0.025
	[0.021]	[0.021]	[0.019]	[0.039]	[0.038]	[0.035]
Self-employed	−0.004	−0.036	−0.050	0.045	0.025	0.033
	[0.035]	[0.034]	[0.033]	[0.058]	[0.057]	[0.049]
Salaried employee	0.065	0.039	0.006	−0.046	−0.058	−0.042
	[0.042]	[0.041]	[0.034]	[0.047]	[0.045]	[0.043]
Housewife	−0.064 *	−0.093 **	−0.111 ***	−0.103*	−0.115 *	−0.116 *
	[0.038]	[0.038]	[0.042]	[0.062]	[0.061]	[0.064]
Living in rural area	−0.039	−0.030	−0.035	−0.071*	−0.042	−0.037
	[0.029]	[0.029]	[0.023]	[0.038]	[0.037]	[0.034]
Intercept	0.006	0.118		−0.668	−0.310	
	[0.145]	[0.146]		[0.533]	[0.509]	
N	1035	1035	1035	1000	1000	1000
R-squared	0.0827	0.1272	0.1831	0.1204	0.1558	0.1487

Note: Figures in brackets are standard deviations. ***, **, and * denote coefficients significant at the 1%, 5%, and 10% statistical levels, respectively. The dependent variable is whether the respondent has any types of savings. Province dummies are included in all estimates. Columns (3) and (6) display the results (marginal effects) from probit estimators, other columns show linear probability regression results. The weighted sample is used in all estimations. Source: Authors' estimates.

However, the OLS estimates may be biased due to reverse causality (i.e., those with savings could improve their financial literacy), omitted variable biases, or measurement error in financial literacy. In order to address these endogeneity problems, we use an instrumental variable (IV). Following Fernandes et al. (2014) and Murendo and Mutsonziwa (2017), we use the mean financial literacy score at the provincial level as an instrument for individual financial literacy.[9]

Columns 2 and 4 in Table 6 are the first-stage estimation results for Cambodia and Viet Nam, respectively, while columns 1 and 3 are the second-stage results, respectively.[10] The first-stage results indicate that the mean financial literacy at the provincial level is highly correlated with individual financial literacy. Also, the first-stage results are not qualitatively different from the estimation results presented in Table 3 where we do not control for regional financial literacy. Underidentification statistics

[9] We also used an IV probit estimator to address possible endogeneity of the financial literacy score. However, the Wald statistics indicate that the IV estimates are consistent but not efficient, so it is more appropriate to use the probit estimator.

[10] We use GMM methods to estimate the savings behavior.

and weak identification tests show that in both countries our IV does not suffer from underidentification or weak instrument problems. Our IV estimation results show a positive and significant impact of financial literacy on individual savings behavior in both Cambodia and Viet Nam. When we control for endogeneity of financial literacy, the coefficient estimate of financial literacy is higher for Cambodia than for Viet Nam. A one standard deviation increase in financial literacy score raises the likelihood of having a formal saving product by 16 percentage points in Cambodia (increased from 7 percentage points if endogeneity is not controlled for) and only 7 percentage points in Viet Nam (reduced from 10 percentage points).

Table 6. Effects of financial literacy on decision to save in Cambodia and Viet Nam (IV).

	(1)	(2)	(3)	(4)
	Cambodia		Viet Nam	
	2nd Stage	1st Stage	2nd Stage	1st Stage
Financial literacy	0.158 **		0.073 **	
	[0.065]		[0.029]	
Income	0.010	0.333 ***	0.056 **	0.237 ***
	[0.027]	[0.050]	[0.024]	[0.048]
With some primary education	−0.108	−0.576 ***	−0.152 ***	−0.416 ***
	[0.069]	[0.164]	[0.039]	[0.073]
With some secondary education	−0.073	−0.340 **	−0.121 ***	−0.140 **
	[0.058]	[0.158]	[0.034]	[0.069]
Aged under 30	−0.089 **	0.206 *	−0.266 ***	−0.136
	[0.037]	[0.107]	[0.077]	[0.158]
Aged from 30 to 60	−0.036	0.271 ***	−0.178 **	−0.053
	[0.038]	[0.101]	[0.075]	[0.153]
Being a male	0.030	0.069	−0.020	−0.050
	[0.022]	[0.065]	[0.028]	[0.057]
Self-employed	−0.068	0.438 ***	0.021	0.221 ***
	[0.042]	[0.099]	[0.037]	[0.074]
Salaried employee	0.011	0.342 ***	−0.060 *	0.130 *
	[0.045]	[0.113]	[0.033]	[0.067]
Housewife	−0.121 **	0.382 ***	−0.111 **	0.134
	[0.048]	[0.121]	[0.043]	[0.089]
Living in rural area	0.015	−0.084	−0.020	−0.299 ***
	[0.023]	[0.068]	[0.031]	[0.058]
Regional literacy level (IV)		0.867 ***		0.353 ***
		[0.172]		[0.021]
Intercept	0.234	−1.961 ***	−0.302	−7.327 ***
	[0.168]	[0.351]	[0.392]	[0.839]
Underidentification test (LM statistic)		25.076		218.448
Weak identification test (F statistic)		25.401		276.152
N	1035	1035	1000	1000
R-squared	0.1611		0.3251	

Note: Figures in brackets are standard deviations. ***, **, and * denote coefficients significant at the 1%, 5%, and 10% statistical levels, respectively. The dependent variable is whether the respondent holds any saving product. The weighted sample is used to estimated. Source: Authors' estimates.

With regards to other control variables, for the case of Cambodia, most covariates that were correlated with savings behavior in Table 5 lose their significance, except for being under 30 years old and being a housewife. The coefficients on income and education become insignificant, suggesting that the correlation of this variable with the savings decision has been captured by the financial literacy score. For the case of Viet Nam, all covariates retain their impacts in determining savings behavior. Moreover, income is positively associated with the likelihood of having a formal saving product, and salaried workers are less likely to have such products than those in the base group.

Individuals may adopt different types of savings to mitigate the risks or maximize the returns. Table 7 presents the estimation results from the multinomial probit regression, which estimates the effect of financial literacy on the savings portfolio (Panel A for Cambodia and Panel B for Viet Nam). In this estimation, respondents who do not save in any form comprise the base group. Column 1 reports the marginal effects of financial literacy on having no savings; columns 2 and 3 present the marginal effects of financial literacy on using only formal savings and using only informal savings, respectively. Column 4 presents the marginal effects on having saved in both formal and informal forms. The results show a negative relationship between financial literacy score and the probability of not saving. A one standard deviation increase in the financial literacy score reduces the likelihood of not saving by 12.4 percentage points in Cambodia and 16.8 percentage points in Viet Nam. Financial literacy is positively correlated with the probability of having informal savings, especially in Viet Nam. While the financial literacy score does not have a significant effect on having only formal savings, it has strong effects on having both formal and informal savings. If the financial literacy score increases by one standard deviation, the likelihood of having saved in both formal and informal forms increases by 7.1 percentage points in Cambodia and 10.5 percentage points in Viet Nam. Appendix C shows the results for having some form of savings (informal, formal, or both) using OLS, probit, and IV estimators.

Table 7. Effect of financial literacy on types of savings.

	No Saving	Formal Savings Only	Informal Savings Only	Both Formal and Informal Savings
Panel A: Cambodia				
Financial literacy	−0.124 ***	−0.004	0.056 ***	0.071 ***
	[0.011]	[0.004]	[0.015]	[0.011]
Income (in log)	−0.002	0.004	−0.029	0.027
	[0.018]	[0.008]	[0.025]	[0.017]
With some primary education	−0.000	−0.007	0.096	−0.089 **
	[0.064]	[0.024]	[0.077]	[0.040]
With some secondary education	−0.011	0.009	0.031	−0.030
	[0.063]	[0.022]	[0.073]	[0.037]
Aged under 30	−0.010	0.025	0.053	−0.068 *
	[0.036]	[0.023]	[0.051]	[0.036]
Aged from 30 to 60	−0.026	0.027	0.030	−0.030
	[0.033]	[0.022]	[0.048]	[0.034]
Being a male	−0.031	0.003	−0.015	0.044 **
	[0.023]	[0.010]	[0.030]	[0.019]
Self-employed	−0.028	−0.021	0.056	−0.007
	[0.032]	[0.014]	[0.046]	[0.034]
Salaried employee	−0.061	−0.011	0.001	0.072 **
	[0.039]	[0.015]	[0.052]	[0.035]
Housewife	−0.003	−0.009	0.043	−0.031
	[0.039]	[0.018]	[0.056]	[0.043]
Living in rural area	0.034	−0.009	−0.061 *	0.035 *
	[0.026]	[0.009]	[0.032]	[0.021]
Number of observations	1035	1035	1035	1035
Panel B: Viet Nam				
Financial literacy	−0.168 ***	−0.003	0.065 ***	0.105 ***
	[0.014]	[0.010]	[0.020]	[0.017]
Income (in log)	−0.092 ***	0.025	0.061	0.006
	[0.026]	[0.021]	[0.038]	[0.027]
With some primary education	0.102 **	−0.109 ***	0.107 *	−0.100 **
	[0.044]	[0.030]	[0.058]	[0.042]
With some secondary education	0.119 ***	−0.022	−0.006	−0.091 ***
	[0.037]	[0.029]	[0.050]	[0.035]

Table 7. *Cont.*

	No Saving	Formal Savings Only	Informal Savings Only	Both Formal and Informal Savings
Panel B: Viet Nam				
Aged under 30	0.038	−0.245 ***	0.265 **	−0.059
	[0.071]	[0.058]	[0.115]	[0.081]
Aged from 30 to 60	−0.009	−0.220 ***	0.253 **	−0.024
	[0.069]	[0.054]	[0.112]	[0.078]
Being a male	0.074 **	−0.031	−0.027	−0.015
	[0.030]	[0.024]	[0.042]	[0.030]
Self-employed	−0.022	0.055	0.017	−0.050
	[0.041]	[0.035]	[0.057]	[0.044]
Salaried employee	−0.065 **	0.038	0.091 *	−0.064 *
	[0.033]	[0.027]	[0.048]	[0.037]
Housewife	−0.015	0.039	0.008	−0.031
	[0.043]	[0.044]	[0.070]	[0.054]
Living in rural area	−0.052	−0.017	0.079 *	−0.010
	[0.034]	[0.025]	[0.045]	[0.030]
Number of observations	1000	1000	1000	1000

Note: Figures in brackets are standard deviations. ***, **, and * denote coefficients significant at the 1%, 5%, and 10% statistical levels, respectively. The dependent variable is categorized as: (i) no savings; (ii) only formal savings; (iii) only informal savings; and (iv) both formal and informal savings. A multinomial probit estimator is used. The weighted sample is used in all estimations. Source: Authors' estimates.

5.3. Effect of Financial Literacy on Financial Inclusion

Table 8 reports our estimation results for the relation between financial literacy and financial inclusion in Cambodia (columns 1–3) and Viet Nam (columns 4–6). The OLS estimator is used in columns 1 and 4, while the instrumental variables estimator is used in the remaining columns. The results using the OLS estimator show that, in both countries, financial literacy is positively associated with financial inclusion, and this relationship is significant at the 1% level. A one standard deviation increase in the financial literacy score is associated with a rise in the financial inclusion score of 41.5 percentage points in Cambodia and 34.4 percentage points in Viet Nam. A higher income is also positively associated with financial inclusion in Cambodia and is also correlated with higher financial inclusion in Viet Nam, but this relationship is only significant at the 10% level. With regards to education, when financial literacy and income are controlled, higher education levels are still significantly associated with higher financial inclusion in Viet Nam, but not in Cambodia. This may be due to the fact that the association between education and financial literacy is stronger in Cambodia than in Viet Nam, as we conjectured regarding the results in Table 3. For Viet Nam, only education level has a statistically significant effect on financial inclusion. However, for Cambodia, higher financial inclusion is also significantly related to those aged 30 to 60, the self-employed, and salaried employees relative to the base group. Housewives and people living in rural areas have lower financial inclusion scores in Cambodia.

Similar to the relationship between financial literacy and the savings decision, the OLS estimates may suffer from endogeneity problems. To address this issue, we also use the mean financial literacy score at the provincial level as an instrument for individual financial literacy. Columns (3) and (6) are the first-stage estimation results for Cambodia and Viet Nam while columns (2) and (5) are the second-stage results, respectively. The test statistics indicate that our IV does not suffer from underidentification or weak instrument problems.

Table 8. Financial literacy and financial inclusion in Cambodia and Viet Nam.

	(1)	(2)	(3)	(4)	(5)	(6)
	Cambodia			Viet Nam		
	OLS	IV, 2nd Stage	IV, 1st Stage	OLS	IV, 2nd Stage	IV, 1st Stage
Financial literacy	0.415 ***	0.735 ***		0.344 ***	0.370 ***	
	[0.028]	[0.187]		[0.038]	[0.065]	
Income	0.158 ***	0.060	0.333 ***	0.125 *	0.126 **	0.237 ***
	[0.048]	[0.078]	[0.050]	[0.064]	[0.054]	[0.048]
With some primary education	−0.212	−0.042	−0.576 ***	−0.538 ***	−0.626 ***	−0.416 ***
	[0.148]	[0.197]	[0.164]	[0.118]	[0.085]	[0.073]
With some secondary education	−0.067	0.030	−0.340 **	−0.452 ***	−0.486 ***	−0.140 **
	[0.143]	[0.165]	[0.158]	[0.101]	[0.075]	[0.069]
Aged under 30	0.026	−0.042	0.206 *	−0.089	−0.095	−0.136
	[0.091]	[0.106]	[0.107]	[0.175]	[0.172]	[0.158]
Aged from 30 to 60	0.245 ***	0.165	0.271 ***	0.017	0.023	−0.053
	[0.088]	[0.109]	[0.101]	[0.168]	[0.167]	[0.153]
Being a male	0.068	0.029	0.069	0.193 **	0.185 ***	−0.050
	[0.058]	[0.062]	[0.065]	[0.079]	[0.062]	[0.057]
Self-employed	0.231 ***	0.011	0.438 ***	−0.178	−0.242 ***	0.221 ***
	[0.084]	[0.120]	[0.099]	[0.109]	[0.082]	[0.074]
Salaried employee	0.309 ***	0.106	0.342 ***	0.024	−0.007	0.130 *
	[0.101]	[0.128]	[0.113]	[0.097]	[0.073]	[0.067]
Housewife	−0.198 **	−0.329 **	0.382 ***	−0.114	−0.177 *	0.134
	[0.096]	[0.137]	[0.121]	[0.122]	[0.096]	[0.089]
Living in rural area	−0.168 **	−0.092	−0.084	−0.026	0.071	−0.299 ***
	[0.074]	[0.067]	[0.068]	[0.076]	[0.069]	[0.058]
Regional literacy level (IV)			0.867 ***			0.353 ***
			[0.172]			[0.021]
Intercept	−0.842 **	−0.319	−1.961 ***	−2.118 **	−1.595 *	−7.327 ***
	[0.378]	[0.480]	[0.351]	[1.044]	[0.870]	[0.839]
Underidentification test (LM stat.)			25.076			218.448
Weak identification test (F stat.)			25.401			276.152
Number of observations	1035	1035	1035	1000	1000	1000

Note: Figures in brackets are standard deviations. ***, **, and * denote coefficients significant at the 1%, 5%, and 10% statistical levels, respectively. The dependent variable is the financial inclusion converted z-score. OLS stands for ordinary least square estimation; IV stands for instrumental variable estimation. In OLS estimation, province dummies are included in all estimates. The weighted sample is used to estimated. Source: Authors' estimates.

With regards to the impact of financial literacy on financial inclusion, the estimation results show a positive and significant impact, actually larger than that of the OLS estimates. This is consistent with all other studies that use IVs for financial literacy, regardless of instruments, to calculate financial literacy scores such as Agnew et al. (2013), and Bucher-Koenen and Lusardi (2011). According to Lusardi and Mitchell (2014), the true effect of financial literacy seems to be biased downward, although the larger magnitude of the IV coefficient may be attributed to either measurement errors or a larger response from those who are affected by the instruments.

The estimation results also indicate that, for the case of Cambodia, other covariates that are correlated with financial inclusion in the OLS estimation (column 1) lose their significance, except for the housewife variable. This suggests that the correlations of the other variables with financial inclusion was captured by the financial literacy score. For the case of Viet Nam, a lower education level is still correlated with a lower level of financial inclusion, while the coefficient for the self-employed becomes statistically significant when an instrument is used for the financial literacy. Higher income is also significantly related to financial inclusion in Viet Nam.

6. Discussion

Our study of adult financial literacy in Cambodia and Viet Nam breaks new ground in two ways: (i) It marks the first implementation of the OECD/INFE survey in the so-called CLMV countries (Cambodia, Lao PDR, Myanmar, and Viet Nam); and (ii) Cambodia and Viet Nam have considerably lower levels of per capita income than the other 30 countries in OECD/INFE (2016). Generally, our study corroborates the findings of studies of other countries but uncovers some differences as well. The overall scores of financial literacy in Cambodia (11.8) and Viet Nam (12.7) are at the low end of the range seen in the other 30 countries that have implemented the OECD/INFE survey, and near those for Poland and Belarus. However, these results are relatively good when taking into account the levels of per capita income in those two countries.

Our analysis shows that that the level of education generally is highly significant and positively correlated with financial literacy in both Cambodia and Viet Nam. This holds for both the overall measure of financial literacy and the subscores for financial knowledge, financial behavior, and for savings. However, the education level was not significant for financial attitudes. These results were consistent with the findings for the other 30 countries reported in OECD/INFE (2016). These results also consistent with those of Bucher-Koenen and Lusardi (2011), and Murendo and Mutsonziwa (2017), which use different measures of financial literacy.

Respondents aged 30–60 had significantly higher overall financial literacy scores than other age groups, but the effects of age on individual subscores were less consistent or significant. In particular, there was no significant effect of age on financial attitude. This generally is consistent with the findings for the other 30 countries where age groups 30–60 generally had higher scores for both financial knowledge and financial behavior.

Interestingly, gender was not very significant for overall financial literacy in either country. The gender coefficient was not significant for Cambodia, while for Viet Nam it was significant, but only about half the average magnitude of the other 30 countries (0.18 vs. 0.32) (OECD/INFE 2016). This result differs from some other studies. For example, Lusardi and Mitchell (2014) find that men typically have higher financial literacy scores than women. While we do not have an explanation for this difference, and cultural factors are probably significant, we conjecture that differences in education levels between men and women in Cambodia and Vietnam may capture most of the gender differences in financial literacy. This issue merits further study.

The results generally showed that self-employed workers and salaried workers had higher levels of financial literacy than other employment categories in both countries, and housewives had higher levels of financial literacy in Cambodia. These results were less strong for the various subscores, but generally pointed in the same direction, especially for financial behavior.

The finding with the most important macroeconomic implications is that both financial literacy and general education levels are positively and significantly related to formal and informal savings activity, and financial literacy has an independent effect even when the general education level is corrected for. Similar to Fernandes et al. (2014) and Murendo and Mutsonziwa (2017), our result still holds when the possible endogeneity of financial literacy is corrected for by using the regional average financial literacy level as an instrumental variable. This implies that improving general education levels is important, but additional gains can be obtained by developing policies such as financial education programs that directly raise financial literacy. Such programs could have important potential impacts in terms of increasing savings in those countries.

Similarly, both financial literacy and general education levels are found to be positively and significantly related to the measure of financial inclusion. This holds in most cases even when the possible endogeneity of financial literacy is corrected by using regional average financial literacy as an instrumental variable. Increased financial inclusion means that increased savings can be made more readily available for investment activity in those countries. Again, this underlines the importance of developing policies to raise both general education and financial literacy.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A.

Table A1. Sample distribution by region in Cambodia and Viet Nam (number of respondents).

	All Sample	Urban	Rural
Cambodia	1035	291	744
Phnom Penh	103	103	0
Coastal			
Kampot	54	11	43
Preah Sihanouk	23	5	18
Plain			
Kampong Cham	268	53	215
Takeo	131	26	105
Plateau and Mountain			
Kratie	91	20	71
Stung Treng	34	8	26
Tonle Sap			
Kampong Chhnang	240	47	193
Otdar Meanchey	91	18	73
Viet Nam	1000	309	700
Red River Delta			
Ha Noi	185	56	129
Vinh Phuc	30	9	21
Thai Binh	50	15	35
Northern Highland and Midland			
Thai Nguyen	30	8	22
Lang Son	20	6	14
Son La	20	6	14
Northern and Coastal Central			
Da Nang	30	9	21
Phu Yen	30	9	21
Nghe An	90	27	63
Highland			
Lam Dong	40	12	28
Dak Lak	50	15	35
Gia Lai	40	12	28
South East			
HCMC	205	62	143
Ba Ria	30	9	21
Tay Ninh	30	9	21
Mekong Delta			
Can Tho	40	12	28
Ca Mau	40	12	28
Ben Tre	40	12	28

Appendix B. Sample Weight Calculations

Table A2. Share of income groups in Cambodia: our sample vs. population.

Income	Our Sample (%)	2017 Media Index
Larger than $500	14%	16%
From $351 to $500	19%	18%
From $201 to $350	35%	28%
From $101 to $200	25%	28%
Less than 100$	8%	11%

Table A3. Share of income groups in rural and urban Viet Nam: our sample vs. population.

	Our Sample		Nielsen Monitoring	
	Rural	Urban	Rural	Urban
VND 15 Mill. or higher	2%	6%	6%	20%
From VND 7.5 Mill. to VND 14.99 Mill.	11%	22%	22%	38%
From VND 4.5 Mill. to VND 7.49 Mill.	32%	32%	38%	32%
From VND 3.0 Mill. To VND 4.49 Mill.	37%	30%	25%	9%
Less than VND 3.0 Mill	18%	10%	10%	2%

Table A4. Share of rural and urban population in six regions in Viet Nam: our sample vs. population.

	Our Sample		GSO 2014	
	Rural	Urban	Rural	Urban
Northern Highland and Midland	71%	29%	82%	18%
Red River Delta	70%	30%	66%	34%
Northern and Costal Central	70%	30%	72%	28%
Highland	70%	30%	69%	31%
South East	70%	30%	37%	63%
Mekong Delta	70%	30%	75%	25%

For the Cambodian sample, the weights are constructed based on income groups (Table A2). We calculate the weights for the Cambodian sample as follows:

$$Weight^{KHM} = \frac{IG_{ip}}{IG_{is}}$$

where IG_{is} is the share of our sample in income group i (5 income groups as above); and IG_{ip} is the share of the population (2017 Media index) in income group i.

For the Vietnamese sample, we construct the weights based on: (i) income group in rural and urban areas (Table A3) and (ii) the share of rural and urban population in each region (Table A4). More specially, our weights for the Vietnamese sample are calculated as follows:

$$Weight^{VNM} = \frac{IG^u_{ip}}{IG^u_{is}} * \frac{Pop^u_{rp}}{Pop^u_{rs}}$$

where IG^u_{is} is the share of our sample in income group i (5 income groups as above) and area u (u is either rural or urban); IG^u_{ip} is the share of the population (Nielsen Monitoring data) in income group i and area u; Pop^u_{rs} is the share of our sample in each region r (6 regions as above) and area u; and Pop^u_{rp} is the share of the population (following GSO) in each region r and area u.

Appendix C. Estimates Based on Broader Definition of Saving

Table A5 reports our estimation results for a broader definition of savings that includes not only those who hold savings products (i.e., formal savings) but also those who save in other forms such as keeping money at home, asking some family members to keep money for them, etc. (i.e., informal savings). The dependent variable takes the value one if an individual has any types of savings and zero otherwise. Columns (1)–(3) are the results using the Cambodian sample, while the remaining columns display the results using the Vietnamese sample. We use both the OLS estimator (columns (1) and (3)) and the probit estimator (columns (2) and (4)). Columns (3) and (6) are estimated using the GMM estimator with our conventional instrumental variables. For both countries, we report only the 2nd stage since the 1st stage is similar to the 1st stage reported in Table 8. The estimation results show an increase in the magnitude of the effect of the financial literacy score on the savings decision. A one standard deviation increase in the financial literacy score raises the likelihood of saving by about 12 percentage points among Cambodian respondents and 16 percentage points among Vietnamese respondents, which is twice as large as the effects on formal savings products alone. Similar patterns are also observed when we use the instrumental variable to address the endogeneity of the financial literacy score. Moreover, while the financial literacy score does not have a significant effect on formal savings behavior among Vietnamese respondents, it becomes a significant factor when informal savings are taken into account.

Table A5. Effects of financial literacy on savings behavior (broad definition), OLS estimators and IV.

	Cambodia			Viet Nam		
	(1)	(2)	(3)	(4)	(5)	(6)
Financial literacy	0.124 ***	0.120 ***	0.426 ***	0.152 ***	0.145 ***	0.221 ***
	[0.012]	[0.011]	[0.091]	[0.017]	[0.015]	[0.028]
Income (in log)	−0.000	0.000	−0.099 ***	0.105 ***	0.113 ***	0.088 ***
	[0.019]	[0.017]	[0.038]	[0.027]	[0.024]	[0.023]
With some primary education	0.015	−0.000	0.204 **	−0.065	−0.107 **	−0.059
	[0.048]	[0.060]	[0.095]	[0.040]	[0.043]	[0.037]
With some secondary education	0.034	0.025	0.142 *	−0.084 **	−0.126 ***	−0.093 ***
	[0.045]	[0.058]	[0.080]	[0.034]	[0.036]	[0.033]
Aged under 30	0.038	−0.001	−0.013	−0.063	−0.057	−0.049
	[0.042]	[0.035]	[0.052]	[0.073]	[0.066]	[0.074]
Aged from 30 to 60	0.032	−0.001	−0.034	−0.001	−0.001	0.003
	[0.040]	[0.032]	[0.053]	[0.071]	[0.065]	[0.072]
Being a male	0.029	0.034	0.007	−0.077 **	−0.078 ***	−0.066 **
	[0.022]	[0.022]	[0.030]	[0.030]	[0.028]	[0.027]
Self-employed	0.109 ***	0.096 ***	−0.063	0.030	0.011	0.029
	[0.040]	[0.032]	[0.058]	[0.044]	[0.039]	[0.035]
Salaried employee	0.098 **	0.087 **	−0.034	0.068 *	0.056 *	0.057 *
	[0.041]	[0.037]	[0.062]	[0.036]	[0.032]	[0.032]
Housewife	0.044	0.021	−0.093	0.010	0.004	0.010
	[0.046]	[0.037]	[0.066]	[0.044]	[0.042]	[0.042]
Living in rural area	0.014	0.014	0.007	0.048	0.062 *	0.068 **
	[0.027]	[0.027]	[0.032]	[0.032]	[0.031]	[0.030]
Intercept	0.734 ***		1.301 ***	−1.127 ***		−0.639 *
	[0.127]		[0.233]	[0.434]		[0.377]
Number of observations	1035	1035	1035	1000	1000	1000
R-squared	0.215	0.2751	0.7807	0.2872	0.2998	0.8068

Note: Figures in brackets are standard deviations. ***, **, and * denote coefficients significant at the 1%, 5%, and 10% statistical levels, respectively. The dependent variable is whether the respondent saved or not (either in formal or informal ways). Weighted samples are used for all estimations.

Appendix D. Estimates Based on Combined Samples of Cambodia and Viet Nam

Tables A6 and A7 present our estimation results for the combined weighted Vietnamese and Cambodian samples, using the OLS estimator and the GMM estimator, respectively. The dependent

variables in Appendix D are: financial literacy score (1), financial knowledge score (2), financial behavior score (3), financial attitude score (4), financial inclusion score (5), and savings behavior (6) and (7). The estimation results show that household income, education, and occupational status are the major determinants of the financial literacy score and its components (especially financial knowledge score and financial behavior score). The financial knowledge score is positively and significantly associated with the financial behavior score, but not with the financial attitude score. Males tend to have a higher financial knowledge score but lower financial attitude score than females.

The OLS results in Table A6 show that financial literacy is positively correlated with financial inclusion and saving behavior. A standard deviation increase in the financial literacy score is associated with an increase in the financial inclusion score of 39 percentage points and in the likelihood of savings of 9 percentage points. Household income, educational level, and, to some extent, occupational statuses are also positively correlated with financial inclusion and savings behavior. While age does not show much correlation with financial literacy score and its components, individuals either under 30 years old or from 30 to 60 years old have somewhat higher financial inclusion and more savings.

Table A6. Determinants of financial literacy and savings behavior (combined sample), OLS estimator.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variables	**Financial Literacy Score**	**Financial Knowledge Score**	**Financial Behavior Score**	**Financial Attitude Score**	**Financial Inclusion Score**	**Saving Behavior (OLS)**	**Saving Behavior (Probit)**
Financial literacy					0.387 ***	0.085 ***	0.089 ***
					[0.023]	[0.010]	[0.011]
Financial knowledge			0.164 ***	−0.012			
			[0.023]	[0.024]			
Income (in log)	0.294 ***	0.116 **	0.258 ***	0.105 **	0.133 ***	0.046 ***	0.050 ***
	[0.042]	[0.047]	[0.042]	[0.046]	[0.039]	[0.017]	[0.017]
With some primary education	−0.468 ***	−0.351 ***	−0.359 ***	−0.072	−0.439 ***	−0.148 ***	−0.104 ***
	[0.082]	[0.098]	[0.084]	[0.092]	[0.090]	[0.041]	[0.032]
With some secondary education	−0.215 ***	−0.133	−0.231 ***	−0.012	−0.330 ***	−0.112 ***	−0.064 **
	[0.073]	[0.085]	[0.076]	[0.075]	[0.081]	[0.039]	[0.028]
Aged under 30	0.147	0.149	−0.016	0.065	0.037	−0.102 ***	−0.092 **
	[0.096]	[0.094]	[0.103]	[0.091]	[0.082]	[0.034]	[0.036]
Aged from 30 to 60	0.220 **	0.118	0.103	0.081	0.209 ***	−0.034	−0.029
	[0.092]	[0.089]	[0.099]	[0.088]	[0.079]	[0.034]	[0.035]
Male	0.030	0.061	0.019	−0.090 *	0.097 **	0.003	−0.003
	[0.044]	[0.045]	[0.044]	[0.048]	[0.044]	[0.020]	[0.018]
Self-employed	0.300 ***	0.100	0.292 ***	0.086	0.010	−0.023	−0.020
	[0.068]	[0.070]	[0.068]	[0.066]	[0.071]	[0.035]	[0.030]
Salaried employee	0.185 ***	0.093	0.130*	0.063	0.115	−0.031	−0.022
	[0.068]	[0.076]	[0.068]	[0.073]	[0.073]	[0.034]	[0.028]
Housewife	0.253 ***	−0.062	0.351 ***	0.231 ***	−0.253 ***	−0.093 **	−0.102 ***
	[0.080]	[0.079]	[0.078]	[0.088]	[0.077]	[0.037]	[0.038]
Living in rural area	−0.193 ***	−0.192 ***	−0.108*	0.007	−0.071	−0.046 *	−0.038 *
	[0.054]	[0.057]	[0.055]	[0.061]	[0.052]	[0.024]	[0.021]
Viet Nam	−1.854 ***	−0.977 **	−1.151 ***	−0.847 *	−1.135 ***	−0.469 **	−0.438 **
	[0.445]	[0.490]	[0.441]	[0.481]	[0.428]	[0.188]	[0.182]
Intercept	−1.991 ***	−0.417	−2.265 ***	−0.200	−0.666 **	0.067	
	[0.287]	[0.314]	[0.288]	[0.321]	[0.270]	[0.115]	
N	2035	2035	2035	2035	2035	2035	2015
R-squared	0.2355	0.1469	0.2573	0.1444	0.3044	0.155	0.1748

Note: Figures in brackets are standard deviations. ***, **, and * denote coefficients significant at the 1%, 5%, and 10% statistical level, respectively. In all estimations, province dummies are controlled for. The weighted sample is used for all estimations.

As before, we attempt to control for endogeneity of the financial literacy score by using the mean financial literacy score at the provincial level. As shown in Table A7, the financial literacy score still has a statistically significant effect on financial inclusion. While the effect of the financial literacy score on narrowly defined savings behavior (i.e., whether the respondents hold any formal savings product) loses its significance after the endogeneity is controlled, the financial literacy score still has a positive

effect on our broader definition of savings (i.e., including those who have savings in informal forms). The latter relationship is significant at the 1% level.

The estimation results shown in Tables A6 and A7 indicate that, after controlling for household income, education, age, occupational status, and other covariates, the coefficients on the "Viet Nam" dummy variable are negative and statistically significant at the 1% level for most equations. This could be attributed to the fact that the financial literacy gap between Cambodia and Viet Nam is rather small, although Viet Nam seems to have higher values in all covariates that determine financial literacy, financial inclusion, and the saving decision. The reasons for this need to be investigated further.

Table A7. Effects of financial literacy on savings behavior and financial inclusion (combined sample), IV.

	(1)	(2)	(3)	(4)
	2nd Stage			1st Stage
	Financial Inclusion	Formal Savings [a]	Savings [b]	
Financial literacy	0.313 ***	−0.009	0.316 ***	
	[0.101]	[0.042]	[0.045]	
Income (in log)	0.154 ***	0.076 ***	−0.007	0.293 ***
	[0.045]	[0.019]	[0.020]	[0.036]
With some primary education	−0.573 ***	−0.194 ***	0.000	−0.517 ***
	[0.083]	[0.035]	[0.037]	[0.070]
With some secondary education	−0.403 ***	−0.127 ***	−0.047	−0.262 ***
	[0.067]	[0.028]	[0.030]	[0.066]
Aged under 30	0.022	−0.098 ***	−0.012	0.113
	[0.084]	[0.035]	[0.038]	[0.088]
Aged from 30 to 60	0.219 ***	−0.017	0.011	0.211 **
	[0.083]	[0.035]	[0.037]	[0.084]
Male	0.104 ***	0.007	−0.025	0.030
	[0.039]	[0.016]	[0.017]	[0.041]
Self-employed	−0.040	−0.000	0.001	0.289 ***
	[0.064]	[0.027]	[0.028]	[0.060]
Salaried employee	0.089	−0.015	0.029	0.171 ***
	[0.062]	[0.026]	[0.028]	[0.062]
Housewife	−0.264 ***	−0.069 **	0.004	0.208 ***
	[0.071]	[0.030]	[0.032]	[0.070]
Living in rural area	−0.018	−0.038 *	0.037	−0.195 ***
	[0.050]	[0.021]	[0.023]	[0.046]
Viet Nam	−1.727 ***	−0.699 ***	−0.073	−2.919 ***
	[0.454]	[0.190]	[0.204]	[0.365]
Regional literacy level (IV)				0.919 ***
				[0.098]
Intercept	−0.504 *	−0.064	0.894 ***	−1.498 ***
	[0.270]	[0.113]	[0.121]	[0.236]
Underidentification test (LM statistic)				84.111
Weak identification test (F statistic)				87.177
N	2035	2035	2035	2035
R-squared	0.2509	0.2342	0.8094	

Note: a: Savings is defined based on whether an individual holds any saving product (i.e., formal savings form); b: Savings is defined based on whether an individual has any savings (either in formal savings forms or informal savings forms). Figures in brackets are standard deviations. ***, **, and * denote coefficients significant at the 1%, 5%, and 10% statistical level, respectively. The weighted sample is used for all estimations.

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Exchange Rate Volatility and Disaggregated Manufacturing Exports: Evidence from an Emerging Country

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Abstract: The link between export performance and exchange rate policy has been attracting attention from policymakers, academics, and practitioners for some time, particularly for emerging countries. It has been recently claimed that implementing a policy that devalues the currency in Vietnam is an important factor for enhancing its export performance. However, it is also argued that such a policy could result in the harmful consequence of exchange rate volatility. This study analyzes the link between exchange rate devaluation, volatility, and export performance. The analysis focuses on the manufacturing sector and 10 of its subsectors that were engaged in the export of goods between Vietnam and 26 key export partners during the 2000–2015 period. Potential factors that could affect this relationship, such as the global financial crisis, Vietnam's participation in the World Trade Organization, or even the export partners' geographic structures, are also accounted for in the model. The findings confirm that a strategy that depreciates Vietnam's currency appears to enhance manufacturing exports in the short run, whereas the resulting exchange rate volatility has clear negative effects in the long run. The impact of exchange rate volatility on manufacturing subsectors depends on two factors, namely, (i) the type of export and (ii) the export destination. Policy implications emerging from these conclusions are presented.

Keywords: exchange rate volatility; export performance; disaggregated data; manufacturing sector; emerging country

JEL Classification: C33; F14; F31

1. Introduction

The impact of exchange rate volatility on exports has generated a great degree of interest among policymakers, economists, and practitioners (exporters and importers in particular). The impact is playing an increasingly important role in many emerging Asian and South American countries, where exports are considered the engine in export-orientated growth models (Kandilov 2008). It is widely believed that an increase in exchange rate volatility could have devastating effects on an economy and its trade, and such outcomes would be the most damaging in emerging nations, where capital markets are likely to be underdeveloped (Prasad et al. 2003). In the context of an emerging market, a comprehensive understanding of the nature and magnitude of the nexus between exchange rate volatility and exports is of great importance to policymakers. Unfortunately, this crucial issue has been largely ignored.

In Vietnam, researchers have examined a variety of factors, such as foreign direct investment (Xuan and Xing 2008), trade policy (Nguyen 2016), and the impact of trade partnerships or agreements

(Xiong 2017), that have affected aggregated exports. Nguyen (2016) examined the trade liberalization policy in Vietnam and its link to the level of export sophistication. The study's findings reveal that trade liberalization has had a stronger effect on the non-manufacturing sector than the manufacturing sector and that being a World Trade Organization (WTO) member does not have any impact on the level of export sophistication in Vietnam. In their analysis, Narayan and Nguyen (2016) used Vietnam as a case study to demonstrate how the variables in the gravity model are dependent on trading partners. Their results indicate that the country's trading activities are more sensitive to exchanges with rich nations than low-income ones. Also, the issue of Vietnam's currency depreciation (or devaluation, to use the more accurate term) has been the subject of debate in recent years. Some believe that although this strategy would enhance export performance, it would have the side effect of making exchange rates volatile, which, in turn, may be harmful to exports.

On balance, there are conflicting views in the literature on the relationship between exchange rate volatility and exports: empirical studies have produced mixed results due to differing methodologies, volatility measurements, and the types of data used. To the best of our knowledge, few of these studies have been conducted in the context of Vietnam, so policies may lack evidentiary support from academic studies. Our efforts here are an attempt to fill this gap. This paper aims to provide empirical evidence of the link between exchange rate devaluation, volatility, and export performance in Vietnam at disaggregated levels over a period of 16 years, from 2000 to 2015.

The contributions of this paper are as follows. *First*, a panel model was used to analyze the relationship between the two main variables of interest—the exchange rate volatility and exports, with a special focus on the manufacturing industry and its 10 subsectors. Details of the 10 subsectors, as well as 26 of Vietnam's key export partners, are shown in Tables A1 and A2 in the Appendix. These partners make up a significant share of Vietnam's export transactions compared with the rest of the world, and the manufacturing sector plays a substantial role in Vietnam's export structure. We argue that, in recent years, Vietnam has become a preferred destination for supply chain production for many multinational corporations (MNCs) due to the rise of China (Hooy et al. 2015). Also, the country has become deeply involved in further international economic integration by joining multilateral free-trade agreements, such as the Regional Comprehensive Economic Partnership (RCEP). *Second*, we reexamined the effect of exchange rate volatility on exports in three different regions (Asia, Europe, and America). We are of the view that the manufacturing exports between Vietnam and its partners in different regions may be influenced by regional factors such as geographic distances, political and economic relationships, and others. This may alter the export structure and the target destination, especially for the manufacturing sector. Therefore, we separated all of the data into three subsamples based on geographical characteristics, which enabled the exploration of whether location contributes to the impact on the nexus between exchange rate volatility and manufacturing exports in Vietnam.

The structure of this paper is as follows. Following this Introduction, information on manufacturing exports and the trend of exchange rate volatility in Vietnam are briefly discussed in Section 2. Section 3 summarizes relevant theories and empirical studies related to exchange rate volatility and exports. Model specifications are presented in Section 4. Section 5 describes the data and presents the empirical results. A concluding remark follows in the remaining section of the paper.

2. Overview of Vietnam's Exports and Exchange Rate

This section provides some background to provide insight into how the exchange rate market in Vietnam operates, as well as the state of manufacturing exports in Vietnam during the 2000–2015 period. In Vietnam, the exchange rate market is controlled by the State Bank of Vietnam (SBV). In early 1999, it was announced that the exchange rate system would follow a managed floating regime, in which the SBV would publish a daily interbank exchange rate, the average of the exchange rate based on the previous day, and a fluctuation band. The SBV predetermines the fluctuation band for exchange rates to adjust to the market forces of demand and supply, and market participants are expected to trade within the setting band. Table 1 provides a summary of fluctuation bands specified by the SBV from

1999 to 2015. Before 2007, the setting bands of VND/USD fluctuated within a narrow range of around 1%. During the 2008 global financial crisis, the SBV allowed the band to widen to 5%, relative to the official quotation, before narrowing it down to 1% in 2011. This band was stable until late 2015, when it increased by 2%. However, according to the exchange rate regime classification by Ilzetzki et al. (2017), Vietnam was classified as a "dual market in which parallel market data is missing" prior to 2002, but the country was set to follow a crawling peg until 2016.

Table 1. Fluctuation Bands of USD/VND Exchange Rate, 1999–2015.

Time	Feb.-1999	Jun.-2002	Jan.-2007	Dec.-2007	Mar.-2008	Jun.-2008	Nov.-2008	Mar.-2009	Nov.-2009	Feb.-2011	Aug.-2015
Bands	+	+/−	+/−	+/−	+/−	+/−	+/−	+/−	+/−	+/−	+/−
(%)	0.1	0.25	0.5	0.75	1	2	3	5	3	1	3

Figure 1 presents the annual values of Vietnam's manufacturing exports, and the line depicts the trend in the VND/USD exchange rate from 2000 to 2015. There was an upward trend over the timeframe considered. The total value of manufacturing exports started at around 10 billion USD in 2000, gradually increased to approximately 45 billion USD in 2008, and then had a relatively slight decrease in 2009 because of the global financial crisis. After that, the increase was even more significant during the 2009–2015 period, ending up at over 150 billion USD in 2015. A similar trend was seen in the export pattern of 26 other major countries. Regarding the exchange rates, the line graph shows an upward trend from around 14,000 VND per 1 USD in 2000 to approximately 22,000 VND per 1 USD in 2015, indicating a depreciation in VND of more than 120% over the selected period. The most striking detail is that, after the global financial crisis, the exchange rate depreciated dramatically, with a depreciation of around 30% over a period of three years.

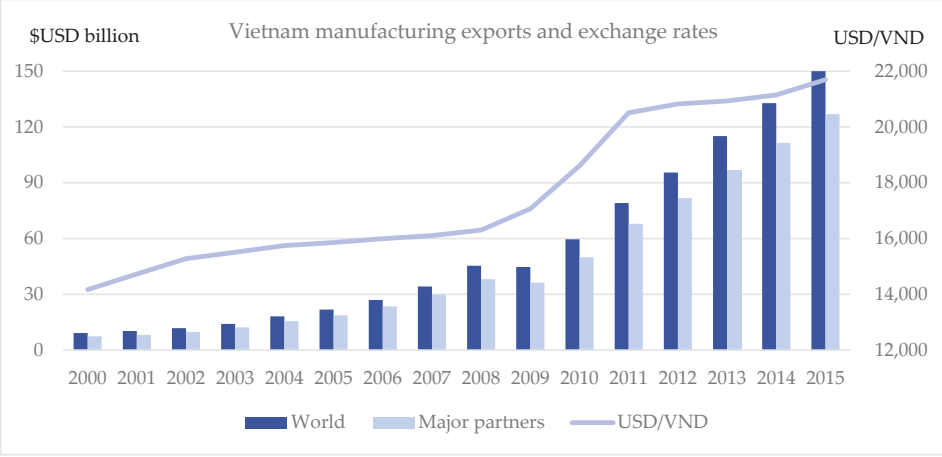

Figure 1. Quarterly Vietnam's Total Exports and VND/USD.

A closer look at Vietnam's manufacturing sectors is illustrated in Figure 2, which shows the percentage of export value from each subsector of the manufacturing sector in four different years during the period from 2000 to 2015. Importantly, these proportions changed significantly over the period surveyed. In 2000, the largest subsector contributing to overall manufacturing exports was *Textiles, wearing apparel, leather*, making up more than two-fifths. This was followed by *Food products, beverages, and tobacco*, which accounted for nearly one-third of the total of manufacturing exports. Textiles continued to account for the majority of exports until 2010. In 2015, *Machinery and equipment* became the most significant contributor after experiencing a considerable rise from nearly 13% in 2000 to just under two-fifths in 2015. *Chemicals, rubber, plastics, and fuel products* and *Furniture, other*

manufacturing products were large contributors to the country's manufacturing exports from 2000 to 2010, but their share declined marginally in 2015. Other industries made up a minuscule part of the total value of manufacturing exports throughout the period of interest.

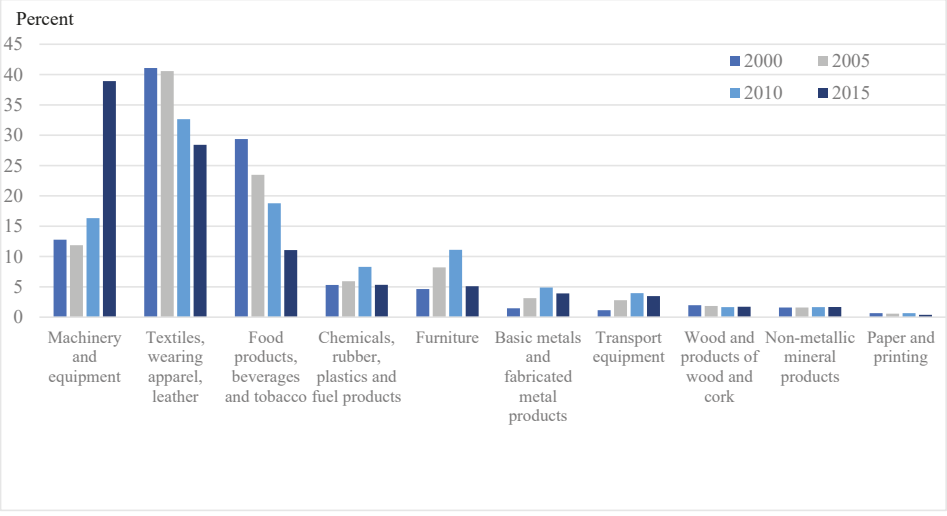

Figure 2. The exporting share of each subsector in the manufacturing industry (%).

Based on the above statistics, some observations can be summarized. *First*, the manufacturing sector is playing an increasingly important role in Vietnam's exports with regard to the monetary value and the share of total exports, but there has been significant variation in its structure, and it is now dominated by machinery and equipment products. *Second*, the VND depreciated and fluctuated over the study period, potentially generating detrimental effects on exports, especially in the manufacturing sector.

3. Literature Review

The exchange rate is a key factor that influences the volume and values of exports. Researchers have examined the effect of exchange rates on exports. For example, Hooy et al. (2015) investigated the effect of the Renminbi real exchange rates on ASEAN exports to China. Although the real exchange rate was found to be positively related to ASEAN exports, its effect on disaggregated levels was mixed. The depreciation of the Renminbi real exchange rate had a positive impact on the export of high- and medium-tech finished goods, as well as parts and components, but it had no effect on basic goods or low-tech, resource-based, and primary products. Recently, in a study by Atif et al. (2017), the exchange rate was found to be a stimulating factor of agricultural exports in Pakistan.

Scholars have also assessed the impact of exchange rate changes on exports from a theoretical perspective. On the one hand, the first strand of the theory's hypothesis is that without a mechanism to mitigate exchange rate risks, volatility will cause a decline in the volume of trade. Exchange rate fluctuations will lead to greater uncertainty in transaction costs, triggering a decrease in the volume of trade (Hooper and Kohlhagen 1978). If traders are uncertain how these fluctuations will influence the company's revenue, the volume of trade will decline (Clark 1973). On the other hand, exchange rate volatility may have a positive effect on trade volume. Volatility can boost trade by increasing the firm's value (Sercu and Vanhulle 1992) or by increasing the probability that the trading price might exceed the trade costs (Sercu 1992). De Grauwe (1988) argued that the worst possible outcome seems to be primarily the concern of very risk-averse agents, so they are likely to export more to prevent

a drastic decrease in their revenue. It is the extent of risk aversion among agents which determines the effect of volatility. Producers exhibiting even a slight degree of risk aversion will export less as their marginal utility for export revenue declines. Some studies have concluded that the introduction of a capital market would not change the impact of volatility. Viaene and Vries (1992) conceded that without hedging instruments, an increase in exchange rate risks leads to the deterioration of both exports and imports. With the appearance of a forward market, the effects of exchange rate volatility on importers and exporters are on opposite ends of the spectrum, because their roles are reversed.

Empirical studies have investigated the link between exchange rate volatility and exports using aggregated trade data. For example, Asteriou et al. (2016) examined the relationship between exchange rate volatility and trade volume of four different nations—Mexico, Indonesia, Nigeria, and Turkey—with the rest of the world. These authors adopted the autoregressive distributed lag (ARDL) bound testing method to address the long-run association and the Granger causality test to detect the short-run relationship. In the long run, there was a marginally negative association between exchange rate volatility and trade volumes in Turkey, while, in the short run, Indonesia and Mexico experienced a causal relationship between these two variables. In their study, Hsu and Chiang (2011) found a negative effect of exchange rate volatility on trade between the US and 13 of its major trading partners, and this finding was unchanged when the sample size was expanded to 30 countries.

Studies have also focused on disaggregated data at commodity or sector levels. Choudhry and Hassan (2015) reported the importance of exchange rate fluctuations for the UK's imports from Brazil, China, and South Africa using an asymmetric ARDL model. The impact of the global financial crisis on the link between volatility and imports was also taken into consideration. Thus, policymakers should be cautious when making decisions, as any policy actions or trade adjustment programs may have unpredicted outcomes if the exchange rate becomes volatile. Bahmani-Oskooee et al. (2013) investigated the impact of exchange rate volatility on the bilateral imports and exports between Brazil and the US between 1971 and 2010 for more than 100 industries. There were several interesting findings. *First*, a vast number of the selected industries were not affected by exchange rate fluctuations, and the positive links significantly dominated the negative effects. *Second*, volatility had a more significant impact on small industries, which account for a smaller share of the total export value. *Third*, each industry reacted differently in response to volatility: for example, agricultural exports in Brazil were found to be negatively related, while there were no recorded impacts on importing machinery products in the US. Nishimura and Hirayama (2013) provided empirical evidence of the effect of exchange rate volatility on Japan–China trade. The findings illustrate that although the exchange rate variation did not affect Japan's exports to China, it had a negative influence on the reverse direction of trade—exporting from China to Japan—during the reform stage.

Authors have also attempted to investigate the long-run and short-run relationship between exchange rate volatility and trade at industry levels between two countries based on the cointegration analysis and bound testing approach. Typical pairs of countries used in these studies include Malaysia and Thailand (Aftab et al. 2017), Malaysia and Japan (Aftab et al. 2015), Malaysia and China (Soleymani and Chua 2014), Canada and Mexico (Bahmani-Oskooee et al. 2012), and the US and China (Bahmani-Oskooee and Wang 2007). These studies, taken together, support both positive and negative impacts of exchange rate volatility on commodity trade between a country and one of its partners. However, the impact may vary across the partners selected in the analysis. This suggests that the impact of exchange rate volatility on exports should be tested case by case; thus, studies on this issue are always valuable.

It is important to consider impacts at the aggregated level so that policymakers have a general enough picture of the effect of the exchange rate on exports. Nevertheless, using aggregated data can lead to aggregated bias problems: the insignificant price elasticity of one industry could overlap with that of another industry, potentially yielding an insignificant elasticity at the aggregated level (Bahmani-Oskooee et al. 2012). Investigating the issue at the disaggregated level provides more detail on the effect of volatility on exports. Without considering the disaggregated level, it is likely

to be difficult for policymakers to ascertain which sectors actually suffer adverse effects of volatility. In this regard, the analysis presented in this paper included both forms of data, rather than a single source. Not only were the aggregated data of the manufacturing sector adopted in the analysis, but the disaggregated data of the manufacturing subsectors were also employed. We aim to add to the literature by investigating a case study of a small open dynamic economy. The aggregated and disaggregated outcomes are expected to supplement one another so that policymakers will have a balanced perspective on this complex effect.

An issue that lacks consistency among researchers is the measure of exchange rate volatility, as there is no universal consensus on the proxy to use in empirical studies. As such, multiple measures have been employed to represent volatility, three of which are widely adopted in empirical studies. The first is the standard deviation of the percentage change in the exchange rate (Chit 2008; Hayakawa and Kimura 2009). The second measure of volatility is the moving average standard deviation (MASD) of the real exchange rate in logarithmic terms (Chit et al. 2010; De Vita and Abbott 2004). The third measure is based on the conditional variance of exchange rates using the generalized autoregressive conditional heteroscedasticity (GARCH) model. While some scholars adopt just one proxy, others have used multiple alternatives as a robustness check. De Vita and Abbott (2004) compared three measures of exchange rate volatility in their study, which examined the effect of volatility on the UK's exports to 14 other European nations. The results indicate that the MASD is likely the optimal volatility measure of total exports and subsector exports from the UK to the whole group of nations studied, while a mix of different alternatives are appropriate for analyzing exports from the UK to each individual country.

4. Model Specifications

Following previous studies (Aristotelous 2001; Chit et al. 2010), the model used for estimating the effects of exchange rate volatility and exports is specified as follows:

$$ln\mathrm{EX}_{it}^{m} = \alpha_{ct} + \beta_1 ln\mathrm{GDP}_{it} + \beta_2 ln\mathrm{REXR}_{it} + \beta_3 ln\mathrm{VOL}_{it} + \varepsilon_{it} \quad (1)$$

where EX_{it}^{m} denotes the real export value in thousands of US dollars of the manufacturing sector as well as its 10 subsectors m at time t from Vietnam to its export partners i. GDP_{it} represents the real Gross Domestic Product (GDP) in a foreign partner country i of Vietnam, deflated by the GDP deflator. The real bilateral exchange rates (REXR_{it}) between Vietnam and its counterparts are measured by multiplying the relative price and the bilateral exchange rates, which are indirectly derived from US-based currency. The relative price is the ratio of the consumer price index (CPI) of export partners to the CPI of Vietnam.[1] Therefore, an increase in the value of the real exchange rate indicates a depreciation of Vietnam's currency. Finally, our variable of interest is the volatility of the bilateral exchange rate (VOL_{it}), measured by the GARCH model.

The first step is to check whether all variables of interest are stationary. We used three panel unit root tests, including those of IPS (Im et al. 2003), Maddala and Wu (1999), and Choi (2001). Unlike other types of panel stationary tests, these tests allow data to be unbalanced. Next, the long-run relationship among these variables was checked using the cointegration tests introduced by Pedroni (1999, 2001), together with long-run estimations based on Panel Dynamic Ordinary Least Squares (DOLS). We used DOLS because it is asymptotically unbiased, normally distributed, and controls for the problem of endogeneity. Finally, to investigate the influence of the exchange rate on the growth of exports during the surveyed period, the equation was transformed in terms of an error correction model (ECM):

[1] We would like to thank an anonymous referee for his/her suggestion to use the real bilateral exchange rate. Many of the countries in the sample had varying inflation rates relative to Vietnam.

$$\Delta ln\mathrm{EX}_{it}^{m} = \alpha_i + \beta_1 \Delta ln\mathrm{EX}_{it-1}^{m} + \sum_{j=0}^{n} \gamma_j \Delta ln\mathrm{GDP}_{it-j} + \sum_{j=0}^{n} \vartheta_j \Delta ln\mathrm{REXR}_{it-j} + \sum_{j=0}^{n} \theta_j \Delta ln\mathrm{VOL}_{it-j} + \varphi \mathrm{EC}_{it-1} + \varepsilon_{it} \quad (2)$$

where Δ represents the difference between variables after taking their logarithm. EC_{it-1} is a lagged error term that is derived by estimating Equation (1).

It is expected that becoming a member of the World Trade Organization (WTO) and the global financial crisis are events that had clear effects on export performance in Vietnam, and they were taken into consideration as well. Nguyen (2016) asserted that the WTO accession was the turning point in Vietnam's trade policy, thus potentially impacting its export performance. The author used Chow breaking tests to detect either a structural change and or regime change between the manufacturing and non-manufacturing sectors. The results reveal that, according to the model, there was a structural change beginning in 2007. In this sense, we employed the dummy variable D_{WTO}, which is given a value of 1 as of 2007, when Vietnam officially entered the WTO. Another dummy D_{Crisis} was assigned the same unit for 2009, the year of the global financial crisis. Thus, the following equation was used for the estimation:

$$\Delta ln\mathrm{EX}_{it}^{m} = \alpha_i + \beta_1 \Delta ln\mathrm{EX}_{it-1}^{m} + \sum_{j=0}^{n} \gamma_j \Delta ln\mathrm{GDP}_{it-j} + \sum_{j=0}^{n} \vartheta_j \Delta ln\mathrm{REXR}_{it-j} + \sum_{j=0}^{n} \theta_j \Delta ln\mathrm{VOL}_{it-j} + \beta_4 D_{Crisis} + \beta_5 D_{WTO} + \varphi \mathrm{EC}_{it-1} + \varepsilon_{it} \quad (3)$$

Annual data over the 2000–2015 period were used in this study. The real foreign GDP, deflated by the GDP deflator, originated from World Bank Indicators, while the values of exports were from Organization and Economic Co-operation and Development (OECD) statistics. Although the Standard Industrial Classification (SIC) Codes classify the manufacturing sector into 22 subsectors, the OECD classification groups them into 10 major ones. As such, we tend to use these 10 subsectors of manufacturing exports because of the data collection. Also, some sectors do not engage in exporting in Vietnam, so using 10 subsectors reduces the problem of missing data. The bilateral exchange rate and the consumer price index (CPI) were taken from International Financial Statistics (IFS). It should be noted that the GARCH model requires high-frequency data to ensure accuracy. Thus, we adopted the monthly bilateral exchange rate to estimate the volatility. To convert monthly volatility to annual data, we averaged the volatility of the relevant year. Table 2 summarizes all of the data in the study.

Table 2. Data description.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Partner's GDP	416	6.78	1.43	1.65	9.72
Bilateral real exchange rate	416	7.71	2.66	0.39	10.71
VOL_GARCH	416	0.03	0.02	0.00	0.14
Manufacturing exports	416	13.45	1.48	9.06	17.30
Food products, beverages and tobacco	415	11.52	1.73	3.91	14.95
Textiles, wearing apparel, leather and related products	416	11.99	1.66	6.99	16.64
Wood and products of wood and cork	414	8.72	1.80	3.71	13.70
Paper and printing	406	7.43	2.00	−1.43	11.52
Chemicals, rubber, plastics and fuel products	415	10.45	1.72	5.86	14.10
Non-metallic mineral products	412	9.85	2.06	0.00	13.54
Basic metals and fabricated metal products	411	8.99	1.86	2.33	12.55
Machinery and equipment	416	11.35	2.20	4.45	15.82
Transport equipment	406	9.21	2.21	2.15	14.46
Furniture and other manufacturing	413	10.09	1.90	3.99	15.10

All variables are in logarithm term, except for volatility measures.

To analyze the impact of geographical characteristics on the link between exchange rate volatility and export performance of the manufacturing sector and its 10 subsectors, we not only used the whole sample for the estimation, but also applied all of the above steps to three different regions (Asia, Europe, and America).

As previously discussed, there are diverse volatility measures used in empirical studies. However, in this study, for a particular nation, we applied the General Autoregressive Conditional Heteroscedasticity (GARCH) model to measure exchange rate volatility. The GARCH model includes two equations: (i) the mean equation and (ii) the conditional variance equation. With the condition that the log difference of an exchange rate series follows the random walk model, the GARCH model is suitable for the measurement of volatility. For GARCH(1,1), the two equations were constructed as follows:

$$e_t^i = \alpha_0 + \alpha_1 e_{t-1}^i + \mu_t^i, \text{ where } \mu_t^i \sim N\left(0,\ h_t^i\right), \text{ and}$$
$$\mathrm{VOL}_{\mathrm{GARCH}} = h_t^i = \beta_0 + \beta_1 \mu_{t-1}^{i^2} + \beta_2 h_{t-1}^i,$$

The conditional variance equation of GARCH(1,1) consists of a constant β_0, an ARCH term $\mu_{t-1}^{i^2}$ and a GARCH term h_{t-1}^i. We utilize the monthly data into the GARCH model and the monthly volatility of exchange rates is the conditional variance.

It is vitally important to adopt the appropriate GARCH model for estimating exchange rate volatility. Nishimura and Hirayama (2013) propose three steps in estimating GARCH-based volatility. The procedure begins with checking the appearance of ARCH effects by using ARCH-LM heteroscedasticity test, and then selecting the length of the optimal lag using Akaike information criterion (AIC) in the mean equation. Next, the second is to estimate the mean and variance equation simultaneously, then determining the appropriate model of ARCH and GARCH terms with the minimum value of Schwarz's Bayesian Information Criterion (SIC). Finally, the Ljung-Box tests are performed on the standardized residuals and standardized residuals squared. The optimal model is determined if these Ljung-Box tests can reject the null hypothesis of no autocorrelation. Although a few studies have attempted to use various lag lengths in the GARCH model (Asteriou et al. 2016), empirical evidence has confirmed that the GARCH(1,1) model is the most appropriate measure of exchange rate volatility (Chit et al. 2010; Erdem et al. 2010). In a recent investigation by Vieira and MacDonald (2016), the use of GARCH(1,1) appeared to predominate among various types of ARCH models for measuring volatility, as it was found in up to 75 out of 106 ARCH series. In addition, Hansen and Lunde (2005) asserted that the GARCH(1,1) model was superior to other complicated GARCH models when they took 330 ARCH-type specifications into consideration. In this sense, the GARCH(1,1) was utilized for the volatility measurement.

5. Empirical Results

5.1. Volatility Measurement

We first calculated the GARCH-based volatility for the exchange rate in terms of the monthly data and then converted it to annual data. The results and diagnostic tests for estimated the GARCH model are presented in Table A3 in the Appendix. Figure 3 depicts, on average, the yearly volatility of the bilateral exchange rate between Vietnam and 26 of its export partners in three different regions. The volatility fluctuates within a range of around 8%, the only exception being Italy. The magnitude of the fluctuation tends to be higher during the global crisis.

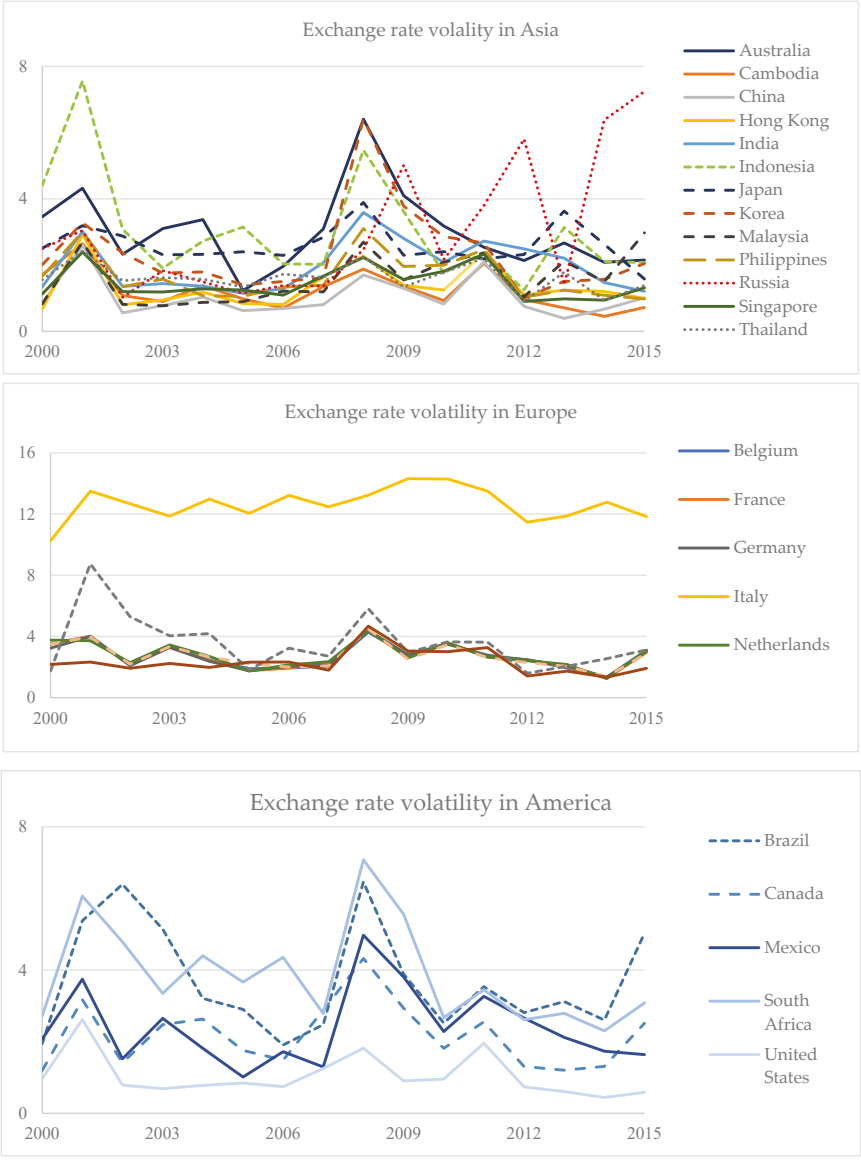

Figure 3. Exchange rate volatility over the 2000–2015 period.

5.2. *Effects of Exchange Rate Volatility on Exports*

This section presents the estimation results pertaining to the effects of exchange rate volatility on manufacturing exports for the whole sample and in three regions—Asia, Europe, and America. We first show the result for the manufacturing sector, followed by its 10 subsectors.

Regarding the manufacturing sector, Tables 3 and 4 show the results of three kinds of panel unit root tests—IPS (Im et al. 2003), Maddala and Wu (1999), and Choi (2001)—for the whole sample and in three regions, respectively. At the manufacturing sector level, strong evidence of unit roots is found for the foreign GDP and real bilateral exchange rate, while, for the difference, the hypothesis that unit

roots are present is strongly rejected. The variable for GARCH-based volatility is stationary for the whole sample and for Asia and America, but it contains unit roots in Europe. A similar pattern is found for manufacturing exports. Thus, the variables of interest are a mixed integration of I(0) and I(1).

Table 3. The unit root test for the full sample.

Variable	IPS	Maddala and Wu		Choi		
		PP	ADF	Z	L	Pm
			Levels			
GDP	0.83	0.97	0.77	0.90	0.89	0.77
Bilateral real exchange rate	0.95	0.99	0.34	0.96	0.98	0.36
VOL_GARCH	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing exports	0.06	0.42	0.00	0.00	0.00	0.00
			1st difference			
GDP	0.00	0.00	0.00	0.00	0.00	0.00
Bilateral real exchange rate	0.00	0.00	0.00	0.00	0.00	0.00
VOL_GARCH	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing exports	0.00	0.00	0.00	0.00	0.00	0.00

Numbers indicate the *p*-values. A maximum of 2 lags were included.

Table 4. The unit root test for three regions.

Variable	IPS	Maddala and Wu		Choi		
		PP	ADF	Z	L	Pm
Panel A: Asia			*Levels*			
GDP	0.77	0.78	0.91	0.93	0.93	0.90
Bilateral real exchange rate	0.19	0.93	0.02	0.09	0.13	0.01
VOL_{GARCH}	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing exports	0.12	0.47	0.00	0.04	0.02	0.00
Panel A: Asia			*1st difference*			
GDP	0.00	0.00	0.00	0.00	0.00	0.00
Bilateral real exchange rate	0.00	0.00	0.00	0.00	0.00	0.00
VOL_{GARCH}	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing exports	0.00	0.00	0.00	0.00	0.00	0.00
Panel B: Europe			*Levels*			
GDP	0.46	0.89	0.32	0.38	0.33	0.35
Bilateral real exchange rate	1.00	1.00	1.00	1.00	1.00	0.98
VOL_{GARCH}	0.00	0.00	0.73	0.50	0.51	0.75
Manufacturing exports	0.19	0.46	0.12	0.29	0.39	0.11
Panel B: Europe			*1st difference*			
GDP	0.00	0.00	0.00	0.00	0.00	0.00
Bilateral real exchange rate	0.00	0.00	0.00	0.00	0.00	0.00
VOL_{GARCH}	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing exports	0.00	0.00	0.00	0.00	0.00	0.00
Panel C: America			*Levels*			
GDP	0.87	0.90	0.50	0.79	0.84	0.56
Bilateral real exchange rate	0.71	0.28	0.47	0.67	0.68	0.52
VOL_{GARCH}	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing exports	0.29	0.31	0.00	0.00	0.00	0.00
Panel C: America			*1st difference*			
GDP	0.05	0.06	0.08	0.06	0.06	0.06
Bilateral real exchange rate	0.00	0.02	0.00	0.00	0.00	0.00
VOL_{GARCH}	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing exports	0.00	0.00	0.01	0.05	0.01	0.00

Numbers indicate the *p*-values. A maximum of 2 lags were included.

The cointegration tests introduced by Pedroni (1999, 2001) were performed to determine the long-run relationship between manufacturing exports and the other variables of interest. Table 5 displays the results for the whole sample and the three regions. Three statistics—group augmented Dickey-Fuller (ADF) test, panel ADF test, and group rho test—strongly support the hypothesis of cointegration. It is worth noting that the group small *t*-test and the group ADF test have a more powerful feature compared with other types of panel statistics, while the panel variance test and group rho test seem to perform poorly. Thus, based on this feature, we conclude that there is a long-run association among the given variables. An exception is the case for countries in the American region, as none of the calculated statistics are significant.

Table 5. The cointegration test for the full sample and three regions.

Sample	Panel v-stat	Panel rho-stat	Panel t-stat	Panel ADF-stat	Group rho-stat	Group t-stat	Group ADF-stat
Full sample	0.29	2.26 **	0.53	4.55 ***	4.35 ***	1.43	6.21 ***
Asia	0.04	1.53	0.14	3.35 ***	3.05 ***	0.87	5.11 ***
Europe	0.16	1.60	1.49	3.87 ***	2.63 ***	2.19 **	4.02 ***
America	0.42	0.64	−1.24	−0.26	1.67	−0.91	0.84

, * indicate the hypothesis of no cointegration is rejected at significance levels of 5%, and 1%.

Next, we performed the long-run estimation among the relevant variables using the panel DOLS estimation in light of the confirmation by cointegration tests. Table 6 presents the estimation result for the whole sample and in three regions—Asia, Europe, and America. Overall, the foreign income is found to be positively related to Vietnam's exports for the whole sample and in Asia and Europe, as the estimated coefficients are significant at a level of at least 10%. The positive sign illustrates that an increase in income among Vietnam' trading partners enhances the exporting performance of manufactured goods for the country. This is consistent with the trade theory that a higher income in foreign nations will lead to an increase in domestic good demands. Also, Hooy et al. (2015) asserted that Vietnam has been deeply engaged in supply chain production due to the rise of China, enhancing both economic growth and exports. According to the results of the present study, the depreciation of the Vietnam Dong is not expected to cause an adverse impact on manufacturing exports in the long run. The effect is found to be negative, although insignificant, for the three regions. Exchange rate volatility has strong reverse effects on manufacturing exports, not only for the whole sample but also in America.

Table 6. The panel DOLS estimation for the full sample and three regions.

Variable	Full Sample	Asia	Europe	America
LnGDP	0.415 ***	0.222 *	0.831 ***	0.598
	(0.054)	(0.119)	(0.296)	(0.441)
LnREXR	−0.065 **	−0.045	−0.305	−0.163
	(0.029)	(0.066)	(0.551)	(0.354)
LnVOL	−0.829 ***	−0.312	−0.476	−1.854 **
	(0.127)	(0.463)	(0.350)	(0.805)
Constant	7.961 ***	11.236 ***	8.779 *	2.916
	(0.658)	(2.203)	(5.079)	(2.435)
Observations	413	205	125	77
R-squared	0.23	0.16	0.41	0.62

"Ln" represents variables defined in terms of logarithm. Standard errors are numbers in the parentheses. *, **, and *** indicate the 10%, 5% and 1% significance level, respectively.

We also examined the short-run relationship on the basis of the ECM model using Equation (3). The results are shown in Table 7, which paint a completely different picture of the effect of exchange rate volatility on manufacturing exports in Vietnam. The coefficients of the lagged error correction terms are negative and significant, supporting the long-run cointegration tests above. The foreign

GDP and the bilateral real exchange rate have a positive association in the estimation for the whole sample and Asia. Europe has a positive significant coefficient for foreign income. The volatility of the exchange rate, on average, has no impact on exports in general in Asia, Europe, and America. The dummy variable representing the participation in the WTO is significant only for the case of Asia, implying that Vietnam gained a significant benefit in exporting goods to Asian countries. The global financial crisis is expected to be harmful, to some extent, to exports. The evidence of negative effects of volatility is weak, suggesting that it can be mostly insured against at low cost. Meanwhile, the price mechanism works via the real exchange rate to ensure that export supply equals demand. These findings imply that the manufacturing exports in Vietnam rely heavily on the partner's income and largely benefit from the depreciation of the Vietnam Dong.

Table 7. The panel OLS estimation for the full sample and three regions.

Variables	Full Sample	Asia	Europe	America
$\Delta LnEX_{it-1}$	0.111 **	0.250 ***	0.180 *	−0.013
	(0.053)	(0.076)	(0.108)	(0.123)
$\Delta LnGDP_{it}$	1.351 **	1.324 *	3.607 ***	0.369
	(0.553)	(0.728)	(0.696)	(2.390)
$\Delta LnGDP_{it-1}$	−0.527	−0.186	−1.562 **	−2.393
	(0.516)	(0.700)	(0.769)	(1.955)
$\Delta LnREXR_{it}$	0.322 **	0.794 ***	−0.150	0.398
	(0.154)	(0.265)	(0.131)	(0.464)
$\Delta LnREXR_{it-1}$	0.210	−0.159	0.195	0.653
	(0.166)	(0.272)	(0.149)	(0.478)
$\Delta LnVOL_{it}$	0.024	0.045	0.042	0.072
	(0.031)	(0.041)	(0.037)	(0.095)
$\Delta LnVOL_{it-1}$	−0.007	0.018	0.019	−0.025
	(0.031)	(0.038)	(0.041)	(0.086)
D_{WTO}	0.029	0.068 *	0.008	−0.044
	(0.027)	(0.038)	(0.029)	(0.081)
D_{Crisis}	−0.186 ***	−0.301 ***	−0.118	0.118
	(0.062)	(0.081)	(0.074)	(0.201)
EC_{t-1}	−0.234 ***	−0.257 ***	−0.185 ***	−0.716 ***
	(0.036)	(0.055)	(0.059)	(0.151)
Constant	0.166 ***	0.084 *	0.130 ***	0.369 ***
	(0.030)	(0.047)	(0.031)	(0.098)
Observations	364	182	112	70
Number of id	26	13	8	5

Δ represents variables defined in terms of difference, indicating growth rate. "Ln" represents variables defined in terms of logarithm. Standard errors are numbers in the parentheses. *, **, and *** indicate the 10%, 5% and 1% significance level, respectively.

When it comes to manufacturing exports at disaggregated levels, we applied the same econometrics procedures to all 10 subsectors for the whole sample and for the three regions. Before the panel DOLS and the panel OLS estimations were run, unit root tests for stationarity and panel cointegration tests were conducted.[2]

The long-run effects of exchange rate volatility on each subsector for the whole sample and in the three regions are depicted in Tables 8 and 9, respectively. Based on all of the data in Table 8, 8 out of 10 manufacturing subsectors suffered adverse effects due to exchange rate volatility. The coefficients of

[2] For minimizing space, the estimated results will be provided upon request. The findings for the 10 subsectors are similar to those for the manufacturing sector. The long-run relationship is confirmed for all 10 subsectors.

two subsectors, namely, *textiles, wearing apparel, leather, and related* products and *chemicals, rubber, plastics, and fuel products*, are statistically insignificant although negative. The effect of the bilateral real exchange rate is also found to be negative in five subsectors in the long run. Thus, a depreciation policy in Vietnam would lead to a decline in export value in the long term as it generates volatility in the exchange rate.

When the geographical factor is taken into consideration, we observe a completely different picture of the relationship between exchange rate devaluation, exchange rate volatility, and export performance at the subsector level. As can be seen from Table 9, exchange rate volatility has almost no effect on exports in Asia and Europe, but America has five subsectors that are negatively related to the exchange rate volatility.[3] It is only the subsector of *non-metallic mineral* products in the American region that enjoys a favorable gain from exchange rate depreciation without being influenced by the exchange rate fluctuation.

Using Equation (3), the short-run effects of exchange rate volatility on export performance at disaggregated levels were regressed and are provided in the next four tables with the application of panel estimation. Table 10 presents the result for the whole sample. The bilateral real exchange rate has a favorable impact on exports in such subsectors as (i) *textiles, wearing apparel, leather, and related products* and (ii) *furniture and other manufacturing products*. This implies that depreciation boosts exports in the short run rather than in the long run in some subsectors. Similarly, exchange rate volatility is found to be positively associated with exports for the subsector of *transport equipment*. Exporters in this subsector may pursue a strategy of exporting more in order to maintain its trading value, as hypothesized by De Grauwe (1988). The subsector of *chemicals, rubber, plastics, and fuel products* is found to be quite sensitive to exchange rate volatility in the short run, given that its estimated coefficient is positive in the current period but becomes negative in the first lag. We find no statistically significant effect of exchange rate depreciation and volatility on export values for the eight remaining subsectors.

A significantly different pattern is seen in Asia, Europe, and America, as indicated in Tables 11–13, respectively. The short-run effects of exchange rate volatility vary considerably across the subsectors, as well as in the given regions. Asia has three subsectors that are positively associated with exchange rate volatility, together with one that reacts negatively. In Europe, the number of subsectors experiencing favorable and harmful effects is three and two, respectively. In America, 3 out of 10 subsectors are found to be positively related to exchange rate fluctuations. Interesting to note is that the export performance in the subsector of *Transport equipment* is observed to benefit from the exchange rate fluctuations, as its estimated coefficients are statistically positive in all three regions. There is an increase in the export performance of *textiles, wearing apparel, leather, and related products* to countries in Europe and America when the exchange rate is volatile. The *Paper and printing* subsector is negatively related to the exchange rate fluctuations in Asia but positively associated in Europe. Other subsectors, such as (i) *wood and products of wood and cork,* (ii) *Chemicals, rubber, plastics, and fuel products*, (iii) *Non-metallic mineral products*, and (iv) *Furniture and other manufacturing products* are influenced by exchange rate volatility, either positively or negatively.

In the short run, the impact of the bilateral exchange rate on the export performance at disaggregated levels is considerably different across the regions. When the real bilateral exchange devaluates, it raises Vietnam's export value in three subsectors—*textiles, wearing apparel, leather, and related products*; *wood and products of wood and cork*; and *paper and printing*—to countries in Europe and America, and it has no effect on the remaining subsectors. In Europe, the estimated results indicate that two subsectors are positively influenced by exchange rate fluctuations, another two react negatively, and results for the rest of the subsectors are inconclusive. All results prove that the impact of the exchange rate on exports at the manufacturing disaggregated level depends on two factors: (i) the type of export and (ii) the exporting destination.

[3] Table A4 presented in indicates the percent change in exports for the manufacturing subsectors resulting from a 1% increase in exchange rate volatility.

Table 8. The panel DOLS estimation for subsectors for the whole sample.

Variable	Ln(ex1)	Ln(ex2)	Ln(ex3)	Ln(ex4)	Ln(ex5)	Ln(ex6)	Ln(ex7)	Ln(ex8)	Ln(ex9)	Ln(ex10)
LnGDP	0.449 ***	0.668 ***	0.416 ***	0.211 ***	0.570 ***	0.306 **	0.591 ***	0.824 ***	0.150 ***	0.267 *
	(0.085)	(0.125)	(0.144)	(0.047)	(0.169)	(0.127)	(0.146)	(0.141)	(0.024)	(0.149)
LnREXR	−0.099 **	0.027	−0.121	−0.213 ***	0.118	0.016	−0.163 **	−0.005	−0.139 ***	−0.184 **
	(0.046)	(0.067)	(0.077)	(0.026)	(0.092)	(0.068)	(0.079)	(0.076)	(0.013)	(0.079)
LnVOL	−0.946 ***	−0.421	−1.175 ***	−0.930 ***	−0.491	−0.879 ***	−0.776 **	−0.888 ***	−0.693 ***	−1.202 ***
	(0.203)	(0.297)	(0.341)	(0.113)	(0.403)	(0.301)	(0.349)	(0.337)	(0.057)	(0.356)
Constant	5.447 ***	5.640 ***	5.142 ***	7.102 ***	3.431	3.425 **	3.486 *	−0.222	7.255 ***	2.421
	(1.050)	(1.535)	(1.766)	(0.583)	(2.091)	(1.569)	(1.802)	(1.745)	(0.293)	(1.842)
Observations	413	413	412	412	410	408	403	411	409	403
R-squared	0.15	0.37	0.24	0.23	0.26	0.12	0.17	0.42	0.12	0.19

"Ln" represents variables defined in terms of logarithm. ex1—Food products, beverages and tobacco; ex2—Textiles, wearing apparel, leather and related products; ex3—Wood and products of wood and cork; ex4—Paper and printing; ex5—Chemicals, rubber, plastics and fuel products; ex6—Non-metallic mineral products; ex7—Basic metals and fabricated metal products; ex8—Machinery and equipment; ex9—Transport equipment; ex10—Furniture and other manufacturing. Standard errors are numbers in the parentheses. *, **, and *** indicate the 10%, 5% and 1% significance level, respectively.

Table 9. The panel DOLS estimation for subsectors for three regions.

Variable	Ln(ex1)	Ln(ex2)	Ln(ex3)	Ln(ex4)	Ln(ex5)	Ln(ex6)	Ln(ex7)	Ln(ex8)	Ln(ex9)	Ln(ex10)
Panel A: Asian region										
LnGDP	0.284	0.477 **	0.274 *	0.101	0.294	0.107	0.355 *	0.901 ***	−0.081	−0.063
	(0.189)	(0.186)	(0.145)	(0.117)	(0.286)	(0.176)	(0.214)	(0.193)	(0.179)	(0.152)
LnREXR	0.074	−0.102	−0.005	−0.141 **	0.071	0.062	−0.102	0.066	−0.109	0.040
	(0.106)	(0.104)	(0.081)	(0.066)	(0.161)	(0.097)	(0.120)	(0.109)	(0.101)	(0.085)
LnVOL	0.015	−0.347	−0.389	−0.853 *	0.316	0.019	0.055	−0.968	0.300	0.173
	(0.739)	(0.726)	(0.566)	(0.461)	(1.133)	(0.688)	(0.849)	(0.761)	(0.704)	(0.597)
Panel B: European region										
LnGDP	1.351 ***	0.700 **	0.738 *	0.811 **	1.014 **	0.639	1.363 ***	0.880 ***	0.581 **	1.239 ***
	(0.448)	(0.279)	(0.442)	(0.344)	(0.404)	(0.509)	(0.335)	(0.278)	(0.227)	(0.297)
LnREXR	−2.317 ***	0.262	−0.393	−1.516 **	0.585	0.489	0.008	0.191	−0.820 *	−0.211
	(0.834)	(0.520)	(0.823)	(0.641)	(0.753)	(0.947)	(0.628)	(0.518)	(0.425)	(0.547)
LnVOL	−0.690	−0.438	−0.285	−0.305	−0.487	−0.543	−0.218	−0.409	−0.287	−0.082
	(0.529)	(0.329)	(0.522)	(0.406)	(0.477)	(0.600)	(0.396)	(0.328)	(0.270)	(0.343)
Panel C: American region										
LnGDP	1.119 **	0.807 ***	0.354	1.210 ***	0.198	0.361	0.387	0.440	0.225	1.181
	(0.531)	(0.309)	(0.655)	(0.363)	(0.713)	(0.585)	(0.511)	(0.389)	(0.750)	(0.941)
LnREXR	−0.615	−0.175	0.071	−0.402	0.315	0.898 *	0.182	0.461	0.267	−0.195
	(0.426)	(0.248)	(0.519)	(0.291)	(0.572)	(0.470)	(0.405)	(0.312)	(0.602)	(0.686)
LnVOL	−1.039	−1.833 ***	−2.166 *	−0.075	−2.482 *	−0.873	−2.319 **	−1.420 **	−1.617	−1.064
	(0.970)	(0.564)	(1.214)	(0.662)	(1.301)	(1.073)	(0.951)	(0.713)	(1.374)	(1.862)

"Ln" represents variables defined in terms of logarithm. ex1—Food products, beverages and tobacco; ex2—Textiles, wearing apparel, leather and related products; ex3—Wood and products of wood and cork; ex4—Paper and printing; ex5—Chemicals, rubber, plastics and fuel products; ex6—Non-metallic mineral products; ex7—Basic metals and fabricated metal products; ex8—Machinery and equipment; ex9—Transport equipment; ex10—Furniture and other manufacturing. Standard errors are numbers in the parentheses. *, **, and *** indicate the 10%, 5% and 1% significance level, respectively.

Table 10. The panel OLS estimation for subsectors for the full sample.

Variable	ΔLnEX1	ΔLnEX2	ΔLnEX3	ΔLnEX4	ΔLnEX5	ΔLnEX6	ΔLnEX7	ΔLnEX8	ΔLnEX9	ΔLnEX10
$\Delta LnEX_{it-1}$	0.169 ***	0.124 ***	0.042	0.056	0.030	0.087 *	0.068	0.024	−0.040	0.047
	(0.050)	(0.044)	(0.050)	(0.049)	(0.043)	(0.049)	(0.048)	(0.051)	(0.043)	(0.050)
$\Delta LnGDP_{it}$	2.967 ***	2.118 ***	−0.389	2.223 ***	2.098 **	4.597 ***	3.854 **	4.289 ***	2.859 **	5.465 ***
	(1.142)	(0.467)	(1.185)	(0.844)	(0.871)	(1.070)	(1.853)	(0.878)	(1.417)	(1.797)
$\Delta LnGDP_{it-1}$	−3.374 ***	−0.682	0.510	−0.436	−0.348	−0.175	−0.721	−0.902	−0.609	−1.603
	(1.041)	(0.435)	(1.073)	(0.773)	(0.790)	(0.984)	(1.732)	(0.808)	(1.302)	(1.628)
$\Delta LnREXR_{it}$	0.062	0.049	0.159	−0.262	0.291	0.269	0.845	0.023	−0.166	−0.912 *
	(0.318)	(0.130)	(0.331)	(0.238)	(0.245)	(0.300)	(0.516)	(0.247)	(0.388)	(0.500)
$\Delta LnREXR_{it-1}$	0.175	0.297 **	−0.129	0.219	−0.014	−0.325	−0.270	0.189	0.401	1.619 ***
	(0.333)	(0.136)	(0.344)	(0.246)	(0.261)	(0.313)	(0.543)	(0.255)	(0.419)	(0.527)
$\Delta LnVOL_{it}$	0.030	−0.033	−0.037	0.062	0.088 *	−0.078	0.098	−0.053	0.273 ***	−0.080
	(0.065)	(0.027)	(0.068)	(0.048)	(0.050)	(0.062)	(0.106)	(0.050)	(0.079)	(0.102)
$\Delta LnVOL_{it-1}$	−0.041	0.018	−0.089	0.028	−0.091 *	−0.063	0.108	0.040	0.092	0.041
	(0.063)	(0.026)	(0.066)	(0.047)	(0.051)	(0.060)	(0.107)	(0.049)	(0.080)	(0.100)
D_{WTO}	0.093 *	−0.015	−0.122 **	−0.050	−0.052	−0.039	0.064	0.035	−0.036	0.077
	(0.056)	(0.023)	(0.058)	(0.041)	(0.043)	(0.052)	(0.090)	(0.043)	(0.068)	(0.089)
D_{Crisis}	−0.005	−0.061	−0.014	−0.189 **	−0.047	0.045	−0.607 ***	−0.134	−0.840 ***	0.101
	(0.126)	(0.052)	(0.132)	(0.095)	(0.097)	(0.119)	(0.203)	(0.097)	(0.155)	(0.200)
EC_{t-1}	−0.255 ***	−0.262 ***	−0.431 ***	−0.357 ***	−0.309 ***	−0.345 ***	−0.452 ***	−0.385 ***	−0.378 ***	−0.422 ***
	(0.036)	(0.030)	(0.045)	(0.041)	(0.040)	(0.038)	(0.047)	(0.046)	(0.048)	(0.050)
Constant	0.239 ***	0.139 ***	0.243 ***	0.190 ***	0.159 ***	0.073	0.197 **	0.034	0.313 ***	−0.032
	(0.061)	(0.025)	(0.063)	(0.046)	(0.048)	(0.057)	(0.100)	(0.047)	(0.077)	(0.097)
Observations	364	364	363	363	361	359	353	362	360	349

Δ represents variables defined in terms of difference, indicating growth rate. ex1—Food products, beverages and tobacco; ex2—Textiles, wearing apparel, leather and related products; ex3—Wood and products of wood and cork; ex4—Paper and printing; ex5—Chemicals, rubber, plastics and fuel products; ex6—Non-metallic mineral products; ex7—Basic metals and fabricated metal products; ex8—Machinery and equipment; ex9—Transport equipment; ex10—Furniture and other manufacturing. Standard errors are numbers in the parentheses. *, **, and *** indicate the 10%, 5% and 1% significance level, respectively.

Table 11. The panel OLS estimation for subsectors for the Asian region.

Variable	ΔLnEX1	ΔLnEX2	ΔLnEX3	ΔLnEX4	ΔLnEX5	ΔLnEX6	ΔLnEX7	ΔLnEX8	ΔLnEX9	ΔLnEX10
$\Delta LnEX_{it-1}$	0.227 ***	0.052	0.333 ***	0.005	−0.031	0.135 **	0.125 *	−0.005	−0.122 *	0.213 ***
	(0.069)	(0.063)	(0.069)	(0.068)	(0.064)	(0.069)	(0.070)	(0.073)	(0.067)	(0.063)
$\Delta LnGDP_{it}$	2.943 **	1.375 **	0.543	2.411 **	1.480	2.747	4.327 *	5.482 ***	3.961 **	3.711 **
	(1.408)	(0.662)	(1.144)	(1.001)	(0.928)	(1.691)	(2.563)	(1.401)	(1.827)	(1.791)
$\Delta LnGDP_{it-1}$	−2.216 *	0.648	−0.280	−0.385	−0.121	0.735	−2.043	−1.957	−1.578	−2.116
	(1.320)	(0.605)	(1.074)	(0.926)	(0.863)	(1.562)	(2.421)	(1.317)	(1.702)	(1.655)
$\Delta LnREXR_{it}$	0.364	0.264	1.265 ***	0.634 *	1.014 ***	0.992	−0.232	0.427	0.229	0.205
	(0.510)	(0.234)	(0.414)	(0.372)	(0.343)	(0.624)	(0.942)	(0.520)	(0.676)	(0.645)
$\Delta LnREXR_{it-1}$	−0.489	−0.137	−0.004	0.160	−0.219	0.045	1.020	0.640	1.222 *	0.815
	(0.510)	(0.233)	(0.422)	(0.364)	(0.354)	(0.609)	(0.935)	(0.510)	(0.691)	(0.643)
$\Delta LnVOL_{it}$	0.053	−0.003	−0.048	0.108 *	0.107 **	−0.074	0.050	−0.037	0.318 ***	−0.172 *
	(0.081)	(0.037)	(0.065)	(0.057)	(0.053)	(0.098)	(0.145)	(0.080)	(0.103)	(0.103)
$\Delta LnVOL_{it-1}$	−0.010	−0.030	0.054	0.101 *	0.035	−0.019	0.136	0.066	0.097	0.040
	(0.074)	(0.034)	(0.061)	(0.053)	(0.050)	(0.089)	(0.136)	(0.074)	(0.098)	(0.095)
D_{WTO}	0.133 *	0.030	0.040	−0.018	−0.003	−0.026	0.063	0.138 *	−0.037	0.019
	(0.073)	(0.033)	(0.059)	(0.051)	(0.048)	(0.087)	(0.132)	(0.072)	(0.093)	(0.094)
D_{Crisis}	−0.027	−0.077	−0.089	−0.162	−0.283 ***	0.226	−0.471 *	−0.158	−0.967 ***	−0.338 *
	(0.153)	(0.070)	(0.125)	(0.111)	(0.101)	(0.183)	(0.276)	(0.152)	(0.203)	(0.196)
EC_{t-1}	−0.251 ***	−0.162 ***	−0.708 ***	−0.266 ***	−0.370 ***	−0.388 ***	−0.468 ***	−0.424 ***	−0.277 ***	−0.435 ***
	(0.048)	(0.044)	(0.075)	(0.052)	(0.068)	(0.053)	(0.072)	(0.069)	(0.064)	(0.066)
Constant	0.099	0.084 **	0.067	0.133 **	0.183 ***	0.107	0.195	−0.023	0.333 ***	0.075
	(0.091)	(0.042)	(0.073)	(0.065)	(0.061)	(0.109)	(0.167)	(0.090)	(0.119)	(0.119)
Observations	182	182	182	181	179	178	177	181	180	179

Δ represents variables defined in terms of difference, indicating growth rate. ex1—Food products, beverages and tobacco; ex2—Textiles, wearing apparel, leather and related products; ex3—Wood and products of wood and cork; ex4—Paper and printing; ex5—Chemicals, rubber, plastics and fuel products; ex6—Non-metallic mineral products; ex7—Basic metals and fabricated metal products; ex8—Machinery and equipment; ex9—Transport equipment; ex10—Furniture and other manufacturing. Standard errors are numbers in the parentheses. *, **, and *** indicate the 10%, 5% and 1% significance level, respectively.

Table 12. The panel OLS estimation for subsectors for the European region.

Variable	ΔLnEX1	ΔLnEX2	ΔLnEX3	ΔLnEX4	ΔLnEX5	ΔLnEX6	ΔLnEX7	ΔLnEX8	ΔLnEX9	ΔLnEX10
$\Delta LnEX_{it-1}$	0.223 **	0.426 ***	−0.134 *	0.116	−0.152 *	0.194 **	−0.123	0.223 **	−0.016	0.029
	(0.099)	(0.095)	(0.081)	(0.094)	(0.082)	(0.097)	(0.093)	(0.107)	(0.056)	(0.109)
$\Delta LnGDP_{it}$	7.087 ***	2.848 ***	6.238 ***	5.563 ***	5.233 ***	6.088 ***	2.002	4.141 ***	0.445	4.602
	(2.364)	(0.737)	(1.825)	(1.797)	(1.125)	(1.193)	(4.198)	(1.207)	(2.561)	(4.079)
$\Delta LnGDP_{it-1}$	−6.557 ***	−2.943 ***	0.289	1.943	−0.239	0.027	−0.269	−1.274	−0.214	0.700
	(1.910)	(0.675)	(1.420)	(1.408)	(0.838)	(1.099)	(3.299)	(0.919)	(2.021)	(3.104)
$\Delta LnREXR_{it}$	−0.604	−0.117	−1.276 ***	0.087	−0.268	−0.154	2.072 ***	−0.218	−0.675	−0.725
	(0.446)	(0.142)	(0.345)	(0.336)	(0.223)	(0.227)	(0.784)	(0.225)	(0.465)	(0.771)
$\Delta LnREXR_{it-1}$	0.232	0.380 **	−0.161	−0.522	−0.521 **	−0.402	−0.026	−0.146	0.732	0.801
	(0.512)	(0.165)	(0.398)	(0.388)	(0.242)	(0.261)	(0.953)	(0.253)	(0.549)	(0.896)
$\Delta LnVOL_{it}$	0.015	0.035	0.052	−0.165 *	0.085	−0.179 ***	0.275	−0.045	0.275 **	−0.034
	(0.128)	(0.039)	(0.097)	(0.096)	(0.060)	(0.066)	(0.216)	(0.064)	(0.130)	(0.225)
$\Delta LnVOL_{it-1}$	−0.017	0.134 ***	−0.340 ***	−0.171	−0.099	−0.178 **	−0.016	−0.121	0.390 **	−0.012
	(0.143)	(0.045)	(0.111)	(0.109)	(0.089)	(0.074)	(0.294)	(0.074)	(0.175)	(0.248)
D_{WTO}	0.098	−0.032	−0.214 ***	−0.085	−0.074	0.028	0.075	0.002	−0.011	0.243
	(0.102)	(0.030)	(0.074)	(0.072)	(0.047)	(0.049)	(0.166)	(0.048)	(0.102)	(0.173)
D_{Crisis}	0.057	−0.088	0.588 ***	0.011	0.026	−0.050	−0.456	0.057	−1.215 ***	0.424
	(0.259)	(0.080)	(0.194)	(0.192)	(0.125)	(0.129)	(0.443)	(0.128)	(0.260)	(0.437)
EC_{t-1}	−0.430 ***	−0.261 ***	−0.632 ***	−0.645 ***	−0.290 ***	−0.227 ***	−0.448 ***	−0.401 ***	−0.409 ***	−0.411 ***
	(0.091)	(0.061)	(0.104)	(0.111)	(0.086)	(0.063)	(0.104)	(0.089)	(0.096)	(0.111)
Constant	0.182 *	0.124 ***	0.153 *	0.110	0.070	−0.058	0.244	−0.008	0.348 ***	−0.235
	(0.104)	(0.033)	(0.081)	(0.082)	(0.056)	(0.054)	(0.191)	(0.054)	(0.119)	(0.186)
Observations	112	112	112	112	112	112	108	112	111	111

Δ represents variables defined in terms of difference, indicating growth rate. ex1—Food products, beverages and tobacco; ex2—Textiles, wearing apparel, leather and related products; ex3—Wood and products of wood and cork; ex4—Paper and printing; ex5—Chemicals, rubber, plastics and fuel products; ex6—Non-metallic mineral products; ex7—Basic metals and fabricated metal products; ex8—Machinery and equipment; ex9—Transport equipment; ex10—Furniture and other manufacturing. Standard errors are numbers in the parentheses. *, **, and *** indicate the 10%, 5% and 1% significance level, respectively.

Table 13. The panel OLS estimation for subsectors for the American region.

Variable	ΔLnEX1	ΔLnEX2	ΔLnEX3	ΔLnEX4	ΔLnEX5	ΔLnEX6	ΔLnEX7	ΔLnEX8	ΔLnEX9	ΔLnEX10
$\Delta LnEX_{it-1}$	0.130	0.134	0.088	0.102	0.134	−0.076	0.174	0.020	0.006	−0.152
	(0.124)	(0.100)	(0.134)	(0.119)	(0.104)	(0.116)	(0.118)	(0.120)	(0.132)	(0.118)
$\Delta LnGDP_{it}$	−0.737	2.376	−4.055	4.259	0.168	10.412 **	6.723	−0.085	9.043	26.903 ***
	(4.799)	(1.818)	(7.342)	(3.717)	(5.163)	(4.251)	(6.912)	(3.239)	(6.431)	(10.124)
$\Delta LnGDP_{it-1}$	−3.140	−2.437	5.179	−5.242 *	−1.020	−7.540 **	0.025	3.905	1.298	−3.896
	(3.990)	(1.540)	(5.591)	(3.022)	(4.120)	(3.458)	(5.721)	(2.558)	(5.168)	(8.156)
$\Delta LnREXR_{it}$	−0.357	−0.053	2.859 **	−0.880	1.308	0.900	0.139	0.209	1.222	−5.376 ***
	(0.960)	(0.351)	(1.336)	(0.692)	(0.947)	(0.782)	(1.289)	(0.600)	(1.197)	(1.792)
$\Delta LnREXR_{it-1}$	0.302	0.666 **	−1.484	1.383 **	0.794	−0.830	−0.498	0.593	−0.526	4.882 ***
	(0.877)	(0.325)	(1.169)	(0.618)	(0.902)	(0.738)	(1.158)	(0.539)	(1.098)	(1.620)
$\Delta LnVOL_{it}$	0.006	−0.117	0.323	0.339 **	0.285	0.242	−0.157	−0.169	0.637 **	−0.007
	(0.189)	(0.074)	(0.262)	(0.145)	(0.198)	(0.164)	(0.268)	(0.126)	(0.253)	(0.353)
$\Delta LnVOL_{it-1}$	−0.178	0.137 *	0.013	0.099	−0.294	0.089	0.355	0.120	0.223	0.098
	(0.173)	(0.075)	(0.246)	(0.131)	(0.194)	(0.151)	(0.259)	(0.117)	(0.231)	(0.338)
D_{WTO}	−0.086	−0.126 **	−0.170	0.067	−0.070	−0.123	−0.087	−0.049	0.016	0.231
	(0.165)	(0.064)	(0.226)	(0.122)	(0.170)	(0.141)	(0.229)	(0.112)	(0.212)	(0.331)
D_{Crisis}	0.118	−0.126	−0.000	−0.119	0.661	0.054	−1.191 **	−0.293	0.390	1.513 *
	(0.396)	(0.152)	(0.550)	(0.311)	(0.413)	(0.339)	(0.548)	(0.256)	(0.522)	(0.799)
EC_{t-1}	−0.618 ***	−0.520 ***	−0.516 ***	−0.514 ***	−0.393 ***	−0.315 **	−0.596 ***	−0.411 ***	−0.656 ***	−0.605 ***
	(0.141)	(0.089)	(0.115)	(0.126)	(0.112)	(0.130)	(0.127)	(0.116)	(0.164)	(0.163)
Constant	0.531 ***	0.312 ***	0.389	0.235	0.265	0.258	0.301	0.113	0.089	−0.546
	(0.198)	(0.076)	(0.266)	(0.151)	(0.210)	(0.179)	(0.287)	(0.140)	(0.270)	(0.399)
Observations	70	70	69	70	70	69	68	69	69	59

Δ represents variables defined in terms of difference, indicating growth rate. ex1—Food products, beverages and tobacco; ex2—Textiles, wearing apparel, leather and related products; ex3—Wood and products of wood and cork; ex4—Paper and printing; ex5—Chemicals, rubber, plastics and fuel products; ex6—Non-metallic mineral products; ex7—Basic metals and fabricated metal products; ex8—Machinery and equipment; ex9—Transport equipment; ex10—Furniture and other manufacturing. Standard errors are numbers in the parentheses. *, **, and *** indicate the 10%, 5% and 1% significance level, respectively.

6. Concluding Remarks

Intensive debates have taken place on the impact of currency depreciation on Vietnam's export performance in recent years. Many may support this strategy because it is argued that doing so will enhance export performance, whereas others assert that the policy could lead to exchange rate volatility, which, in turn, is harmful to exports. This study was conducted to shed light on the link between exchange rate volatility and exports between Vietnam and 26 of its key export partners for the 2001–2015 period using data from the disaggregated level for both the manufacturing sector and its 10 subsectors.

Key findings from this empirical study are as follows. *First*, with regard to the manufacturing sector, the strategy of devaluing the VND provides a positive impact on Vietnam's manufacturing exports in the short run, but it creates exchange rate volatility, causing a decline in export value in the long run. In the short run, this strategy is beneficial only for the exports to Asian countries, while there is no supporting evidence for a clear short-run effect for all three regions—Asia, Europe, and America. Exchange rate volatility is, on average, harmful in the long run, especially when the exporting destination is a European country. Interestingly, no influence on export performance is shown in the short run for either the whole sample or the three subsamples. *Second*, Vietnam's manufacturing exports benefit from an increase in foreign income, as well as its participation in the WTO, to some extent. Meanwhile, the global financial crisis hindered the export value of the manufacturing sectors in Vietnam, as expected. *Third*, with regard to 10 specific subsectors in Vietnam, exchange rate volatility has negative effects on export performance for most of them in the long run, whereas mixed evidence is found for some in the short run.

On balance, the findings from this study confirm that, in the context of Vietnam, the level of the bilateral real exchange rate between the VND and other currencies is far more important than currency volatility for enhancing export performance for Vietnam in the short run. Thus, Vietnam's authorities could take advantage of depreciation to enhance exports, thus balancing the current net trade. Yet, intervention involving the exchange rate market should be conducted with caution, as it causes fluctuations in exchange rates, resulting in poor export performance in the long run. Also, it should be noted that at disaggregated levels, exchange rate volatility seems to cause more harm to exporters to the American region than to Asian and European partners, especially in some specific subsectors. Thus, it is suggested that exporters to American markets in these sectors use hedging instruments in the derivatives market to maintain their targeted export value and profitability.

There are some shortcomings in the current study. First, it is possible that exchange rate devaluation, volatility, and export performance have a reversed causal relationship with one another. When there are problems with exports, the exchange rate reacts more severely with greater depreciation, thus making exchange rates more volatile. Second, the effect of increases and decreases in exchange rate volatility on exports may be considerably different, raising the asymmetric effect. Nishimura and Hirayama (2013) find an asymmetric effect of the level of exchange rate and the volatility have different effects on bilateral exports between China and Japan. Thus, it would be worth taking those issues into consideration in future research using higher-frequency data, especially for a small open dynamic country like Vietnam. The country has targeted its exports as an important factor in boosting economic growth and is becoming increasingly integrated into the region and the world.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix

Table A1. List of Sub-subsector.

Code	OECD	SIC	Sector
EX	D10T32	D10-D32	Manufacturing exports
EX1	D10T12	D10, D11, D12	Food products, beverages and tobacco
EX2	D13T15	D13, D14, D15	Textiles, wearing apparel, leather and related products
EX3	D16	D16	Wood and products of wood and cork, except furniture
EX4	D17T18	D17, D18	Paper and printing
EX5	D19T22	D19, D20, D21, D22	Chemicals, rubber, plastics and fuel products
EX6	D23	D23	Non-metallic mineral products
EX7	D24T25	D24, D25	Basic metals and fabricated metal products, except machinery and equipment
EX8	D26T28	D26, D27, D28	Machinery and equipment
EX9	D29T30	D29, D30	Transport equipment
EX10	D31T32	D31, D32	Furniture and other manufacturing

OECD and SIC represent the classification of the manufacturing export based on the OECD database and Standard Industrial Classification (SIC) Codes, respectively.

Table A2. List of Countries.

Regions	Countries
Asia	Australia, Cambodia, Hong Kong, China, India, Indonesia, Japan, Korea, Malaysia, Philippines, Russian, Singapore, Thailand
Europe	Belgium, France, Germany, Italy, Netherlands, Spain, Turkey, United Kingdom
America	Brazil, Canada, Mexico, South Africa, United States

Table A3. Results of GARCH(1,1) model for the measure of exchange rate volatility.

Parameter	α_0		α_1		β_1		β_2		Q_{20}	Q^2_{20}	LM^{ARCH}_{20}
Australia	0.00	(0.002)	0.289 ***	(0.094)	0.235 ***	(0.082)	0.283	(0.292)	17.08	14.53	19.31
Belgium	−0.002	(0.002)	0.321 ***	(0.071)	0.024	(0.031)	0.92 ***	(0.075)	12.54	16.15	19.51
Brazil	−0.001	(0.003)	0.334 ***	(0.079)	0.329 ***	(0.114)	0.110	(0.210)	18.93	12.34	23.99
Cambodia	0.00	(0.001)	−0.127	(0.104)	0.488 ***	(0.158)	−0.009	(0.162)	22.25	13.91	10.79
Canada	−0.001	(0.002)	0.288 ***	(0.085)	0.124 ***	(0.039)	0.763 ***	(0.097)	21.66	9.72	14.69
Hong Kong	−0.002 **	(0.001)	−0.117	(0.100)	0.599 ***	(0.192)	0.332 **	(0.133)	30.51	6.03	10.34
China	0.00	(0.001)	0.045	(0.128)	0.147 **	(0.062)	0.334	(0.266)	16.14	6.85	7.48
France	−0.002	(0.002)	0.322 ***	(0.071)	0.043	(0.038)	0.903 ***	(0.077)	10.86	17.62	20.84
Germany	−0.002	(0.002)	0.319 ***	(0.071)	0.040	(0.041)	0.903 ***	(0.095)	15.03	17.17	21.47
India	0.00	(0.001)	0.082	(0.086)	0.165 *	(0.091)	0.703 ***	(0.139)	45.44	9.74	12.10
Indonesia	0.00	(0.002)	0.149 *	(0.090)	0.826 ***	(0.169)	0.136	(0.084)	19.09	17.55	9.93
Italy	0.005	(0.090)	−0.280 ***	(0.002)	−0.216 ***	(0.050)	0.359	(0.698)	9.97	24.63	22.22
Japan	−0.003 *	(0.002)	0.119	(0.081)	0.077	(0.110)	0.502	(0.749)	13.73	21.67	12.47
Korea	0.00	(0.001)	0.242 ***	(0.082)	0.218 ***	(0.075)	0.708 ***	(0.109)	12.52	9.09	11.02
Malaysia	−0.002	(0.001)	0.143	(0.088)	0.261 **	(0.104)	0.567 ***	(0.144)	17.80	5.31	6.95
Mexico	−0.003 *	(0.001)	0.173 **	(0.081)	0.343 ***	(0.070)	0.603 ***	(0.068)	28.09	11.49	8.84
Netherlands	−0.002	(0.002)	0.319 ***	(0.074)	0.013	(0.029)	0.931 ***	(0.059)	11.95	18.72	19.32
Philippines	0.00	(0.001)	0.118	(0.094)	0.134 ***	(0.048)	0.833 ***	(0.051)	17.34	14.54	11.32
Russian Federation	0.004 **	(0.002)	0.260 ***	(0.079)	0.449 ***	(0.114)	0.58 ***	(0.074)	13.31	12.40	13.79
Singapore	−0.001	(0.001)	0.065	(0.085)	0.180 ***	(0.065)	0.726 ***	(0.086)	20.80	13.36	19.78
South Africa	−0.004	(0.003)	0.267 ***	(0.095)	0.085 **	(0.040)	0.85 ***	(0.063)	21.50	16.71	17.08
Spain	−0.002	(0.002)	0.292 ***	(0.069)	0.033	(0.037)	0.916 ***	(0.078)	13.39	19.43	25.17
Thailand	−0.001	(0.001)	0.188 **	(0.074)	0.081 ***	(0.030)	−0.88 ***	(0.104)	16.92	6.96	6.57
Turkey	0.001	(0.002)	0.237 ***	(0.068)	0.601 ***	(0.145)	0.236	(0.151)	17.71	13.42	17.83
United Kingdom	−0.001	(0.002)	0.094	(0.081)	0.336 **	(0.153)	0.144	(0.265)	14.07	15.81	15.18
United States	−0.002 ***	(0.000)	−0.047	(0.099)	0.620 ***	(0.210)	0.354 **	(0.151)	35.47	6.86	10.62

The mean equation: $e^i_t = \alpha_0 + \alpha_1 e^i_{t-1} + \mu^i_t$ and the variance equation: $\mathrm{VOL}_{\mathrm{GARCH}} = h^i_t = \beta_0 + \beta_1 \mu^{i^2}_{t-1} + \beta_2 h^i_{t-1}$. LM^{ARCH}_{20} is the Lagrange multiplier test statistic for the null hypothesis that there is no ARCH effect up to order 20. Q_{20} and Q^2_{20} are the Ljung-Box statistics with lag 20 for standardized residuals and standardized residuals squared, respectively. Standard errors are numbers in the parentheses. *, **, and *** indicate the 10%, 5% and 1% significance level, respectively.

Table A4. A summary of effects of exchange rate volatility on exports.

Panel	Ex1	Ex2	Ex3	Ex4	Ex5	Ex6	Ex7	Ex8	Ex9	Ex10
Panel A: The whole sample	−0.9%	na	−1.17%	−0.93%	na	−0.88%	−0.78%	−0.89%	−0.69%	−1.20%
Panel B: Asian region	na	na	na	−0.85%	na	na	na	na	na	na
Panel C: European region	na	na	na	na	na	na	na	na	na	na
Panel D: American region	na	−1.83%	−2.17%	na	−2.48%	na	−2.32%	−1.42%	na	na

Ex1—Food products, beverages and tobacco; Ex2—Textiles, wearing apparel, leather and related products; Ex3—Wood and products of wood and cork; Ex4—Paper and printing; Ex5—Chemicals, rubber, plastics and fuel products; Ex6—Non-metallic mineral products; Ex7—Basic metals and fabricated metal products; Ex8—Machinery and equipment; Ex9—Transport equipment; Ex10—Furniture and other manufacturing. na indicates exchange rate volatility have no effects on exports in the long run. Otherwise, a 1% increase in exchange rate volatility lead to x% change in exports (by geographic region and by sector origin).

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Using Unconventional Wisdom to Re-Assess and Rebuild the BRICS

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Abstract: In 2015, Goldman Sachs closed its BRIC (Brazil, Russia, India, China) fund after years of losses and plummeting assets. Emerging markets had, once again, turned into submerging markets. Their dependence on "developed" markets and established institutions had failed them in a post-Global Financial Crisis (GFC) era, anchored in protectionism, risks, volatility, and uncertainty. The once commonly-accepted wisdom that called for US housing prices to always increase was part of the problem and contagion. Rebuilding the BRICS (S for South Africa) using conventional wisdom would probably not work. A new approach is necessary, especially since the last key contributions to show the inadequacy of a conventional wisdom-based strategy in emerging markets are more than ten years old. To help fill this gap, this paper proposes a holistic analytical framework for strategists to re-assess risks and opportunities in the BRICS. We illustrate how five basic assumptions can be proven wrong and lead to the creation of unconventional wisdom that can help derive some strategic insights. We find that rebuilding the BRICS for them to be more resilient is possible, if not vital, for the health of the global economy.

Keywords: emerging markets; globalization; protectionism

1. Introduction

In 2001, an economist at Goldman Sachs by the name of Jim O'Neill coined the BRIC term based on a paper that would change the world of investing and how we perceive risks in emerging markets (O'Neill 2001). Through his analysis, O'Neill, now Baron O'Neill of Gatley, convinced millions of investors that the opportunities outweighed the risks. The analysis was so timely that it became a type of conventional wisdom, expected to "show the path" for emerging markets through 2050 (Wilson and Purushothaman 2003). However, the path came to a dead-end in 2015 when Goldman Sachs closed the BRIC fund after years of losses and plummeting assets[1], about a year after O'Neill's retirement.[2] Whereas other acronyms have been invented (e.g., Next Eleven), none of them have managed to be as convincing and widely used.

In 2001 as well, Khanna and Rivkin's quantitative study of 12 emerging markets (3 out 5 BRICS were represented) confirms the inadequacy of conventional wisdom in advanced economies that "unrelated diversification depresses profitability" (Khanna and Rivkin 2001, p. 45). More specifically, these Harvard Business School scholars demonstrate statistically that "business group[3] affiliates earn higher accounting profits than do otherwise comparable unaffiliated firms" in several of the markets

[1] https://www.ft.com/content/89f59acc-8679-11e5-8a12-b0ce506400af.
[2] https://www.reuters.com/article/us-goldman-oneill/goldman-sachs-oneill-aka-mr-bric-to-retire-idUSBRE91411320130205.
[3] Definition: "a business group is a set of firms which, though legally independent, are bound together by a constellation of formal and informal ties and are accustomed to taking coordinated action" (Khanna and Rivkin 2001, pp. 47–48).

examined (Khanna and Rivkin 2001, p. 68). This important study, published in the *Strategic Management Journal*, led to more contributions on emerging markets and was followed by two instrumental studies (Wright et al. 2005; London and Hart 2004).

In "Strategy Research in Emerging Economies: Challenging the Conventional Wisdom," Wright et al. point out the rising prominence of emerging economies in the world economy and explain the limitations of theoretical contributions based on institutional theory alone. By combining four strategies[4] in emerging economies with four theoretical perspectives[5], they give strategists a multidimensional lens for them to better understand emerging markets while challenging conventional wisdom. Their study builds on London and Hart (2004), whose exploratory analysis based on interviews of MNC managers, 24 original case studies, and archival materials, challenges the transnational model by suggesting that "Western-style patterns of economic development may not occur in low-income [emerging] markets" (London and Hart 2004, p. 350). Furthermore, they find that that "successful strategies suggest the importance of MNCs developing a global capacity in social embeddedness" through relationships with non-traditional partners (London and Hart 2004, p. 350).

Since 2005, no major contributions have been published to show strategists how to navigate a new normal where conventional wisdom no longer holds true. In our new normal, uncertainty, volatility, protectionism, and risks abound in the aftermath of the Brexit vote and the surprise election of Donald Trump that created the BRUMP effect (Ghemawat 2018). Therefore, a closer look at practice and a combination of theory and practice might be a source of greater insights.

In fact, whereas the 2008 GFC erased trillions of dollars in wealth, John Paulson made billions with his bet against the conventional wisdom on subprime loans and housing (Zuckerman 2010). The GFC, not only taught just about everyone the limitations of that wisdom, but also put institutions in the hot seat for having failed to protect investors and for being associated with the root cause of the main issue: greed (Pandit 2018). Specifically, one of the oldest institutions in the world received much criticism: the university and its business school (Giacalone and Wargo 2009; Howard and Cornuel 2012; Currie et al. 2010), the main source of talent on Wall Street. Therefore, in the post GFC era, it might be expected to marginalize business schools after this devastating crisis, in the same way that a comeback to protectionism—supposed to make things better at home—appears to be the most appropriate reaction against globalization and its risks. We think otherwise and challenge conventional wisdom on emerging and "developed" markets by using a holistic framework and five typical assumptions as our basis for illustration. We then carry out a comparative analysis of events and patterns across countries, institutions, and industries, in order to see if those assumptions are substantiated or invalidated in a broader and more complex context between 2000 and 2018, basing our inductive approach on a few theoretical framework and scholarly contributions.

This paper provides a simple framework to generate strategic insights to strategists and leaders who seek to re-assess the risks and opportunities in emerging markets and increase their resilience, essentially rebuilding the BRICS. Using the resulting unconventional wisdom, this rebuilding is, not only vital for the economic health of these emerging countries, but also for that of the global economy.

2. Materials and Methods

In this section, we discuss our inductive research approach and seek to answer how to derive any strategic insights going beyond the often-misleading conventional wisdom. Five assumptions associated with conventional wisdom have been formulating, as illustration, by the author who relies on his research and 25 years of international experience, including 10 years in corporate positions and

[4] (1) Firms from developed economies entering emerging economies, (2) domestic firms competing within emerging economies, (3) firms from emerging economies entering other emerging economies, (4) firms from emerging economies entering developed economies" (Wright et al. 2005, p. 1).

[5] Institutional theory, transaction cost theory, resource-based theory, and agency theory (Wright et al. 2005, p. 1).

15 years in academia.[6] It must be noted that these assumptions serve as examples to demonstrate the dangers of conventional wisdom. Each strategist must go deeper in the analysis, using the suggested framework below (please see Figure 1), as well as tools provided by well-respected scholars, such as Michael E. Porter, Pankaj Ghemawat, and others cited in this paper and in the literature.

In order to start our approach in the conventional wisdom realm, we must define what that is. According to the respected Merriam-Webster dictionary, conventional wisdom is "the generally accepted belief, opinion, judgment, or prediction about a particular matter (example: Conventional wisdom in Hollywood says that a movie can't succeed unless it stars a famous actor or actress)."[7] The basis for each assumption will be strengthened by at least one relevant academic reference.

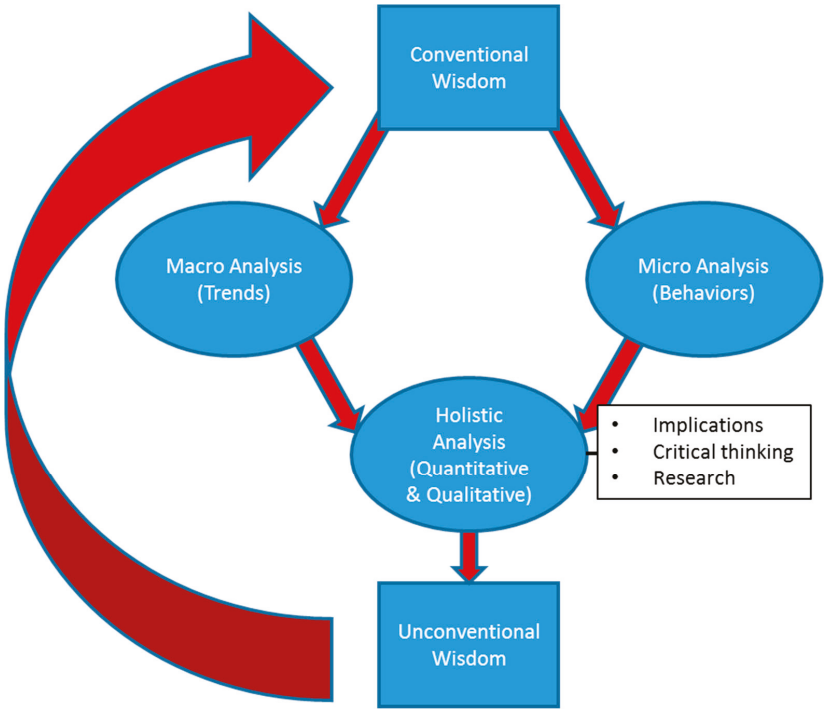

Figure 1. Holistic Risk and Opportunity Analytical Framework (HROAF).

(A) Five assumptions and conventional wisdom

Assumption 1. *In an increasingly protectionist world, a domestic mindset is the way to go.*

According to some respected scholars, globalization died after the GFC (Rugman 2012). As a result and since 2016, both the UK (Brexit vote) and the US (America First foreign policy) have implemented domestically-oriented policies to protect domestic jobs, especially by imposing tariffs on steel and

[6] The author obtained his NASD Commodity Futures (Series 3) trading license in 2003. He is trilingual and well-traveled. He has visited the BRICS at least once, except for Brazil and has lived and worked in four different developed countries. He has been teaching economics and business courses to undergraduate and graduate students since 2002 (e.g., principles of macro- and micro economics, strategic management, international marketing, global strategy) in the US and in Europe. He has published his expertise in several academic journals, as well as in the specialized press (e.g., *Les Echos* and the *Financial Times*). He is the recipient of several corporate, teaching, and service awards. Whereas his international business background is quite extensive, it must be noted that the researcher has natural biases.

[7] https://www.merriam-webster.com/dictionary/conventional%20wisdom.

aluminum for the latter (Galbraith 2018). Other protectionist measures have included anti-immigration rhetoric and a re-focus on nationalism and patriotism in these countries and in others (e.g., Hungary, Italy, and Austria). In essence, globalization, once the notion that called for integration and collaboration in business and lifted hundreds of millions of people out of poverty (Ahlstrom 2010), has now become defunct for some and the enemy for others, even if the latter do not fully grasp the benefits that they have been deriving from it (Betts 2016).

Assumption 2. *Developed countries will always lead the global economy, others should follow their best practices.*

Since the end of WWII, industrialized nations have developed a new industrial order (Drucker 2017) and lowered trade barriers in order to boost global trade and foster peace among nations. This proven model for more than 70 years has propelled the US multinationals to unrivaled dominance. Therefore, all other countries tend to imitate the US (industrialized) model, especially developing or emerging countries.

Assumption 3. *Developed countries have better institutions. Therefore, people who lead them know better.*

Among modern institutions, universities are considered as some of the oldest ones. They date back as far as the Middle Ages and were established in Europe (Altbach 1998) and used Latin as the common language (e.g., Bologna University, est. 1088 in Italy) to create and disseminate knowledge. This century-old process has attracted millions of students from the BRICS to Western Europe or to other developed countries that, over time, replaced Latin with English, as the lingua franca among scholars. Nonetheless, it took centuries for universities to create the concept of a business school.

The world's first collegiate business school was created in Philadelphia, Pennsylvania in 1881 with a gift from entrepreneur and industrialist Joseph Wharton to produce graduates who would become "pillars of the state, whether in private or in public life."[8] Based on this intellectual legacy in industrialized or developed countries, the assumption has been that people who lead institutions in these countries know better.

Assumption 4. *Emerging markets cannot produce world-class companies.*

For decades, the concentration of power in US firms has been accumulated in systematic and strategic fashion (White 2002). This dominance has been the source of much admiration around the world thanks to the Forbes and Fortune 500 lists that have now become a ranking mechanism of reputation (Bermiss et al. 2013) and prestige. Most of the firms in those list are American companies. Therefore, it is easy to assume that emerging markets cannot produce companies that could come close to rival with a world-class American company.

Assumption 5. *Among institutions, universities and their business schools do not play a major role in society since business has been criticizing and ignoring business schools for decades.*

In the 1950s and as a result of in-depth reports (Gordon and Howell 1959; Pierson 1959), the American business schools' community was described as resembling trade schools which lacked academic rigor. These reports also recommended that business education leverages the model of medical and law school for business to become a profession so that business can find its place in society. Whereas the latter recommendation fell on deaf ears, the first one led to an (over)emphasis on analytical skills and theories. This produced more criticisms about business education lacking relevance (Pfeffer and Fong 2002) and the speculation as to whether the MBA will still exist in 2020 (Schlegelmilch and Howard 2011). In any case, the disconnect between business schools and the

[8] https://www.wharton.upenn.edu/about-wharton/.

business community has been clear and widely publicized (Skapinker 2011, 2008). Based on this, it can be assumed that business schools do not play a major role in society.

As reasonable as these assumptions may appear to be, they need to be checked against the chronology of multiple events and patterns across countries, institutions, and industries.

(B) Chronology: from the dream of the BRICS to the nightmare of the GFC

In 2001 and in the developed world, many dreamed about the BRICs, not suspecting that a few years later, the 2008 GFC would become their worst nightmare. Trillions of dollars and millions of jobs lost, due to greed and miscalculated risks in the developed world gave way to the BRICS and their emerging multinationals to rise. Unbeknownst to most in the developed world, the GFC also created some deep cracks in society (increased income inequality, financial bankruptcies), whereas the BRICS started collaborating with one another like never before. A closer look at the chronology of these events and the trends that materialized informs us about the "big picture" that has affected the global economy by taking into account what happened in both developed and emerging markets with a special look at the automotive industry, among other industries between 2000 and 2018 and as follows:

- 2000: The MSCI (Emerging Markets) index doubles within two years to reach 500 for the time. The shift from developed to emerging markets is starting. After two drops to 230 and 250 in 2001 and 2002, respectively, this closely-watched index will climb above 1300 in October 2007 without suffering any major setbacks.[9]
- 2000: Tata Tea buys Tetley Tea (UK).[10]
- 2000: John (Jack) C. Bogle, legendary investor and founder of the Vanguard Group ($5 trillion of assets under management, as of 2018), warns investors about the dangers of a "sound premise" and provides timeless advice against conventional wisdom (Bogle 2000).
- 2001: Jim O'Neill coins the term BRIC.
- 2001: China joins the WTO.
- 2002: UN Secretary General, K. Annan, introduces the idea of inclusive globalization in a speech at Yale University (Gemmill et al. 2002).
- 2005: Lenovo buys IBM's PC division.
- 2007: against conventional wisdom on subprime loans and housing prices, John Paulson, hedge fund manager, places his bet and executes the best trade ever, being rewarded with billions of dollars and fame (Zuckerman 2010).
- 2008: The GFC starts with the collapse of Lehman Brothers (Mensi et al. 2016). The largest bankruptcy in US history; i.e., more than $600 bn, went against the conventional wisdom that Lehman was too big to fail and was going to be rescued by the US government like other financial institutions. It wasn't and its collapse had many consequences in the financial markets, across industries and countries. It bankrupted two out of three of the American BIG THREE. It left Ford moribund with record losses of $14.6 billion and fueled the growth of EMNCs, such as Tata Motors and Geely. Except for Russia, which goes into isolation, the BRICS' financial markets recouple with that of the US with increased linkages (Mensi et al. 2016) and later demonstrate the importance of stocks from developed countries in optimal portfolios (Mensi et al. 2017). High risks typically call for high rewards that will be delivered by the US stock market in a subsequent long-term bull market.

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9 https://seekingalpha.com/article/211305-the-shift-from-developed-to-emerging-markets-what-does-it-mean-for-investors.

10 https://www.indiatoday.in/magazine/cover-story/story/20091228-2000-tata-tea-tetley-merger-the-cup-that-cheered-741660-2009-12-25.

- 2008: Tata Motors buys Jaguar-Land Rover from Ford for $2.3 bn in cash.[11]
- 2008: China becomes a vital market for Ford since it passed the US as the largest market in the world for all automakers in 2010 and became their largest foreign market.
- 2008: According to McKinsey, the number of connected devices equals the world's population.[12]
- 2008: Lenovo becomes the sponsor of the Beijing Olympics.
- 2009: Bernie Madoff is convicted and sentenced to 150 years in prison for the largest Ponzi scheme in history.
- 2009: GM files for bankruptcy after more than 100 years in business.
- 2009: from an all-time high of 1337 in 2007, the MSCI (Emerging Markets) index plummets to 499 in February 2009.[13]
- 2010: Geely acquires Volvo cars from Ford and could have been seen as a partner. However, additional moves by the EMNC indicate that it is becoming a competitor to reckon with, both in China and at home, not to mention in Europe.
- 2010: Grupo Bimbo (Mexico) acquires the North American fresh bakery business of Sara Lee.
- 2011: MSCI (Emerging Markets) index recovers from the 2009 crash and reaches 1204 (see footnote 13).
- 2012: the MOOC revolution starts: greater access to business education at a fraction of the cost. MOOC courses are offered to millions by Wharton, Harvard, MIT, etc.
- 2012: The end of globalization? (Rugman 2012). The conventional wisdom about the benefits of globalization starts to change. Globalization becomes the enemy of many. Populism (Mudambi 2018) and protectionism grow in the UK, US, Spain, Italy, Russia, China, and Brazil.
- 2012: Dalian Wanda Group (China) acquires AMC Theaters for $2.6 bn.
- 2013: Jim O'Neill retires from Goldman Sachs as Chairman of the Asset Management Division.
- 2015: Goldman Sachs closes its BRIC fund after years of losses and assets under management free-falling from $800 to $100 million.
- 2015: LinkedIn reaches 500 million users and is increasingly used by scholars to socialize their research.
- 2016: Brexit vote takes place. It catches financial markets and political science experts by surprise. Unaware of the consequences of leaving Europe, millions of British turn to google to better understand the EU that they just rejected in a historic vote.
- 2016: Haier buys GE's appliances division for $5.4 billion.
- 2016: Donald Trump is elected President of the US.
- 2016: the MSCI (Emerging Markets) index plummets again to 742 (see footnote 13).
- 2017: President Trump announces his America First policy and exits the Transpacific Partnership Agreement which was going to reduce tariffs, create jobs, and boost trade.
- 2017: ChemChina completes the largest foreign takeover by a Chinese firm by acquiring Syngenta for $43 billion.[14]
- 2017: Geely buys Lotus (UK).
- 2018: the MSCI (Emerging Markets) index climbs to 1254 in January and loses 23.84% of its value by 2 January 2019, trading at the level of 955 (see footnote 13).
- 2018: amidst a trade war between the US and China ((Trump administration decision to impose 25 per cent tariffs on steel and 10 per cent aluminum imported from China, retaliation from China,

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11 http://shares.telegraph.co.uk/news/article.php?id=2799469&archive=1&epic=500570.
12 https://www.slideshare.net/AhmedALBilal/2017-q2-mckinsey-quarterly-global-forces.
13 https://www.investing.com/indices/msci-emerging-markets-historical-data.
14 https://www.reuters.com/article/us-syngenta-ag-m-a-chemchina/chemchina-clinches-landmark-43-billion-takeover-of-syngenta-idUSKBN1810CU.

and escalation with other tariffs between the two countries), the conventional wisdom on the permanence of free trade agreements and free-trade policies started after WWII is rocked to its core. Major financial markets enter correction territory.

- 2018: Geely buys a stake in the truckmaker AB Volvo and took a 10% stake in Daimler (parent company of Mercedes-Benz). All of these brands are sold in the US.
- Late August 2018: Geely announces the building of a new plant to produce bigger vehicles (trucks, SUVs, and cross-overs) and expected 90% of its cars to be electric by 2020. This confirms the growth of Geely both as an automaker but also as a threatening competitor to Ford.

If we compare and contrast the assumptions with the events and patterns above, we might be able to uncover some unconventional wisdom, also known as strategic insights.

3. Results

Finding Some Unconventional Wisdom to Derive Strategic Insights

In this section, we aim to find new strategic insights by reviewing the five assumptions based on the above chronology.

Assumption 1. *In an increasingly protectionist world, a domestic mindset is the way to go.*

Based on decades of research, the IMF re-affirmed in 2001, the year that China joined the WTO, that:

> "Policies that make an economy open to trade and investment with the rest of the world are needed for sustained economic growth. The evidence on this is clear. No country in recent decades has achieved economic success, in terms of substantial increases in living standards for its people, without being open to the rest of the world."[15]

Between 2001 and 2016, even with globalization suffering an identity crisis, the world remained more global-minded than protectionist and a global mindset was proven to be a predictor of success in global leadership positions (Javidan and Teagarden 2011; Beechler and Javidan 2007; Lane et al. 2009).

A research update as to whether tariffs are protecting American jobs also confirms that this is not the case since Ford prepared mass layoffs at the end of 2018 in order to off-set some $1 billion lost due to tariffs imposed by China in retaliation to US tariffs.[16] Other industries and more than 200 companies were also suffering from the tariffs in the US, cutting costs through layoffs and fore-going expansion.[17]

With the Smoot-Haley Tariff Act of 1930 in the US (Kennedy 2003) and the Imports Duties Act of 1932 in the UK, history has also shown that protectionism can be destructive rather than protective. In 2010, Oxford University Press published a great analysis which explained that "Hoover refused to listen to the pleas of 1,038 American economists who, in 1930, urged him to veto the Smoot–Hawley tariff bill. When it became law, this legislation raised US import duties and ultimately led to retaliatory action throughout the world. Not surprisingly, US foreign trade declined once the depression began to bite" (Crafts and Fearon 2010).

Clearly, this assumption is invalidated. It is a myth based on fear (Kennedy 2003). By definition, the 21st global economy cannot function based on a protectionist mindset. Globalization may be changing. However, the world remains inter-dependent and semi-globalized, where global trade represents at least 30% of the global economy (Ghemawat 2018).

Assumption 2. *Developed countries will always lead the global economy, others should follow their best practices.*

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15 https://www.imf.org/external/np/exr/ib/2001/110801.htm.
16 http://fortune.com/2018/10/09/ford-stock-today-layoffs-trump-trade-tariffs/.
17 https://www.cato.org/publications/commentary/here-are-202-companies-hurt-trumps-tariffs.

This assumption is based on the current context, a view that suffers from myopia. When taking a much broader look at business and economic history, we should remember that China and India were dominant countries during previous centuries and that Russia was a mighty empire led by strategic tsars.

By focusing on China alone, it must be noted that the Han Dynasty established as a major power more than 2000 years ago.[18]

In all fairness, China's current economic development, growing faster than developed nations (e.g., Japan) for decades since the 1980s (Kang 2007) but still considered "developing" due to institutional voids (Khanna and Palepu 2010, 2005), cannot be the only period used to assess this 5000 year old civilization that goes back much farther in history than most developed countries. For example, it must be noted that China developed fast when Europe was experiencing turmoil during the Middle-Ages after the fall of the Roman Empire. According to a highly-cited book, published by the OECD, an important development was the "Chinese settlement of the relatively empty and swampy lands south of the Yangtse, and introduction of new quick–ripening strains of rice from Vietnam suitable for multicropping" between the eighth and thirteenth centuries (Maddison 2007, p. 18). During these five centuries, "population growth accelerated, per capita income rose by a third, and the distribution of population and economic activity were transformed. In the eighth century only a quarter of the Chinese population lived south of the Yangtse; in the thirteenth, more than three quarters. The new technology involved higher labour inputs, so productivity rose less than per capita income" (Maddison 2007). Today, China and other countries are considered developing countries or emerging economies whereas they once dominated, similarly to the Roman Empire. Dominance is not permanent. No developed country can aspire to always lead the global economy. Last but not least, adopting policies from the West or the "developed" nations, also referred as the "Washington Consensus," with the premise that they would be successful elsewhere, can result in economic disaster in developing nations (Chang 2002). Therefore, this assumption is also invalidated.

Assumption 3. *Developed countries have better institutions. Therefore, people who lead them know better.*

Institutions, such as universities and business schools, can create and hire scholars who can come from any country in the world and many have come from the BRICS. Scholars can also be born out of institutions, even if it remains an exception rather than the norm. Indeed, one of the foremost mathematicians who was born in India, Srinivasa Ramanujan, solved very complex problems and advanced theories through a series of breakthroughs in his youth without having much formal education (Singh 2017). Other scholars from Russia include many Nobel Laureates in several disciplines, especially physics (Dardo 2004). For all these reasons, the assumption on the "superiority" of institutions in developed countries and of the knowledge accumulated by the people who lead them is invalidated.

Assumption 4. *Emerging markets cannot produce world-class companies.*

This assumption is also based on the perception that emerging markets are "not there yet" (Khanna and Palepu 2000; Khanna and Palepu 2010) and therefore cannot compete with industrialized countries' giants, such as IBM, Boeing, Ford, Apple, etc. The reality is much different: Lenovo, once a regional player has become the largest PC vendor in the world after acquiring the PC division of IBM. Embraer (Brazil) is another success story, and so is Tata Motors which acquired Jaguar and Land Rover from Ford in 2008, or even Huawei overtaking Apple in global smartphones sales in 2018.[19] These are just a few examples among many. A closer look at the largest companies in the world, measured by

[18] https://www.bbc.com/news/world-asia-pacific-13017882.
[19] https://qz.com/1345496/apple-was-just-overtaken-by-huawei-in-global-smartphone-sales/.

revenues, also indicates that 3 out of the first 5 largest are Chinese.[20] This assumption is a myth that is easily busted once researched.

Assumption 5. *Among institutions, universities and their business schools do not play a major role in society since business has been criticizing and ignoring business schools for decades.*

This assumption is often based on the misunderstanding associated with the value and contributions of education to society. According to a 2017 UNESCO report, the total number of higher-education students has doubled between 2000 and 2014[21] and represents a healthy 5% increase on an annual basis. Business education is the most popular choice among all disciplines; it attracts about a quarter of all university students. This assumption is often based on a quantitative analysis which does not account for qualitative contributions, such as launching new businesses, finding solutions to societal problems, etc. Business education has even transformed an emerging market like China by going from Marx to a hybrid capitalistic model (Tsinghua)[22] or profoundly boosting the country's competitiveness: India (Indian Institutes of Management), FGV (Brazil, and Skolkovo (Russia). Therefore, this assumption is also invalidated.

Many of the higher education students earn an MBA, the passport to management and especially to careers in Finance or Consulting. Business actually touches all disciplines and vice versa (e.g., medicine). To better assess the role of business schools in society, we must wonder how the world economy would perform without them and without business education in general. Clearly, if the BRICS have made so much economic progress, a large part of that can be attributed to education, the social elevator, and one of the best ways to help a country navigate the global economy competitively. Education provides the tools to make better decisions, solve problems, and redistribute wealth. In both emerging and developed countries, what is needed is not less education but more. We will discuss this in greater details below.

4. Discussion

Invalidating assumptions that seemed reasonable at first can lead to a state of confusion. What should we believe now? This is where higher-education and business schools, in particular, have a particularly important role to play and can make a positive and global impact on society. Business schools teach the hard skills (e.g., research, analytics, problem-solving, and reasoning) and the soft skills (communication, cross-cultural literacy, and conflict resolution). In addition, business schools socialize their students with the rest of the university and the business community through general education courses on ethics or other matters, such as political science, computer science, and foreign languages. Students, not only acquire knowledge that is crucially important in the 21st century economy that is more internationally interdependent than ever, but also learn appropriate behaviors and perspectives unlike their own. These skills and behaviors applied to the problems faced by today's society can advance all of us toward a resolution that is acceptable to all (e.g., sharing values and reducing income inequality). In short, business education can help us coexist and reduce conflicts within each country and between countries. To achieve this collaborative approach and avoid divisive issues, an inter-disciplinary education is very important. However, all too often, students focus on one discipline whereas problems call on several disciplines to be solved. These and our society are more complex than ever. Therefore, we must get both the small and the big pictures right.

By combining the reasonable assumptions above which were based on a narrow perspective with a bigger picture approach, this paper aims to provide a better understanding of key issues that have been plaguing emerging markets. That big picture approach reminds us that the largest two of them

[20] http://fortune.com/global500/.
[21] http://unesdoc.unesco.org/images/0024/002478/247862E.pdf.
[22] https://money.cnn.com/magazines/fortune/fortune_archive/2005/05/16/8260218/index.htm.

by population (China and India) represent 40% of the world's population. We also need to think in human terms, not just in numbers terms. Qualitative analysis must supplement quantitative analysis to better understand progress to date, as well as the risks and opportunities that lie ahead.

For example, the pattern of world-class companies coming out of emerging markets has surprised many executives and investors in developed markets. In some cases, some of them misunderstood their competition and the threat associated with those emerging multinationals. Some scholars spotted the trend early on (Khanna and Palepu 2010; Guillén and García-Canal 2009; Ramamurti 2012; Holtbrügge and Kreppel 2012). However, due to the focus of most business executives on the small picture and short-term results, many of them did not benefit from these important research contributions. They were blindsided by the risks. It is, therefore, necessary to conceptualize a new and holistic framework [Figure 1] to challenge conventional wisdom in order to improve our assessment of risks and opportunities. This framework combines the quantitative and qualitative analyses of macro trends, micro behaviors (of institutions, firms, customers, especially if they become movements, such as populism), implications, critical thinking, and research. It should result in strategic insights that we call unconventional wisdom, as it challenges pre-conceived ideas and contributes to new conventional wisdom through a feedback loop of continuous improvement.

Education is a choice. We can choose to identify problems, prioritize them, and look for solutions that are acceptable to all and will avoid the worst catastrophic risks from materializing. An inclusive globalization based on shared values (Porter and Kramer 2011) would be advisable since we are all inter-dependent and "all in it together." To put this important concept in practice, business schools play a vital role in the economy and society, in regards to, not only create prosperity but also help re-distribute it, while staying relevant. They must train their students about that role and increasingly about disruptions that affect countries, people –their future and the future of work in the context of artificial intelligence (AI) advances, unparalleled until now—institutions, industries, and markets. Thankfully, business schools are not alone in this daunting tasks. Organized among peers by the Association for the Advancement of Colleges and Schools of Business (AACSB) International since 1916, world's largest business education alliance, they clearly benefit from valuable resources.[23] The new AACSB Chair as of 31 January 2018 shared the organization's new vision and the key success factors for business schools: (1) cultivate a position at the intersection of academe and practice, (2) be a driver of innovation in higher education, and (3) connect with other disciplines (Beck-Dudley 2018). Disruptions and change in general, provide challenges and opportunities. Business schools, as well as the graduates and scholars that they produce, have the unique capacity to address challenges and capitalize on opportunities. It will fascinating to watch how they evolve in society and what positive contributions they will continue to make.

5. Conclusions

Conventional wisdom, used knowingly or unknowingly, has not always been the friend of the strategist, especially in an emerging market environment where institutional voids, rampant corruption, and other dangers loom large and can be found next to unparalleled opportunities. Due to the scarcity of strategic frameworks to assess the BRICS since the GFC, this paper aims to help fill this gap by providing a simple but holistic and analytical framework that we call the Holistic Risk and Opportunity Analytical Framework (HROAF). It relies on both qualitative and quantitate data, as well as macro (trends) and micro (behaviors) analyses. It can provide the strategist with a different lens to manage a new normal of uncertainty, volatility, risks, and opportunities, thereby creating some unconventional wisdom and a sustainable competitive advantage for him or her. Whereas the HROAF should allow strategists to generate some initial insights, each strategist is expected to dive deeper in each portion of our multi-dimensional framework, as needed. We believe that, when used regularly,

[23] https://www.aacsb.edu/newsroom/2018/2/new-leadership-named-to-aacsb-board-of-directors.

this framework could become a useful tool to unleash the potential of a new strategic and global mindset that will help reduce the biases and dangers that come from conventional wisdom.

Limitations: as useful as this approach may be, it has limitations. It is based on only one researcher, his experience, his research, and his natural biases. Only five assumptions were tested as a basis for illustration. It is possible that additional assumptions would unleash more insights. In addition, mixing methods can be challenging and require a large team supporting each strategist. Not everyone can expect to have such support to implement this framework.

More research, a deeper dive, and more triangulation are needed, especially on how deeply-rooted in conventional wisdom any assumptions are. In an era of fake news, scholars have the societal responsibility to redirect assumptions and bust myths that have been misleading investors, policymakers, and voters. Uninformed decisions can have catastrophic economic and human consequences for any given country and the world economy.

Using our Holistic Risk and Opportunity Analytical Framework to discover some much-needed unconventional wisdom and setting inclusive globalization as a priority could be a way to rebuild the BRICS and allow everyone to prosper in peace.

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Contagion Risks in Emerging Stock Markets: New Evidence from Asia and Latin America

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Abstract: The purpose of this study is to investigate whether contagion actually occurred during three well-known financial crises in 1990s and 2000s: Mexican "Tequila" crisis in 1994, Asian "flu" crisis in 1997 and US subprime crisis in 2007. We apply dynamic conditional correlation models (DCC-GARCH(1,1)) to daily stock-index returns of eight Asian stock markets, six Latin American stock markets and US stock market. Defining contagion as a significant increase of dynamic conditional correlations, we test for contagion by using a difference test for DCC means. The results obtained shows that there is a pure contagion from crisis-originating markets to other emerging stock markets during these three crisis. However, the contagion effects are different from one crisis to the other. Firstly, during the Mexican crisis, contagion is detected in only the Latin American region. Secondly, during the Asian crisis, we find evidence of contagion in some markets in both the Asian and Latin American regions. Finally, contagion is proved to be present in all stock markets with the only exception for Brazil during US subprime crisis.

Keywords: international financial contagion; shift contagion; emerging stock markets; Asian crisis; Mexican crisis; US subprime crisis; DCC-GARCH

JEL Classification: F30; G10; G15

1. Introduction

Since the 1990s, many widespread financial crises have been witnessed such as the Exchange Rate Mechanism (ERM) attacks in 1992, Mexican "Tequila" crisis in 1994, Asian "flu" crisis in 1997, the Russian collapse in 1998, the Brazilian devaluation in 1999, the US subprime crisis in 2007 and more recently, the Greek and European sovereign debt crisis in 2011. One common feature of these crises is that they have provoked economic depressions not only for the crisis-originating market but also for the others. This phenomenon is usually described as "contagion". The question about how an initial shock of one market could be transmitted to the others have attracted as much attention of policy makers as academic researchers, especially after Asian crisis in 1997. The latter have so far investigated the transmission mechanisms of the crises and the existence of contagion phenomenon across financial markets.

Understanding contagion effect of financial crisis, especially the channels through which crisis is transmitted, would provide important implications for policy makers. It will help to adopt appropriate policy measures in order to reduce the vulnerability of a country to an external shock. Policy implications differ depending on shock propagation through fundamentals or shock propagation unrelated to fundamentals (Forbes and Rigobon (2002)). If the crises are channeled through short-run linkages which only exist after the crisis occurs (i.e., investors' behavior) then temporary measure like liquidity assistance can be a helpful response. Otherwise, if the crises are transmitted through permanent linkages, such as trade or financial linkages, liquidity support might only delay the transmission of a crisis from one country to another but cannot be effective in reducing a country's vulnerability to a crisis. In this case, policy measures improving the fundamentals are necessary (Moser (2003)).

Up to now, there are many studies investigating the existence of contagion during financial crises. However, their results are not all compatible with one another. It depends how "contagion" is defined and empirical method used to detect for contagion. All of these issues will be discussed in Section 2. The results of King and Wadhwani (1990) support for contagion effects during the stock market crash in 1987. Calvo and Reinhart (1996) find evidence of contagion during the Mexican crisis. Baig and Goldfajn (1999) also find the presence of contagion during the Asian crisis in 1997. However, Forbes and Rigobon (2002) reexamine contagion effects during these three crises with tests corrected for heteroskedasticity biases and find *no contagion, only interdependence* [1]. On the other hand, Corsetti et al. (2005) reconsider the international transmission of shocks from the Hong Kong stock market crisis in October 1997 during the Asian crisis and find *some contagion, some independence*. They find evidence for contagion for 5 countries in the sample of 17 including Singapore, the Philippines (among the emerging markets) and France, Italy and the UK (among the industrial countries). Concerning the US subprime crisis, Horta et al. (2008) find evidence for effects of financial contagion from the US subprime crisis in G7 markets. Naoui et al. (2010) also find contagion effects from US toward some emerging (India, Malaysia, Singapore, China, Hong Kong and Tunisia) and developed markets (France, Germany, Italy, Netherlands and United States).

In this paper, we investigate again the presence of contagion effects in Asian and Latin American stock markets during three major crises: the Mexican "Tequila" crisis in 1994, the Asian "flu" crisis in 1997, and the US subprime crisis in 2007. We consider the contagion as the significant increase of assets' price co-movements after a shock in a country, as labeled "shift contagion" by Forbes and Rigobon (2000). In the first step, we employ multivariate DCC-GARCH models proposed by Engle (2002) to examine how dynamic conditional correlations across markets vary in time. We apply this kind of model in order to capture the dynamics of conditional correlation. In the second step, we use t-tests to compare the correlations between markets' returns in stable period and turmoil period. If there is an increase of these correlations after a shock then contagion occurs.

The contribution of this paper is that we study the contagion risks among some selected emerging countries in Asia and Latin America during three major crises: one occurred in Latin America, one in Asia, and one in US after their financial liberalisation. The results will show us how the financial contagion spills over to these countries during the crises and help us to compare the contagion effects of the three crisis. In fact, most of emerging countries began their financial liberalization in late 1980s and early 1990s. Theoretically, financial markets become more integrated as a result of the liberalization process and hence, they may suffer greater contagion from external shocks. As a consequence, market liberalization, accompanied by market integration, may lead to increased contagion risks. The results of this paper will show us somehow the effects of financial liberalization in emerging markets which is necessary for policy makers. The paper is structured as follows. Section 2 presents a brief review of the literature. Section 3 offers the methodology employed. Section 4 presents the data and statistics of stock returns. Section 5 discusses empirical results. Section 6 draws conclusions.

2. Review of Studies

Contagion has been the subject of extensive academic literature. There exist several definitions for this concept[2]. In general, contagion is usually used to refer to the spread of market turbulences from one country to the others. It needs to be distinguished from a common shock that affect many country simultaneously. Masson (1998) proposes the term "monsoonal effects" rather than contagion for a such phenomenon.

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[1] The interdependence term here refers to a high level of market comovement in all periods.
[2] See Pericoli and Sbracia (2003) for a review of contagion definition.

Contagion can be divided into two categories[3]: The first category is "fundamental-based contagion", which refers to spillovers resulting from interdependence among markets. In this case, a shock to a market can be transmitted to the others through the linkages (trade, financial linkages) between these markets. Forbes and Rigobon (2001) show that trade linkages are important in transmitting a crisis internationally during the currency crisis in 1990s. Kaminsky and Reinhart (2000) find that beside trade links, financial links are powerful channels of fundamental-based contagion. However, there are several authors who do not consider cross-country propagation of shocks through fundamentals as contagion (See Masson (1998), Forbes and Rigobon (2002)) because it reflects normal interdependence but in crisis period. Hence, another category of contagion labeled "pure contagion" or "non-fundamental based contagion" is considered. This form of contagion cannot be explained by the fundamentals, but rather by the behaviors of investors. When a crisis occurs in one country, investors can withdraw their investments from many markets. "Pure contagion" is hence a panic movement which cannot be justified by economic linkages between markets (See Moser (2003)). In the paper of Kumar and Persaud (2001), the authors show that investors' appetite for risk can conduct to pure contagion.

Based on these two categories of contagion, theories on shock transmission are also divided into two groups: non crisis-contingent theories and crisis-contingent theories. On the one hand, the non crisis-contingent theories, which refer to the "fundamental-based contagion" category, assume that transmission mechanisms do not change after a shock. On the other hand, the crisis-contingent theories, which refer to the "pure contagion" category, propose that there is a significant difference in transmission mechanisms between stable and crisis periods and therefore cross-market linkages increase after a shock[4].

In this paper, we follow the second group of theories mentioned above. More specifically, we use the definition of contagion established by Forbes and Rigobon (2001) and Forbes and Rigobon (2002). These authors label "shift-contagion" instead of simply "contagion". They define contagion as *"a significant increase in cross-market linkages after a shock to an individual country (or group of countries)"*. If two markets always show high correlations in all states of the world, this situation should be referred to "interdependence" and not "contagion". Although this definition is clearly narrow and restrictive, it exhibits two important advantages. First, it gives a simple empirical method to test for the existence of contagion. We can simply compare the linkages between two markets during stable periods with those during crisis periods. If there is a shift in linkages between markets during crisis period then we conclude that contagion occurs during the crisis under investigation. Second, by defining contagion as a significant increase in cross-market linkages, we can differentiate the mechanisms of transmission of shocks. The evidence of "shift-contagion" would support for crisis-contingent theories.

One of the statistics used to measure cross-market linkages is cross-market correlation coefficients. The cross-markets linkages can also be measured by probability of a speculative attack, transmission of shocks or volatility. In summary, there are four kinds of tests that are usually used: tests on the correlation coefficients, tests estimating the variance-covariance transmission mechanism across countries, tests for co-integration and tests measuring changes in the propagation by identifying a model with simple assumptions and exogenous events (Forbes and Rigobon (2002)). The tests for contagion based on this statistics will test for an increase in the correlation coefficients between two markets after a shock. Due to its simplicity, this methodology is used in many papers such as King and Wadhwani (1990), Calvo and Reinhart (1996). They all find a significant increase in cross-market correlation during crisis period which gives evidence for the existence of contagion. However, as demonstrated by Forbes and Rigobon (2002), the results of this kind of tests are biased in the presence of heteroskedasticity in market returns. They show that even though the linkages

[3] See Dornbusch et al. (2001).
[4] See Forbes and Rigobon (2001).

between two markets do not change after a shock, these tests do show an increase in cross-market correlation coefficients because of an increase in market volatility. Hence, these tests of contagion need to be corrected for this bias. In their paper, by using tests for contagion based on cross-market correlation coefficient corrected for heteroskedasticiy, Forbes and Rigobon (2002) found no contagion, only interdependence during the 1994 Mexican Peso Crisis, the 1997 Asian Crisis and the 1987 US crisis.

Nevertheless, Billio and Pelizzon (2003) raises an issue with the methodology proposed by Forbes and Rigobon (2002) mentioned above. They show that even if correlation coefficients are adjusted for heteroskedasticity, the traditional tests for contagion are highly affected by the source of crisis and the windows used. Moreover, splitting a sample according to realized or observed values (i.e., high and low volatility) may provide misleading results due to the selection bias (See Boyer et al. (1999)).

Since this test for contagion based on simple correlation coefficients presents obvious limitations, another econometric technique is developed in the literature to study financial contagion: They are dynamic conditional correlation models (DCC-GARCH models). This method has four advantages. First, these models capture the dynamics of correlation coefficients. Many studies prove that cross-market correlations are not constant but vary over time (See Longin (1995), Ramchand and Susmel (1998)). Second, the DCC-GARCH models estimate correlation coefficients of standardized residuals and thus account for heteroskedasticity directly[5]. Third, the DCC-GARCH models can be used to examine multiple asset returns without adding too many parameters. Finally, this method allows to examine all possible pair-wise correlations for all markets in only a single model (Chiang et al. (2007)).

Recently, this methodology has been usually used in examining financial contagion. Chiang et al. (2007) found evidence of contagion effects during the Asian financial crisis with heteroskedasticity-adjusted simple correlation analysis as well as dynamic correlation analysis. Cho and Parhizgari (2008) otherwise studied contagion during the Asian financial crisis in 1997 by using dynamic conditional correlation (DCC) means and medians difference tests. They considered two sources of contagion, Thailand and Hong Kong, and found the presence of contagion in equity markets across all markets studied: Korea, Malaysia, Philippines, Singapore, Taiwan, Indonesia. Naoui et al. (2010) investigated contagion during the 2007 US subprime crisis in using DCC-GARCH models and adjusting correlation coefficients to control for heteroscedasticity. They found contagion effects from US toward Argentina, Brazil, Korea, Hong Kong, Malaysia, Mexico and Singapore.

3. Methodology

3.1. Dynamic Conditional Correlation Model

As mentioned in the previous section, we use the DCC-GARCH model developed by Engle and Sheppard (2001), Engle (2002) to examine the time-varying correlation coefficients in this study. Generally, the DCC(1,1)-GARCH(1,1) specification is enough to capture the characteristics of heteroscedasticity of stock and financial variables (See Bollerslev et al. (1992)). This model is estimated by applying log likelihood estimation procedures.

The estimation of dynamic correlation coefficients between the returns of two markets consists of three steps. Firstly, we have to filter the returns in order to obtain residual returns (See Engle and Sheppard (2001)). We employ the model specification proposed by Chiang et al. (2007) as follows:

$$r_t = \gamma_0 + \gamma_1 r_{t-1} + \gamma_2 r_{t-1}^{US} + \varepsilon_t \tag{1}$$

An AR(1) process is used to account for the autocorrelation of stock returns. r^{US} is the U.S. stock index returns, used as the global factor.

[5] Problem raised by Forbes and Rigobon (2002) as discussed above.

Secondly, the parameters in the variance models are estimated using the residual returns (ε_t) from the first step.

$$\varepsilon_t = D_t v_t \sim N(0, H_t) \tag{2}$$

$$v_t \sim N(0, R_t) \tag{3}$$

and

$$H_t = D_t R_t D_t \tag{4}$$

where:

- ε_t is a *k.1* column vector of residual returns of r_t.
- D_t is a *k.k* diagonal matrix of the time varying standard deviations of residual returns.
- v_t is a column vector of standardized residual returns.
- H_t is a *k.k* matrix of time-varying covariance.
- R_t is a *k.k* matrix of time-varying conditional correlations.

The elements in D_t are obtained from the univariate GARCH(1,1) models with $\sqrt{h_{i,t}}$ on the *i*th diagonal.

$$h_{i,t} = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1} \tag{5}$$

for *i* = 1,...,k.

The correlation coefficients are then estimated. The correlation between stock index returns *i* and *j* at time *t* is defined as:

$$\rho_{ij,t} = \frac{E_{t-1}(\varepsilon_{i,t}\varepsilon_{j,t})}{\sqrt{E_{t-1}(\varepsilon_{i,t}^2)E_{t-1}(\varepsilon_{j,t}^2)}} \tag{6}$$

Substituting $\varepsilon_{i,t} = \sqrt{h_{i,t}} v_{i,t}$ and $\varepsilon_{j,t} = \sqrt{h_{j,t}} v_{j,t}$ to the Equation (6), we will have:

$$\rho_{ij,t} = \frac{E_{t-1}(\sqrt{h_{i,t}} v_{i,t} \sqrt{h_{j,t}} v_{j,t})}{\sqrt{E_{t-1}(h_{i,t} v_{i,t}^2)E_{t-1}(h_{j,t} v_{j,t}^2)}} = \frac{E_{t-1}(v_{i,t} v_{i,t})}{\sqrt{E_{t-1}(v_{i,t}^2)E_{t-1}(v_{j,t}^2)}} = E_{t-1}(v_{i,t} v_{j,t}) \tag{7}$$

with $E_{t-1}(v_{i,t}^2) = E_{t-1}(h_{i,t}^{-1}\varepsilon_{i,t}^2) = h_{i,t}^{-1} E_{t-1}(\varepsilon_{i,t}^2) = 1$ and $E_{t-1}(v_{j,t}^2) = E_{t-1}(h_{j,t}^{-1}\varepsilon_{j,t}^2) = h_{j,t}^{-1} E_{t-1}(\varepsilon_{j,t}^2) = 1$. The conditional correlation is hence the covariance of standardized disturbances. Let Q_t the time-varying covariance matrix of v_t ($Q_t = E_{t-1}(v_t v_t')$) then we have:

$$R_t = (diagQ_t)^{-1/2} Q_t (diagQ_t)^{-1/2} \tag{8}$$

Q_t in this equation is a *nxn* positive symmetric matrix. It is defined by:

$$Q_t = (1 - \theta_1 - \theta_2)\bar{Q} + \theta_1 v_{t-1} v_{t-1}' + \theta_2 Q_{t-1} \tag{9}$$

where:

- $\bar{Q}$ is the unconditional covariance of the standardized residuals resulting from the univariate GARCH(1,1) equation.
- θ_1 and θ_2 are positive parameters which satisfy $\theta_1 + \theta_2 < 1$.

The conditional correlation coefficient, also the element of matrix R_t, is then:

$$\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t} q_{jj,t}}} \tag{10}$$

$$\rho_{ij} = \frac{(1 - \theta_1 - \theta_2)\bar{q}_{ij} + \theta_1 v_{i,t-1} v_{j,t-1} + \theta_2 q_{ij,t-1}}{\sqrt{\left[(1 - \theta_1 - \theta_2)\bar{q}_{ii} + \theta_1 v_{i,t-1}^2 + \theta_2 q_{ii,t-1}\right]}\sqrt{\left[(1 - \theta_1 - \theta_2)\bar{q}_{jj} + \theta_1 v_{j,t-1}^2 + \theta_2 q_{jj,t-1}\right]}} \tag{11}$$

As proposed by Engle (2002), the DCC model can be estimated by using a two-stage approach to maximize the log-likelihood. Let θ and ϕ be denoted the parameters respectively in matrices D and R, the log-likelihood function to determine the parameters in the Equations (1) and (5) can be written as follows:

$$\begin{aligned} L(\theta,\phi) &= -\frac{1}{2}\sum_{t=1}^{T}(nlog(2\pi) + log\,|H_t| + \varepsilon_t' H_t^{-1}\varepsilon_t) \\ &= -\frac{1}{2}\sum_{t=1}^{T}(nlog(2\pi) + log\,|D_t R_t D_t| + \varepsilon_t' D_t^{-1} R_t^{-1} D_t^{-1}\varepsilon_t) \\ &= -\frac{1}{2}\sum_{t=1}^{T}(nlog(2\pi) + 2log\,|D_t| + log\,|R_t| + v_t' R_t^{-1} v_t) \end{aligned} \tag{12}$$

where $v_t \sim$ N(0,R_t) are the residuals standardized on the basis of their conditional standard deviations. Rewriting (12) gives:

$$\begin{aligned} L(\theta,\phi) &= -\frac{1}{2}\sum_{t=1}^{T}(nlog(2\pi) + 2log\,|D_t| + \varepsilon_t' D_t^{-2}\varepsilon_t \\ &\quad + -\frac{1}{2}\sum_{t=1}^{T}(log\,|R_t| + v_t' R^{-1}{}_t v_t - v_t' v_t) \\ &= L_1(\theta) + L_2(\phi) \end{aligned} \tag{13}$$

where:

$$L_1(\theta) = -\frac{1}{2}\sum_{t=1}^{T}(nlog(2\pi) + 2log\,|D_t| + \varepsilon_t' D_t^{-2}\varepsilon_t) \tag{14}$$

$$L_2(\phi) = -\frac{1}{2}\sum_{t=1}^{T}(log\,|R_t| + v_t' R^{-1}{}_t v_t - v_t' v_t) \tag{15}$$

$L_1(\theta)$ is log-likelihood function of variances and $L_2(\phi)$ is that of correlations. In the first stage, the parameters of variances in L_1 are determined by maximizing $L_1(\theta)$. In the second stage, given the estimated parameters in the first stage, the likelihood function $L_2(\phi)$ is maximized to estimate the correlation parameters in $L_2(\phi)$.

3.2. Contagion Tests

Contagion occurs when there is a significant increase in correlations during the turmoil period compared with those during the tranquil period. However, the estimates of correlation coefficient can be biased by market volatility heteroscedasticity, as pointed out by Forbes and Rigobon (2002). In fact, market volatility tends to increase after a shock or a crisis, which makes the correlation coefficients increase even though the underlying cross-market relationship is the same as during more stable periods. In this paper, the correlation coefficients of stock returns are estimated by the DCC GARCH models, and hence vary with market variances through time. Thus, the conventional contagion effect test that ignores the adjustment for heteroscedasticity can be improved.

To test for the existence of contagion, we use a one-sided t-test for the difference between average conditional correlation coefficients of stable and turmoil periods. The test is as follows:

- H_0: $\rho_2 = \rho_1$
- H_1: $\rho_2 > \rho_1$

where ρ_1 and ρ_2 are respectively average conditional correlation coefficients of stable and turmoil periods. Rejecting the null hypothesis supports for the contagion.

This t-test of the equality of means is preceded by the preliminary test of the equality of variances.

4. Data and Descriptive Statistics

The data used in this paper are daily returns of stock price indexes obtained from Datastream, which are all expressed in local currency. Following the conventional approach, equity market returns are computed through log-differentiation and expressed as percentages. The Asian sample consists of 8 markets: Hong Kong, Thailand (taken as alternative sources of contagion), Indonesia, Malaysia, the Philippines, South Korea, Taiwan, Singapore. The Latin American sample includes Mexico (considered as source of contagion), Argentina, Chile, Venezuela, Colombia.

For the Mexican crisis of 1994, the period preceding the crisis is from the 1 January 1993 to 31 March 1995. This crisis is triggered by the devaluation of the Mexican peso in 19 December 1994. Hence, the total period is divided into two sub-periods: from 1 January 1993 to 16 December 1994 (pre-crisis period) and from 19 December 1994 to 31 March 1995 (crisis period).

In line with Cho and Parhizgari (2008), the period of the analysis of the contagion during the Asian "flu" crisis begins from January 1, 1996 to December 30, 1998. The choice of the beginning date is explained by the fact that it is relatively distanced from the Mexican crisis of 1994. The two dates often considered as inception of the turmoil periods are July 2, 1997 when the Thailand baht was devalued and 17 October 1997 when Hong Kong stock market crashed (See Cho and Parhizgari (2008)). We consider both Hong Kong and Thailand as originating countries.

The US subprime crisis is generally identified to begin on 1 August 2007. The total period determined to analyze the contagion from American market to emerging markets stretches from the 3 January 2006 to 31 December 2008. Hence, the stable period is between the 3 January 2006 and 31 July 2007. The crisis period is between 1 August 2007 and 31 December 2008.

The summary statistics of stock-index returns are presented in Tables 1–4. We divide the entire periods in tranquil periods and turmoil periods by using the break dates for each crisis as mentioned above. One similar result drawn when comparing the first two moments of stock returns for two sub-periods is that the stock returns are generally higher during tranquil periods while variances are higher during turmoil periods (except for Mexican crisis). Moreover, every series of stock returns exhibits non-normality with significantly positive excess kurtosis, which is common to daily equity stock returns. This reveals the existence of extreme returns for these markets. The skewness parameters are not all significant for markets included in the sample.

Table 1. Descriptive statistics on stock returns: The Mexican crisis.

	Stable Period *1 January 1993–16 December 1994*					**Turnoil Period** *19 December 1994–31 March 1995*				
	Mean	**Std Dev**	**Skewness**	**Kurtosis**	**N**	**Mean**	**Std Dev**	**Skewness**	**Kurtosis**	**N**
Asian emerging markets										
Indonesia	0.1004	0.9222	−0.4486 ***	2.6498 ***	511	0.0150	1.0549	−0.6917 **	0.9270	75
Hong Kong	0.0802	1.5790	−0.2401 **	1.7596 ***	511	0.0528	1.7043	0.1988	0.9235	75
Korea	0.0929	1.2632	0.1009	1.1744 ***	511	−0.0995	1.3775	−0.2445	0.6534	75
Malaysia	0.0811	1.4140	0.0312	7.9182 ***	511	0.0554	1.5279	0.5262 *	1.9441 ***	75
Philippines	0.1901	1.1940	−0.0740	1.4608 ***	511	−0.1428	1.4014	−0.6524 **	1.1863 **	75
Singapore	0.0548	0.8429	0.0260	3.6975 ***	511	−0.0522	1.0070	−1.3139 ***	5.2778 ***	75
Taiwan	0.1695	1.8683	0.3141 ***	2.2656 ***	511	−0.0700	1.2675	0.0863	1.9812 ***	75
Thailand	0.1344	1.6338	−0.1610	3.3274 ***	511	−0.0396	1.5237	0.0994	1.1044*	75
Latin American emerging markets										
Argentina	0.0628	1.7080	−0.4579 ***	1.7082 ***	511	−0.3181	3.4888	0.5977 **	1.2190 **	75
Chile	0.1474	0.9804	−0.1968 *	1.4879 ***	511	−0.0893	1.9833	0.8658 ***	2.1619 ***	75
Colombia	0.1092	0.8248	0.6607 ***	4.2164 ***	511	0.0963	0.7902	1.8254 ***	4.5397 ***	75
Mexico	0.0588	1.3187	−0.0576	2.2076 ***	511	−0.2413	2.5392	0.2928	0.6904	75
Venezuela	0.1356	2.8743	0.8210 ***	8.0160 ***	511	0.0285	1.4287	1.3654 **	7.0395 **	75

The returns are in percentages. *, **, *** represent statistical significance at the 1%, 5%, 10% levels of risk.

Table 2. Descriptive statistics on stock returns: The Asian crisis (Source of contagion: Thailand).

	Stable Period *1 January 1996–1 July 1997*					Turmoil Period *2 July 1997–31 December 1998*				
	Mean	**Std Dev**	**Skewness**	**Kurtosis**	**N**	**Mean**	**Std Dev**	**Skewness**	**Kurtosis**	**N**
Asian emerging markets										
Indonesia	0.0782	1.0492	−0.3121 **	2.3480 ***	392	−0.0727	3.1918	0.2923 **	3.2094 ***	392
Hong Kong	0.1164	1.0426	−1.2222	8.9774	392	−0.1301	2.7824	0.4175	5.8187	392
Korea	−0.0467	1.3586	0.1910	0.7480 ***	392	−0.0060	3.3631	0.3847 ***	1.1348 ***	392
Malaysia	0.0225	0.8135	−0.4775 ***	2.6060 ***	392	−0.1452	3.3526	0.6484 ***	12.4451 ***	392
Philippines	0.0406	0.9691	−0.1981	2.5731 ***	392	−0.0839	2.2471	0.2459 **	2.1380 ***	392
Singapore	−0.0264	0.80150	−0.1321	0.6031 **	392	−0.0665	1.8973	0.3777 ***	3.6296 ***	392
Taiwan	0.1674	1.3831	−0.0006	3.6794 ***	392	−0.0752	1.7950	−0.0360	1.4828 ***	392
Latin American emerging markets										
Argentina	0.0976	1.2867	−0.1673	1.9277 ***	392	−0.0763	2.3432	−0.5134 ***	6.2535 ***	392
Brazil	0.1766	0.9540	0.14830	3.4620 ***	392	−0.1811	2.4182	−0.6825 ***	3.1787 ***	392
Chile	0.0252	0.6937	0.4481 ***	0.5236 **	392	−0.1179	1.1195	0.1355	3.4237 ***	392
Colombia	0.0587	1.0545	−0.7724 ***	47.0383 ***	392	−0.0800	1.0778	−0.0039	9.7246 ***	392
Mexico	0.1178	0.9133	0.5029 ***	1.6971 ***	392	−0.0380	1.7365	0.0213	7.6136 ***	392
Venezuela	0.3457	1.6706	1.0121 ***	3.7608 ***	392	−0.1866	2.7841	1.1492 ***	12.5781 ***	392

The returns are in percentages. **, *** represent statistical significance at the 5%, 10% levels of risk.

Table 3. Descriptive statistics on stock returns: The Asian Crisis (Source of contagion: Hong Kong).

	Stable Period *1 January 1996–16 October 1997*					Turnoil Period *17 October 1997–31 December 1998*				
	Mean	**Std Dev**	**Skewness**	**Kurtosis**	**N**	**Mean**	**Std Dev**	**Skewness**	**Kurtosis**	**N**
Asian emerging markets										
Indonesia	0.0166	1.4280	0.6768 ***	12.7077 ***	469	−0.0178	3.3212	0.1758	2.8525 ***	315
Hong Kong	0.0663	1.2338	−0.7219 ***	7.0780 ***	469	−0.1157	2.9568	0.4178 ***	5.3991 ***	315
Korea	−0.1033	1.3825	0.0313	0.9223 ***	469	0.0882	3.6760	0.3107 **	0.5446 *	315
Malaysia	−0.0367	1.2673	1.5841 ***	25.3818 ***	469	−0.0981	3.5274	0.5284 ***	12.0150 ***	315
Philippines	−0.0352	1.2483	−0.3863 ***	7.4819 ***	469	−0.0015	2.2680	0.2740 **	1.9341 ***	315
Singapore	−0.0393	0.9059	−0.2921 **	1.8088 ***	469	−0.0572	2.0150	0.4080 ***	3.3187 ***	315
Taiwan	0.1163	1.4502	−0.1110	2.5102 ***	469	−0.0584	1.8105	0.0031	1.9019 ***	315
Thailand	−0.1493	2.0219	0.6848 ***	3.3557 ***	469	−0.1054	3.2393	0.7468 ***	2.1230 ***	315
Latin American emerging markets										
Argentina	0.1020	1.2704	−0.1831	1.7405 ***	469	−0.1255	2.5457	−0.4468 ***	5.2178 ***	315
Brazil	0.1530	1.1524	−0.3935 ***	6.2960 ***	469	−0.2335	2.5350	−0.6586 ***	2.9229 ***	315
Chile	0.0041	0.6880	0.4351 ***	0.5212 **	469	−0.1215	1.2074	0.1294	2.8595 ***	315
Colombia	0.0850	0.9906	−0.8211 ***	50.7480 ***	469	−0.1530	1.1604	0.1292	8.7253 ***	315
Mexico	0.1322	0.9512	0.3708 ***	1.2385 ***	469	−0.0975	1.8516	0.0865	7.1560 ***	315
Venezuela	0.3240	1.6112	0.9646 ***	3.8058 ***	469	−0.2844	3.0353	1.1840 ***	10.8894 ***	315

The returns are in percentages. *, **, *** represent statistical significance at the 1%, 5%, 10% levels of risk.

Table 4. Descriptive statistics on stock returns: The US subprime Crisis.

	Stable Period *1 January 2006–31 July 2007*					Turnoil Period *1 July 2007–31 December 2008*				
	Mean	**Std Dev**	**Skewness**	**Kurtosis**	**N**	**Mean**	**Std Dev**	**Skewness**	**Kurtosis**	**N**
Asian emerging markets										
Indonesia	0.1522	1.2398	−0.7613 ***	4.3101 ***	411	−0.1525	2.3802	−0.4674 ***	4.1386 ***	371
Hong Kong	0.1202	0.9329	−0.7289 ***	2.4423 ***	411	−0.1491	2.5215	0.0562	3.1464 ***	371
Korea	0.0724	1.0974	−0.4801 ***	1.3515 ***	411	−0.1397	2.2650	−0.2754 **	4.6030 ***	371
Malaysia	0.1043	0.7091	−1.2220 ***	7.4879 ***	411	−0.1226	1.2308	−1.3304 ***	10.6139 ***	371
Philippines	0.1311	1.1670	−0.863 ***	5.8259 ***	411	−0.1711	1.7675	−0.6680 ***	5.8814 ***	371
Singapore	0.1081	0.8867	−0.9309 ***	2.9231 ***	411	−0.1902	1.8069	−0.1860	3.0287 ***	371
Taiwan	0.0665	1.0303	−0.8786	3.1950 ***	411	−0.1804	1.9659	−0.0510	0.8381 ***	371
Thailand	0.0488	1.5232	−2.8566 ***	53.3222 ***	411	−0.1798	2.1168	−0.6096 ***	5.6193 ***	371
Latin American emerging markets										
Argentina	0.0882	1.0504	−0.9743 ***	5.9111 ***	411	−0.1113	1.3972	−0.0210 ***	3.3975 ***	371
Brazil	0.1365	1.2836	−0.3056 **	1.5830 ***	411	−0.1121	2.4737	−0.0278	2.9948 ***	371
Chile	0.1152	0.7406	−1.1789 ***	5.9941 ***	411	−0.0788	1.3721	0.5007 ***	7.4257 ***	371
Colombia	0.0333	1.6017	−0.0702	12.4863 ***	411	−0.0312	1.4454	−0.4301 ***	6.7485 ***	371
Mexico	0.1359	1.1573	−0.1752	3.0393 ***	411	−0.0828	1.7243	0.3276 **	3.6350 ***	371
Venezuela	0.1247	1.5929	−3.0199 ***	33.0170 ***	411	−0.0758	0.6730	0.5511 ***	3.1822 ***	371
US stock market										
US	0.0397	0.6747	−0.5250 ***	2.5716 ***	411	−0.1268	2.2007	−0.1491	5.2257 ***	371

The returns are in percentages. **, *** represent statistical significance at the 5%, 10% levels of risk.

5. Empirical Findings

5.1. Dynamic Conditional Correlations

We now use the dynamic conditional correlation (DCC) multivariate GARCH models presented in the previous section to test whether the contagion occurred among the region's markets during the two periods of international financial crises: the Mexican "Tequila" crisis of 1994 and the Asian "flu" crisis of 1997. Contagion from the American stock market toward emerging stock markets (consisting of Asian and Latin American markets) is also tested in the period of the US subprime crisis of 2007. One advantage of DCC GARCH models is that we can estimate the pair-wise dynamic conditional correlations for all investigated markets in a single system. In this paper, we apply three DCC-GARCH(1,1) models for three crises in order to estimate DCC for each pair of the source and target countries. The Tables 5–7 report the estimates of the returns and conditional variances equations. The AR(1) terms in mean equation are significant except for Singapore, Taiwan (during the Mexican crisis); Singapore, Taiwan and Thailand (during the Asian crisis); and Indonesia, Taiwan, Thailand, Colombia, Mexico (during US subprime crisis). The coefficient of US returns in mean equations are highly significant, which confirms the impact of the American stock market on emerging stock markets. We just do not find significant coefficients of US returns for Colombia and Mexico during the Mexican crisis. The coefficients of lagged variances and shock-square terms are all significant at 1%, which means that the volatilities of these markets are time-varying. Hence, it supports completely the GARCH(1,1) models. The estimated parameters θ_1 and θ_2 of DCC processes are all significant at 1%. The conditions that $\theta_1 + \theta_2 < 1$ are all satisfaites.

The computed dynamic conditional correlations during the three crises are presented in Figures 1–4. The vertical continuous lines represent the break dates: 19 December 1994 for the Mexican "Tequila" crisis, 2 July 1998 for the Asian "flu" crisis (if crisis-initiating market is Thailand), 17 October 1998 (if Hong Kong) and 1 August 2007 for the US subprime crisis.

For the Mexican crisis, as shown in Figure 1, what we can observe clearly is that the Latin American stock markets exhibit higher correlations with Mexico compared to Asian stock markets. However, we cannot state increases in the correlation between crisis-originating market and target markets except for Argentina and Chile.

During the Asian crisis (Figures 2 and 3), the correlations between the market originating crisis (Thailand or Hong Kong) and Asian emerging stock markets are higher compared to their correlations with Latin American emerging stock markets. Indeed, the correlations of Latin American emerging stock markets do not exceed 35% while those of Asian emerging stock markets are sometimes more than 50%. However, the DCCs of the markets of these two regions with Thailand or Hong Kong share one common characteristic: the correlations become more volatile after the crisis. There are obviously increases in these correlations beyond the break points in most cases.

The Figure 4 shows the DCCs of all emerging stock markets under investigation with the US stock market during the US subprime crisis occurred in 2007. In the early stage of the US subprime crisis, the DCCs fluctuate lightly. Then they peak around the final quarter of 2008. At that time, their values are very high, especially those with Latin American emerging stock markets. Except for Venezuela, which is less than 10%, the DCC reach at 80% for Mexico, 70% for Chile, 50% for Argentina while the highest correlation between the US stock markets and the Asian emerging stock markets is about 50% for Hong Kong. This period corresponds to the Lehman Brothers' collapse[6]. Hence, the bankruptcy of Lehman Brothers seems to have the big impact on the contagion of the US subprime crisis toward the Asian and Latin American emerging stock markets. An increase in the volatility of DCCs after the crisis is also observed.

[6] Lehman Brothers is the fourth largest U.S. Investment Bank, which filed for bankruptcy on 15 September 2008.

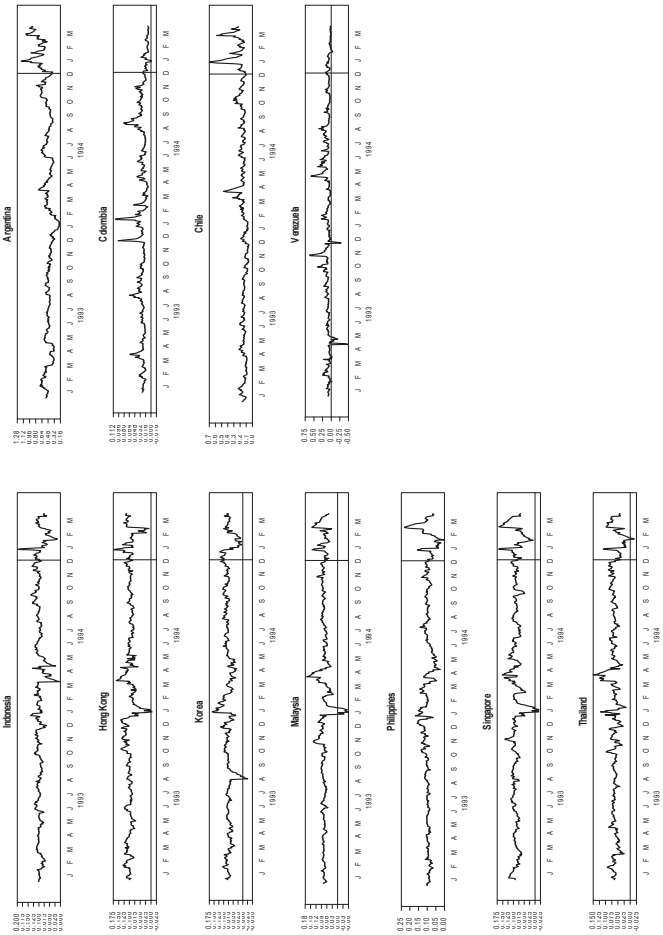

Figure 1. The dynamic correlation estimation for the Mexican "Tequila" crisis. The vertical continuous line represents the break date: 19 December 1994.

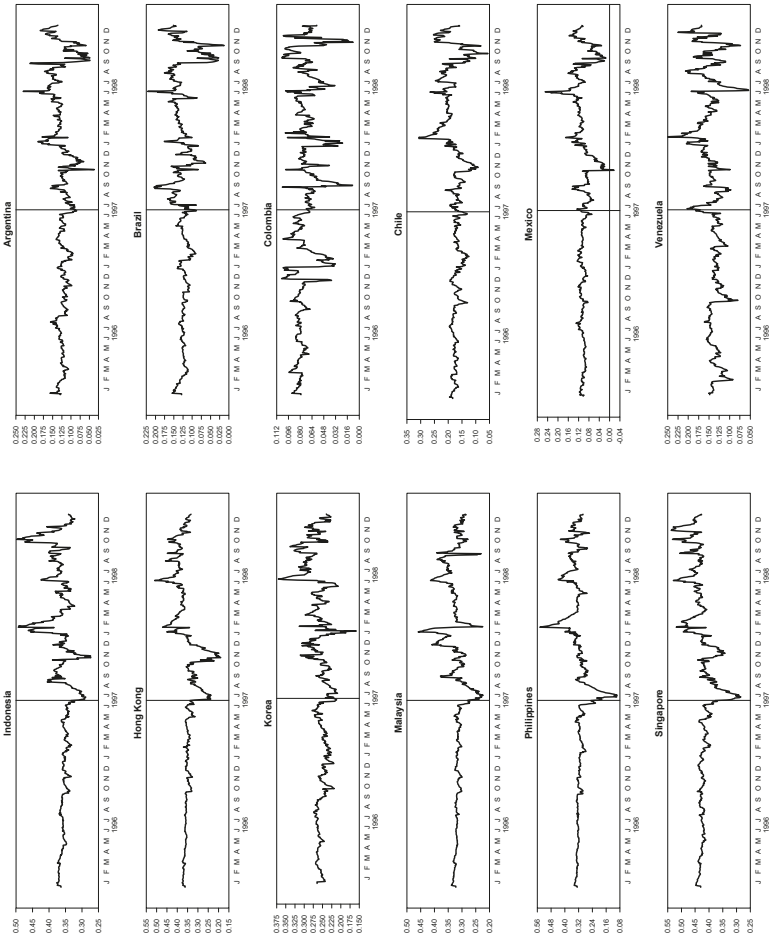

Figure 2. The dynamic correlation estimation for the Asian "flu" crisis (Source of contagion: Thailand). The vertical continuous line represents the break date: 2 July 1997.

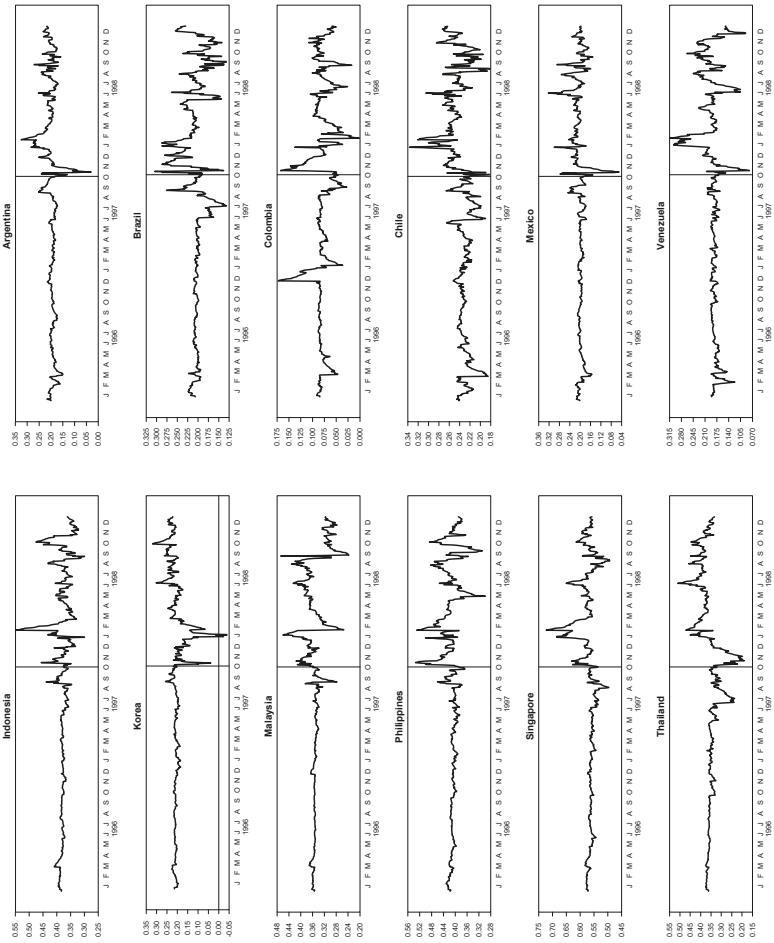

Figure 3. The dynamic correlation estimation for the Asian "flu" crisis (Source of contagion: Hong Kong). The vertical continuous line represents the break date: 17 October 1997.

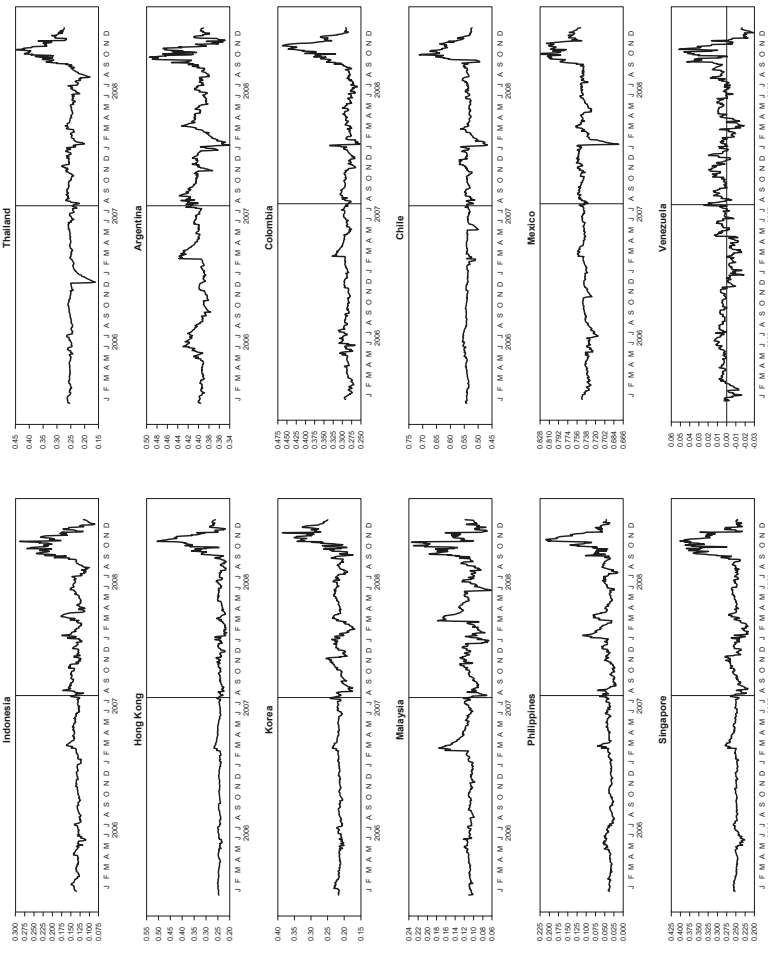

Figure 4. The dynamic correlation estimation for the US Subprime crisis. The vertical continuous line represents the break date: 1 August 2007.

Table 5. Estimation of DCC-GARCH model for the Mexican "Tequila" crisis.

$r_t = \gamma_0 + \gamma_1 r_{t-1} + \gamma_2 r_{t-1}^{US} + \varepsilon_t$
$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}$
$Q_t = (1 - \theta_1 - \theta_2)\bar{Q} + \theta_1 \nu_{t-1}\nu_{t-1}' + \theta_2 Q_{t-1}$

Parameter	γ_0	γ_1	γ_2	ω	α	β
			Asian emerging markets			
Indonesia	0.0629 ***	0.2630 ***	0.2332 ***	0.4799 ***	0.2687 ***	0.2094 **
	(2.6687)	*(8.7874)*	*(6.6515)*	*(6.9350)*	*(5.2765)*	*(2.4816)*
Korea	−0.0016	0.0926 ***	0.0944	0.0748 ***	0.0586 ***	0.8927 ***
	(−0.0453)	*(2.8503)*	*(1.6300)*	*(2.8749)*	*(4.2400)*	*(34.4931)*
Malaysia	0.0466 **	0.0656 ***	0.3697 ***	0.0417 ***	0.0752 ***	0.8974 ***
	(1.9780)	*(2.8854)*	*(8.9527)*	*(3.1666)*	*(5.2569)*	*(44.3229)*
Philippines	0.0709 **	0.1821 ***	0.2813 ***	0.0176 ***	0.0458 ***	0.9394 ***
	(2.3330)	*(5.7971)*	*(5.2114)*	*(2.7262)*	*(4.3183)*	*(72.2894)*
Singapore	0.0113	−0.0098	0.2945 ***	0.1085 ***	0.1297 ***	0.7113 ***
	(0.6121)	*(−0.3630)*	*(8.4910)*	*(4.8621)*	*(5.0067)*	*(15.1351)*
Taiwan	0.0413	−0.0324	0.2365 ***	0.1313 ***	0.0628 ***	0.8874 ***
	(0.8180)	*(−1.0263)*	*(2.7341)*	*(3.1662)*	*(5.1356)*	*(38.8341)*
Hong Kong	0.0502 *	−0.0493 *	0.7935 ***	0.0117 ***	0.0444 ***	0.9503 ***
	(1.7065)	*(−1.7108)*	*(18.8004)*	*(2.8495)*	*(7.5667)*	*(168.3592)*
Thailand	0.0211	0.0780 **	0.4172 ***	0.0372 **	0.0674 ***	0.9193 ***
	(0.6028)	*(2.5041)*	*(6.6277)*	*(2.1545)*	*(4.9942)*	*(50.8437)*
			Latin American emerging markets			
Argentina	0.0554	0.0738 ***	0.3022 ***	0.1122 ***	0.0865 ***	0.8827 ***
	(1.2221)	*(2.6945)*	*(4.0964)*	*(3.1756)*	*(5.2608)*	*(41.3832)*
Chile	0.0201	0.2549 ***	0.0988 **	0.0595 ***	0.1957 ***	0.7527 ***
	(0.8533)	*(8.9928)*	*(2.3914)*	*(5.4924)*	*(8.2280)*	*(28.7125)*
Colombia	−0.0175	0.4280 ***	−0.0162	0.0700 ***	0.2050 ***	0.6914 ***
	(−1.1340)	*(11.8014)*	*(−0.6823)*	*(7.4205)*	*(7.5636)*	*(21.9471)*
Venezuela	0.0334	0.1197 ***	0.1559 *	0.4403 ***	0.3591 ***	0.6256 ***
	(0.5934)	*(3.7851)*	*(1.7650)*	*(5.1880)*	*(7.3100)*	*(15.6333)*
Mexico	0.0748 **	0.1240 ***	0.0867	0.0540 ***	0.0772 ***	0.8957 ***
	(2.1861)	*(4.4517)*	*(1.4082)*	*(2.9099)*	*(4.7209)*	*(41.8666)*

θ_1 = 0.0091 *** *(2.5764)* ; θ_2 = 0.8750 *** *(9.7801)*. Note: Italic numbers in parentheses are t-statistics. *, **, *** represent statistical significance at the 1%, 5%, 10% *(p value)* of parameters.

Table 6. Estimation of DCC-GARCH model for the Asian "flu" crisis.

$r_t = \gamma_0 + \gamma_1 r_{t-1} + \gamma_2 r_{t-1}^{US} + \varepsilon_t$
$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}$
$Q_t = (1 - \theta_1 - \theta_2)\bar{Q} + \theta_1 \nu_{t-1}\nu_{t-1}' + \theta_2 Q_{t-1}$

Parameter	γ_0	γ_1	γ_2	ω	α	β
			Asian emerging markets			
Indonesia	0.0738	0.1152 ***	0.4308 ***	0.0355 ***	0.1043 ***	0.9056 ***
	(1.6114)	*(5.2387)*	*(9.4292)*	*(2.9913)*	*(7.1851)*	*(79.3786)*
Hong Kong	0.1029 ***	0.0702 ***	0.6562 ***	0.0500 ***	0.1086 ***	0.8900 ***
	(2.9622)	*(−2.6696)*	*(16.3620)*	*(3.7141)*	*(6.8789)*	*(58.8206)*
Korea	0.0153	0.0932 ***	0.2868 ***	0.0276 **	0.0725 ***	0.9281 ***
	(0.2672)	*(2.7627)*	*(5.1863)*	*(1.9922)*	*(6.8351)*	*(89.4653)*
Malaysia	0.0484 *	0.0590 **	0.3088 ***	0.0128 ***	0.1229 ***	0.8934 ***
	(1.6858)	*(1.9972)*	*(8.1332)*	*(3.2957)*	*(8.8803)*	*(97.8157)*
Philippines	0.0494	0.1459 ***	0.3143 ***	0.1023 ***	0.2091 ***	0.7831 ***
	(1.4304)	*(4.9254)*	*(8.4482)*	*(5.1229)*	*(7.7183)*	*(32.4725)*
Singapore	0.0495	0.0086	0.3732 ***	0.0344 ***	0.0715 ***	0.9202 ***
	(1.5878)	*(−0.3252)*	*(9.9155)*	*(3.0880)*	*(4.9210)*	*(58.3597)*

Table 6. *Cont.*

Taiwan	0.0989 **	0.0259	0.2771 ***	0.1180 **	0.0662 ***	0.8918 ***
	(2.0661)	*(0.7897)*	*(6.2478)*	*(2.5499)*	*(4.3803)*	*(33.6636)*
Thailand	0.0321	0.0344	0.3467 ***	0.0913 ***	0.1073 ***	0.8932 ***
	(−0.5486)	*(1.0719)*	*(4.8863)*	*(2.5801)*	*(6.7971)*	*(61.1801)*
Latin American emerging markets						
Argentina	0.0967 **	0.0681 ***	0.0867 **	0.2440 ***	0.1284 ***	0.8076 ***
	(2.4066)	*(2.6343)*	*(2.1024)*	*(5.6291)*	*(7.4994)*	*(35.4268)*
Brazil	0.1461 ***	0.0513 **	0.1783 ***	0.1234 ***	0.1427 ***	0.8349 ***
	(4.1852)	*(2.1644)*	*(4.6334)*	*(4.8453)*	*(6.7531)*	*(37.5869)*
Chile	0.0207	0.2515 ***	0.0852 ***	0.0241 ***	0.0764 ***	0.8968 ***
	(0.8866)	*(9.0373)*	*(3.8795)*	*(3.4661)*	*(5.2825)*	*(51.0718)*
Colombia	0.0128	0.2275 ***	0.0769 ***	0.1084 ***	0.2233 ***	0.7303 ***
	(−0.8760)	*(9.8500)*	*(3.9644)*	*(6.2665)*	*(5.9507)*	*(21.8016)*
Mexico	0.1073 ***	0.0873 ***	0.1191 ***	0.0968 ***	0.1067 ***	0.8522 ***
	(3.2568)	*(3.4749)*	*(3.4945)*	*(3.9108)*	*(6.5547)*	*(38.7641)*
Venezuela	0.0253	0.2219 ***	0.2545 ***	0.2062 ***	0.2084 ***	0.7679 ***
	(0.4845)	*(6.6611)*	*(4.5883)*	*(4.6099)*	*(6.4188)*	*(26.0453)*

θ_1 = 0.0100 *** *(5.1374)* ; θ_2 = 0.9204 *** *(52.0098)*. Note: Italic numbers in parentheses are t-statistics. *, **, *** represent statistical significance at the 1%, 5%, 10% *(p value)* of parameters.

Table 7. Estimation of DCC-GARCH model for the US Subprime crisis.

$$r_t = \gamma_0 + \gamma_1 r_{t-1} + \gamma_2 r_{t-1}^{US} + \varepsilon_t$$
$$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}$$
$$Q_t = (1 - \theta_1 - \theta_2)\bar{Q} + \theta_1 \nu_{t-1}\nu'_{t-1} + \theta_2 Q_{t-1}$$

Parameter	γ_0	γ_1	γ_2	ω	α	β
Asian emerging markets						
Indonesia	0.2265 ***	−0.0371	0.4390 ***	0.1915 ***	0.1371 ***	0.8175 ***
	(5.7232)	*(−1.3703)*	*(14.8630)*	*(2.7140)*	*(3.9892)*	*(16.3024)*
Korea	0.1426 ***	−0.0591 ***	0.4602 ***	0.0451 ***	0.0677 ***	0.9227 ***
	(4.2410)	*(−2.7507)*	*(16.6541)*	*(3.7266)*	*(6.3664)*	*(80.1653)*
Malaysia	0.1051 ***	0.0245	0.2148 ***	0.0277 ***	0.1524 ***	0.8425 ***
	(5.5955)	*(0.9712)*	*(15.0682)*	*(3.1640)*	*(6.1689)*	*(30.6932)*
Philippines	0.1073 ***	0.0432 **	0.4816 ***	0.1307 ***	0.2038 ***	0.7557 ***
	(3.6841)	*(2.0841)*	*(24.7262)*	*(4.1638)*	*(7.1927)*	*(24.0974)*
Singapore	0.1526 ***	−0.1309 ***	0.4332 ***	0.0370 ***	0.0719 ***	0.9157 ***
	(5.7167)	*(−7.1061)*	*(19.0871)*	*(5.9154)*	*(9.3246)*	*(110.2176)*
Taiwan	0.1129 ***	−0.0351	0.4178 ***	0.0308 ***	0.0490 ***	0.9431 ***
	(3.2060)	*(−1.4837)*	*(16.4201)*	*(3.0436)*	*(5.1028)*	*(80.4188)*
Hong Kong	0.1726 ***	−0.0933 ***	0.5775 ***	0.0474 ***	0.0915 ***	0.9057 ***
	(5.4715)	*(−5.1091)*	*(21.4708)*	*(4.6845)*	*(8.9123)*	*(92.2507)*
Thailand	0.1680 ***	−0.0329	0.3372 ***	1.0153 ***	0.2215 ***	0.4901 ***
	(4.2402)	*(−1.2364)*	*(11.6561)*	*(4.5281)*	*(4.2943)*	*(4.7025)*
Latin American emerging markets						
Argentina	0.1442 ***	0.0375	0.1114 ***	0.1799 ***	0.0746 ***	0.8276 ***
	(4.0163)	*(1.1469)*	*(4.2305)*	*(4.9710)*	*(4.8060)*	*(27.1994)*
Brazil	0.2432 ***	−0.1042 ***	0.1159 ***	0.0944 ***	0.0599 ***	0.9090 ***
	(6.2098)	*(−5.2976)*	*(3.4103)*	*(4.1900)*	*(6.3348)*	*(62.2301)*
Chile	0.1276 ***	0.0995 ***	0.0496 ***	0.0650 ***	0.1224 ***	0.8094 ***
	(5.6065)	*(3.8369)*	*(2.9036)*	*(5.0398)*	*(6.9301)*	*(31.73603)*
Colombia	0.1238 ***	0.0370	0.1040 ***	0.1820 ***	0.2388 ***	0.6475 ***
	(4.2682)	*(1.0867)*	*(5.4842)*	*(7.4010)*	*(8.2245)*	*(20.6911)*
Mexico	0.1784 ***	−0.0144	0.0521 ***	0.0569 ***	0.0611 ***	0.9105 ***
	(5.7761)	*(−0.6505)*	*(1.8097)*	*(4.2185)*	*(6.6728)*	*(67.41723)*

Table 7. *Cont.*

Venezuela	−0.0111	0.1535 ***	0.0535 ***	0.1026 ***	0.5049 ***	0.5477 ***
	(−0.7179)	*(5.7888)*	*(4.4745)*	*(5.8995)*	*(9.9013)*	*(14.22591)*
US	0.0946 ***	−0.1055 ***		0.0199 ***	0.0823 ***	0.9067 ***
	(3.7963)	*(−3.8855)*		*(4.8415)*	*(8.6645)*	*(88.7960)*

$\theta_1 = 0.0086$ *** *(4.3979)* ; $\theta_2 = 0.9211$ *** *(34.2800)*. Note: Italic numbers in parentheses are t-statistics. *, **, *** represent statistical significance at the 1%, 5%, 10% *(p value)* of parameters.

5.2. Contagion Tests

Although increases in some correlations between crisis markets and target markets during three crises have been noticed, we are not sure if they are statistically significant, which is the evidence of shift contagion. Hence, in order to test for the existence of contagion, we firstly calculate the average correlations in pre-crisis and crisis periods, and then use the *t*-test as presented in Section 3 to verify if the average correlation in crisis period is statistically higher than that in pre-crisis period. The results are reported in Tables 8–11.

5.2.1. Contagion during the Mexican "Tequila" Crisis

In the Mexican "Tequila" crisis, we do not find contagion from Mexican stock market to Asian emerging stock markets. Actually, the DCCs between Indonesia, Korea and Singapore increase lightly after the crisis with respectively 0.0017%, 1.1157%, and 2.1926% (8). However, these increases are not statistically significant. The t-statistics are inferior to the critical values, leading to accept the null hypothesis of non contagion. This implies an interdependence phenomen between these markets and Mexican market, and not a shift contagion. On the contrary, concerning Latin American stock markets, there is a pure contagion phenomenon from Mexican stock market to Argentinian, Chilian stock markets. The DCCs between these two markets and Mexican stock markets increased significantly at 1% between two periods. These results allow us to conclude that Mexican crisis was just a regional phenomenon. This finding is consistent with the work of Bodart and Candelon (2009).

5.2.2. Contagion during the Asian "flu" Crisis

The contagion tests from Thailand to other emerging stock markets during the Asian "flu" crisis show that there is shift contagion from the crisis-originating market to the both Asian and Latin American regions. We can see that contagion is present in all Asian emerging stock markets under investigation. For Latin American stock markets, the contagion tests demonstrate the presence of contagion in Argentina, Brazil, Chile and Venezuela. Based on the increase in DCC mean in percentage term (See Table 9), Taiwan is most influenced by contagion in Asian region[7] and Venezuela in Latin American region.

In considering Hong Kong as the market originating Asian "flu" crisis instead of Thailand, we also find the presence of contagion effects in the both Asian and Latin American regions. However, the results are slightly different. For Asian emerging stock markets, the contagion effects are present in the Philippines, Singapore, Taiwan and Thailand, and not in Indonesia, Korea and Malaysia. For Latin American emerging stock markets, shift contagion phenomenon is found in most markets except Colombia.

[7] This result is consistent with the work of Cho and Parhizgari (2008).

Table 8. Results of contagion test in emerging stock markets: The Mexico "Tequila" crisis in 1994.

	Stable Period *1 January 1993–16 December 1994*			Turnoil Period *19 December 1994–31 March 1995*					
	Mean	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean Increase (%)**	**t Statictis**	**Contagion**
Asian emerging markets									
Korea	0.0775	0.0197	511	0.0668	0.0316	75	−13.7570	−2.8409	N
Malaysia	0.0762	0.0235	511	0.0802	0.0261	75	5.2683	1.2577	N
Philippines	0.0989	0.0198	511	0.0933	0.0509	75	−5.6818	−0.9455	N
Singapore	0.0897	0.0202	511	0.0891	0.0377	75	−0.6939	−0.1401	N
Taiwan	0.0425	0.0153	511	0.0355	0.0370	75	−16.4346	−1.6127	N
Thailand	0.0659	0.0156	511	0.0491	0.0274	75	−25.5032	−5.1963	N
Latin American emerging markets									
Argentina	0.4734	0.6880	511	0.7406	0.1717	75	56.4643	13.1390	C ***
Chile	0.1494	0.3865	511	0.2638	0.1381	75	76.5546	7.1045	C ***
Colombia	0.0279	0.1669	511	0.0126	0.0056	75	−54.8510	−18.0838	N
Venezuela	0.1070	0.3271	511	0.0490	0.0456	75	−54.1615	−8.6066	N

*** represents statistical significance at the 10% level of risk. N: No contagion; C: Contagion.

Table 9. Results of contagion test in emerging stock markets: The Asian "flu" crisis in 1997 (Contagion source: Thailand).

	Stable Period *1 January 1996–1 July 1997*			Turnoil Period *2 July 1997–31 December 1998*					
	Mean	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean Increase (%)**	**t Statictis**	**Contagion**
Asian emerging markets									
Indonesia	0.3559	0.0097	392	0.3673	0.0411	392	3.2073	5.3562	C ***
Hong Kong	0.3547	0.0116	392	0.3593	0.0586	392	1.2997	1.5284	C *
Korea	0.2529	0.0129	392	0.2640	0.0314	392	4.3660	6.4443	C ***
Malaysia	0.3175	0.0092	392	0.3252	0.0404	392	2.4180	3.6650	C ***
Philippines	0.3182	0.0166	392	0.3266	0.0615	392	2.6663	2.6372	C ***
Singapore	0.4230	0.0120	392	0.4298	0.0472	392	1.6002	2.7536	C ***
Taiwan	0.1475	0.0001	392	0.1665	0.0015	392	12.8759	9.2121	C ***
Latin American emerging markets									
Argentina	0.1228	0.0112	392	0.1267	0.0302	392	3.1683	2.3918	C ***
Brazil	0.1231	0.0108	392	0.1290	0.0338	392	4.8054	3.2968	C ***
Chile	0.1714	0.0140	392	0.1854	0.0406	392	8.1982	6.4719	C ***
Colombia	0.0784	0.0126	392	0.0688	0.0172	392	−12.2519	−8.9302	N
Mexico	0.1045	0.0088	392	0.1012	0.0365	392	−3.1670	−1.7448	N
Venezuela	0.1341	0.0142	392	0.1513	0.0287	392	12.8308	10.6444	C ***

*, *** represent statistical significance at the 1%, 10% levels of risk. N: No contagion; C: Contagion.

Table 10. Results of contagion test in emerging stock markets: Asian "flu" crisis in 1997 (Contagion source: Hong Kong).

	Stable Period *1 January 1996–16 October 1997*			Turnoil Period *17 October 1997–31 December1998*					
	Mean	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean Increase (%)**	**t Statictis**	**Contagion**
Asian emerging markets									
Indonesia	0.3802	0.0094	469	0.3766	0.0379	315	−0.9470	−1.6517	N
Korea	0.2086	0.0089	469	0.2023	0.0518	315	−3.0045	−2.1265	N
Malaysia	0.3517	0.0090	469	0.3524	0.0442	315	0.1975	0.2748	N
Philippines	0.4080	0.0105	469	0.4199	0.0390	315	2.8981	5.2614	C ***
Singapore	0.5599	0.0118	469	0.5807	0.0362	315	3.7174	9.8697	C ***
Taiwan	0.2336	0.0157	469	0.2499	0.0486	315	6.9547	5.7406	C ***
Thailand	0.3468	0.0252	469	0.3723	0.0558	315	7.3427	7.5909	C ***
Latin American emerging markets									
Argentina	0.1939	0.0136	469	0.2056	0.0353	315	6.0226	5.6008	C ***
Brazil	0.2016	0.0153	469	0.2102	0.0342	315	4.3050	4.2230	C ***
Chile	0.2297	0.0131	469	0.2494	0.0237	315	8.5714	13.4455	C ***
Colombia	0.0811	0.0175	469	0.0781	0.0251	315	−3.7808	−1.8855	N
Mexico	0.1983	0.0111	469	0.2071	0.0306	315	4.4270	4.8752	C ***
Venezuela	0.1983	0.0111	469	0.2071	0.0306	315	4.4270	5.1917	C ***

*** represents statistical significance at the 10% level of risk. N: No contagion; C: Contagion.

Table 11. Results of contagion test in emerging stock markets: The US subprime crisis in 2007.

	Stable Period *1 January 2006–31 July 2007*			Turnoil Period *1 August 2007–31 December 2008*					
	Mean	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean Increase (%)**	**t Statictis**	**Contagion**
Asian emerging markets									
Indonesia	0.1337	0.0073	411	0.1468	0.0324	371	9.8224	7.6402	C ***
Hong Kong	0.2451	0.0053	411	0.2555	0.0494	371	4.2302	4.0262	C ***
Korea	0.2159	0.0058	411	0.2255	0.0350	371	4.4430	5.2203	C ***
Malaysia	0.1119	0.0116	411	0.1147	0.0283	371	2.4937	1.7711	C **
Philippines	0.0378	0.0067	411	0.0548	0.0332	371	45.0331	9.6879	C ***
Singapore	0.2502	0.0069	411	0.2617	0.0371	371	4.6221	5.9123	C ***
Taiwan	0.1233	0.0056	411	0.1326	0.0274	371	7.4918	6.3644	C ***
Thailand	0.2485	0.0143	411	0.2651	0.0443	371	6.6707	6.8943	C ***
Latin American emerging markets									
Argentina	0.3998	0.6323	411	0.4016	0.0237	371	0.4424	1.2989	C *
Brazil	0.7134	0.8447	411	0.7146	0.0350	371	0.1562	0.6085	N
Chile	0.5401	0.7349	411	0.5463	0.0350	371	1.1536	3.3411	C ***
Colombia	0.2901	0.5386	411	0.2997	0.0386	371	3.3137	4.6816	C ***
Mexico	0.7391	0.8597	411	0.7523	0.0212	371	1.7914	11.5450	C ***
Venezuela	0.0008	0.0290	411	0.0048	0.0125	371	472.0685	5.4992	C ***

*, **, *** represent statistical significance at the 1%, 5%, 10% levels of risk. N: No contagion; C: Contagion.

5.2.3. Contagion during the US Subprime Crisis

As presented in Table 11, the DCCs between US and Asian emerging stock markets are generally smaller than those between US and Latin American emerging stock markets. Exceptionally, the DCCs for Philippines and Venezuela are very small compared to other markets, respectively about 5% and 1%. The highest DCC for Asian region is about 27% (for Singapore) while the highest DCC for Latin American region is more than 75% (for Mexico). However, they all show an increase after the crisis occurs. The t tests for the significant increases of DCCs between tranquil and turmoil periods lead to the rejection of non contagion for most of the markets, except Brazil. In fact, the DCCs between U.S. and Brazil increase after the crisis but it is not statistically significant. However, they are very high, respectively 71.34% and 71.46% in tranquil and crisis periods. This indicates an interdependence phenomenon between Brazil and US and not a shift contagion.

6. Conclusions

Since the international financial crises that occurred in the last two decades, there have been a variety of papers that investigate whether contagion risk is present in financial markets during the crisis periods. In fact, as observed in reality, financial shocks in one country have important impacts in other countries. This raises the question about the role of contagion in the literature. However, how to define and measure contagion is still a contentious problem.

In this paper, we use a traditional definition of contagion which indicates it as a significant increase in cross-market linkages after a shock to one country. Hence, the method applied to test for the existence of contagion in stock markets under investigation is to test if the correlations increase significantly after the crisis. The increase of cross-market correlations is the evidence of contagion risk. This approach is used in many works that deals with the problem of financial contagion risk as it is rather simple compared to other methods like including dummy variables.

We study contagion effects in emerging stock markets during the 1994 Mexican crisis, the 1997 Asian crisis and the 2007 US crisis. The sample consists of eight emerging stock markets in Asia (Indonesia, Hong Kong, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand), and six markets in Latin America (Argentina, Brazil, Chile, Colombia, Mexico, Venezuela) and the US stock market. To compute conditional correlations across markets, we apply DCC-GARCH(1,1) to daily stock index returns of all the markets in the sample for three crises. We then test for a significant

increase in means of dynamic conditional correlations of target markets with source markets during crisis periods.

We find evidence for contagion risk in emerging stock markets during three crises. However, there is a difference of degree of spread among these crisis. During the Mexican crisis, there is a shift contagion from Mexico to two other markets in the same region (Argentina and Chile, all at 1%). During the Asian crisis, contagion is not only detected in Asian region but also in Latin American region. If considering Thailand as contagion source, we find evidence for contagion from Thailand to Indonesia, Hong Kong, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand (in Asia) and Argentina, Brazil, Chile, Venezuela (in Latin America), all at 1% except for Hong Kong (10%). Alternatively, if we assume that the Asian crisis was triggered by the crash of Hong Kong stock market, the results show that Philippines, Singapore, Taiwan and Thailand (in Asia) and Argentina, Brazil, Chile, Mexico, Venezuela (in Latin America) suffer contagion effects from Hong Kong, all at 1%. With respect to the US subprime crisis, we can detect support for contagion in all studied markets at 1% apart from Brazil. This confirms once again the undeniable impact of US stock market to emerging stock markets.

Among three studied crises, only the Mexican crisis in 1994 is found to be a regional phenomenon. However, this crisis occurred more than twenty years ago, when these countries had just begun their liberalization processes. Afterward, the financial crises became more contagious. Regarding the Asian crisis in 1997, contagion is also detected in the Asian and Latin American regions. The US subprime crisis in 2007 is found to be the most contagious as contagion is detected in most of studied markets in both Asian and Latin American regions. Thereby, the contagion effect seems evident in emerging stock markets in the context that these countries become more open and integrated in the global economy after their liberalization processes.

In summary, in this paper, shift contagion in emerging stock markets during crisis periods has been found present. As a result, the most important element that causes contagion effects across markets is the behavior of investors. In the literature of contagion, a shock to one market can make changes in the anticipations of investors in other markets, and hence lead to portfolio rebalancing. In the presence of information asymmetry, this may transfer the crisis to other markets. Consequently, this can be a subject for more detailed researches in the future. Besides, this paper still presents some shortcomings. The main problem of this study concerns the definition of contagion. In this paper, we consider the contagion as an increase of correlation between the markets. Moreover, we apply a simple method to detect the contagion. We use one side t-test instead of other persistent measures. Therefore, these problems must be further examined in the future.

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Assessment of Upstream Petroleum Fiscal Regimes in Myanmar

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Abstract: This study aims to assess Myanmar's upstream petroleum fiscal regimes by applying comprehensive indicators to rank the level of attractiveness of Myanmar. The indicators include government take (GT), front loading index (FLI), and composite score (CS). The decision maker's attitude for GT and FLI were considered in CS linear weighting method in ranking the fiscal terms attractiveness. The results showed that Myanmar's upstream petroleum fiscal regime has low attraction compared to its competing countries from the investor's point of view, both in terms of the risk to the investor in the earlier part of the project and in terms of evaluation with or without the time value of money. Also, royalty and cost recovery were identified to have an impact on the attractiveness rank of petroleum fiscal regime in Myanmar. Therefore, Myanmar should consider improving its fiscal regimes that are not neutral—particularly, royalty, tax, profit split, and cost recovery—for a favorable investment climate.

Keywords: Myanmar; petroleum fiscal regimes; upstream oil and gas; fast and intuitive method; discounted cash flow model

1. Introduction

The petroleum industries in oil and gas producing nations play an important role in economic growth through revenue generation for the government (Odularu 2008). However, oil prices have been relatively low due to the increase in global petroleum supply which has outweighed demand (Sieminski 2014). The fall in oil prices may affect petroleum investors in the oil and gas sector due to the large amount of capital invested in exploration activities during the period of high oil prices (Evans-Pritchard 2015). The investors now tend to focus on the country's fiscal regimes with regard to the valuation of oil and gas exploration and production (Nakhle 2015).

Petroleum fiscal regimes are set of laws, regulations, and agreements in a country which governs the benefits derived from petroleum exploration and production (Gudmestad et al. 2010). This links the host government as the political entity and the international oil company as the legal entity in the transaction. Also, the petroleum fiscal regime sets a standard for the production of oil and gas as well as the income allocation between these two entities (Bindemann 1999; Sunley et al. 2003; Løvås and Osmundsen 2009). The petroleum fiscal regime is important to the government because it ensures the appropriate management of the country's natural resources (Natural Resource Governace Institute (NRGI) 2015). To the petroleum investors, petroleum fiscal regimes influence their investment decisions in any country of interest (Hvozdyk and Mercer-Blackman 2010).

Ensuring an effective and attractive petroleum fiscal regime is vital and challenging in some developing counties (Sunley et al. 2003; Cottarelli 2012). Myanmar is a resource rich developing country

with an estimated proven natural gas and oil reserves of 10 trillion cubic feet and 50 million barrels respectively. Myanmar exports about 12.7 billion cubic meters (2014 estimates), making Myanmar the 17th largest natural gas exporting country in the world[1]. The petroleum sector is important for Myanmar's economic growth as natural gas contributes about 25% of its foreign earnings. As a developing country, petroleum exploration in Myanmar is mainly carried out by overseas investors (Khine 2008; Asian Development Bank (ADB) 2014). Therefore, it is vital to ensure that the petroleum fiscal regime becomes attractive to petroleum investors through reforms that will lead to economic growth (McLaughlin 2012; Robinson 2012).

This study aims to analyze Myanmar's upstream petroleum regimes, to ascertain whether its current regimes are attractive when compared to its competing countries, from the investor's perspective. In conducting an in-depth analysis of the fiscal regimes, it is necessary to use comprehensive indicators to rank the attractiveness level of Myanmar, as different indicators are used by different investors depending on their experience, in deciding the overseas selection. The research also intends to consider the attitude of investors in real situation, especially those in Korean energy institutions. Moreover, there are potentially over 14 countries competing with Myanmar oil and gas exports. This research regarding the assessment of Myanmar upstream petroleum fiscal regimes is timely and of significance to both the Myanmar government and investors for a wide range of reasons.

Firstly, the Myanmar government needs to know the exact level of attractiveness of its oil and gas exploration and production investment climate, as the government takes measures and policy reform in various sectors for the time being. Secondly, the findings from this research can help international oil companies (IOC) in making overseas investment decisions, because the evaluation and comparison of petroleum fiscal terms have practical significance. Thirdly, this study can also contribute to basic insights into the Myanmar petroleum fiscal regimes package as it thoroughly analyses the whole fiscal package in the Myanmar petroleum industry. Fourthly, the major contribution of this research is to provide policy recommendations for a more favorable investment climate in the Myanmar petroleum Exploration & Production (E&P) industry. Finally, research focusing on the combination of decision maker's attitudes and quantitative analysis regarding petroleum fiscal regimes are scarce. Therefore, this study intends to fill in the gap in the literature.

The rest of this study is arranged as follows. Section 2 presents the theoretical framework based on concept of economic rent. Section 3 the literature survey followed by the quantitative analysis for the analysis of upstream petroleum fiscal regimes in Section 4. The results are presented in Section 5, while Section 6 summarizes the study with some major findings and policy recommendations.

2. Theoretical Framework: Concept of Economic Rent

Economic rent is defined as "the true value of natural resource which is the difference between the revenues generated from resource extraction and the costs of extraction" (Dickson 1999; Nakhle 2007). Most IOCs use cash flow models which are based on the concept of economic rent to evaluate petroleum resource projects. This is due to the model's simplicity as its equations can project cash flow for the whole project's lifespan and reveal the profitability of the project. Moreover, it is also defined as "the surplus return above the value of the capital, labor and other factors of production employed to exploit the resource. It is the surplus revenue of the resource after accounting for the costs of capital and labor inputs" (Banfi et al. 2005).

Significant economic rent can be generated from the exploitation and utilization of exhaustible natural resources, especially oil and gas resources which are exhaustible resources as well as a strategic commodity with no perfect substitute. This implies that the extraction of oil and gas can earn huge economic rent. Rowland and Hann (1987) asserted that "the economic worth of a license to produce oil from a tract may be measured by the present value of the flow of the future revenues from that tract's

[1] https://www.cia.gov/library/publications/the-world-factbook/geos/bm.html.

production less the present value of associated future costs, where the costs include monetary items such as equipment as well as non-monetary items such as exposure to risks. The difference between these two amounts, is the economic rent of that tract. It implies that the licensee enjoys more profits than those who induce the production of petroleum (pure profits)". Similarly, Raja (1999) argued that "taxes should be aimed at taxing positive net present value because the method discounts all future cash flows and incorporates all the relevant rewards to factors of production".

It can be argued that a positive net present value could be considered as economic rent representing the surplus over and above that which is necessary to induce investment. Therefore, in practical terms, it can be suggested that taxes should be aimed at taxing positive present values. When entering a project, IOC can calculate a return. Economic rent may thus be a bonus, a financial return not required to motivate desired economic behavior. This study agrees with simple and practical concept of economic rent by applying it in the discounted cash flow model used for the analysis to measure the attractiveness level of petroleum fiscal regimes. The major concepts of economic rent are shown in Table 1. The economic rent is used in this study due to its simplicity and practical representation of revenue allocation between the host government and the IOC. In addition, oil and gas resources can naturally maximize the economic rent of a country through petroleum fiscal regimes.

Table 1. Major Concept of Economic Rent.

No.	Concept	Author
1	Economic rent is extra revenue earn by investors.	Raja (1999)
2	The true value of the natural resource is the difference between the revenues generated from resource extraction and the costs of extraction.	Dickson (1999)
3.	The surplus return above the value of the capital, labor and other factors of production for resource exploitation or surplus revenue of the resource after the costs of capital and labor inputs.	Banfi et al. (2004)
4.	The idea of surplus return drives from the reason of ownership in which the state should receive compensation above the normal taxes paid by other industries.	Tilton (2003)
5.	In general, the studies contend that a tax based on economic rent is likely to be an ideal tax.	Nakhle (2004)
6.	Economic rent concept is important since the government attempts to capture as much economic rent possible through various levies, taxes, royalties, and bonuses.	Lubiantara (2007)
7.	A fiscal regime that has been designed to capture the economy tends to increase when economic rent increases, and reduce government take when economic rent decreases.	Nakhle (2008)
8.	The reason to adopt the economic rent theory as a framework is that taxes levied on economic rent will not act as a disincentive on investor to undertake any activity.	Nakhle (2008)
9.	Economic rent constitutes a justifiable base for petroleum taxation.	Kyari (2013)

3. Literature Survey

3.1. Upstream Petroleum Fiscal Regimes

The upstream petroleum fiscal regimes in oil and gas E&P industry are royalties, various kinds of tax including profit-based tax and non-profit-based tax, bonus payments, cost recovery limits, profit split, host government participation, domestic market obligations, investment credit, etc. (Johnston 1994). However, different countries have different petroleum fiscal systems which typically include royalty and tax systems. Petroleum fiscal regimes of international contracts adjust the profit of the IOC and the host government. This determines the income allocation of all parties, which

contract fiscal terms with a distinctive petroleum feature and the core of the contract (Cameron 2006; Cottarelli 2012).

Petroleum fiscal regimes depend on resource facts the IOC has to consider if they would like to enter a country. Its attractiveness has a major impact on the feasibility of the project and the project of the IOC. Hence, they are significant when judging a country's oil and gas resource investment climate. Moreover, evaluation and comparison of fiscal terms are crucial and will provide basis for the IOC's overseas investment decision, and contribute to the most active implementation of upstream oil and gas E&P business (Boykett et al. 2012). Due to the importance of upstream fiscal terms in investment, there are several studies regarding the upstream fiscal regimes for oil-producing countries, in OECD countries (Zhao and Dahl 2014); Indonesia (Abidin 2015); Malaysia (Manaf et al. 2014); Pakistan and Thailand (Zahidi 2010); Nigeria, Ghana, and Cameroon (Ghebremusse 2015); and Australia (Hunter 2008). However, there has still been a scarcity of studies for some developing countries including Myanmar

3.2. Quantitative Method for Petroleum Fiscal Regimes Assessment

There are different types of petroleum co-operation in different regions, depending on national petroleum legislation, international relations and the stage of oil and gas development. However, the major difference is only resource ownership transfer (Johnston et al. 2008). From the petroleum fiscal point of view, there are four steps: firstly, investment for oil and gas production; secondly, allocation of royalties or similar expenses attributable to the host government; thirdly, cost recovery, tax deduction and other compensation for IOC; and finally, profit split (Mabadi 2008; Serova 2015).

In the previous studies of Mommer (2001), Baunsgaard (2001), and Mommer (2002), the upstream fiscal regimes are analyzed based on the concept of economic rent through tax instruments such as royalties, bonuses, fixed fees, etc. Baunsgaard (2001) ascertained the equivalent fiscal regimes in different fiscal designs. For instance, the cost recovery concept in PSC is similar to the royalty of concessionary, and profit split in PSC is also similar to the initial tax rate in concessionary. It supports the concept that "fiscal regimes differences between contract types can be ignored when evaluating the attractiveness of the fiscal terms" (Luo and Yan 2010). As the number of types of fiscal contract designs is more than the number of countries (Johnston 1994), such findings for equivalent regimes has the advantage for comparative analysis of different fiscal contract types in different countries. This study agrees with those findings since the concessionary system uses only royalty and tax while PSC fiscal design uses various fiscal components.

3.3. Host Government Take (GT)

Government take (GT) is one of the most important criteria in making comparative analysis among worldwide petroleum fiscal systems and calculated in various ways in the petroleum industry (Boodoo 2012). GT puts the impacts of several fiscal regimes such as bonus, royalties, profit split, and taxation of all levels, government equity participation and other factors into one indicator. In other words, GT is defined as the proportion of the host nation's income from investment project to the total project revenue within the valid period of the contract (Luo and Yan 2010). GT measures how much the government takes through upstream petroleum fiscal terms as analyzed in previous studies by Kaiser and Pulsipher (2004), Iledare and Kaiser (2006), Adenikinju and Oderinde (2009), Hao and Kaiser (2010), Kemp and Stephen (2011, 2012), Manaf et al. (2014), and Sen (2014). In the aforementioned studies, GT is calculated through a cash flow model based on historical data or reasonable assumptions combined with the given parameters in the fiscal system.

3.4. Non-Discounted Cash Flow Method (NDCF) and Discounted Cash Flow Method (DCF)

Without taking time value of money into consideration, cash inflows and outflows of the contract period are simulated at a certain level of oil price and output. Consequently, the appropriate deductions and allocations of the contract are made in line with the fiscal terms of the contractual system, and the

proportion of the host nation's return to the total project revenue within the whole project period is the non-discounted GT (Johnston 1994). The formulae necessary for the computation of NDCF as well as DCF cash flows in the whole project life are based on the economic rent concept. The results of cash flow model can be used by an investor to assess the profitability of a project and establish how much GT for the host country.

According to Wenrui et al. (1999), the discounted cash flow (DCF) method for the consideration of time value of money is considered for the calculation of GT, as the project life cycle of the oil and gas E&P projects lasts generally more than 20 years. The best way to calculate GT requires detailed economic modelling using cash flow analysis (Johnston 2008).

The DCF method is calculated for the discounted host nation take based on a certain discounted rate. Cash inflow/outflow time of the host nation during the project life is simulated at a certain level of oil price and output. Moreover, the present value of the host nation's income during the entire life of the oil and gas project is calculated as per a certain discount rate (Luo and Yan 2010). DCF can be used to show how the tax take is calculated (Nakhle 2004). Furthermore, DCF method has been mostly applied in previous studies and is currently used by IOCs (Emhjellen and Alaouze 2001). According to Siew (2001), it has been found that 99% of IOCs used this DCF technique. In addition, the most common technique widely used for project evaluation in energy industry has been the DCF for several decades (Laughton et al. 2000).

Wenrui et al. (1999) measured the profitability of upstream oil and gas projects by two systems measures: NPV[2] and IRR[3] through a cash flow model. However, building a cash flow model takes some time and needs several data inputs. Moreover, a constantly discounted factor in DCF can overestimate the project profitability. Kaiser and Pulsipher (2004) developed an analysis of upstream fiscal regime by the real options theory to overcome the weakness of DCF. However, since this research considers the combination effect with the opinions of decision makers for the evaluation method, it is necessary to use the most commonly applied method. Thus, about 99% of DCF is widely used by IOCs and was applied in this study.

3.5. Prompt and Intuitive Method

The prompt and intuitive method is the easiest and fastest way for an investor to make a decision as soon as they know some fiscal regimes of the specific country (Luo and Yan 2010). As a matter of fact, forecasting the cash flow requires large amount of data, complex calculations, and multidisciplinary collaborations. In addition, cash flow calculation is difficult to complete in a short time. Therefore, a fast estimation method or the fast and intuitive method is recommended.

In the fast estimation method, the total income of the project is assumed as 100%, and the calculation is made in accordance with the order and proportion of the contractual system. Its strength is that the IOCs can evaluate the attractiveness of the fiscal terms of the resource country in a simple way. If IOCs are not aware of the detailed fiscal regimes of a specific country, it can also be used. However, the assumption of 100% total income for the entire project life cannot provide further insights.

According to Jiuliang and Fenglan (2001), there is no widely-accepted method for evaluating and comparing different types of petroleum fiscal regimes used in the upstream oil and gas contracts worldwide. Therefore, it is difficult to choose the indicators that can reflect the combined effects of different fiscal systems. This research develops the evaluation method applied by Luo and Yan (2010). Different indicators—namely, government take (GT), front loading index (FLI), and composite score (CS)—are included in this evaluation method. Luo and Yan (2010) ascertained that these indicators are selected based on qualifications such as comprehensiveness, reflection of income allocation ratio between the IOC and resource-based country under the combined effects of fiscal regimes, considering

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[2] Net Present Value.
[3] Internal Rate of Return.

the impact of the allocation order due to time value of money and time sequence of allocation obtained by different parties. Hence, the method using these indicators can affect the final benefit of the IOC.

3.6. Front Loading Index (FLI)

The FLI of IOCs are applied in this study to reflect the impact of time sequence differences of the host nation on the project and IOC's profit, with the intention of making up the weakness of the gap between GT and GTi indicators. FLI can reflect the combination level of a contract's fiscal term. In the international oil and gas E&P industry, the time sequence of incomes gained by the host country is a crucial issue that an IOC should consider. This is because the IOC can recover costs as soon as possible for a higher return for an E&P project by delaying payment to the host country. Consider a case where the host resource country maximizes its government take (GT) based on the profit gained by the IOC. There would be no front-loading for the IOC and discounted GTi, while non-discounted GT would be the same.

However, most of the host nations do not receive income, depending on profit from the project. There are some factors contributing to the difference of host nation's proportion with discounted GTi and non-discounted GT. The fiscal regimes in the early project life are signature bonus and production bonus. In addition to these early fiscal terms, other fiscal regimes[4] in the construction period and regimes in the production phase[5] may cause revenue of the host government to grow faster than the projected profit. This can cause front-loading to the IOC. The definition of FLI of an IOC is the ratio of the difference between non-discounted GT and the discounted GTi to GT. The interpretation by Luo and Yan (2010) for the FLI relating to attractiveness is that the smaller the FLI is, the less risk the IOC will face in the earlier stage of the project life. Also, the less risk in the earlier phase of the project, the more attractive the petroleum fiscal regimes used in the E&P project.

3.7. Composite Score (CS)

Composite score (CS) is selected because it is a comprehensive evaluation indicator to evaluate the fiscal regimes of oil and gas projects. The linear weighting method is used to evaluate the indicators of GT and FLI. Thus, the linear weighting function of the composite score is built as $CS = W1 \times GT + W2 \times FLI$, where W1 and W2 reflect the attitude of the investor relating to the contribution of GT and FLI to the attractiveness of the fiscal regimes. This is determined by the decision-maker in accordance with their own experience. As the composite score is a comprehensive indicator that reflects the attractiveness of fiscal regimes, the interpretation for the CS is that the smaller the CS, the greater the attractiveness of the fiscal terms in the petroleum contract. The DCF and ROT could show the impact of fiscal terms and identify fiscal regimes of oil production countries.

Moreover, it is the most common method used by the IOC (Siew 2001). However, it does not consider the impact of different time sequences on the attractiveness of the fiscal terms. The model which combines DCF, NDCF, FLI, and CS by Luo and Yan (2010) overcame this weakness and reflected the combination level of the contract's fiscal terms more comprehensively. This is due to the consideration of time different impact. However, the attitudes of the decision-maker were assumed for the linear weighting method in the Luo and Yan (2010) study. Hence, it can limit the insight into the attractiveness level of fiscal terms. With the intention of filling the gap in the literature, this study develops a comprehensive model of DCF, NDCF, FLI, and CS. The model considers the attitudes of decision-makers in the Korean energy industry for the combined effects of fiscal terms to impact more realistically.

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[4] For example, business tax, value-added tax, import tax levied on the investment.
[5] For example, royalty, profit split, host government participation, bonus based on income and profit levels.

4. Quantitative Analysis for the Assessment of Upstream Petroleum Fiscal Regimes

4.1. Method

In the oil and gas E&P industry, international investors use a wide range of methods and evaluation techniques. Various methods have different results and limitations. Currently, there is no widely accepted method to evaluate and compare different types of petroleum fiscal regimes used in the upstream oil and gas contracts worldwide. Therefore, it is difficult to choose the indicators that can reflect the combined effects of different fiscal systems. This research develops the evaluation method by Luo and Yan (2010). Different indicators—namely, government take (GT), front loading index (FLI), and composite score (CS)—are included in this evaluation method. These indicators have been selected due to its comprehensiveness, reflection of the income allocation ratio between IOCs and resource-based country under the combined effects of the fiscal regimes. It takes into account the impact of allocation order due to the time value of money and the time sequence of allocation obtained by different parties. The indicators used in this method can affect the final benefit of the IOCs.

4.1.1. Modelling Framework

The proposed modelling framework (Figure 1) is based on the literature survey in Section 3, regarding the assessment of Myanmar upstream petroleum fiscal regimes in comparison to selected competing countries.

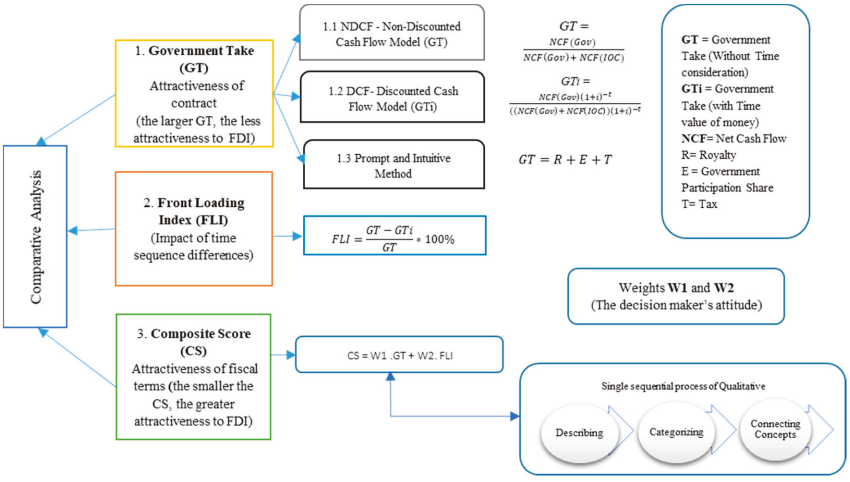

Figure 1. Proposed Modeling Framework.

4.1.2. Host Government Take (GT)

Government take (GT) is the fundamental indicator of this study because other indicators are calculated based on the results of GT. Hence, GT is calculated in various ways used in the petroleum industry. As discussed in the literature review, GT puts the impacts of several fiscal regimes into one indicator. GT is defined as the proportion of the host nation's income to the total project revenue within the valid period of the contract. According to Bindemann (1999), the equation of GT is

$$GT = (NCF(Gov))/(NCF(Gov) + NCF(IOC)) \times 100\% \quad (1)$$

where, NCF (Gov) is the net cash flow of the host government and NCF (IOC) is that of the international oil company.

The interpretation of GT indicator relating to the attractiveness of fiscal regime is that "the larger GT is, the less attractive the fiscal regimes of the contract is to the IOC". In this research, GT is calculated in two ways; the first way is the fast and intuitive method and the second is the non-discounted cash flow model (NDCF).

Prompt and Intuitive Method

In the fast estimation method, the total income (I) is assumed as 100%, and calculation is made in accord with the order and the proportion of the contractual system. The calculation is conducted as follows: first, the host nation receives royalties (R), with a proportion of the royalties (Rt). Second, IOC recovers costs, with cost recovery limit (Rr). Third, after the deduction of the first and second steps, the remainder is the portion of the profit split of oil/gas (profit-sharing oil), from which the host nation take (Er) %, while IOCs gets the remaining percentage. Fourth, IOC has to pay income tax (T) to the host nation at tax rate (Tr). Taxable income is the income IOC get from oil/split profit. The host nation's income mainly includes three parts: R, E and T. Therefore, GT is calculated as

$$GT = R + E + T \tag{2}$$

where, $R = I \times Rt$, $I = 100\%$, $E = (I - R)\,(I - Rr)\,Er$ and $T = (I - R)\,(I - Rr)\,(I - Er)\,Tr$.

Non-Discounted Cash Flow Method (NDCF)

Without taking into consideration the time value of money, cash inflows/outflows of the contract period are simulated at a certain level of oil price and output. Then, the appropriate deductions and allocations of the contract are made in line with the fiscal terms of the contractual system. Also, the proportion of the host nation's income to total project revenue in the whole project period is the non-discounted GT.

In the cash flow simulation, the equations will be varied in terms of the contractual policy used in different countries. In this research, Myanmar, Cambodia, Indonesia, and Vietnam adopt a production sharing contract (PSC) policy, while the U.S., Canada, Australia, and Mozambique practice the concessionary system. The differences between these two systems are discussed in Chapter 3. The calculations in detail are mainly based on the sample production sharing contract cash flow projection and sample concessionary system cash flow projection (Johnston 1994). The equations used in the PSC cash flow are

$$\text{Gross revenue} = \text{Oil/Gas production} \times \text{Revenue} \tag{3}$$

$$\text{Royalty} = \text{Gross revenue} \times \text{Rate of royalty} \tag{4}$$

$$\begin{gathered}\text{Cost recovery or cost of oil/gas} = \text{intangible capital expenditure} + \text{operating expense} \\ + \text{DD\&A if gross revenue is greater than zero: up to a maximum rate (cost recovery} \\ \text{limit) of gross revenue}\end{gathered} \tag{5}$$

$$\text{Total profit oil/gas} = \text{gross revenue} - \text{Cost recovery} \tag{6}$$

$$\text{Contractor (IOC) profit oil} = \text{total profit oil} \times \text{profit split} \tag{7}$$

$$\text{Income Tax} = \text{Contractor (IOC) profit oil} \times \text{Tax rate} \tag{8}$$

$$\begin{gathered}\text{Contractor (IOC) After Net Cash Flow} = \text{Gross Revenue} - \text{Intangible cost} - \text{Tangible} \\ \text{Capital Costs} - \text{Operating Expenses} - \text{Total profit oil} + \text{Contractor Profit Oil} - \text{Income Tax}\end{gathered} \tag{9}$$

Consequently, the government take (GT) is calculated according to Equation (1) as mentioned in Section 4.1.2. The cash flow simulations of Myanmar, Cambodia, Indonesia, and Vietnam obtained by using these equations are attached in from Tables S1–S8 in Supplementary Material. In regards to the equations for cash flow simulation for U.S., Canada, Australia, and Mozambique adopting the

concessionary system, the gross revenue and royalty are calculated through Equations (3) and (4) respectively. The remaining equations necessary for the concessionary system are

$$\text{Net revenue} = \text{Gross Revenue} - \text{Royalty} \tag{10}$$

$$\begin{gathered}\text{Total Applied Deductions} = \text{If Intangible capital expenditure} + \text{Operating expense} \\ + \text{DD\&A is greater than or equal to Net revenue, then Net revenue, Otherwise Intangible} \\ \text{Capital expenditure} + \text{Operating expense} + \text{DD\&A}\end{gathered} \tag{11}$$

$$\text{Taxable income} = \text{Net revenue} - \text{Intangible capital expenditure} - \text{Operating expense} - \text{DD\&A} \tag{12}$$

$$\text{Income tax} = \text{If Taxable income is positive, Tax rate} \times \text{Taxable income, otherwise (0)} \tag{13}$$

$$\begin{gathered}\text{After Net Cash Flow} = \text{Gross Revenue} - \text{Royalty} - \text{Intangible capital expenditure} \\ - \text{Tangible Capital expenditure} - \text{Operating expense} - \text{Income Tax}\end{gathered} \tag{14}$$

$$\text{NCF (Gov)} = \text{Royalty} + \text{Income Tax} + \text{Resource Rent Tax} \tag{15}$$

$$\text{NCF (IOC)} = \text{After Net Cash Flow} - \text{Royalty} - \text{Income Tax} - \text{Resource Rent Tax} \tag{16}$$

Finally, GT is calculated in accordance with Equation (1) for the PSC cash flow. Likewise, the cash flow simulations of the U.S., Canada, Australia, and Mozambique obtained by using these equations are attached. Since the concepts of GT by the fast and intuitive method and those of GT by NDCF are similar due to lack of consideration of the time value of money, the average assumption of these two results are represented as GT.

4.1.3. Government Take (GTi) through Discounted Cash Flow Method (DCF)

In addition to the two methods for GT mentioned above, this study also takes into account, the DCF for the consideration of time value of money due to long project life. The DCF method, which calculates the discounted host national take, is based on a certain discounted rate. The cash inflow/outflow of the host nation during the project life is simulated at a certain level of oil price and output. Moreover, the present value of the host nation's income during the entire life of the oil/gas project is calculated as per a certain discount rate. The formula is

$$\text{GTi} = \text{NCF(Gov)}\ (1 + \text{i})^{-\text{t}} / ((\text{NCF(Gov)} + \text{NCF(IOC)})\ (1 + \text{i})^{-\text{t}} \times 100\% \tag{17}$$

where i refers to the discount rate, t means time and GTi is the host government take at i discount rate.

The DCF cash flow spreadsheets of each country's GTi are attached from Tables S1–S17 in Supplementary Material. GT is calculated by the fast-intuitive method and NDCF. The GTi which is calculated by the DCF can reflect the attractiveness of upstream oil and gas fiscal regimes in different contracts to some extent. However, these methods have a significant flaw in the comparison by different fiscal terms combinations. The method can only reflect the total amount of the host nation's income without considering the influence of different time sequences of income acquisition by the host nation on the benefit of IOC and the attractiveness of the contact. Therefore, it can be established that there is a huge gap result between the GT and the GTi. This gap shows that the time sequence differences of income acquisition by host nations will affect the benefit of the host nation and IOCs, as well as impact on the attractiveness sequences of the oil and gas fiscal terms.

4.1.4. Front Loading Index (FLI)

The definition of FLI by Luo and Yan (2010) is the ratio of the difference between non-discounted GT and the discounted GTi to GT. FLI can be calculated as

$$\text{FLI} = (\text{GT} - \text{GTi})/(\text{GT}) \times 100\% \tag{18}$$

Luo and Yan's interpretation of the FLI relating to attractiveness is that the smaller the FLI, the less risk the IOC will face in the earlier stage of the project life. Consequently, the lower the risk of the earlier phase, the more attractive the petroleum fiscal regimes used in the E&P project.

4.1.5. Composite Score (CS)

Composite score (CS) is selected because it comprehensively evaluates the fiscal regimes of oil and gas projects. The linear weighting method is used to consider the indicators of GT and FLI. Thus, the linear weighting function of the composite score is built as

$$CS = W1 \times GT + W2 \times FLI, \tag{19}$$

where W1 and W2 reflect the attitude of the investor relating to the contribution of GT and FLI to the attractiveness of the fiscal regimes. This is determined by the decision-makers in accordance with their own experience. The CS is a comprehensive indicator that reflects the attractiveness of fiscal regimes. The interpretation for the CS is that the smaller the CS, the greater the attractiveness of the fiscal terms in the petroleum contract.

4.2. Data

If the fiscal regimes such as royalties, profit split, and cost recovery are in a sliding scale system, the average values of parameters in the whole project life are considered in the calculation[6]. The data for fiscal regimes of Myanmar, Cambodia, Indonesia, and Vietnam are collected from the paper presented by the international consultant at a research and training meeting at the Ministry of Energy, Myanmar. The main fiscal parameters for the remaining countries: the U.S., Canada, Australia, and Mozambique are from the Global Oil and Tax Guide (Ernst & Young 2015). The data for each indicator used in the evaluation techniques are collected from primary sources (survey questionnaire), secondary sources (government documents) and assumptions from previous studies.

Table 2 presents the sources of data and the assumptions based on previous studies. All the upstream petroleum fiscal regime packages for the four countries which applies the PSC system are presented in Table 3. The main fiscal parameters—royalty, tax, profit split, cost recovery limits, host government participations—of Myanmar, Cambodia, Indonesia, and Cambodia for the calculation of PSC system are shown in Table 4. Moreover, the main fiscal parameters for the U.S., Canada, Australia, and Mozambique for the calculation of the concessionary system are presented in Supplementary Material 9. A summary of the main fiscal parameters for all countries is depicted in Table 5, while a summary of concessionary and PSC are presented in Table 6.

Oil production data for the cash flow model are retrieved from Kaiser (2007), since the study deals with the effects of fiscal parameters for a favorable investment climate regardless of the project scale[7]. Similarly, since it is difficult to retrieve capital cost, operating cost, tangible cost, an intangible cost for every project in eight different countries, costs are also assumed in the same source as for other studies. Current Brent oil price ($/bbl) was retrieved from the U.S. Energy Information Administration (United States Energy Information Administration (EIA) 2014) as most of the countries in the comparative analysis in this study use the Brent crude oil price. Depletion, depreciation, and amortization (DD & A) and tax losses are taken from the *Global Oil and Gas Tax Guide* (Ernst & Young 2015). Nakhle (2004) also asserted that an assumption of oil price and relevant taxes is sufficient to calculate expected cash flows to determine the investor's return and government take (GT).

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6 Luo and Yan (2010) also made an average assumption for the sliding scales of petroleum fiscal regimes.

7 Likewise, Bindemann (1999) also made the same assumptions for the study of upstream fiscal regime comparison. This production profile came from the sample cash flow sheet by Johnston (1994).

Table 2. Data Sources for each Indicator.

Indicator	Necessary Parameters	Data Source	Previous Studies
GT (NDCF)	Production profile, CAPEX, OPEX, DD& Price Fiscal Term Variables (Royalty, Bonus, Cost Recovery, Profit Split, Tax)	Kaiser (2007) US Energy Information Administration 1. Ernst & Young (2015). Global Oil & Gas Tax Guide 2. PSC Features for Offshore Petroleum Exploration: Ministry of Energy, Myanmar	Same Assumptions 1. (Kaiser (2007) 2. Bindemann (1999) 3. Johnston (1994) Assumption of oil price and relevant taxes is sufficient: - to calculate expected cash flows to determine the investor's return and government take (GT) (Nakhle 2004)
GT (DCF)	Discount Rate (10%)	Nakhle (2004). Petroleum taxation.	Assumption 10 per cent in real terms, - as was applied in the majority of published studies, - to mirror to industry's discount rate.
CS	Weights (Attitude of Decision Makers)	Primary source of data by survey questionnaire to subject matter experts of Korean companies.	Scores and Weightings should be determined using a technique such as Delphin or Peer review or a questionnaire (Henriksen and Traynor 1999).
Comparative Analysis	Country Selection	Primary source by survey questionnaire	

Table 3. Petroleum Fiscal Terms of PSC System.

Descriptions	Cambodia		Indonesia		Myanmar		Vietnam	
	Gov	IOC	Gov	IOC	Gov	IOC	Gov	IOC
Royalty Rate	12.5%				12.5%		6%	
FTP			10%					
Profit Petroleum	35%	65%	60%	40%	60%	40%	40% to 80%	
Cost Recovery	90%		100%		50%		70%	
Production Bonus			Negotiable		1 MM$ To 10 MM$		Negotiable	
Domestic requirement	To meet the domestic demand		25%		25%		-	
Training Fund	1.5 L to 2.5 L		Negotiable		0.5 L to 1 L		Subject to Each Contract	
R&D Fund	Nil		Nil		0.5% of Profit		Nil	
Government Participation	Subject to agreement		10%		20% to 25%		15%	
Tax	25%		44%		25%		35% to 55%	

Source: PSC Features for Offshore Petroleum Exploration: Research and Training (Ministry of Energy, Myanmar, 2012), Edwin@vdb-loi.com.

Table 4. Main Fiscal Parameters of Myanmar, Cambodia, Indonesia, and Vietnam.

Descriptions	Cambodia		Indonesia		Myanmar		Vietnam	
	Gov	IOC	Gov	IOC	Gov	IOC	Gov	IOC
Royalty Rate	12.50%				12.50%		6%	
FTP			10%					
Profit Petroleum	35%	65%	60%	40%	60%	40%	40–80%	60–20%
Cost Recovery	90%		100%		50%		70%	
Tax	25%		44%		25%		35–55%	
Host Gov Participation	Open and subject to the petroleum agreement		10%		15–25% (if reserves is greater than 5 trillion cubic feet)		Subject to negotiation. Normally 15%	

Table 5. Petroleum Fiscal Regimes of Concessionary System.

	U.S		Canada		Australia		Mozambique	
	Gov	**IOC**	**Gov**	**Cont**	**Gov**	**IOC**	**Gov**	**IOC**
Royalty Rate (Onshore)	12.5–30%		10–45%		0–12.5%		6–10%	
(Offshore)	18.75%							
Average Royalty Rate	20		27.0%		6.25%		8%	
Corporate Income Tax	CIT **35%**, State Income Tax 0–12%		Federal Corporate Tax 15%		30%		32%	
Profit-Based Tax			Provincial Tax Rate 10% to 16%		40%			
Depreciation		10 year Straight-Line	Nil			Immediate write-off		Nil
Bonus			Nil			Negotiable		Signature Bonus 0.5–5% of assets
Tax-Loss		Carried back 2 years		Carried forward 20 years and backward 3 years		Carried back 2 years		Carried forward 5 years

Table 6. Summary of Main Fiscal Parameters in Concessionary and PSC.

Fiscal Term Policy	Country	ROY (%)	Tax (%)	ROY + Tax (%)	Cost Recovery (%)	Profit Split (%)	Gov-Participation (%)	Depreciation (Year) (Straight Line Method)
Concessionary	Mozambque	8	32	40				Not applicable
	Australia	6.25	30	36.25				Not applicable
	Canada	27.5	15	42.5				Not applicable
	U.S	20	35	55				10
PSC	Cambodia	12.25	25	37.25	90	35	Negotiable	5
	Myanmar	12.25	25	37.25	50	60	15 to 25	5
	Indonesia	10	44	54	100	60	10	5
	Vietnam	6	55	61	70	40	Negotiable	5

Source: "PSC Features for Offshore Petroleum Exploration", paper presented at a research and training meeting in Ministry of Energy, Myanmar. www.vdb-loi.com, and *Global Oil and Gas Tax Guide* (Ernst & Young 2015).

The discount rate for the discounted cash model is assumed as 10% in real terms, as it was applied in most published studies to mirror the industry's discount rate. The weights for the CS linear weighting method are collected from experts of Korean energy companies through survey technique[8]. Scores and Weightings are determined using techniques such as Delphin or peer review or a questionnaire (Henriksen and Traynor 1999). Moreover, the countries that should be compared with Myanmar for their petroleum fiscal regimes are also based on the respondents' choice through a survey questionnaire[9].

5. Results

The results of the indicators GT, GTi, and FLI are presented in Table 7. The table shows that different indicators have different results for ranking the attractiveness of the fiscal terms. According to the GT, without considering the time value of money, the attractiveness of the eight countries' fiscal terms is ranked in descending order as Cambodia, Australia, Indonesia, Mozambique, Vietnam, Canada, Myanmar, and U.S. However, in terms of GTi, which is calculated with consideration of the time value of money, the attractiveness of the fiscal regimes of eight countries is ranked in descending order as Australia, Mozambique, Cambodia, Canada, Myanmar, Indonesia, Vietnam, and U.S. If sorted by FLI, the attractiveness of eight countries' fiscal terms is ranked in descending order as Indonesia, Cambodia, Vietnam, U.S., Myanmar, Mozambique, Australia, and Canada.

Table 7. Results of GT, GTi, and FLI.

Country	GT (Without Time Consideration)	GTi (With Time Value of Money)	FLI (Front Loading Index)
Myanmar	63.37%	22.06%	65.19%
Cambodia	41.01%	17.13%	58.23%
Indonesia	49.32%	23.34%	52.67%
Vietnam	58.31%	23.34%	59.97%
Australia	43.92%	14.08%	67.94%
U.S.	72.74%	25.67%	64.71%
Canada	58.36%	18.00%	69.15%
Mozambique	49.39%	16.15%	67.30%

In accordance with the results in Table 7, it can be found that calculating with different indicators makes the ranks different. Hence, the comprehensive indicator (composite score—CS) is used to fully reflect the level of attractiveness. In order to compare the attractiveness rank of the eight countries, GT and FLI are considered comprehensively in the calculation of CS[10]. According to the data collected through survey technique in a previous study (Thiri Swe and Vincent Emodi), the decision makers determine weights of GT and FLI as 42% and 58%, respectively. Based on the weights of decisions makers, CS is calculated by the Equation (19)[11]. The result of CS value is provided in Table 8. The attractiveness rank of eight countries' fiscal regimes in descending order is Cambodia, Indonesia, Australia, Vietnam, Mozambique, Myanmar, Canada, and U.S.

[8] Attitudes of the decision makers for the weights regarding the indicators GT and FLI were explained in Section 3 in detail.
[9] Can be provided at a request to the authors.
[10] Luo and Yan (2010).
[11] $CS = W1 \times GT + W2 \times FLI$.

Table 8. CS Value and Attractiveness Rank of Eight Countries.

Country	CS (Composite Score)	Attractiveness Rank
Cambodia	51.00%	1
Indonesia	51.26%	2
Australia	57.85%	3
Vietnam	59.27%	4
Mozambique	59.78%	5
Myanmar	64.43%	6
Canada	64.62%	7
U.S.	68.08%	8

5.1. Analysis of Results in GT and GTi

In terms of the definition of GT and GTi, the attractiveness ranks of eight countries are depicted in Figures 2 and 3, respectively. According to the attractiveness rank of GT without time consideration (Figure 2) and GTi considering (Figure 3) the time value of money, almost all countries have different ranks except the U.S. which has an obvious disadvantage in terms of fiscal regime. Concerning four countries' (Australia, Canada, Mozambique, U.S.) concessionary fiscal regimes[12], the combination of royalty 20% and tax 35% of U.S., 55%, is the highest rate. Thus, the highest rate (55%) of royalty and tax makes the attractiveness rank of the U.S. low both in GT and GTi.

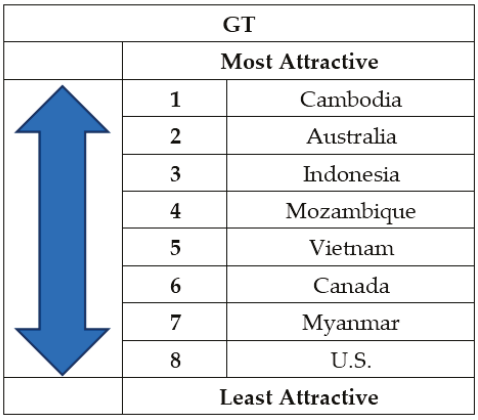

Figure 2. Attractiveness Rank of Eight Countries by GT.

Unsurprisingly, tax and royalty affect the attractiveness level of the fiscal regimes. The host government attempts to capture as much rent as possible through taxes and royalties according to the nature of economic rent (Johnston 1994). Likewise, in GTi, since the combination of royalty 6% and tax 55% of Vietnam, 61%, is the highest rate in PSC countries, Vietnam holds the second lowest attractiveness rank after the U.S. and conversely, the lowest combination rate 36.25% of Australia gets the highest attractiveness rank. Hence, the high royalty can make the attractiveness rank low in GTi.

[12] In FLI in Table 7, the three highest attractiveness rank countries adopt the PSC system while the three lowest attractiveness rank countries practice the concessionary system. Likewise, In CS in Table 8, the two highest attractiveness rank countries adopt PSC while the two lowest rank countries use concessionary. Hence, it is better to analyze separately for PSC and concessionary.

GTi (DCF)		
	Most Attractive	
	1	Australia
	2	Mozambique
	3	Cambodia
	4	Canada
	5	Myanmar
	6	Indonesia
	7	Vietnam
	8	U.S.
	Least Attractive	

Figure 3. Attractiveness Rank of Eight Countries by GTi.

In GT, the pattern of the ranks of countries in the concessionary system is the same as in GTi, in line with royalty and tax regimes (Figure 2). As with GTi, the higher the royalty/tax, the lower the attractiveness rank in GT. Royalty and tax affect the fiscal regime attractiveness rank both in GT and GTi for the concessionary system. However, regarding the countries adopting the PSC system, the pattern of the attractiveness ranks of countries in the PSC system (Cambodia, Indonesia, Myanmar, and Vietnam) in GT is not the same as in GTi[13]. In particular, the third lowest rank of Indonesia in GTi jumps to the third highest rank in GT due to its 100% cost recovery incentive and conversely, the attractiveness rank of Myanmar decreases from the fifth rank in GTi to the seventh attractiveness rank in GT (Figures 2 and 3) due to its low-cost recovery limit of 60%. Similarly, since the cost recovery of Vietnam (70%) is higher than cost recovery of Myanmar (50%), the ranking of Vietnam is higher than that of Myanmar in GT, opposing to the rank in GTi. Therefore, in GT, cost recovery also affects the attractiveness level of the fiscal terms for the countries practicing the PSC system.

Normally, the PSC system and the Concessionary system can be distinguished by cost recovery, and its range is typically 30% to 60%. Moreover, Johnston (2008) pointed out that cost recovery can make a difference in cash flow calculations. As such, the finding in this study shows that the highest cost recovery (100%) in Indonesia makes an obvious difference between cash flows by DCF and NDCF so that the attractiveness levels of Indonesia in DCF and NDCF vary dramatically. Moreover, Cambodia's attractiveness rank increases from the third rank in the calculation of DCF[14] to the first attractiveness rank in the calculation of NDCF[15] due to its high incentive cost recovery (90%).

5.2. Analysis of Results in FLI

Luo and Yan (2010) applied FLI for a more realistic combination of fiscal regimes from the investor's point of view. Moreover, the impact of time sequence differences of the host country on the project, and profit of the investor are also reflected by FLI. According to Figure 4, Indonesia, Cambodia, and Vietnam, which adopt the PSC system, have the most attractive ranking of fiscal terms. Whereas Canada, Australia, and Mozambique, practicing the concessionary system, have the least attractive rankings in terms of the IOC's risk in the earlier stage. The combination level of fiscal components in the PSC system are more attractive than those of the concessionary system.

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13 Attractiveness Ranks of GTi for the countries in PSC are 1. Cambodia, 2. Myanmar, 3. Indonesia, 4, Vietnam (Figure 3), but the ranks of GT are 1. Cambodia, 2. Indonesia, 3. Vietnam, and 4. Myanmar (Figure 2).

14 Discounted Cash Flow Model for the calculation of GTi.

15 Non-Discounted Cash Flow Model for the calculation of GT.

FLI		
	Most Attractive	
	1	Indonesia
	2	Cambodia
	3	Vietnam
	4	U.S.
	5	Myanmar
	6	Mozambique
	7	Australia
	8	Canada
	Least Attractive	

Figure 4. Attractiveness Rank of Eight Countries by FLI.

Although the U.S. possesses the lowest rank in GT and GTi (Figures 2 and 3), it is in the middle rank (fourth) in FLI (Figure 4), because[16] the ratio of the difference between GT and GTi to GT is neither small nor large compared to other countries. Thus, the risk the IOC will face in the earlier stage of the project in the U.S. is neither high nor low, although the U.S. is the least attractive one in terms of GT and GTi[17]. Myanmar is in the fifth rank of attractiveness in FLI after the U.S. (Figure 4) and the attractiveness rank is low from the investor point of view. The risk which the IOC will face in the earlier stage of the project in Myanmar is higher than in the U.S., Vietnam, Cambodia, and Indonesia.

5.3. Analysis of Results in CS

In terms of CS, the rank of the fiscal term attractiveness is depicted in Table 8 and calculated based on the decision maker's attitude to the contribution of the two indicators, GT and FLI[18]. According to the findings of the decision maker's attitude through the survey questionnaire, the weight for FLI is greater than GT. From the investor's point of view, Cambodia's petroleum fiscal regime is the most attractive one in the PSC system, while Australia's petroleum fiscal regime is the most attractive in the Concessionary system. Myanmar falls in the position of sixth rank out of eight competing countries.

6. Summary, Policy Recommendations, and Further Studies

6.1. Summary

Based on the assessment of upstream petroleum fiscal regimes, the findings in CS will be useful to the IOCs when making decisions for overseas selection phase in fiscal terms. Cambodia, Indonesia, and Australia are the most attractive for international investors in terms of CS. The findings that Indonesia ranks below Cambodia conforms to the results of Putrohari et al. (2007) who stated that Indonesia PSC provides a better project value compared to other countries. This is because the Indonesian government strives to maximize wealth through its natural resources by revising the fiscal terms over time, though Indonesia had the toughest fiscal regimes in the past.

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16 The attractiveness rank of U.S. in terms of FLI (Table 8).

17 The smaller the FLI, the less risk the IOCs will face in the earlier stage, and the more attractive the contract fiscal terms are to the IOCs (Luo and Yan 2010).

18 Scores and weightings should be determined using a technique such as Delphin or Peer review or a questionnaire (Henriksen and Traynor 1999).

From the result for FLI, the highest ranks belong to the countries practicing the PSC system such as Indonesia, Cambodia, and Vietnam. The lowest ranks belong to the countries adopting a concessionary system such as Canada, Australia, and Mozambique. This implies that PSC fiscal policy is more attractive than the concessionary policy. This supports previous finding from Kyari (2013) and Iledare (2004) where the PSC system was more favorable than other systems. Due to differences between PSC and concessionary, it is better to separately analyze the effects of each fiscal regime in the PSC system and those in a concessionary system.

The main findings of GT and GTi suggests that there are three main issues in this study. Firstly, royalty and tax affect the attractiveness rank of fiscal regimes in the evaluation of petroleum resource development projects, with or without consideration of the time value of money, especially for countries which use a concessionary policy. Secondly, in the PSC system, royalty and tax also affect the attractiveness rank of a fiscal regime, but only in an evaluation that considers the time value of money. Thirdly, cost recovery[19] affects the attractiveness of fiscal regimes in the evaluation of projects without consideration of the time value of money.

The findings about royalty and tax effect on upstream petroleum fiscal terms in this research are consistent with the previous results by Nakhle (2004) and Kyari (2013). Likewise, the findings about cost recovery effect on the fiscal regimes' attractiveness rank, the cost recovery rate in Myanmar also supports the concept that the low-cost recovery limit has a big impact (Johnston 2008).

Myanmar ranks sixth out of eight competing countries. With this low rank, it is not so attractive for investors, especially in comparison with regional countries such as Indonesia, Cambodia, and Vietnam. Disregarding the U.S., Australia, Mozambique, and Canada, which adopt a concessionary system, Myanmar is the least attractive country among those countries which practice a PSC policy in terms of both FLI and CS. In summary, the Myanmar upstream petroleum fiscal regime has a low attraction compared to its competing countries from the investor's point of view, both in terms of the risk to the investor in the earlier part of the project and in terms of evaluation with or without the time value of money.

6.2. Policy Recommendations

The main motivation for this study came from the necessity to assess the attractiveness rank of Myanmar upstream petroleum fiscal regimes in the E&P investment climate, since Myanmar needs to develop its oil and gas resources to fulfil increasing domestic demand without harming its existing natural gas exports[20]. As the Myanmar upstream oil and gas investment climate is not favorable, this study suggests some fiscal regime policy recommendations.

First, analysis of findings in GTi by DCF, considering the time value of money, suggests that, in order to encourage investors in the development of Myanmar's oil and gas E&P industry, the lower the royalty and tax are dropped, the more attractive it will be for the investor. Similarly, the finding for the qualitative analysis of the effects of Myanmar fiscal regimes shows that the Myanmar royalty rate (12.5%), as a non-neutral regime, impacts on the investment decision. To reduce the distortions caused by the imposition of royalty, a sliding scale royalty may be applied. Such a royalty is based on charging different rates of tax, depending on the level of production or oil price. Therefore, the existing royalty regime of Myanmar should be a sliding scale depending on production level or oil price or water depth in offshore oil and gas blocks.

Second, the finding in the analysis of GT, without time consideration, by NDCF suggests that the higher cost recovery incentives are, the more favorable the investment climate. Currently, Myanmar's cost recovery regime (50%) is the lowest among its competing countries. Although it is between the typical cost recovery range 30–60%, its attractiveness level is low compared to competing countries

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[19] Cost recovery regime is used only in PSC fiscal system.
[20] 25% of foreign earnings comes from natural gas export in Myanmar.

in this study. All competing countries' cost recovery regimes are higher than Myanmar's[21]. Such a low-cost recovery regime will hinder the attractiveness of its petroleum fiscal regimes. The FLI indicator shows that the countries with the highest attractiveness rank (Indonesia, Cambodia, and Vietnam) adopt the PSC fiscal contractual system. Hence, it suggests that the PSC contractual system, which is currently used in Myanmar, will provide a more favorable investment climate than another system.

Third, the design of an efficient fiscal system must consider the political and geological risks as well as the potential rewards. Even though some countries have the toughest petroleum fiscal regimes, they are still attractive to the investors due to high geological prosperity which significantly reduces exploration costs. Thus, it is recommended that 92% of such factors as geological condition, location, political stability, and investment opportunity should be taken into account before changing Myanmar's existing petroleum fiscal regimes[22]. Moreover, Myanmar should consider improving its fiscal regimes that are not neutral—royalty, tax, profit split, and cost recovery—for a favorable investment climate from the Korean investors' perspective. This is because the current Myanmar fiscal regimes package, composed of four non-neutral regimes, can create high uncertainty for investors.

Finally, the indicator CS for the decisions of investors shows that Myanmar is in the position of sixth attractiveness rank, while Cambodia, Indonesia, and Australia hold the first three ranks[23]. Hence, in terms of upstream petroleum fiscal regimes, this research suggests that Cambodia, Indonesia, and Australia will be the most attractive countries among eight competing nations where Korean investors want to invest in the oil and gas E&P industry. Selecting the most attractive countries for E&P investment will help them achieve greater operational efficiency, as well as securing and increasing the value of assets by adjusting their business strategy according to their own conditions.

6.3. Further Studies

Based on the discounted cash flow model, it would be interesting to extend the study to analyses other economic indicators—such as NPV, internal rate of return, etc.—with a view to assisting the project selection phase for the investor. Furthermore, this research shows that the PSC system is more attractive than the concessionary system solely in terms of fiscal regimes. However, according to previous studies, there are lots of advantages in the concessionary system such as simplicity and no government intervention, which are beyond the scope of this study. Therefore, it would be interesting to make a comparative analysis of contract systems in the oil and gas E&P industry. This study shows that there are several factors in addition to fiscal regimes which affect the investment decision. Hence, future study can explore the attractiveness rank of petroleum investment, considering the effects of all competing factors on the IOC's investment decision such as political stability, resource potential, location, project scale, and impact of oil price.

Supplementary Materials: The following are available online at http://www.mdpi.com/1911-8074/11/4/85/s1, Table S1: PSC Myanmar Cash Flow Projection of Petroleum Exploration & Production, Table S2: PSC Myanmar Cash Flow Projection of Petroleum Exploration & Production (Cont.), Table S3: PSC Cambodia Cash Flow Projection of Petroleum Exploration & Production, Table S4: PSC Cambodia Cash Flow Projection of Petroleum Exploration & Production (Cont.), Table S5: PSC Indonesia Cash Flow Projection of Petroleum Exploration & Production, Table S6: PSC Indonesia Cash Flow Projection of Petroleum Exploration & Production (Cont.), Table S7: PSC Vietnam Cash Flow Projection of Petroleum Exploration & Production, Table S8: PSC Vietnam Cash Flow Projection of Petroleum Exploration & Production (Cont.), Table S9: Concessionary U.S Cash Flow Projection of Petroleum Exploration & Production, Table S10: Concessionary U.S Cash Flow Projection of Petroleum Exploration & Production (Cont.), Table S11: Concessionary Mozambique Cash Flow Projection of Petroleum Exploration & Production, Table S12: Concessionary Mozambique Cash Flow Projection of Petroleum Exploration & Production

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21 Cost Recovery—50% in Myanmar, 100% in Indonesia, 90% in Cambodia, 70% in Vietnam (Table 7). Cost recovery regime is used only in the PSC system.

22 The stability of the fiscal regime is also considered to maintain the investor's confidence.

23 Assessment and comparison of fiscal terms in different countries can help the IOC in selection of investment areas and adjust its business strategy according to its own situation, to achieve greater operational efficiency and secure and increase the value of assets.

(Cont.), Table S13: Concessionary Australia Cash Flow Projection of Petroleum Exploration & Production, Table S14: Concessionary Australia Cash Flow Projection of Petroleum Exploration & Production (Cont.), Table S15: Concessionary Canada Cash Flow Projection of Petroleum Exploration & Production, Table S16: Concessionary Canada Cash Flow Projection of Petroleum Exploration & Production (Cont.), Table S17: Petroleum Fiscal Regimes of Concessionary System.

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Incorporating Credit Quality in Bank Efficiency Measurements: A Directional Distance Function Approach

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Abstract: The objective of the study was to measure the risk-adjusted efficiency of banks in 24 emerging economies for the period of 1999–2013. A two-stage network data envelopment analysis (DEA), with separate deposit mobilization and loan financing stages was used. Efficiency was measured using directional distance functions with DEA, featuring non-performing loans as undesirable outputs. The distributions of efficiency scores were different when credit quality was taken into account. The distribution of efficiency scores varied systematically with accumulation of non-performing loans across regions. The financial crisis of 2007–2008 impacted more adversely the regions that had higher proportions of non-performing loans in banks' portfolios. The results of a follow-on non-parametric regression showed that smaller, better capitalized, and private banks were more efficient. The conditions conducive for high levels of technical efficiency by banks were found to be characterized by economic growth and low inflation.

Keywords: emerging economies; banks; directional distance functions; network DEA; non-parametric regression

1. Introduction

The financial system plays a vital role in the economic development of an economy. Financial intermediaries, particularly the banks, mobilize funds from a diverse set of savers to investors (Drigă and Dura 2014). Efficient intermediation contributes to growth (Saini and Sindhu 2014) and economic stability. On the other hand, crisis in the banking sector could lead to broader macroeconomic instability (Baily and Elliott 2009) and adversely impact growth (Moyo et al. 2014). Despite their crucial importance to the economy, banks are prone to agency problems that may induce some managers to take excessive risks (Acharya and Naqvi 2012), and potentially jeopardize bank solvency. According to one study, 73% of the 171 failed banks in the United States for the period of 1979–1987 engaged in aggressive risk-taking (Office of the Comptroller of the Currency 1988).

There is a voluminous body of literature on the efficiency of banks (Kumar and Gulati 2014). With a few exceptions, this literature did not take into account the excessive risk-taking, often manifested in the form of non-performing loans. Moreover, almost all previous studies employed a single-stage, black-box, conceptualization of banking operations (Färe and Grosskopf 2000).[1] From a risk-modeling perspective, this is an inadequate representation of the actual banking operations, which have two stylized stages—a deposit mobilization stage and a loan financing stage—with excessive risk-taking relevant to the latter stage only. The technologies used for converting productive inputs into outputs

[1] Most previous studies used either the production or the intermediation approach to model bank efficiency.

may vary across different stages of bank operations; therefore, single-stage efficiency measurement approaches may lead to serious misspecification of the efficient technological frontier, and the resulting efficiency measurements may be misleading. To the best of our knowledge, there are only two studies that incorporated risk-taking or credit quality into efficiency measurements, following Chung et al. (1997), while using a sufficiently flexible representation of the banking operations (Akther et al. 2013; Fukuyama and Weber 2010). These studies, however, considered banks in single countries. There is a need for applying these more robust measurement approaches for investigating bank efficiency in a multi-country, emerging economy setting over time. This would allow the efficiency patterns to be compared across countries and regions and also make it possible to investigate the impacts on bank efficiency of macroeconomic shocks such as the 2007–2008 financial crisis.

The present study attempted to fill this gap. It used a two-stage network data envelopment analysis (DEA), with separate specification of technologies for the deposit mobilization and the loan financing stages using a directional distance function. In line with the stylized banking operations, the loan financing stage in the study was modeled with an undesirable output (non-performing loans) along with a good output. The risk-adjusted efficiency scores were found to be markedly different from scores obtained without accounting for bad loans, and these differences were more pronounced in the loan financing stage, thus underscoring the restrictive nature of the common technology assumption across banking operations that was extensively used in the extant literature. A second contribution of the study is that it investigated the determinant of bank efficiency using non-parametric regression that does not rely on ad hoc assumptions. Finally, the significant differences in measured efficiency scores across regions and countries served to highlight the importance of a studying bank efficiency in a cross-country setting in the emerging economies. The regional and cross-country comparisons are important as they help answer the question how global economic shocks, such as the Asian financial crisis of 1997 and the global financial crisis of 2007–2008, impacted bank efficiency in individual countries and regions.

2. Review of Literature

Charnes et al. (1978) invented the term data envelopment analysis and proposed an input-orientated DEA that measured efficiency in terms of radial contraction of input vectors necessary to reach the efficient frontier while assuming constant returns to scale. Banker et al. (1984) extended the DEA analysis to variable returns to scale (see (Emrouznejad and Yang 2017; Liu et al. 2013)).

Efficiency studies mostly model a single-stage decision-making process. However, many organizational operations, including banks, have multiple stages that offer possibilities for separate measurements of efficiency for each stage. The pioneering paper of Charnes et al. (1988) introduced the notion of network DEA structures for the measurement of efficiency in multi-stage operations.

The network DEA was used for measuring the efficiency of US banks across profitability and marketing stages (Seiford and Zhu 1999), Taiwanese banks for deposit mobilization and loan financing stages (Yang and Liu 2012), and Brazilian banks for cost efficiency and productive efficiency stages (Wanke and Barros 2014).

A separate strand of literature attempted to measure bank efficiency in the context of non-performing loans by employing single-stage directional distance functions (Chung et al. 1997), seeking to reduce inputs and undesirable outputs while increasing desirable outputs (Fukuyama and Weber 2008).

As mentioned earlier, credit risk arises in the second (loan financing) stage of banking operations. Given the considerable interest of the researchers in investigating efficiency measurements in the presence of non-performing loans, network DEA—with non-performing loans at the financing stage modeled as an undesirable output—is a natural direction for extending this literature. However, very few studies modeled bank efficiency in the presence of bad loans using the network DEA framework.

Wang et al. (2014) measured the efficiency of Chinese banks through hyperbolic Farrell-type efficiency measures proposed by Färe et al. (1989). The study divided the overall efficiency into two sub-processes, i.e., deposit producing and profit earning. Huang et al. (2014) examined the super

efficiency of Chinese banks using a two-stage network model with bad outputs by extending the network slack-based measure model (NSBM) of Tone and Tsutsui (2009). The non-performing loans were modeled as a second-stage undesirable output.

Fukuyama and Weber (2010) proposed two-stage directional distance functions for measuring the efficiency of Japanese banks with non-performing loans as bad output in the second stage. Akther et al. (2013) estimated the efficiency of banks in Bangladesh through two-stage directional distance functions, which modeled bad loans as an undesirable output in the second stage. While these studies employed two-stage DEA and modeled undesirable outputs following Chung et al. (1997), they all focused on single countries. This is a serious limitation as it does not permit cross-country and regional comparisons of bank efficiency measurements, which, as noted above, could shed light on differential impacts on countries of common macroeconomic shocks such as global financial crises.

The selected countries were operated under different banking regulations and supervision. This was an important consideration investigated for cross-country comparison. Barth et al. (2013) conducted a survey to collect data and measures of bank regulatory and supervisory policies for the period of 1999–2011 in 180 countries. The authors collected the data based on several bank related questions. The study concluded that the supervision and regulation of banks differ in many dimensions across selected countries. Moreover, the study found divergence in bank regulatory regimes over the past decade despite the worst global financial crisis since the Great Depression.

Most DEA efficiency studies in the existing literature conducted a follow-on analysis to investigate the determinants of efficiency, using a Tobit model (Tobin 1985) that produced point estimates of contributions of different variables. This approach relies on ad hoc distributional assumptions. An alternative is non-parametric regression based on Kernel density estimation (Rosenblatt 1956), which does not suffer from ad hoc assumptions. For example, Illueca et al. (2009) examined the productivity of Spanish savings banks by employing kernel density estimations and non-parametric regression. However, the study did not consider non-performing loans within a multi-stage network DEA.

The present study makes the following contributions: (i) incorporation of credit risk in efficiency measurements of banks; (ii) use of a sufficiently flexible multi-stage network DEA framework, which better captures stylized banking operations where credit risk arises at the loan financing stage and manifests in the form of non-performing loans; (iii) extension of efficiency measurements to a multi-country setting making possible comparisons across countries; and application of non-parametric regression, avoiding ad hoc assumptions in estimating the impact of bank characteristics and other relevant variables on efficiency.

3. Methodology

3.1. Directional Distance Functions with Undesirable Outputs

Consider a technology T with inputs $x \in R_+^N$, desirable outputs $y \in R_+^M$, and undesirable outputs (such as bad loans) $b \in R_+^J$. The directional distance function introduced by Chung et al. (1997), which seeks to directionally increase desirable outputs, while decreasing inputs and undesirable outputs, can be defined as follows:

$$\vec{D}_T\,(x,\ y,\ b;\ \mathrm{g}) = \mathrm{Sup}\ \{\beta\ :\ (x - \beta g_x, y + \beta g_y, b - \beta g_b)\ \in\ T\}, \tag{1}$$

where the nonzero vector g = $(-g_x, g_y, -g_b)$ determines the directions in which the inputs, desirable outputs, and undesirable outputs are scaled. The reference technology set $T = \{(y, b)$: x can produce $(y, b)\}$ and is assumed to satisfy the assumptions of constant returns to scale, strong disposability of desirable outputs and inputs, and weak disposability of undesirable outputs.

Supposed there were $k = 1, 2, \ldots\ K$ decision-making units (DMUs). Then, according to Chung et al. (1997), the directional distance function can be obtained by solving the following DEA problem:

$$\mathrm{Max}\beta = \vec{D}_T(x, y, b; g_x, g_y, g_b),$$

subject to

$$\sum_{k=1}^{K} z_k y_{km} \geq y_{km} + \beta y_{km}, \quad m = 1, 2, \ldots, M; \tag{2}$$

$$\sum_{k=1}^{K} z_k y_{kj} = y_{kj} - \beta y_{kj}, \quad j = 1, 2, \ldots, J; \tag{3}$$

$$\sum_{k=1}^{K} z_k x_{kn} \leq x_{kn} - \beta x_{kn}, \quad n = 1, 2, \ldots, N; \tag{4}$$

$$\sum_{k=1}^{K} z_k = 1, \tag{5}$$

$$z_k \geq 0, \qquad k = 1, 2, \ldots, K;$$

where $\sum_{k=1}^{K} z_k y_{km}$ is the efficient frontier formed as a linear combination of outputs of the other firms. Equation (2) states that the actual output (y_{km}) produced by the firm, plus the possible expansion (βy_{km}), should be at most as large as the output represented by the efficient frontier. Likewise, Equation (3) requires that the input use (x_{kn}), minus the possible input contraction (βx_{kn}), should be at least as large as $\sum_{k=1}^{K} z_k x_{kn}$, the linear combination of inputs used by the other firms. The undesirable output, i.e., the bad loans are represented by y_{kj}, while βy_{kj} is the possible reduction in the undesirable output. The weights z_k are the intensity variables for expanding or shrinking the individual observed activities of DMUs to construct convex combinations of the observed inputs and outputs.

Given the network DEA, the efficiency scores were obtained separately for the deposit mobilization stage and the loan financing stages. The overall efficiency score for the bank was obtained by multiplying the two sores.

3.2. Non-Parametric Regression

Most previous studies that measured efficiency also attempted to model the determinants of efficiency in a second-stage follow-on regression, often employing the Tobit specification (McDonald 2009), which relies on ad hoc parametric assumptions. Ashraf et al. (2017) measured bank risk-taking behavior with three alternative proxies considered as dependent variables, while taking into account the non-performing loans as measures of risk in the efficiency measurement of banks. In contrast, the present study modeled the determinant of efficiency using non-parametric regression (Hayfield and Racine 2008), which does not rely on arbitrary assumptions. Moreover, it dealt differently with continuous and discrete variables.

$$Y_{it} = m(Z_{it}) + \varepsilon_i, i = 1, 2, \ldots, N; \tag{6}$$

where Y_{it} is the dependent variable, i.e., the efficiency score of the bank. Since regressors may be either continuous or discrete, the study defined $Z_{it} = (Z_{it}^c, Z_{it}^d)$, where Z_{it}^c refers to the vector of continuous regressors and Z_{it}^d refers to the vector of discrete regressors, t is the time in years, I is the bank in emerging economies, and N is the total sample observations (5685).

This non-parametric regression technique yields partial derivatives that are permitted to vary over the domain for the variable in question, in contrast with parametric multivariate linear regression techniques, in which the partial derivative is typically assumed to be constant over its domain (Racine 1997). The np package was used to estimate non-parametric regressions that suggested more robust interpretations (Hayfield and Racine 2008). The kernel bandwidths were selected via least-squares cross-validation and calculated as $3.45\sigma n^{-\frac{1}{5}}$ (Racine 2008). For hypothesis testing in non-parametric regression, the study employed the bootstrapping procedures for continuous variables proposed by Racine (1997) and Racine et al. (2006) for categorical variables.

4. Data

This study employed annual data of the banking sector from the *BankScope* database. The sample covered the study period of 1999–2013. The study analyzed the performance of 918 banks in 24 *Emerging Economies* from six regions of the world. The study included the following regions (number

of banks): East Asia (213), Southeast Asia (164), South Asia (95), Latin America (244), Emerging Europe (126), and Africa and the Middle East (76). The combination of variables in both stages to measure the efficiency of banks is listed in Table 1.

Table 1. Stage-wise inputs and outputs of banking operations. DEA—data envelopment analysis.

Process	Variables		Method
	Inputs	Outputs	
Deposit mobilization stage	• Personnel expenses • Other administrative expenses • User cost of fixed assets	• Total deposits	Directional distance function based on network DEA
Loan financing stage	• Total deposits • Personnel expenses • Other administrative expenses • User cost of fixed assets	• Total loans • Other earning assets • Non-performing loans[2]	

In addition, the determinants of efficiency were investigated using the estimated efficiency scores from the DEA model as the dependent variable in a non-parametric regression, with the following bank characteristics, financial ratios, and macro variables as independent variables:

Size = log of total assets
Capital adequacy = ratio of total equity to total assets
Liquidity = ratio of total loans to total deposit
GDP_GR = growth rate of gross domestic product (GDP)
Inflation rate = annual inflation rate
Public bank dummy = 1 if the bank ownership is public; 0 otherwise.
Crisis 2007–2008 Dummy = 1 for the year 2007–2008; 0 otherwise.
East Asia dummy = 1 for banks from East Asia; 0 otherwise.
Southeast Asia dummy = 1 for banks from South East Asia; 0 otherwise.
South Asia dummy = 1 for banks from South Asia; 0 otherwise.
Latin America dummy = 1 for banks from Latin America; 0 otherwise.
Emerging Europe dummy = 1 for banks from Emerging Europe; 0 otherwise.

5. Results

The distributions of efficiency scores for each stage, as well as that of the overall score, are negatively skewed, as shown in Table 2, indicating clustering of individual banks' scores at higher efficiency levels (see Figure 1).

The measured efficiency at the deposit mobilization stage was 93%, which indicates that, at this stage of operations, banks were highly efficient, possibly reflecting managerial performance metrics that reward deposit creation.

At the loan financing (second) stage, the efficiency level was 0.85 on average, and most measurements were clustered in the interval of 0.80–1.0. The banks were somewhat less efficient in the loan financing stage. This inefficiency was mainly caused by high non-performing loans because of adverse borrower selection. Our results were found to be consistent with the findings of Hamid et al. (2017); Zago and Dongili (2011).

[2] It may be argued that, instead of the non-performing loans (NPLs), the loan loss provisions are an alternative representation of the undesirable output in the model. Note, however, that the loan loss provisions are also calculated on the basis of non-performing loans (Bholat et al. 2016). The previous studies employed non-performing loans as an undesirable output in measuring efficiency through directional distance functions. See, for example, (Akther et al. 2013; Barros et al. 2012; Zhu et al. 2015). We followed the same convention and used NPLs to represent undesirable outputs in this study.

Table 2. Descriptive information of efficiency scores *.

Variable	Skewness	Kurtosis	Mean	Std. Deviation
Efficiency of deposit mobilization (Stage I)	−3.11	12.51	0.93	0.1293
Efficiency of loan financings (Stage II)	−1.98	3.21	0.85	0.2311
Overall efficiency	−1.60	1.79	0.80	0.2463

Note: * The model was estimated including non-performing loans (NPLs) as an undesirable output.

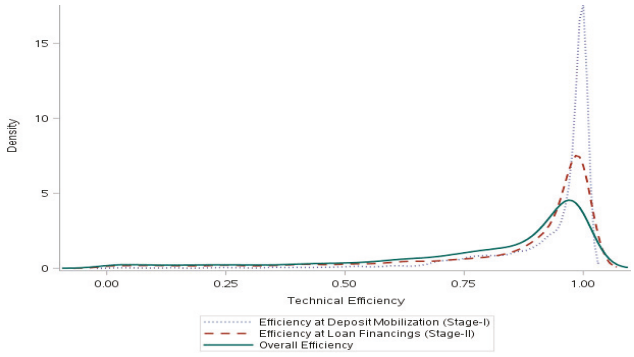

Figure 1. Distributions of measured efficiency scores.

A non-parametric Kolmogorov–Smirnov test was used to measure the equality of distributions of efficiency scores with and without the inclusion of undesirable outputs in modeling. A significant difference at the 1% level of significance was found. This implied that, once non-performing loans (NPLs) were taken into account, the technical efficiency of banks increased significantly, suggesting that an important aspect of banking production (i.e., credit quality) needs to be considered when evaluating banks' performances. Several studies employed this test to investigate the equality of distributions (Banker et al. 2010; Johnes et al. 2014; Titko et al. 2014).

By contrast, the efficiency scores calculated from the model that did not take NPLs into account had greater dispersion, and more of the mass of the distribution was concentrated in the lower efficiency range, represented by the interval of 0.25–0.75, compared to the distribution obtained upon including NPLs in the model (see Figure 2).

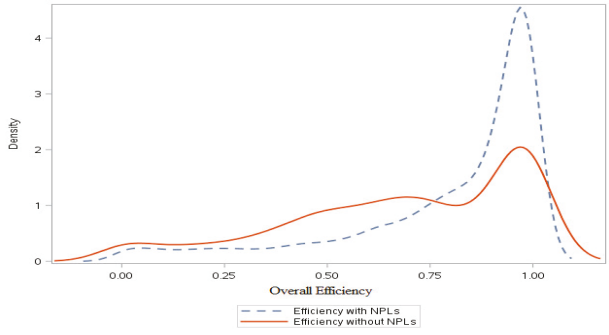

Figure 2. Comparative distribution analysis of efficiency scores with and without non-performing loans (NPLs).

The same non-parametric test was employed to measure the equality of distributions for pre-crisis and post-crisis efficiency scores (Figure 3), also finding a significant difference at the 1% level.

The distribution of efficiency scores pre-crisis were more skewed to the left. In addition, the mass of the distribution was concentrated at higher efficiency levels. By contrast, the efficiency scores post-crisis were concentrated in the lower efficiency range, represented by the interval of 0.70–0.90. The overall average efficiency score pre-crisis was 0.85; however, it dropped to 0.74 post-crisis (see Table 5). This reconfirmed that the global financial crisis hit banking efficiency in emerging economies.

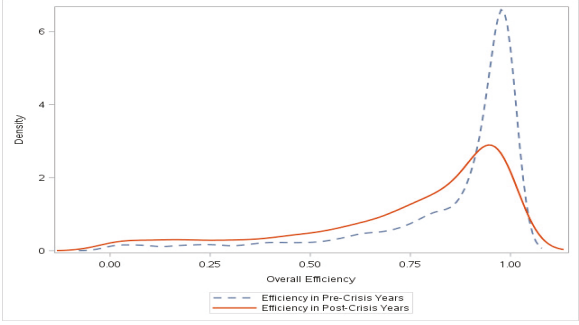

Figure 3. Comparative distribution analysis of efficiency scores pre-crisis and post-crisis.

Table 3 presents the technical efficiency scores for stage I (deposit mobilization) and stage II (loan financing), and their regional and national breakdown. The overall bank efficiency was 0.80, which resulted from a much higher average efficiency (93%) in the deposit mobilization stage than in the loan financing stage (85%). The most inefficient banks were in Africa and the Middle East where the average efficiency score was only 0.55. This was followed by South Asia and Emerging Europe, where the average efficiency scores were 0.67 and 0.68, respectively. The average overall bank efficiency scores for some countries were very low, for example, in Egypt (0.37), United Arab Emirates (UAE; 0.55), and Pakistan (0.61).

Table 3. Regional and national bank efficiency patterns. UAE—United Arab Emirates.

Region	Country Name	Number of Banks	Number of Observations	Stage I	Stage II	Overall Average Efficiency Scores	
Southeast Asia	Indonesia	80	562	1.00	0.86	0.86	0.83
	Malaysia	46	137	0.99	0.64	0.64	
	Philippines	32	191	1.00	0.94	0.94	
	Thailand	6	54	1.00	0.69	0.68	
South Asia	India	69	587	0.93	0.72	0.69	0.67
	Pakistan	26	219	0.91	0.65	0.61	
Latin America	Argentina	57	506	0.96	0.98	0.95	0.93
	Brazil	96	640	0.96	0.97	0.93	
	Chile	30	134	0.91	0.96	0.89	
	Colombia	14	93	0.95	1.00	0.95	
	Mexico	32	225	0.93	0.97	0.90	
	Peru	15	124	0.91	0.99	0.90	
Emerging Europe	Czech Republic	25	148	0.69	0.73	0.54	0.68
	Greece	16	99	0.75	0.91	0.69	
	Hungary	13	94	0.80	0.93	0.74	
	Poland	33	173	0.83	0.86	0.72	
	Turkey	39	276	0.86	0.83	0.71	
East Asia	China	151	744	0.98	0.85	0.84	0.85
	South Korea	15	61	1.00	0.91	0.91	
	Taiwan	47	164	0.97	0.94	0.91	
Africa and the Middle East	Egypt	22	91	0.60	0.52	0.37	0.55
	Morocco	12	57	0.91	0.79	0.72	
	South Africa	18	91	0.85	0.70	0.65	
	UAE	24	215	0.87	0.60	0.55	
	Average	**918**	**5685**	**0.93**	**0.85**	**0.80**	**0.80**

Despite overall higher efficiency in the deposit mobilization stage, banks in some countries were very inefficient in mobilizing deposits. For example, the first-stage efficiency scores in Egypt, Czech Republic, and Greece were 0.60, 0.69, and 0.75, respectively. This suggested that there was huge potential for saving the productive input resources used by the banks, while achieving the same level of mobilization of deposits.

For the (second) loan financing stage—where the bank's risk-taking behavior may be manifested in the accumulation of non-performing loans—the average efficiency score was 85%, which is much lower than the first-stage efficiency score. In this second stage, the efficiency scores of banks in Malaysia, Thailand, Pakistan, India, Egypt, UAE, and South Africa were quite low. Again, the Egyptian banks had the lowest average efficiency score with only 52%.

Next, we discuss the regional comparisons of the overall average efficiency along with the stage-wise average efficiency. The Latin American banks were found to be the leaders in emerging economies and registered an overall average efficiency of 0.93, which was the result of an average efficiency of 0.95 at the deposit mobilization stage, and 0.97 at the loan financing stage. This was followed by East Asian and Southeast Asian banks, which registered good average efficiency scores of 0.85 and 0.83, respectively.

An important question is how taking into account bad loans as an undesirable output impacts the efficiency measurements. Zago and Dongili (2011) argued that "recognizing banks' efforts to reduce bad loans increases their efficiency". Our results (Table 4) showed that the overall efficiency scores after allowing for non-performing loans were higher at 0.80, compared to only 0.69 when NPLs were excluded. This was also true for all regions where the non-performing loans were a higher proportion of the banks' loan portfolios. However, for Latin America, where the proportion on NLPs was only about half the average proportion of NPLs across all regions, the average efficiency scores with and without the inclusion of non-performing loans were quite similar. This suggests that it is important to incorporate non-performing loans, in addition to the undesirable output DEA formulation, for measuring bank efficiency in countries and regions with higher proportions of bad loans exist in the banks' loan portfolios.

Table 4. Average overall efficiency scores with and without non-performing loans (NPLs).

Region	Share of NPLs	Efficiency Scores	
		With NPLs	Without NPLs
Southeast Asia	9.76	0.83	0.61
South Asia	7.29	0.67	0.51
Latin America	3.97	0.93	0.94
Emerging Europe	10.74	0.68	0.54
East Asia	4.11	0.85	0.71
Africa and the Middle East	8.98	0.55	0.41
Average	**7.48**	**0.80**	**0.69**

Table 5 shows that the overall average efficiency score during the period of 1999–2007 before the global financial crisis was 0.85. However, it dropped to 0.74 during the post-crisis period (2008–2013). A closer look at the stage-wise efficiency scores suggests that efficiency declines in the post-crisis period were more pronounced for the loan financing stage and were largely concentrated in the countries of South Asia, Africa and the Middle East, and emerging Europe—regions where the proportion of NPLs was higher. This suggests that non-performing loans had a role in the efficiency declines during the post crisis period.

Table 5. Average efficiency and NPLs pre- and post-crisis by region.

Classification	Southeast Asia	South Asia	Latin America	Emerging Europe	East Asia	Africa and the Middle East	Overall Efficiency of Banks
Efficiency pre-crisis							
Deposit mobilization stage	1.00	0.94	0.96	0.83	0.98	0.83	
Loan financing stage	0.87	0.76	0.97	0.82	0.94	0.59	**0.85**
Overall	**0.87**	**0.73**	**0.94**	**0.68**	**0.93**	**0.53**	
Efficiency post-crisis							
Deposit mobilization stage	1.00	0.91	0.92	0.78	0.98	0.81	
Loan financing stage	0.78	0.63	0.98	0.86	0.83	0.65	**0.74**
Overall	**0.78**	**0.60**	**0.90**	**0.68**	**0.81**	**0.56**	
Share of non-performing loans (%)							
Pre-crisis	12.44	8.15	4.12	9.41	5.99	7.95	
Post-crisis	6.24	6.19	3.63	11.85	2.98	9.57	

Non-Parametric Regression

The non-parametric regression estimated in the study explained efficiency scores with the help of various financial ratios and macroeconomic variables (see Table 6). A set of dummy variables representing the ownership status, financial crisis of 2007–2008, and regional banks is also included.

Table 6. Non-parametric regression results. GDP—gross domestic product.

	Model I		Model II		Model III	
Variable	**Band Width**	***p*-Value**	**Band Width**	***p*-Value**	**Band Width**	***p*-Value**
Size	0.2853	0.07518	1.6045	0.06767	0.2852	0.41353
Capital adequacy	0.0177	0.21303	69358	<0.0001	0.0143	0.06015
Liquidity	0.1325	0.26566	17.1520	0.38346	0.1264	0.54386
GDP growth rate	7.3452	0.84962	0.01462	0.37093	4.9081	0.06516
Inflation gate	3.1927	0.02005	0.3356	0.75188	3.6092	0.02256
Public banks	0.0746	<0.0001	0.4999	0.02757	0.0463	<0.0001
Financial crisis of 2007–2008	0.4293	<0.00251	0.2600	0.0802	0.4474	<0.0001
East Asia	–	–	–	–	0.02753	<0.0001
Southeast Asia	–	–	–	–	0.000073	<0.0001
South Asia	–	–	–	–	0.01635	<0.0001
Latin America	–	–	–	–	0.00037	<0.0001
Emerging Europe	–	–	–	–	0.00059	<0.0001
Indonesian crisis dummy	–	–	0.5	0.48622	–	–
Malaysian crisis dummy	–	–	0.49999	0.74686	–	–
Philippines crisis dummy	–	–	0.49999	0.28070	–	–
Thailand crisis dummy	–	–	0.3107	0.08521	–	–
Brazil crisis dummy	–	–	0.49999	0.44611	–	–
Argentina crisis dummy	–	–	0.5	0.99749	–	–
Colombia crisis dummy	–	–	0.40188	0.97744	–	–
Turkey crisis dummy	–	–	0.46401	0.89724	–	–
Egypt crisis dummy	–	–	0.12138	0.01253	–	–
Morocco crisis dummy	–	–	0.49999	0.89474	–	–
Czech Republic crisis dummy	–	–	0.49999	0.58897	–	–
Greece crisis dummy	–	–	0.49999	0.59398	–	–
	$R^2 = 0.80$		$R^2 = 0.48$		$R^2 = 0.78$	
Dependent variable: overall efficiency scores						

Model I: country fixed effect; Model II: country fixed effect and country crises dummies; Model III: regional fixed effects (dummies). Note: In Model II, the details of the country crisis dummies are as follows: Indonesian crisis 1997–1999, Malaysian crisis 1997–1999, Philippines crisis 1997–2001, Thailand crisis 1997–2000, Brazil crisis 1999, Argentina crisis 1999–2002, Colombia crisis 1999, Turkey crisis 2001, Egypt crisis 2011–2013, Morocco crisis 2009, Czech Republic crisis 2009–2011, and Greece crisis 2009–2013.

Note that the effects of individual independent variables were tested against the null hypothesis of no effect over the entire domain of the regression function (Racine 1997). The *p*-values corresponding to the derived test statistics also referred to responses across all domains. Also, note that the non-parametric regression allows the effects of individual independent variables to vary locally. Both

these considerations have to be borne in the mind when interpreting the non-parametric regression results presented in Table 6 (and in Figure 4). Table 6 reports the band width and the p-values for individual independent variables.

The efficiency of banks may also depend on the regulatory regime, which could vary from country to country (Barth et al. 2008).[3] There are some very detailed World Bank surveys that provide a rich set of indicators of the bank regulatory environments for a large number of countries. These surveys capture the various features of the regulatory regimes as they existed at specific points in time, i.e., 1999, 2002, and 2006 (ibid. p. 5). This study used a research design based on a panel of annual bank-level data from 24 emerging economies from 1999 to 2013. The integration of both datasets for use in model estimation, where the other bank characteristics were observed annually, is not a trivial matter.[4] However, failing to control for the regulatory regime in some way may bias the results. We tried to control for the country-specific regulatory environment by introducing country fixed effects in Model I and Model II (see Table 6).

The Model I results suggest that bank size significantly affected efficiency with a p-value of 0.075, which was somewhat above the conventional threshold of 5%. The ownership status (public bank) was also highly significant. No other bank characteristic had a statistically significant effect. Among the two indicators of macroeconomic environment, inflation had a significant effect on bank efficiency and the GDP growth rate variable was insignificant. The impact of the 2007–2008 financial crisis on efficiency was highly significant.

While the financial crisis of 2007–2008 had global effects, individual countries also had financial crises whose effects were less contagious. Model II included country financial crisis dummies. For the country in question, these dummy variables took the value of 1 during the crisis period, and 0 otherwise. Model II was also estimated with country fixed effects. The results presented in Table 6 suggest that, in addition to size and ownership status, capital adequacy was a highly significant determinant of bank efficiency. None of the macroeconomic variables had statistical significance, and the dummy variable for the 2007–2008 financial crisis had a p-value of 0.08, making it significant at the 10% level. Among the country financial dummies, only the dummy variables for Egypt and Thailand were statistically significant, with the latter only marginally so. The model R^2 value was only 0.48 compared to the R^2 of 0.80 for Model I.

In contrast to Models I and II, Model III did not specify country fixed effects, and instead included dummy variables for regions to capture the regional heterogeneity of efficiency scores. All regional dummies were statistically highly significant. The model R^2 was 0.78, which was comparable to that of Model I. The bank characteristics that had statistically significant effect on efficiency were found to be capital adequacy and ownership status, with p-values of 0.06 and <0.0001, respectively. Both variables reflecting macroeconomic conditions were statistically highly significant. The dummy variable representing the impact on bank efficiency of the global financial crisis was also highly significant.

We present the partial regression plots for Model I in Figure 4. The plots for Models II and III can be found in the Appendix A. The graphs from all plots show a high degree of similarity.

Increases in the capital adequacy ratio raised technical efficiency across the entire domain (top right panel of Figure 4). However, the imprecision of this effect increased, especially for capital adequacy ratios higher than 0.3. Several other studies found a positive relationship between capital adequacy and bank efficiency, for example, see (Gropp and Heider 2010; Kleff and Weber 2008).

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[3] We would like to thank an anonymous referee for this point.

[4] The surveys contain a wealth of information that, when suitably combined with other sources of bank-level data, could offer rich possibilities for further research. We hope to explore some of these possibilities in our own future research. Models I and II that incorporated country fixed effects in an attempt to capture the individual country regulatory environment, while not fully capturing the dynamics of the regulatory regimes, were motivated by Barth et al. (2008).

Figure 4 also provides a graphical representation of the relationship between bank technical efficiency and the macroeconomic environment in which the banks operated. These graphs reveal interesting empirical regularities in different segments of the domain of the relationship. The banks operating in stagnant or contracting economies had poor efficiency scores (top panel), which were also highly volatile in that part of the domain.[5] As GDP growth entered positive territory, the bank efficiency score also increased. This pattern was observed to be positive at growth rates of up to about 5%. Vu and Nahm (2013) pointed out that high growth led to more savings and, hence, more deposits with the banks at a relatively low cost. For growth rates exceeding 5%, however, the technical efficiency scores became considerably more volatile and showed a somewhat declining trend.

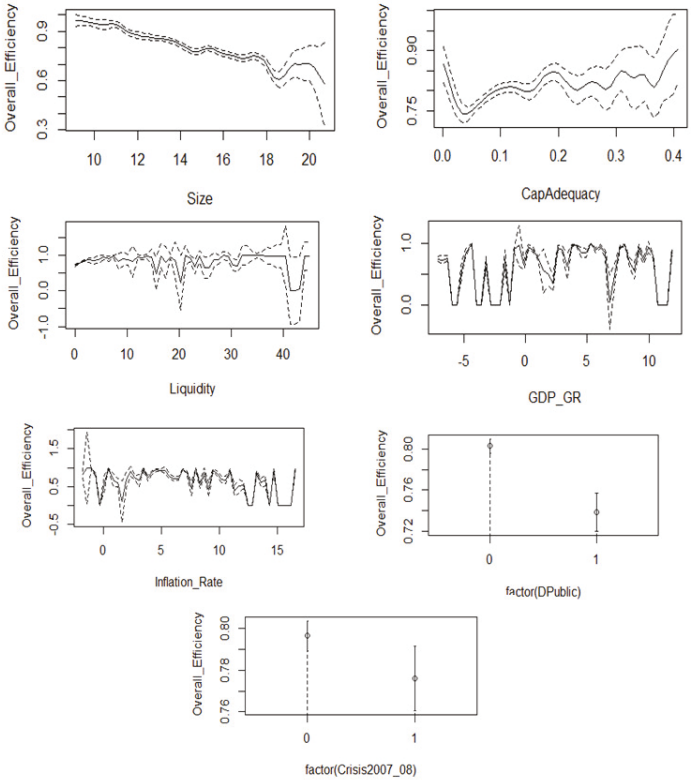

Figure 4. The relationship between technical efficiency, bank characteristics (size, capital adequacy, liquidity and public bank dummy), macroeconomic indicators (GDP growth rate and inflation rate), and the financial crisis of 2007–2008.

Higher bank efficiency scores were found at low to moderate rates of inflation. Vu and Nahm (2013) also found that low inflation was associated with high levels of bank efficiency. As inflation exceeded 6%, the relationship became somewhat more volatile and declining efficiency scores were observed.[6] With inflation rates in excess of 10%, efficiency scores showed great variation and declined

[5] In our sample, the economies of countries such as Greece, Hungary, Czech Republic, Turkey, and UAE experienced negative growth rates and poor bank efficiency during various sub-periods.

[6] In our sample, the economies of countries such as Turkey, Argentina, Indonesia, Malaysia, and Pakistan experienced high inflation at various sub-periods and highly volatile technical efficiency scores for banks.

sharply. This finding is consistent with that of Batir et al. (2017) who pointed out that high inflation caused the efficiency of banks to decline.

The ownership status of banks indicates that public banks performed significantly poor at the 1% level of significance as compared to private banks. Several other studies pointed out the poor performance of public banks; for example, private banks were more efficient than public banks in Czech Republic and Poland (Weill 2003); public banks were less efficient compared to private banks in 15 East European transition countries (Fries and Taci 2005); joint-stock banks which were not owned by the government were found to be more efficient than state-owned banks in China (Xiaoqing Maggie and Heffernan 2007).

The results of Model III suggested that the financial crisis of 2007–2008 caused efficiency scores to decline in emerging economies. The regional banks in East Asia, Southeast Asia, and Latin America performed significantly better with p-values < 0.01. The banks in these regions had a lower proportion of non-performing loans in their portfolios. In contrast, banks in the regions of South Asia and Emerging Europe performed significantly poorly with p-values < 0.01.[7] The banks in these regions had a high proportion of non-performing loans (see Table 4). This suggests that the negative impact of the crisis on bank efficiency was associated with the accumulation of non-performing loans.

6. Concluding Remarks

The present study modeled banking operations as consisting of two stylized stages—the deposit mobilization stage, and the loan financing stage—and separately estimated technical efficiency at each stage. An important feature of the study was the use of a cross-country panel dataset for efficiency measurement. To the best of our knowledge, no other study estimated technical efficiency for a panel or emerging economy banks using network DEA and directional distance functions featuring NPLs. This research design made it possible to perform regional comparisons of bank efficiency and also to investigate the impact of global macroeconomic shocks. Our results indicated that lower efficiency scores were concentrated in regions where the proportions of non-performing loans in banks' loan portfolios were higher.

The results obtained allowed not only profiling the efficient banks, but also a meaningful characterization of the macroeconomic environment conducive for achieving higher levels of bank efficiency. The efficient banks were smaller, better capitalized, and privately owned. The macroeconomic conditions conducive for bank efficiency were a growing economy, and low to moderate inflation rates (below ~5%). The financial crisis of 2007–2008 negatively impacted the technical efficiency of banks. The analysis of regional patterns of efficiency scores suggested that the most vulnerable banks were located in regions (South Asia and emerging Europe) where the proportion of non-performing loans was high.

Policy Implications

The study provides several policy implications. Our results indicated that banks need to be sufficiently capitalized. This may require regulations setting capital adequacy requirements that the bank could achieve by attracting capital from shareholders and investors, or acquired through mergers and acquisitions. Our results also support regulatory authorities forcing the less capitalized banks to merge.[8]

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[7] The negative impact on efficiency of banks was due to generating higher NPLs and administrative expenses faced by banks as a result of crises in the regions of South Asia and emerging Europe.

[8] For example, if a small bank is merged with a large bank, then it is an empirical question whether or not the effect of the larger size on efficiency would outweigh the effect of improved capital adequacy. This study helps answer such empirical questions.

A high proportion of non-performing loans increases the risk of bank failures, macroeconomic crisis, and contagion, depending on whether the accumulation of non-performing loans took place at a single bank, within the banking system, or in countries across the region, respectively.

Finally, good macroeconomic management provides an environment in which banks can perform efficiently. Our results indicated that two dimensions of this environment were economic growth and low inflation.

Author Contributions: The research problem was identified by A.Q.; the analytical solution was pointed out by K.R.; The algorithmic implementation was performed by A.Q.; Both authors contributed to the specification of models and the interpretation of results; the paper was written by A.Q. with input from K.R. who also supervised the research.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

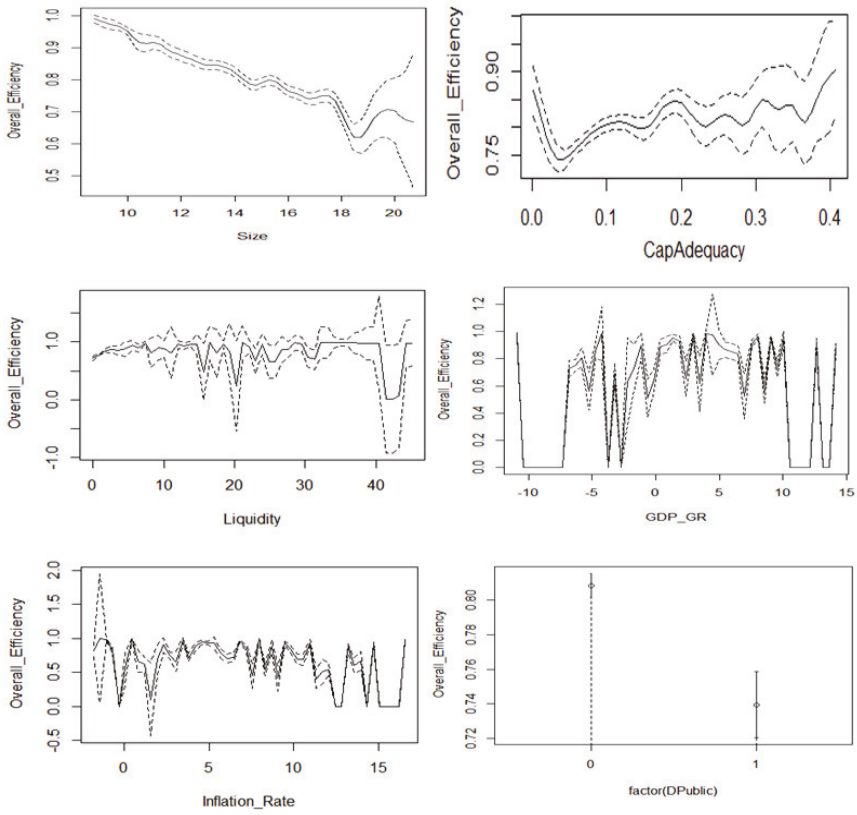

Figure A1. The relationship between technical efficiency, bank characteristics (size, capital adequacy, liquidity and public bank dummy), and macroeconomic indicators (GDP growth rate and inflation rate) (Model II).

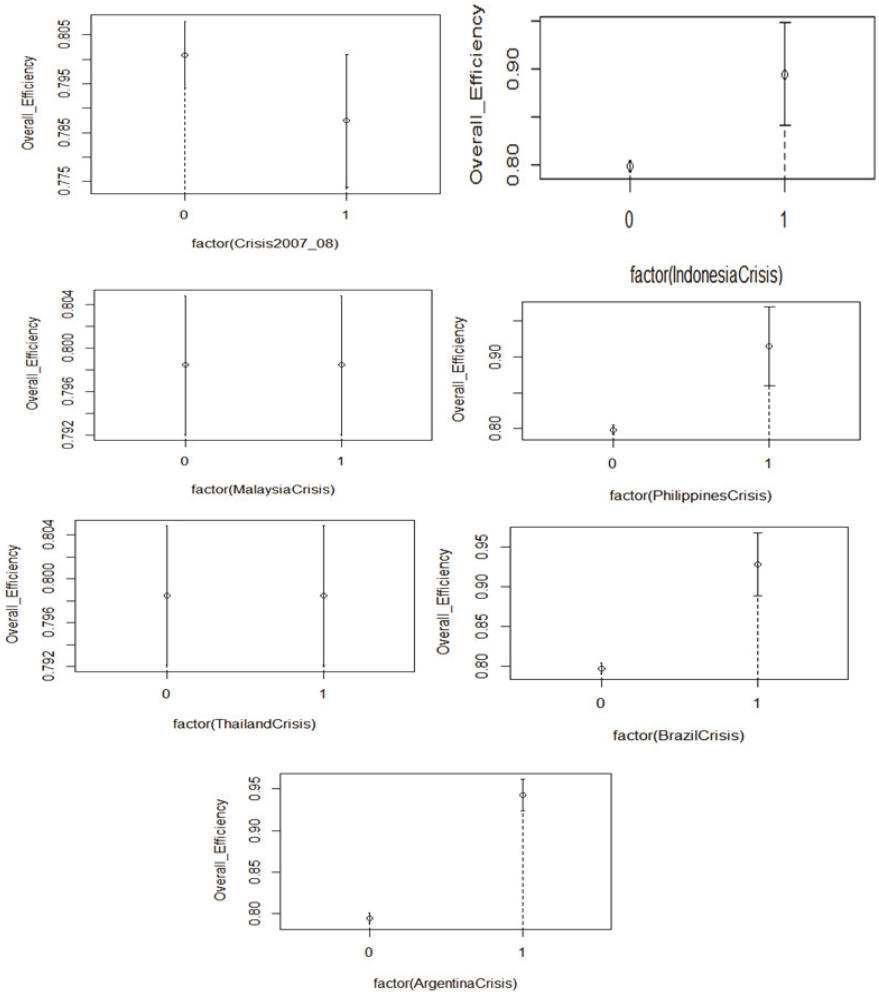

Figure A2. The relationship between technical efficiency and the financial crisis of 2007–2008, along with country crisis dummy variables (Indonesia crisis 1999 dummy, Malaysia crisis 1999 dummy, Philippines crisis 1999–2001 dummy, Thailand crisis 1999–2000 dummy, Brazil crisis 1999 dummy and Argentina crisis 1999–2002 dummy) (Model II).

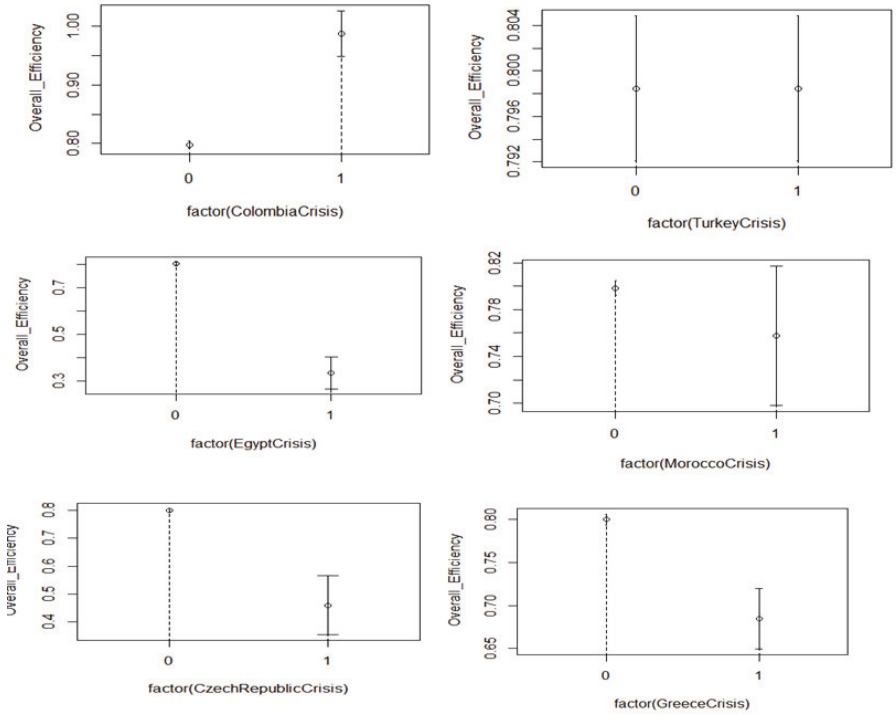

Figure A3. The relationship between technical efficiency and country crisis dummy variables (Colombia crisis 1999 dummy, Turkey crisis 2001 dummy, Egypt crisis 2011–2013 dummy, Morocco crisis 2009 dummy, Czech Republic crisis 2009–2011 dummy and Greece crisis 2009–2013 dummy) (Model II).

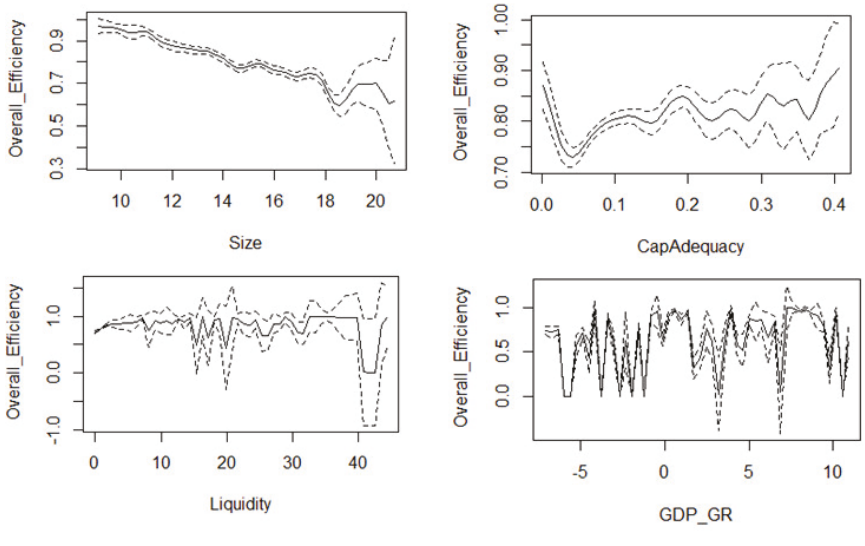

Figure A4. *Cont.*

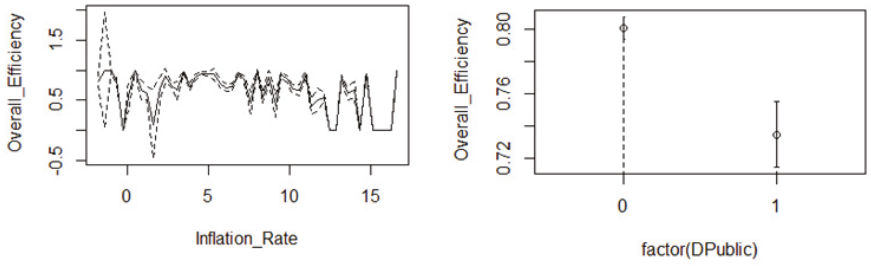

Figure A4. The relationship between technical efficiency, bank characteristics (size, capital adequacy, liquidity and public bank dummy) and macroeconomic indicators (GDP growth rate and inflation rate) (Model III).

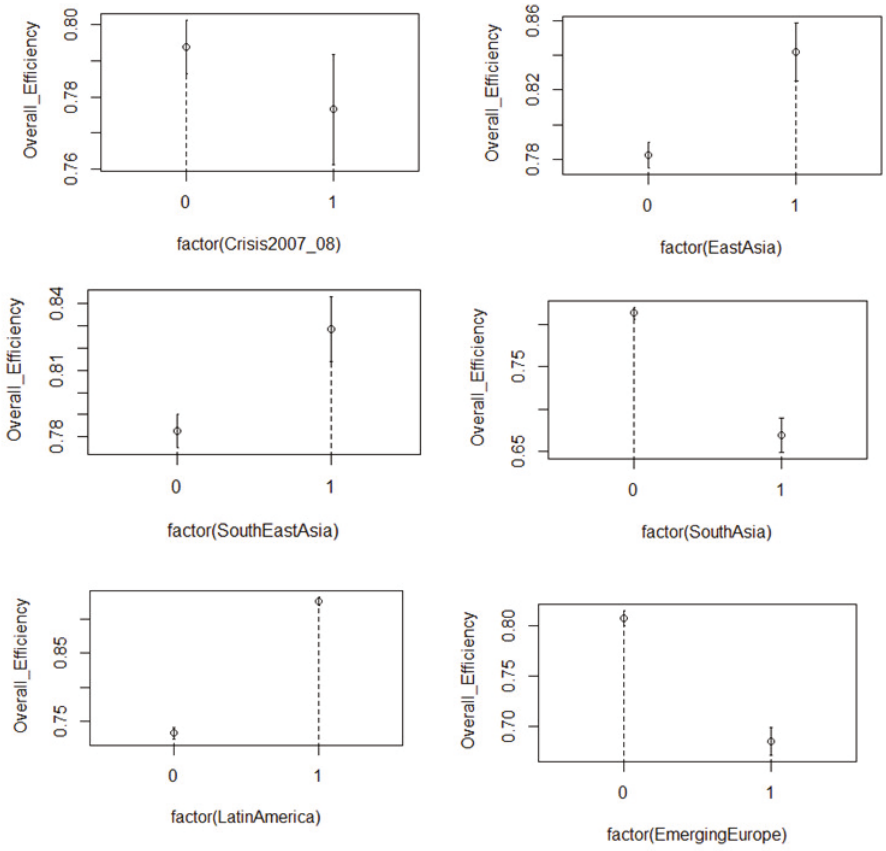

Figure A5. The relationship between technical efficiency and the financial crisis of 2007–2008, along with regional dummy variables (East Asia dummy, Southeast Asia dummy, South Asia dummy, Latin America dummy and emerging Europe dummy) (Model III).

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A Test of Market Efficiency When Short Selling Is Prohibited: A Case of the Dhaka Stock Exchange

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Abstract: A ban on short selling exists on several exchanges, especially in emerging markets. In most cases, short selling has always been prohibited, thus making it difficult to examine the ban's effect on price discovery. In this paper, we consider data from the Dhaka Stock Exchange (DSE) to test for a short selling ban on market efficiency. The analysis examines runs in daily stock returns and then forms a distribution of return clusters according to their duration. Using Monte Carlo simulation, we find that runs of longer duration appear more frequently in the DSE data than we would expect in efficient markets. We compare these results to stocks in the Dow Jones Industrial Average (DJIA). We find that the same runs tests accord with market efficiency for liquid and easily shorted DJIA stocks.

Keywords: emerging market exchange; market efficiency; non-parametric tests of efficiency; Monte Carlo simulation

1. Introduction

The practice of short selling and profiting from a fall in share price has been around for at least four centuries. In 1609, Isaac Le Maire formed a secret company to short shares in the East India Company in anticipation of a new French firm that would offer stiff competition (Bris et al. 2007). As events played out, the creation of the French rival never occurred, and the ensuing litigation provided yet another argument to ban short selling practices in the marketplace.

Potential abuse has led regulators to ban short selling in a number of national exchanges. Restrictions on short selling are especially commonplace in emerging markets, and exist because of an outright ban or lack of institutional mechanisms to borrow stock.[1] Moreover, in many of these markets there are no parallel option markets to effect a short sale through the buying of puts or writing of calls. As short selling restrictions inhibit information flow, market prices may be slow to adjust to news.

While potential abuse has led to a ban on short selling in a number of exchanges, a strain of research suggests that short sale restrictions may inhibit the price discovery process. For example, Miller (1977) argues that with divergence of opinion, a short sales ban results in the overvaluation of a security. Diamond and Verrecchia (1987) develop a formal model to discuss the importance of short selling in the asset price adjustment process. They show that constraints do not bias prices upward, although they do reduce the adjustment speed of prices to private information.

One way to test for the effect of a short selling ban is to investigate any differences in price discovery across regime shifts. For example, Beber and Pagano (2013) examine how temporary bans

[1] For a list of global short selling regulations, see Jain et al. (2013).

in short selling around the world following the financial crisis of 2007–2009 led to a deterioration in market liquidity.

This was especially true for stocks with small market capitalization and no listed options.[2] They displayed slower price discovery, especially in bear markets.[3]

A short selling ban may hinder price discovery even when news is positive. This can occur if investors overreact to information, leading to a reversal of prices (see, De Bondt and Thaler 1985). Atkins and Dyl (1990) first find evidence of market overreaction using daily returns. To the extent that market corrections require a decrease in returns, a ban on short sales may further inhibit the price discovery process.

In the following analysis, we examine the effect of short sale restrictions on market efficiency for the Dhaka Stock Exchange (DSE). The DSE has always had a ban on short selling of securities, so performing any type of test that depends upon a regime change is not possible. Instead, we rely on a battery of runs tests to examine market efficiency and the ability of prices to adjust rapidly to new information. In particular, we test for statistical independence, and employ a standard non- parametric runs test that looks at clusters of price changes in the same direction.

To further test for the effect of short selling restrictions, we also consider the distribution of daily price runs. Any evidence of an asymmetric distribution with an unusual number of long, negative return runs would suggest that a ban on short selling inhibits rapid price adjustment to adverse information. On the other hand, if investors overreact to positive news, a short sale ban may delay any market correction. In this situation, the distribution of daily price runs would display an unusual number of longer runs with positive price changes.

Previous work on the Dhaka Stock Exchange provides conflicting evidence regarding market efficiency on the Dhaka Stock Exchange. Islam and Khaled (2005) consider DSE index returns for the period 1990–2001. They suggest that structural changes put in place after the market crash of 1996 led to market efficiency. Their statistical tests show short term predictability of share prices prior to the crash, but not subsequently.

Mollik and Bepari (2009) use the runs test to investigate the weak form market efficiency of the DSE. They examine two stock indices from 2002–2007 to see whether there was an unusual number of runs. In contrast to Islam and Khaled (2005), they find that returns do not follow a random walk, and reject weak form efficiency of the DSE in the post-crash period.

In addition to DSE index returns, Mobarek et al. (2008) examine individual stock returns from 1988–2000 provided by a data vendor. Even allowing for structural changes following the 1996 crash, they find that there is significant auto correlation over the sample period. They reject weak form market efficiency and call for additional studies using market price information.

Our analysis updates the sample time period, and following the suggestion of Mobarek et al. (2008), examines the dynamics of individual stock price data obtained directly from the exchange. This allows us to also adjust for dividends, share splits, and other corporate events. Additionally, we introduce runs tests that specifically investigate for the effect of short sale restrictions on price adjustment; for robustness, we compare our results to evidence from the U.S. and Australian stock markets.

The runs test analysis suggests that DSE stock returns are not independent. Moreover, DSE stock prices appear to incorporate information more slowly than one would expect, with the daily runs

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[2] Swidler (1988) provides one early empirical study of the effect of short shale restrictions on stock prices and the further effect when there is option trading. He shows that with heterogeneous expectations, estimation risk is more important than short selling restrictions in explaining asset returns. Moreover, for stocks with listed options, investors can synthetically sell short via long puts or short calls. The evidence finds that for stocks with listed options, only estimation risk is important in determining asset returns.

[3] Still another study that looks across regime changes is Wang (2014). He finds that when Chinese regulators lifted the short selling ban on 90 stocks in 2010, they experienced a significant price decline. Moreover, the price declines were positively related to the amount of short selling and is consistent with the notion that short selling can be used as a mechanism to correct for overvaluation.

distributions exhibiting fatter tails for DSE stocks than for US stocks. In other words, for both good and bad news, the DSE ban on short selling causes prices to adjust more slowly to a new equilibrium, resulting in a disproportionate number of lengthy return runs. For emerging market exchanges that have never experienced short selling, this novel application of the runs test provides a valuable tool to analyze the effect of short sale restrictions on asset price dynamics.

2. Data and Methodology

2.1. Data

The analysis focuses on the 21 most liquid stocks on the Dhaka Stock Exchange (DSE). We use daily stock prices from January 1999 through December 2014. This yielded roughly 4000 stock prices for each of the 21 different stocks.

In addition to looking at individual stock price changes, we also consider stock indices representing the DSE market as a whole. As no single broad index exists for the entire sample period, we rely on two of the more popular indices. The DSE Broad Index, referred to as DSEX, represents 97% of market capitalization. This free-float broad index became effective in 2013. The previous broad index, the DSE General Index or DGEN, existed from December 2002 until July 2013. We thus use the DGEN index from December 2002 through July 2013, and continue with the DSEX index from August 2013 through the end of 2014. Hereafter, we will refer to the broad market index as the DSEX, recognizing that it represents both the DGEN and DSEX in their respective sample periods.

The Dhaka Stock Exchange library provided daily stock prices and data for the Dhaka Stock. We adjust all prices for cash and stock dividends, splits, bonus and right shares. It is important to remember that the 21 individual stocks chosen are the most liquid stocks, have trading on virtually every business day; therefore, they are likely among the most efficiently-priced stocks on the Dhaka Stock Exchange.

For matters of robustness, we compare the DSE results to similar tests using US data. Specifically, we consider the Dow Jones Industrial Average and the component stocks. The analysis covers the similar 1999–2014 period for individual stocks and 2002–2014 for the DJIA index. Because Visa was only a constituent stock of the index for part of the time, we exclude it from the analysis. Thus, we examine price dynamics for the DJIA index and the remaining 29 stocks.

2.2. Methodology—Calculating Runs and Testing for Statistical Independence

The runs test is a non-parametric test that can be used to examine randomness in stock returns. Let returns be defined as $(P_{t+1} - P_t)/P_t$, where P_t is the adjusted stock price on day t. We then define a run as a string of daily returns all of the same sign. If the data follows a binomial distribution, we assume that a 0 return continues the run. Thus, the end of a run and beginning of a new run is when the sign changes from either positive to negative, or vice versa. Put another way, the end of a run only occurs when there is a sign change.

To illustrate how runs are calculated, let P denote a positive return, N a negative return, and 0 denote no change in daily prices. Suppose that the price data yields the following string of returns:

PPPP N0N PP N PPP0P NNNNN PPP NN

This string of 25 daily returns includes 8 separate runs, the shortest being a 1 day run with a negative return, and the longest a 5 day run for both positive and negative returns.

Suppose, for the moment, we believe that 50% of returns are positive and 50% are negative. Given this binomial distribution, we can calculate the number of runs and see if it is more or less than the number we expect. If the number of runs differs significantly from what we expect, we reject the null hypothesis that the data was randomly generated and accept the alternative that the sequence was not produced in a random manner.

Comparing the number of runs to the expected value is a test of statistical independence. If, for example, we find significantly fewer runs than expected, that would suggest that the data is highly clustered. Thus, positive returns likely follow positive returns, and negative returns likely follow negative returns, a result that implies a positive serial correlation of returns. On the other hand, if there is little clustering and signs change frequently, such a pattern would indicate negative autocorrelation.

From the above discussion, we compare observed runs patterns to what we expect. In turn, expectations depend upon the true probability of success, for example, the probability of observing a positive return and the number of trials or observations in the sample. In our samples, the number of observations is approximately 4000 for stocks and 3200 returns for each index. With large samples, it is reasonable to assume as a first approximation that the observed frequency of positive outcomes is equal to the true probability of "success." Mollik and Bepari (2009) implicitly follow this line of reasoning and make this assumption in their runs tests.

Table 1 presents the percentage of positive returns and negative returns for each asset class. For both the DSEX and Dow Jones indexes, the observed frequency of positive returns is close to 53%. For stocks, however, the Dhaka and U.S. stocks diverge in the proportion of positive returns. For DSE stocks, the average frequency of positive returns is 46.33%, whereas for stocks in the Dow, the average percentage of positive returns is 51.13%.

Table 1. Proportion of Positive and Negative Returns (DSE vs. DJIA).

Indices/Sample Stocks	Period	Average Proportion of Positive Returns	Average Proportion of Negative Returns
DSEX	January 2002–December 2014	52.70%	47.30%
DJIA	January 2002–December 2014	53.06%	46.94%
21 DSE Stocks	January 1999–December 2014	46.33%	53.67%
29 Dow Jones Stocks	January 1999–December 2014	51.13%	48.87%

2.3. Methodology—Monte Carlo Simulation and Forming Expectations

To form expectations on the number of runs to expect in a sample, we rely on a Monte Carlo simulation. Consider the case of the DSEX that has 3119 returns. If we observe positive returns 53% of the time, we generate 3119 returns from the binomial distribution, with a success rate of 53%. We then count the number of runs found in our trial. The simulation then repeats this process 10,000 times to form a distribution of runs generated from all the trials.

Figure 1 illustrates the results of our 10,000 trial simulation given 3119 returns. Based on a success rate of 53%, 95% of the time we find that the number of runs is between 1497 and 1609. Thus, if the number of runs observed for the DSE Index is outside the 95% confidence interval, we reject the null hypothesis of statistical independence. If the number of runs exceeds 1609, that suggests negative serial correlation, whereas runs fewer than 1497 implies positive serial correlation.

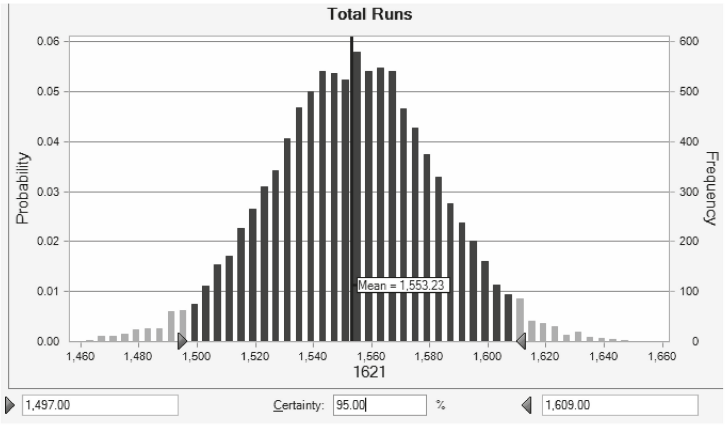


Figure 1. Monte Carlo Simulation for Number of Runs Observed over 10,000 Trials. This graph assumes the DSE based parameters of 3119 returns and a success rate of 53%.

We perform a similar Monte Carlo simulation for the DJIA index with 3272 returns. Again assuming a 53% success rate, 95% of the time the number of runs is between 1573 and 1685. If the observed number of runs is outside this confidence interval, we reject the null hypothesis of independent returns.

2.4. Methodology—The Distribution of n Day Runs and Implications for the Short Selling Ban

While the standard runs test considers statistical independence, it does not directly examine whether the tails of the runs distribution are larger than expected. If, as Diamond and Verrecchia (1987) and Beber and Pagano (2013) suggest, a short selling ban inhibits price discovery given bad news, then the returns distribution would be more negatively skewed than in an efficient market. This implies finding more runs than expected in the left hand tail of the distribution. Additionally, if markets overreact after good news, a short selling ban might impede a correction. If that were the case, we would observe longer, positive return runs than expected yielding a fatter right hand tail of the distribution.

To appreciate what the tails of the n day run distribution might look like, consider again the Monte Carlo simulation. For each trial, we can also collect the number of n day runs we observe. So for example, we can observe the number of two day, negative return runs (n = −2) in one trial. We can then generate the average number of −2 day runs for the 10,000 trials and calculate a 95% confidence interval for each n day run. We collect this information for all values of n starting with negative return runs of 10 days or longer (n = −10+) all the way up to positive return runs of 10 days or longer (n = 10+).

To give the flavor of what the tails of the distribution might look like, consider a probability of success equal to 50% for a sample of 4000 returns. Table 2 illustrates the tails of the distribution under these conditions. The second row shows the percentage of n day runs we observe, on average, for the 10,000 trials. From Table 2, negative and positive return runs of 10+ days each typically comprise 0.10% of all runs in a sample. Looking between |5| and |10+| day runs, we see that in total, this represents 6.16% of all runs (row 3, Table 2). Thus, the 5% tails of the distribution are for runs that are 5 days or longer.

In the following analysis, we examine the distribution of n day runs by splitting the sample into runs of 5 days or longer and runs between 1 and 4 days. Observing more runs than expected that are 5 days or longer suggests fat tails, and implies a short selling ban impedes price discovery leading to extended periods for markets to digest new information. If that result is obtained, it necessarily follows that shorter run periods (1–4 days) will have fewer runs than expected in an efficient market.

Table 2. Tails of the n day distribution (probability of success assumed equal to 50%).

−5	5	−6	6	−7	7	−8	8	−9	9	−10+	10+
3.14%	3.13%	1.56%	1.56%	0.78%	0.78%	0.39%	0.39%	0.20%	0.20%	0.10%	0.10%
3.13% *		4.69%		5.47%		5.86%		6.06%		6.16%	

* Cumulates percentages from day |5| to day n.

3. Empirical Results

3.1. Results for Statistical Independence of Index Returns

The first test is to see whether index returns are statistically independent. Consider the returns to the DSE index. In Table 3, we observe that the total number of runs based on DSEX returns equals 1334, below the lower bound of the 95% confidence interval. We reject the null hypothesis of statistical independence, and the fact that there are fewer runs than expected suggests a positive, serial correlation. For returns on the DSE index, similar sign returns follow each other more than expected, a result that indicates that the markets are slow to adjust to new information.

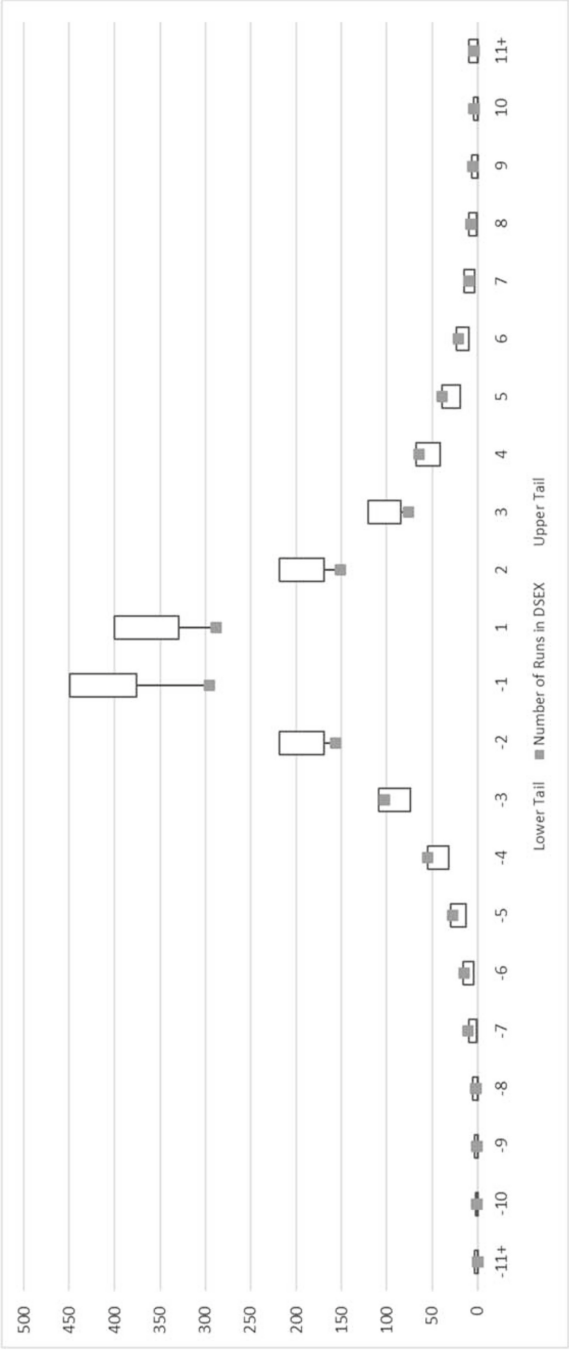
Table 3. Statistical Independence of Index Returns.

Indices	Actual Number of Runs	Lower Tail, 95% CI	Upper Tail, 95% CI
DSEX	1334	1497	1609
DJIA	1727	1573	1685

For returns on the Dow Jones Industrial Average, the number of runs equals 1727, which is slightly higher than the upper bound of the 95% confidence interval, 1685. This result also rejects statistical independence, instead implying a negative serial correlation of returns. A finding of slight negative serial correlation is in line with earlier studies of U.S. markets. Fama (1965), for instance, finds that 8 of the 30 stocks listed in the Dow had negative serial correlations, but that most of the serial correlations are less than 0.05. French and Roll (1986) repeat Fama's tests for NYSE and AMEX stocks during 1963–1982 period. They report a small but significant negative serial correlation of daily returns. To get a better idea of the runs distribution for both indexes, Figure 2A,B plots the number of n day runs and the 95% confidence intervals. From Figure 2A, the number of runs observed from −2 to +2 is well below the lower bound of each confidence interval. Conversely, the number of obtained longer runs tend to be higher than expected. In comparison, Figure 2B illustrates the runs distribution for the Dow Jones index. Short runs (−2 to +2) occur slightly more often than expected, while longer n day runs happen within expected boundaries. These results further confirm our previous findings. For the DSE index, information is more slowly digested in the market, thus yielding positive, serial correlation. On the other hand, for the U.S. index, runs accord nearly as anticipated, with only slightly more short-term runs than one might expect in an efficient market. In the next section, we consider the runs pattern for the individual stocks in both the DSE and DJ indexes and see if similar results are obtained.

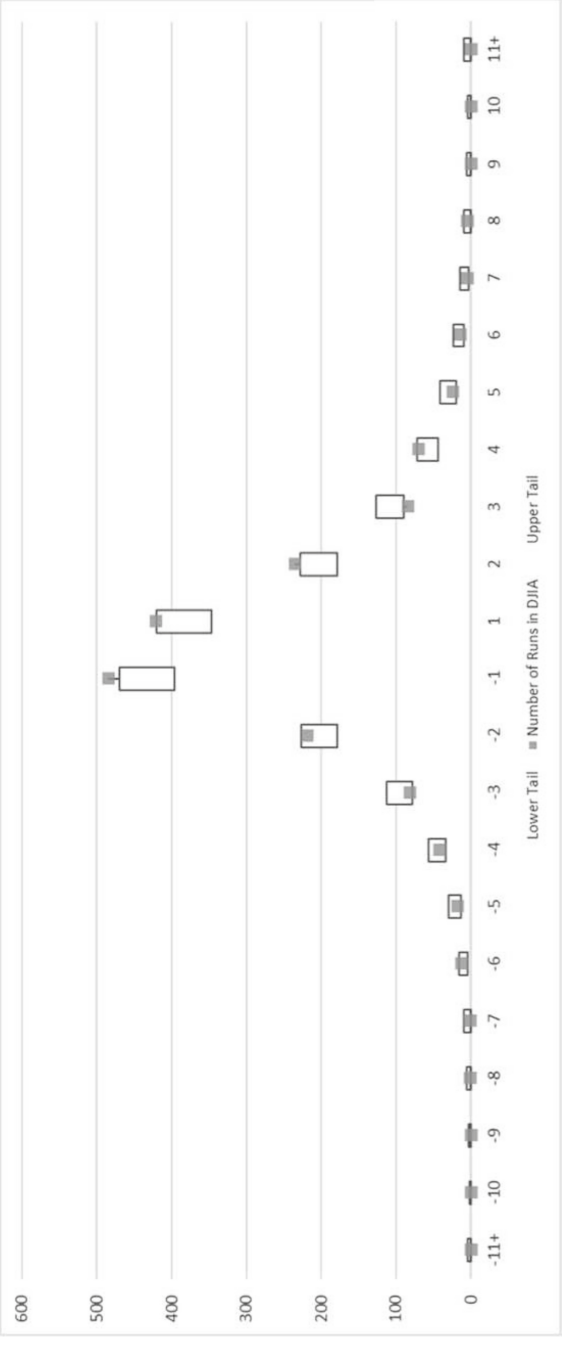
3.2. Run Results for Individual Stock Returns

In order to examine runs for individual stocks, we must first investigate the success rate of a positive return occurring for each firm in our sample. Figure 3A,B graph the percentage of positive and negative returns for the 21 DSE and 29 DJ stocks in our sample. As reported earlier, the average success rate for DSE stocks is 46.33% and equals 51.13% for DJ stocks. The figures reveal that the success rate for each individual stock is near the relevant average; therefore, we base our confidence intervals for DSE and DJ stocks on the 46.33% and 51.13% success rates, respectively.



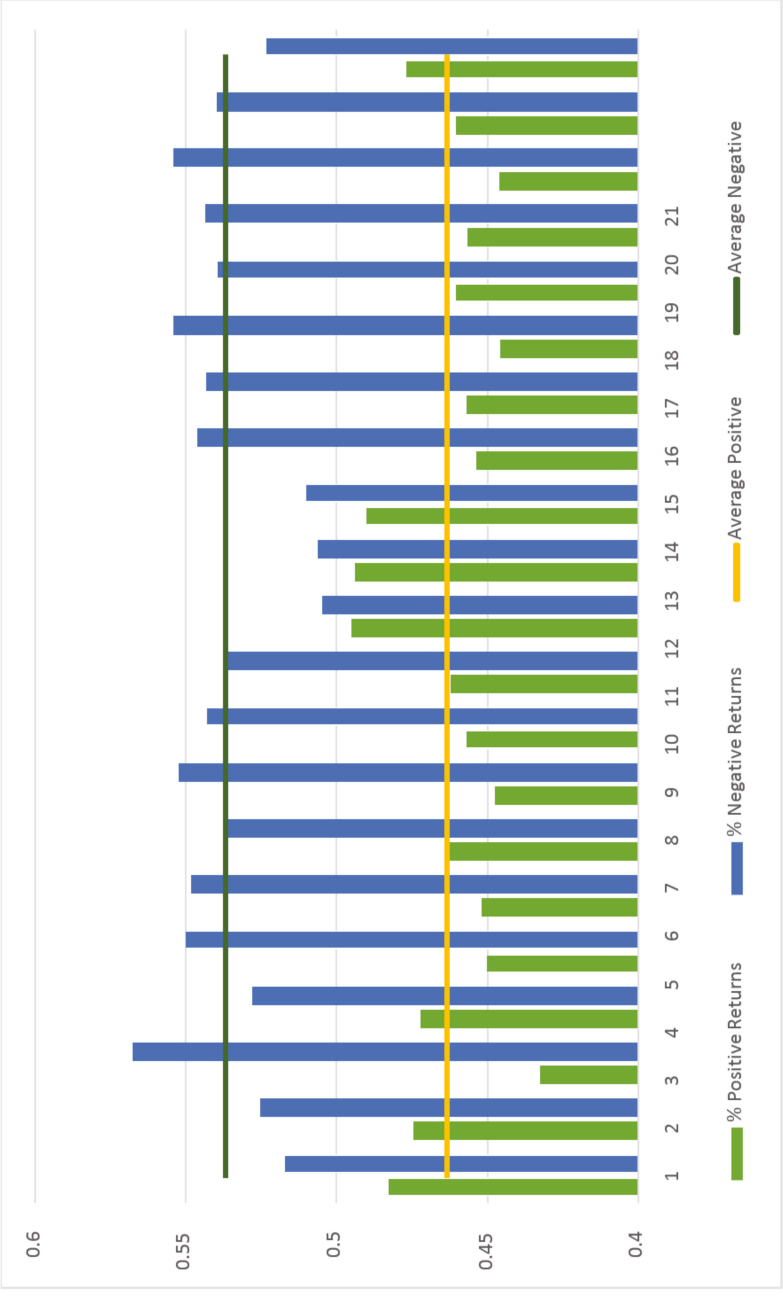
(A)

Figure 2. *Cont.*



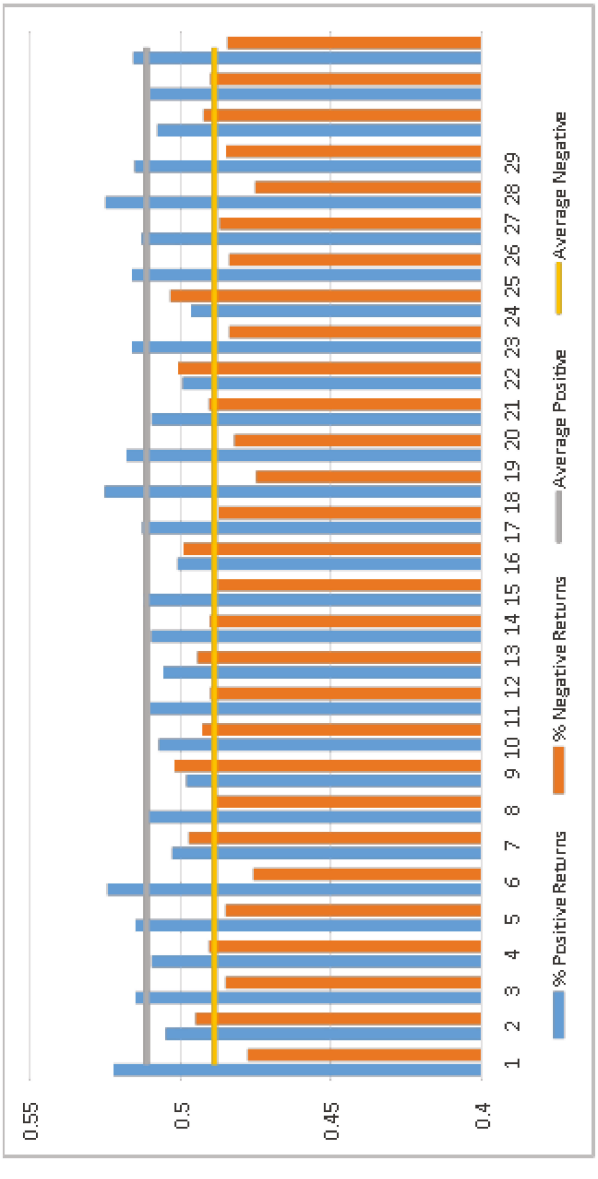
(**B**)

Figure 2. (**A**) DSEX Number of n Day Runs and 95% Confidence Intervals; (**B**) DJIA Number of n Day Runs and 95% Confidence Intervals.



(A)

Figure 3. *Cont.*



(B)

Figure 3. (**A**) Percentage of Positive and Negative Returns in Each of the 21 DSE Stocks. Average success rate (positive returns) equals 46.33% for DSE stocks; (**B**) Percentage of Positive and Negative Returns in Each of the 29 Dow Jones Stocks. Average success rate (positive returns) equals 51.13% for Dow Jones stocks.

Table 4A displays the number of runs in the middle of the distribution for each of the 21 DSE stocks. From before, that includes runs that are between 1 and 4 days, and represents almost 90% of the distribution. Table 4B exhibits the number of runs for the same 21 firms, except in this panel, |n| is equal to or greater than 5. This region represents the tails of the distribution, and covers approximately 10% of all runs.

Table 4. (**A**) Number of Runs in the Middle of the Distribution (n between −4 and +4) for DSE Stocks. (**B**) Number of Runs in the Tails of the Distribution (|n| equal to or greater than 5) for DSE Stocks.

(A)

CI 46.33%	**LB 55** **UB 87**	**113** **155**	**221** **278**	**426** **501**	**494** **577**	**223** **279**	**95** **135**	**40** **68**
Stocks	**−4**	**−3**	**−2**	**−1**	**1**	**2**	**3**	**4**
Square Pharma	78	112	247	367	430	229	95	63
Heidelberg	73	141	235	399	467	231	114	60
Shinepukur	78	143	235	312	429	247	107	44
National Bank	75	133	222	348	390	235	118	61
Beximco Pharama	76	142	244	299	401	223	119	64
Fu-Wang Ceramic	71	144	226	356	430	246	113	54
Olympic Industries	72	125	238	401	464	252	115	55
Apex Foods	90	146	239	368	466	264	106	53
ACI	78	130	255	378	469	254	106	49
Aramit Limited	81	132	208	356	412	236	95	65
BATBC	62	138	232	400	427	236	115	56
Islami Bank	70	100	212	382	390	221	101	62
Padma Oil	38	79	180	320	330	188	56	46
Confidence Cement	82	139	209	391	463	231	114	68
Square Textile	49	108	180	305	346	155	80	45
Keya Cosmetics	71	109	186	310	346	185	87	46
Bangladesh Lamps	79	149	260	381	480	250	116	60
Monno Ceramic	79	130	253	399	495	250	98	
Quasem Drycells	83	115	208	325	399	243	95	47
Meghna Cement	87	148	242	362	450	256	104	59
Bata Shoes	67	137	253	430	509	217	119	57

(B)

CI 46.33%	**LB 0** **UB 10**	**0** **5**	**0** **7**	**2** **11**	**5** **18**	**12** **29**	**27** **49**	**16** **34**	**6** **19**	**1** **10**	**0** **6**	**0** **4**	**0** **2**	**0** **4**
Stocks	**−11+**	**−10**	**−9**	**−8**	**−7**	**−6**	**−5**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
Square Pharma	2	1	3	8	16	20	39	24	27	12	6	0	2	5
Heidelberg	0	2	4	3	13	26	38	25	21	8	4	3	1	1
Shinepukur	7	1	8	8	16	27	42	24	13	9	1	2	0	0
National Bank	3	2	2	7	19	27	38	38	17	7	6	2	2	0
Beximco Pharama	7	3	5	11	15	19	43	28	15	11	0	0	1	2
Fu-Wang Ceramic	5	2	11	5	14	22	41	31	10	9	5	0	0	0
Olympic Industries	0	1	5	4	14	22	57	25	17	3	6	2	0	0
Apex Foods	0	1	8	9	14	18	40	20	12	6	5	1	0	0
ACI	4	2	4	9	14	22	36	19	17	10	4	3	0	1
Aramit Limited	1	1	4	3	8	29	33	30	9	6	1	1	0	0
BATBC	0	3	4	6	15	14	31	27	16	10	8	2	3	5
Islami Bank	6	2	4	4	14	26	40	37	17	8	8	3	6	6
Padma Oil	3	0	4	5	6	15	24	18	12	9	3	3	3	1
Confidence Cement	2	1	3	10	12	26	48	27	12	4	2	2	0	0
Square Textile	2	0	3	3	8	27	31	24	10	2	2	3	2	0
Keya Cosmetics	4	2	6	2	12	24	44	29	10	7	3	3	0	0
Bangladesh Lamps	3	0	3	5	8	19	47	24	10	8	3	1	0	1
Monno Ceramic	2	6	2	4	8	20	46	31	15	5	3	0	0	1
Quasem Drycells	5	2	6	5	25	35	42	33	13	9	8	1	0	2
Meghna Cement	0	1	1	5	10	25	43	30	13	8	3	0	0	0
Bata Shoes	3	0	3	10	9	16	29	20	18	9	6	1	1	1

At the top of Table 4A,B are 95% confidence intervals for each n day run. For example, the number of expected 2-day, negative return runs (n = −2) is between 221 and 278. This assumes nearly 4000 stock

returns and a success rate equal to 46.33%. Any violation below the lower bound of the confidence interval is shaded a dark gray, while a light gray cell denotes an upper bound violation.

From Table 4A, we observe a number of confidence interval violations. All but one breach the lower bound of the relevant 95% band. In contrast, Table 4B reveals several violations of the confidence interval's upper bound. Taken together, these results suggest that the n day run distributions have a skinnier than expected middle, and have fat tails. This evidence implies that the short sale ban on the Dhaka Stock Exchange contributes to market lags in fully digesting information. Long runs for both positive and negative returns occur more frequently than you would expect if returns were independent.

As a matter of robustness, we compare these findings to the run distributions of U.S. stocks and see if similar results are obtained. Table 5A,B replicate the analysis for 29 of the 30 stocks in the DJIA. The Dow Jones results are in stark contrast to those of the stocks in the DSE. Specifically, we note relatively few violations for the U.S. stocks. Roughly 5% of the entire sample breach the confidence intervals, as we would expect. Moreover, the violations are not all in one direction for the middle of the distribution and the other direction for the tails. Breaches of the upper and lower bound violations appear randomly sprinkled throughout Table 5A,B. Thus, the Dow Jones stocks, unlike those in the DSE, have n day return distributions which are consistent with return independence. Thus, the results suggest that U.S. markets incorporate information readily, and that returns follow some type of Markov process.

Table 5. (**A**) Number of Runs in the Middle of the Distribution (n between −4 and +4) for Dow Jones Stocks. (**B**) Number of Runs in the Tails of the Distribution (|n| equal to or greater than 5) for Dow Jones Stocks.

(**A**)

CI 51.13%	**LB 46** **UB 75**	**104** **144**	**225** **280**	**473** **554**	**453** **537**	**224** **278**	**108** **149**	**51** **80**
Stocks	**−4**	**−3**	**−2**	**−1**	**1**	**2**	**3**	**4**
Apple Inc.	60	138	264	512	506	236	137	60
American Express Company	57	128	270	550	544	261	143	57
The Boeing Company	58	130	235	550	507	273	109	65
Caterpillar Inc.	65	127	248	485	468	256	121	69
Cisco Systems, Inc.	63	147	274	498	522	244	104	75
Chevron Corporation	57	126	264	529	499	246	127	73
E.I. du Pont de Nemours and Company	57	127	260	512	516	242	127	66
The Walt Disney Company	58	143	269	484	482	250	122	80
General Electric Company	54	129	281	491	506	263	131	64
The Goldman Sachs Group, Inc.	63	116	262	521	511	253	116	73
The Home Depot, Inc.	76	115	268	514	506	253	119	64
International Business Machines Corporation	56	128	245	534	511	260	131	60
Intel Corporation	63	134	241	519	502	263	127	54
Johnson & Johnson	56	128	274	514	505	254	141	56
JPMorgan Chase & Co.	53	139	266	535	527	270	142	57
The Coca-Cola Company	56	121	240	533	508	246	116	66
McDonald's Corp.	56	133	244	530	467	256	143	66
3M Company	59	127	266	517	499	247	135	55
Merck & Co. Inc.	68	112	271	480	470	230	156	64
Microsoft Corporation	58	140	248	530	535	256	124	60
Nike, Inc.	75	123	281	484	470	250	146	75
Pfizer Inc.	70	108	260	504	503	260	122	61
The Procter & Gamble Company	56	123	273	527	500	263	130	73
The Travelers Companies, Inc.	51	107	265	560	525	264	126	65
UnitedHealth Group Incorporated	53	128	246	541	486	267	125	65
United Technologies Corporation	60	118	287	546	523	266	133	69
Verizon Communications Inc.	53	113	279	519	527	237	131	68
Wal-Mart Stores Inc.	62	125	259	543	519	260	136	62
Exxon Mobil Corporation	39	127	278	565	530	270	138	57

Table 5. *Cont.*

(B)

CI 51.13%	0 5	0 3	0 4	0 8	2 13	7 22	19 41	23 46	10 25	3 15	1 9	0 5	0 4	0 9
Stocks	**−11+**	**−10**	**−9**	**−8**	**−7**	**−6**	**−5**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
Apple Inc.	0	0	0	0	6	9	26	31	23	6	7	4	3	1
American Express Company	0	0	0	4	4	14	29	27	7	9	4	3	1	0
The Boeing Company	0	0	3	1	5	10	36	37	25	4	5	1	2	0
Caterpillar Inc.	0	1	1	1	7	20	31	31	25	8	4	2	2	0
Cisco Systems, Inc.	0	0	1	2	2	9	24	40	15	9	5	4	1	1
Chevron Corporation	1	0	1	2	1	12	27	44	14	5	5	5	1	1
E.I. du Pont de Nemours and Company	1	1	3	4	7	14	29	33	15	11	1	3	0	1
The Walt Disney Company	0	2	1	5	6	13	19	33	18	10	2	2	0	1
General Electric Company	0	1	0	5	9	16	31	30	8	5	5	2	2	1
The Goldman Sachs Group, Inc.	1	0	1	4	3	12	30	33	17	4	3	0	0	2
The Home Depot, Inc.	1	0	1	4	6	12	21	47	12	10	5	1	0	0
International Business Machines Corporation	1	1	1	2	8	12	36	34	11	11	3	1	0	2
Intel Corporation	0	0	1	2	5	8	42	30	21	7	5	3	1	2
Johnson & Johnson	0	1	1	3	6	12	27	37	13	7	4	4	1	1
JPMorgan Chase & Co.	0	1	0	2	8	14	29	31	14	3	2	1	1	0
The Coca-Cola Company	1	0	2	2	8	15	34	35	24	7	8	1	1	0
McDonald's Corp.	1	0	2	1	5	12	25	46	15	12	1	2	0	1
3M Company	0	2	0	1	8	10	26	44	20	11	1	1	1	2
Merck & Co. Inc.	1	2	0	5	5	18	26	34	24	5	2	1	1	1
Microsoft Corporation	0	1	0	3	8	17	29	29	15	9	4	1	0	1
Nike, Inc.	0	0	0	0	7	12	22	35	14	8	3	2	0	1
Pfizer Inc.	0	1	3	3	9	24	26	32	17	6	3	3	1	0
The Procter & Gamble Company	0	1	0	2	2	16	29	33	19	4	5	1	0	1
The Travelers Companies, Inc.	1	0	0	4	5	21	28	31	17	6	3	3	1	1
UnitedHealth Group Incorporated	0	1	0	4	11	13	17	32	15	11	4	4	4	2
United Technologies Corporation	0	0	2	2	9	10	16	31	16	8	1	2	1	0

3.3. Further Tests of Robustness—Causality

The previous analysis shows that markets with short selling bans exhibit positive serial correlation and fat tail return distributions. However, that does not necessarily imply that it is the prohibition of short selling that causes market inefficiency. Islam and Khaled (2005) note that "emerging stock markets are in many cases characterised by a lower volume and frequency of trading ('thin trading'), ease of manipulation by a few large traders, weaker disclosure and accounting requirements, settlement delays, and a generally less than smooth transmission of financial information." Thus, any or all of these conditions, rather than a short selling ban, might lead to market inefficiencies and the return distributions for DSE stocks that we document.

To link a short selling ban with positive serial correlation and fat-tail return distributions, we look for a developed market that experienced a recent short-selling ban to see if the return distributions are structurally different before after the ban. In contrast to emerging markets, exchanges in developed countries tend to be more liquid, less prone to manipulation, and have greater informational transparency. If after the structural shift the returns distribution changes and looks similar to our DSE results, we can conclude that it is the short selling ban, and not other market impediments, that is at the root of our findings.

To perform our analysis, we turn to a natural experiment precipitated by the financial crisis. Worldwide, a number of countries banned short selling of stock on their national exchanges at the onset of the financial crisis. In some cases, regulators restricted the short selling ban to the stock of financial intuitions. Thus, we can examine run distributions before and after the ban and look for any differences. However, to do that, the short selling ban period must be long enough for the sample of runs to be indicative of the underlying population.

From Beber and Pagano (2013), we find that one of the longest short sale bans occurred in Australia, where prohibition of short selling financial institution stocks occurred from 22 September 2008 to 1 June 2009, a total of 170 trading days. The Australian Stock Exchange (ASX Group 2018) is the

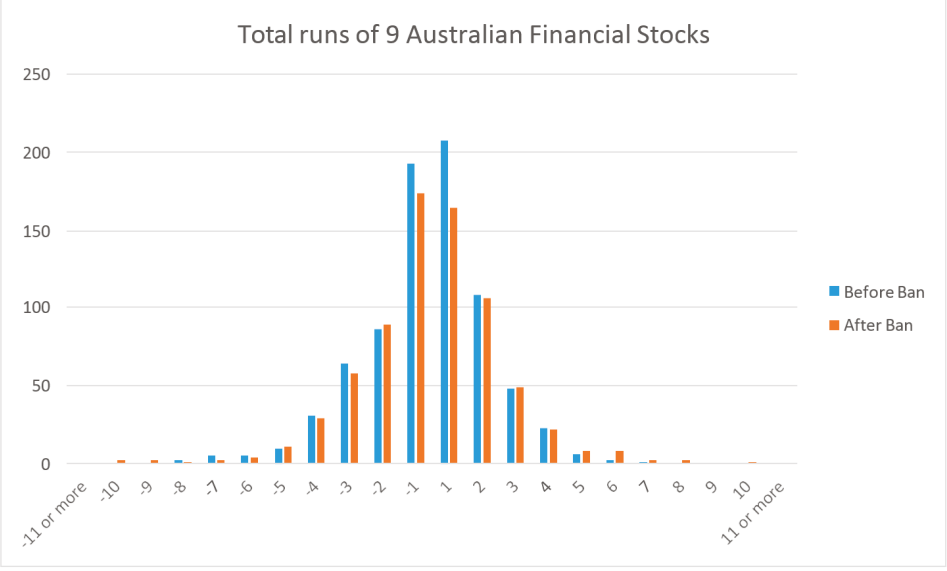
15th largest, with market capitalization of $1.442 trillion (World Federation of Exchanges 2017). In its corporate overview, the ASX states that it operates in a "world class regulatory environment", and its clearing houses are "among the most secure and well capitalised in the world." To further confine our analysis to the most liquid stocks, we examine the nine financial institutions in the ASX 200 index.

Table 6 illustrates the number of runs observed 170 days before and after the ban for each of the financial institution stocks in the ASX 200 index. In 7 of 9 cases, and in total, there are fewer runs after the ban. This result suggests that a short selling ban contributes to inefficiency and a positive serial correlation of returns.

Table 6. Number of Runs before (B) and After (A) Short Selling Ban in Australia.

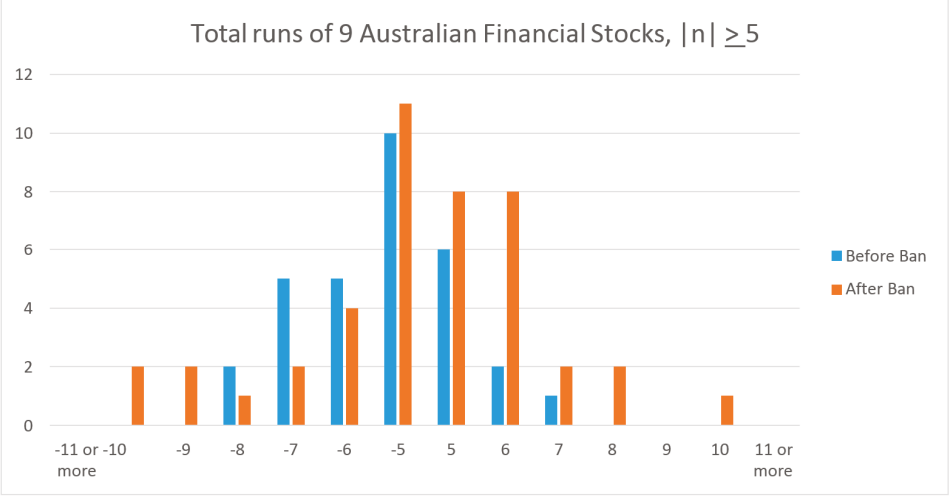
CBA	WBC	ANZ	NAB	MQG	SUN	QBE	AMP	ASX	Total
B 88	86	88	88	94	90	80	96	82	792
A 87	81	76	76	72	74	86	92	84	728

Given the limited number of banned short selling days, we artificially constructed a longer time period by combining all nine stocks into one distribution. This simulates a return run distribution covering approximately six years. Figure 4A graphs the number of runs both before and after the ban. Similar to our earlier DSE results, there are fewer short runs (4 days or less) and more long runs (5 days or more) during the period in which short selling is banned. Figure 4B more clearly illustrates the long runs observed in the tails of the distribution. There are several more runs of positive returns that are 5 days or longer after the ban. Whereas the longest positive return run observed is 7 days before the ban, after the prohibition of short selling, we find one 10 day run. For negative return runs, the longest period observed is 8 days, whereas there are several examples of 9 and 10 day runs after the ban. In total, evidence from a natural experiment shows that prohibiting short sales contributes to relatively greater frequency of long runs, and reflects the market's need for additional time to digest new information.



(**A**)

Figure 4. *Cont.*



(**B**)

Figure 4. (**A**) Runs Distribution for Australian Stock Returns Before and After Short Selling Ban; (**B**) Tails of the Runs Distribution for Australian Stock Returns ($|n| \geq 5$ days).

4. Concluding Remarks

Regulators for a number of national exchanges have banned the practice of short selling. This is often the case in emerging markets. Whether the reason is fear of market manipulation or simply the lack of an institutional framework to borrow shares, a short selling ban potentially impedes the impounding of information in market prices.

Previous studies typically consider the effect of a short selling ban on price discovery by examining price dynamics before and after changes in short selling regulations. However, for many exchanges in emerging economies, investors have never been able to short sell securities. Thus, testing for differences across regime shifts is not possible.

To address that problem, our analysis compares the return runs we observe to what we would expect if markets were otherwise efficient. We first construct a simple runs test for statistical independence of daily stock returns, a necessary condition for market efficiency. A run is a series of returns all of the same sign, and the test calls for comparing the total number of runs in a given time period to the expected number of runs. We use Monte Carlo simulation to determine the latter. We then extend the analysis by considering the number of days for each run and form a distribution of return clusters according to their duration. Again, we compare the distribution to expectations based on a Monte Carlo simulation. The extended analysis considers whether runs of longer duration appear more or less frequently than anticipated if markets are efficient.

Additionally, we examine the symmetry of the distribution to see whether any effects are obtained for both positive and negative return runs.

Using data from the Dhaka Stock Exchange, we examine whether a short selling ban affects market efficiency. The runs test provides strong evidence that returns are not independent. Moreover, a runs distribution reveals fat tails, implying that runs of longer duration appear more frequently in the DSE data than we would expect in efficient markets.[4] Thus, for both positive and negative return

[4] While a short selling ban appears to affect both tails of the runs distribution, the tests depend on the success rate, the percentage of positive returns observed. For all DSE stocks, the success rate is less than 50%, while for all Dow Jones stocks

runs, we observe a relatively large number of runs that are 5 days or longer. We next consider similar tests for the DJIA and stocks within the index. This list includes extremely liquid stocks that are easily shorted. In contrast to the DSE results, the runs tests generally accord with market efficiency. Finally, to further show causality, we examine Australian stock return runs before and after a ban on short selling. After the prohibition, the findings are similar to the DSE results and reproduce the longer time necessary for markets to reach a new equilibrium. The evidence taken as a whole suggests that a short selling ban delays the market's digestion of information. This is true for both positive and negative news. In light of these results, regulators may want to rethink the prohibition of short selling securities.

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the success rate is greater than 50%. Thus, it may be that a short selling ban affects the success rate itself causing these markets to exhibit negative returns more frequently. It should be noted that theory does not give any guidance to what the success rate must be if markets are efficient and follow some type of Markov process. Indeed, it can be shown that if stock prices follow some type of geometric Brownian motion, the success rate increases with the stock returns drift term and decreases with idiosyncratic risk and can theoretically be greater or less than 50%.

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Financial Risk Disclosure and Financial Attributes among Publicly Traded Manufacturing Companies: Evidence from Bangladesh

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Abstract: We explore the relationship between the degree of financial risk disclosure and a firm's financial attributes. Financial risk disclosure indices (FRDIs) are calculated based on a set of 30 disclosure identifiers through content analysis of the annual reports of 48 manufacturing companies over a six-year period (2010–2015) in Bangladesh. We find no common practice among the companies in disclosing financial risk by integrating a customized financial risk disclosure into their financial reporting process. The results indicate that firm size, financial performance, and auditor type are positively and significantly associated with the level of financial risk disclosure.

Keywords: financial risk; annual report; developing countries; financial attributes; Bangladesh

1. Introduction

Risk disclosure is information that describes firms' major risks and their expected economic impact on their current and future performance (Miihkinen 2010). The 2007–2009 global financial crises have significantly raised concerns about the aggressive risk taking of public companies, research interest in risk management, and disclosure around the world and triggered regulatory reforms from various government agencies and accounting standard setters (Dobler 2005; Rezaee 2016). Prior research (e.g., Linsley and Shrives 2006; Abraham and Cox 2007; Linsley and Lawrence 2007; Hasan et al. 2008) states that corporate risk disclosure has become an integral part of business disclosure because it provides greater transparency and increases investors' confidence in the context of developed countries and markets. The Dodd–Frank Act (DOF) of 2010 requires large financial institutions in the United States to have a board-level risk committee that oversees the assessment, management, and disclosure of financial risks (Dodd–Frank Wall Street Reform and Consumer Protection Act 2010). Aliabadi et al. (2013) find that the adoption of enterprise risk management (ERM) in assessing and disclosing risk reduces the risk-taking behavior of management. Prior research (e.g., Beasley et al. 2008; Pagach and Warr 2007) finds that firms with financial challenges and stock price volatility are more likely to adopt ERM and disclose their financial risk. However, the empirical evidence on financial risk disclosure in the context of developing countries is rare. As a result, this study attempts to bridge this gap by examining corporate financial risk disclosure in an emerging economy like Bangladesh.

Motivated by risk disclosure research and its inconclusive results in developed countries, we examine the association between financial risk disclosure and financial attributes in Bangladesh, one of the fast-developing markets and economies. We focus on financial risk disclosure in Bangladesh for several reasons. First, the 1996 and 2010–2011 Bangladesh stock market crashes indicate that

the traditional reporting culture fails to provide enough information to investors in making sound investment decisions (Das et al. 2015). Second, the Institute of Chartered Accountants of Bangladesh (ICAB) adopted the International Financial Reporting Standard No. 7 (IFRS-7) as Bangladesh Financial Reporting Standard (BFRS)-7 in 2010. BFRS No. 7 requires the disclosure of information relating to both recognized and unrecognized financial instruments, their significance, performance, accounting policies, terms, conditions, net fair value, and risk information, as well as company policies for controlling risk and exposure.

Third, the Bangladesh National Parliament enacted the Financial Reporting Act of 2015 (FRA) on 6 September 2015 (FRA 2015). The FRA requires the establishment of a new oversight body, referred to as the Financial Reporting Council (FRC). The main purpose of the FRC is to regulate the financial reporting procedure followed by the reporting entities. The FRA recognizes the major functions of the FRC and monitoring of financial reporting including risk assessment and management. The FRC is intended to bring a level of discipline into corporate financial reporting, and thus strengthen the safety and soundness of capital markets. From that perspective, this study could provide evidence pertaining to the efficacy of the FRA. Finally, the type and extent of risk disclosure vary and are influenced by the factors related to a given company in Bangladesh (Al-Mulhem 1997).

We posit that the degree of financial risk disclosure is positively associated with financial attributes. Our rationale for such an association is the following: (1) risk disclosure provides greater transparency and enhances investors' confidence that may lead to higher firm value; (2) leveraged firms are obliged to disclose more risk information to satisfy the needs of investors and creditors; (3) large firms are more exposed to public scrutiny than small firms, and hence they are more likely to disclose more information; (4) higher financial performance could persuade management to provide more information to demonstrate its ability to create shareholder value; and (5) liquidity risk might encourage reporting entities to enhance the extent of risk disclosure to notify shareholders that management is considering such a risk.

The theoretical intuition for our prediction of the relationship between risk disclosure and financial attributes is based on signaling theory and the institutional settings in Bangladesh. Signaling theory explains management's incentives for disclosing financial risk to differentiate its firm's risk tolerance and appetite from other firms with higher financial risk to avoid adverse selection problems (Verrecchia 1983; Ng and Rezaee 2015). The institutional settings are relevant to our study as many provisions of regulatory measures in Bangladesh specifically address management risk assessment and disclosure. For example, provisions of Section 184 of the Companies Act of 1994, Rule 12 of the Bangladesh Securities and Exchange Rules of 1987, Bangladesh Securities and Exchange Commission (BSEC), and Accounting Standards as adopted by the ICAB require that listed companies report their true and fair position to shareholders. After the adoption of IFRS-7 as BFRS-7, financial risk disclosure has been reinforced.

We use financial risk disclosure indices (FRDIs) calculated based on a set of 30 disclosure identifiers through content analysis to assess the level of financial risk disclosure in the annual reports of 48 manufacturing companies in Bangladesh over a period of six years (2010–2015). The association between the level of financial risk disclosure and firm specific characteristics has been examined using regression analyses. The content analysis of individual FRDIs shows that there is no common practice among the companies in disclosing financial risk and they treat financial risk disclosure in a heterogeneous way. However, the regression model reveals that firm size, financial performance, and auditor type are positively and significantly associated with the level of financial risk disclosure.

This study contributes to the accounting and business literature in several ways. First, this paper contributes to corporate risk disclosure literature in the Anglo-Saxon countries by using the setting of Bangladesh as a highly speculative and volatile capital market of an emerging economy. Second, this manuscript adds to relatively limited literature relating to risk disclosure in emerging economies and markets. Another contribution is the development of a risk disclosure index based on financial risk disclosure identifiers in the light of reporting standards, professional requirements, prior research, and

the regulatory framework of Bangladesh. The examination of the relationship between firm specific characteristics and the extent of financial risk disclosure not only enhances our understanding of the reasons behind the variation of the disclosure, but also assists policy makers in adopting the appropriate tools to alleviate inconsistencies. Third, this study provides policy and practical implications by finding an association between financial leverage and liquidity and the level of financial risk disclosure, which may stimulate the regulatory bodies of the country to consider it and act accordingly. Undoubtedly, the Institute of Chartered Accountants of Bangladesh (ICAB) has adopted IFRS 7 as Bangladesh Financial Reporting Standard 7 (BFRS 7) to ensure understandable, comparable, reliable, and transparent financial risk reporting for a sound, organized, and stable capital market in Bangladesh. However, empirical results document a compliance gap and suggest for full compliance of BFRS 7 without any deviation to achieve comparability and reliability in disclosing financial risk. An analysis of the link between the level of financial risk disclosure and the firm's attributes has not previously been done in the context of Bangladesh.

Fourth, we measure the level of aggregate disclosure (both mandatory and voluntary) on financial risk in the annual reports of Dhaka Stock Exchange (DSE) listed manufacturing companies in terms of financial risk indices for a period of six years from 2010 to 2015 in response to BFRS-7. Thus, this manuscript enables regulators, policy makers, and corporate managers to understand the financial risk disclosure pattern of publicly traded manufacturing companies in Bangladesh and to set an appropriate risk disclosure policy with guidelines to minimize the heterogeneous problem relating to corporate financial risk disclosure. Finally, prior related research does not directly address financial risk disclosure in emerging markets and economies.

The remainder of the paper is organized as follows: Section 2 presents the legal framework for disclosure in Bangladesh. The literature review is provided in Section 3. The theoretical framework and hypothesis development are presented in Section 4. Methodology, description of our sample, and descriptive analysis are provided in Section 5. The results and their interpretations are presented in Section 6 and the last section concludes the paper.

2. Legal Framework for Risk Disclosure in Bangladesh

Generally, each country has its own regulatory framework that governs corporate disclosure within the country. The corporate reports, in general, include information in accordance with reporting and disclosure requirements of the regulatory body, and as such, the reporting entity needs to provide at least the required amount of information to facilitate the evaluation of securities (Akhtaruddin 2005). In Bangladesh, the Companies Act of 1994, Securities and Exchange Rules 1987, and accounting standards adopted by ICAB provide the framework for corporate disclosure. The disclosure best practices can affect the extent of risk disclosure by listing regulations of stock exchanges (DSE and CSE—Chittagong Stock Exchange) and Income Tax Ordinance 1984. Besides, BSEC issues notifications and guidelines from time to time on different issues, which increases the level of corporate disclosure.

The Companies Act of 1994 provides the basic requirements for corporate disclosure and reporting in Bangladesh. The Act requires that the corporate financial statements must reflect the true and fair view of the reporting entity. Concomitantly, BSEC plays the leading role in monitoring and enforcing mandatory disclosure compliance of publicly traded companies. Moreover, Accounting Standards adopted by the ICAB, in addition to its own disclosure provisions, gain mandatory status through the directives of the BSEC.

3. Literature Review

Risk has different notions and researchers have defined risk disclosure in different ways and contexts. Basically, risk disclosure is the communication of information concerning a firm's strategies, characteristics, operations, and other external factors that have the potential to affect expected results (Beretta and Bozzolan 2004). Firms incur different types of risks to attain their

mission and aims throughout their life-cycle and management, and financial risks are among these (Lombardi et al. 2016). For our study, we have considered five categories of risks (i.e., capital structure risk, credit risk, liquidity risk, interest rate risk, and exchange risk) and the disclosure of these risks in annual reports. Several studies examine risk disclosure in developed countries including the United Kingdom (Linsley and Shrives 2006; Abraham and Cox 2007), Italy (Beretta and Bozzolan 2004), Canada (Lajili and Zéghal 2005), and Australia (Poskitt 2005). These studies address corporate overall risk with less emphasis on financial risk. Lombardi et al. (2016) examine financial risk disclosure in the setting of Italy by addressing the commodity price risk category.

In the context of Bangladesh, there are a few studies on corporate disclosure, including Akhtaruddin (2005); Hasan et al. (2008); Hasan et al. (2013); Das et al. (2015). Specifically, Akhtaruddin (2005); Hasan et al. (2008); and Das et al. (2015) investigate corporate mandatory disclosure, whereas Hasan et al. (2013) examine financial disclosure. These studies, while finding a positive association between corporate disclosure and financial attributes for firms in Bangladesh, do not directly address financial risk disclosure. Basically, financial risk disclosure practice started in Bangladesh after the adoption of IFRS-7 by the ICAB in 2010, hence its implementation is at an early stage. We contribute to the literature by providing an initial understanding and a portrait of financial risk disclosure practice in developing countries.

4. Theoretical Framework

Several theories are suggested in the accounting and finance literature in providing an explanation of the voluntary disclosure practices of business entities. The most common theories that are relevant to our research issues are the following: agency theory, signaling theory, political cost theory, capital need theory, and legitimacy theory. We briefly discussed these theories and their implications for our research because there is no specific theory perceived to explain the motivation for voluntary disclosure (Khlifi and Bouri 2010).

Agency theory can explain voluntary disclosure phenomena in many countries with a different social, political, and economic context (Ferguson et al. 2002; Akhtaruddin and Hossain 2008; Hossain and Taylor 2007). Disclosure is seen as a monitoring mechanism in agency theory. Healy and Palepu (2001) argue that demand for financial reporting and disclosure arises from information asymmetry along with agency conflicts between managers and outside investors. Prior research (Oliveira et al. 2011a, 2011b; Konishi and Ali 2007) uses firm size as a proxy for agency costs and assumes a positive association between disclosure and firm size and argues that leverage represents the agency cost between debt-holders and managers, and is thus reflected in disclosure practices.

Signaling theory also explains why companies voluntarily disclose information in their annual reports (Haniffa and Cooke 2002; Akhtaruddin and Hossain 2008). In accordance with this theory, a firm's information disclosure can be considered a signal to capital markets, directed to reduce information asymmetry that often exists between management and stakeholders, as well as to increase the firm's value (Connelly et al. 2011; Rezaee 2016).

Under political cost theory, firms with high political visibility in the market place tend to increase disclosure as a means of mitigating potential political costs. The political cost theory is usually discussed in relation to the corporate size hypothesis, in which the manager of a big corporation is more likely to select accounting procedures that defer reported earnings from current to future periods. (Milne 2002). The capital needs theory also helps explain the reasons behind companies' disclosure of voluntary information by suggesting that companies disclose more information to raise capital at the lowest cost (Core 2001). The capital needs theory predicts that increased voluntary disclosure is likely to lower the cost of capital because of the reduced uncertainty from an investor's perspective (Schuster and O'Connell 2006).

The legitimacy theory assumes that a company has no right to exist unless its values are perceived as being matched with those of the society at large in which it operates (Magness 2006). Companies may disclose information voluntarily for improving communication with society that helps societal

people to believe that the entities are operating within the social value system. In summary, the above theories have implications for financial risk disclosure in the sense that firms should assess, manage, and disclose risk to shareholders in compliance with agency theory, disclosing management risk appetite, and risk-taking under the signaling theory, focusing on financial risk disclosure as a means of mitigating political costs and government intervention in accordance with political cost theory, and communicating risk tolerance under legitimacy theory. Although all these theories are relevant to our study, the two prevailing theories that provide the foundations for our research hypotheses, as described in the next section, are the signaling and political cost theories. The signaling theory suggests that firms have incentives to disclose their good information to the capital markets and the political cost theory explains the institutional setting in Bangladesh.

5. Hypothesis Development

Dodd Frank Act of 2010 (DOF) was the United States Congress' response to the 2007–2009 global financial crisis primarily caused by a lack of proper risk assessment and management (Dodd–Frank Wall Street Reform and Consumer Protection Act 2010). The DOF Act requires banks in n establishing either a risk and compliance board committee or a risk and compliance executive position. Prior research (e.g., Beasley et al. 2008; Aliabadi et al. 2013) argues that firms with financial challenges and high stock price volatility are more likely to adopt ERM in managing and disclosing their risks. Earlier empirical studies (e.g., Oliveira et al. 2011a, 2011b; Alsaeed 2006; Kamal Hassan 2009) that examined the relationship between the extent of disclosure and firm-specific attributes have shown that there are several firm characteristics that may influence the extent of disclosure in annual reports. Based upon theoretical discussion and previous empirical research on disclosure, we have selected six characteristics (firm size, financial performance, corporate financial leverage, liquidity, industry type, and auditor type) for this study to test their relationship with the extent of financial risk disclosure exclusively in the context of a developing country as there is hardly any empirical evidence on the same in literature.

5.1. Firm Size and Level of Financial Risk Disclosure

Prior research (Linsley and Shrives 2006; Abraham and Cox 2007; Beretta and Bozzolan 2004; Hasan et al. 2008; Das et al. 2015) suggests that firm size is an important determinant of the level of disclosure and presents mixed results regarding the link between size and the extent of disclosure. Brammer and Pavelin (2008) argue that larger firms tend to be more visible to stakeholders as they tend to be more complex, and thus are subject to more inherent risk. Agency theory also suggests that larger companies have higher information asymmetry between managers and owners, and as such, higher agency costs arise. To reduce these agency costs, larger companies disclose more information than smaller companies. Political cost theory also supports this notion. We posit that larger firms provide more financial risk disclosure and formulate the following hypothesis:

H1. *There is a positive association between the level of financial risk disclosure and firm size.*

5.2. Firm Performance and Level of Financial Risk Disclosure

Prior research (Inchausti 1997) supports the existence of a relationship between company performance and risk disclosure in light of signaling theory. However, empirical results are mixed. Some studies (Wang et al. 2008; Nandi and Ghosh 2013) find a positive association, whereas other studies (Reverte 2009; Bujaki and McConomy 2002) report an insignificant relationship between firm performance and the extent of risk disclosure. However, studies (Hasan et al. 2008) in the context of Bangladesh find insignificant association between profitability and comprehensiveness of disclosure. Thus, we formulate the following hypothesis:

H2. *There is a positive association between the financial performance level of a company and financial risk disclosure level.*

5.3. Corporate Financial Leverage and Level of Financial Risk Disclosure

The corporate financial leverage, as measured by total debt to total assets, may affect the level of financial risk disclosure. Companies with high levels of debt tend to be highly leveraged, more speculative, and riskier. Debt-holders have greater power over the financial structure of such companies. From an agency theory perspective, creditors of highly leveraged companies have strong incentives to encourage management to disclose more information. Linsley and Shrives (2006) argue that firms with higher levels of risk disclosure provide greater amounts of risk-related information as managers are willing to explain the causes of high risk. Thus, we formulate the following hypothesis:

H3. *There is a positive association between corporate financial leverage and financial risk disclosure.*

5.4. Liquidity and Level of Financial Risk Disclosure

Wallace and Naser (1995) argue that liquidity is an essential factor to disclose more information about a company's ability to meet its obligation, as well as to testify that the company is a going concern to dispel the fears of investors and creditors. According to signaling theory, a firm with a high liquidity ratio tends to disclose more information in order to be differentiated from other firms with a lower liquidity ratio. Conversely, agency theory proposes that firms with lower liquidity disclose more information to reduce conflict between shareholders and creditors. Findings of prior studies are mixed. For example, Naser et al. (2002) support this reasoning of agency theory, whereas other studies (Alsaeed 2006; Barako et al. 2006) do not support either of these two theories by reporting no association between liquidity and financial disclosure. These contradictory results provide an incentive to test this association between liquidity and disclosure. Thus, we formulate the following hypothesis:

H4. *The level of liquidity is associated with the extent of financial risk disclosure.*

5.5. Industry Type and Level of Financial Risk Disclosure

The financial literacy level of capital market investors and participants is relatively low in Bangladesh, and thus in most cases, their source of information is only the audited annual reports of public companies, unlike in the United States with voluntary financial and non-financial information disseminated to the capital markets (e.g., management discussion and analysis, short sellers, financial analysts, institutional investors). As stated earlier, high volatility and market manipulation is a common phenomenon in Bangladesh capital markets. Thus, a standardized risk reporting format is an urgent requirement to achieve greater financial transparency and to make investors aware of the financial risks in this highly unpredictable environment. Homogeneous disclosure practices could be very helpful in this regard. Thus, the heterogeneous/varied financial risk disclosure practices of companies impedes obtaining an efficient capital market and informed assessment of the investors.

The industry type has been identified as a significant factor that influences the disclosure practices (Amran and Haniffa 2011). The signaling theory suggests a positive association between industry type and the level of risk disclosure. However, the prior empirical studies indicate mixed results, with some studies suggesting the association to be significant (Haniffa and Cooke 2002), whereas Naser et al. (2002) find an insignificant association between industry type and risk disclosure. Firms in the financial and chemical industries have more incentives to provide financial risk disclosure. Thus, we state the following hypothesis:

H5. *The industry type is associated with the extent of financial risk disclosure.*

5.6. Auditor Type and Level of Financial Risk Disclosure

It is reported that financial statements of firms that are audited by the Big 4 audit firms are perceived to be more credible than those audited by non-Big 4 firms (Das et al. 2015). These larger and well-known audit firms tend to encourage firms to disclose more information to safeguard the audit firms' reputation and avoid reputational costs to them (Chalmers and Godfrey 2004). Lopes and

Rodrigues (2007) find a positive relation between audit firm size and the extent of disclosure (Lopes and Rodrigues 2007). On the other hand, Deumes and Knechel (2008) report a negative association between auditor type and the extent of disclosure. The Big 4 international audit firms tend to operate in smaller capital markets through a local audit firm, and Bangladesh is one such setting where this unique alliance occurs (Kabir et al. 2011). Thus, we formulate the following hypothesis:

H6. *Audit firm size is associated with the extent of financial risk disclosure.*

6. Methodology

6.1. Sample

Our sample is limited to manufacturing companies for a period of six years from 2010 (Commencement year of BFRS-7) to 2015. We did not consider companies under the financial category because of their differing nature of business and type of financial statements. The listed manufacturing companies are divided into twelve industrial sectors. Six sectors (50%) from these twelve industrial sectors have been selected using a simple random sampling technique so that the results could be generalized. The selected industrial sectors are Cements, Engineering, Fuel & Power, Jute, Pharmaceuticals & Chemicals, and Tannery, which comprise 91 companies as of 31 December 2015. Out of these 91 companies, 48 (53%) companies have been selected for this study based on continuity of operation. All companies included in our sample experienced financial risks described in Table 1. Finally, our sample size is 288 (48 × 6) firm-year observations in the 2010–2015 period, as the data for 2016 and onwards were not available at the time of our analyses.

Table 1. Grid of risk reporting. FR—financial risk.

Category of FR	No.	Disclosure Identifier
Liquidity Risk	1	Definition or motivation
	2	Classification of debts by type and maturity
	3	Comparison with previous years
	4	Quantitative data on available cash or cash equivalents
	5	Company's approach toward managing liquidity
	6	Current ratio and quick ratio
Credit Risk	1	Definition or motivation
	2	Quantitative or qualitative data on exposure to credit risk
	3	Classification of customers' obligations in terms of their creditworthiness (rating)
	4	Aging schedule of accounts receivable
	5	Comparison with previous years
	6	Alternative credit classification (by activity, geographical area, others)
	7	Notes on the concentration of credit
Interest Rate Risk	1	Definition or motivation
	2	Classification of debt by interest rate (fixed/variable)
	3	Sensitivity analysis
	4	Information on derivative hedging instruments
Currency Risk	1	Definition or motivation
	2	Detail of items in foreign currencies
	3	Comparison with previous years
	4	Sensitivity analysis
Capital Structure Risk	1	Company's ability to continue as a going concern
	2	Leverage ratios
	3	Capital expenditure forecast (quantitative and qualitative)
	4	Forecast of growth capacity (both qualitative and quantitative)
	5	Capital expenditure commitment
	6	Long term credit rating
General	1	Financial risk management policy
	2	Information on responsibility for establishment and oversight of the risk management framework
	3	Review of risk management policies, procedures and systems To reflect changes in market conditions and the company's activities

6.2. Method of Analysis

The method used in this study for analyzing financial risk disclosure is content analysis, as the study is focused on the extent of financial risk disclosures and not on the quality of financial risk. Following Lombardi et al. (2016), a financial risk disclosure index is developed to ensure the reliability of inference. We use multiple regression models to assess the relationship between the level of financial risk disclosure and firm specific characteristics in testing our hypotheses.

6.3. Financial Risk Category Selection

We examine the sections of annual reports covering information on risks and uncertainties in the management report and notes to the financial statements on risk management of each sample company—looking exclusively at financial risks. Specifically, we focus on financial risks only and not general risks (operational, strategic, and context-related). Finally, we identify categories of financial risks for the sample firms. Accordingly, we have the following five categories of financial risk: capital structure risks, credit risks, liquidity risks, exchange risks, and interest rate risks. All five types of these financial risks were considered in the construction of the financial risk disclosure index presented in Section 6.5. For example, if a company incurred a currency risk, we included such risk in the calculation of the financial risk disclosure index (FRDI).

6.4. Item Selection for Financial Risk Description

After selection of categories of financial risk, we prepare a set of items or disclosure identifiers (grid risk report—GRR). Our GRR contains the most significant items for each risk category and we have chosen those items that a firm should specify to provide adequate information on that risk. To obtain a common framework that would allow us to study how and when the sample firms report on their financial risks, we consider only the most significant items that are described by a substantial number of firms, which is at least 10% of the sample companies. Accordingly, we compare all the items and give an importance rating of 10% following the study of Lombardi et al. (2016). Thus, if an item is recorded by at least 5 out of 48 companies, the item is considered significant and has been included in the general framework. At the end of this procedure, we construct our GRR, which is presented in Table 1. The number of items in each category vary as we find seven items for credit risks, six for liquidity risk, four for currency risk, four for interest rate risks, six for capital structure risk, and three for general items. Thus, the overall financial risk disclosure index is composed of a total of 30 items.

6.5. Financial Risk Disclosure Index

A financial risk disclosure index (FRDI) is constructed as a benchmark for measuring the level of financial risk disclosure by the listed companies. We apply our GRR model to the annual reports of the sample companies for the study period. To examine the correspondence of the revealed disclosure with the GRR items, we estimate the disclosure index for each category of financial risk and an overall financial risk disclosure index. We assign scores to each item depending on the completeness of information held in the documents. If an item is expressed in a clear and systematic way, we assign a score of 1, otherwise a score of 0 is assigned when there is no qualitative or quantitative information about the item. The score obtained (equal to the sum of scores assigned to the various items that compose the risk) is compared with the maximum score, equal to the total number of items belonging to the risk being analyzed. To estimate the disclosure index for the risk examined, we use the following formula.

$$0 \leq \text{FRDIj} = \frac{\text{Score obtained from the jth company}}{\text{Maximum possible score}} \leq 1.$$

6.6. Measurement of Variables

The dependent variable of the study is financial risk disclosure and the independent variables are firm specific characteristics. The firm specific characteristics are measured in terms of the size of the company, financial performance, corporate financial leverage, liquidity, type of auditor, and the industry to which the company belongs. Table 2 presents the list of variables used in the paper and their methods of measurement.

Table 2. List of variables and their measurement methods. FRDI—financial risk disclosure index; FS—firm size; ROA—return on assets; FL—financial leverage; LIQD—liquidity; IT—industry type; AT—auditor type.

Name of Variables	Type of Variables	Proxies	Acronyms	Measurement
Financial Risk Disclosure	Dependent	Financial Risk Disclosure Index	FRDI	Ratio of score obtained by a company and maximum possible score
Firm Specific Characteristics	Independent	Firm Size	FS	Logarithm of Total Assets
		Financial Performance	ROA	EBIT/Total Assets
		Corporate Financial leverage	FL	Total Liabilities/Total Assets
		Liquidity	LIQD	Current Assets/Current Liabilities
		Industry Type (Dummy)	IT	1 or 0
		Auditor Type (Dummy)	AT	1 or 0

6.7. Model Development

Consistent with prior research (Amran and Haniffa 2011; Amran et al. 2008), we use multiple regressions to assess the variability of the extent of financial risk disclosure and its association with firm characteristics. This statistical method is widely used in previous studies. Thus, the following regression model is developed in testing our hypotheses:

$$\begin{aligned} \text{FRDIi} = \text{b0} + \text{b1FS} + \text{b2ROA} + \text{b3FL} + \text{b4LIQD} + \text{b5CEM} + \text{b6FP} + \text{b7JUTE} \\ + \text{b8PHARM} + \text{b9TAN} + \text{b10AT} + \epsilon_i \end{aligned}$$

where

FRDI = financial risk disclosure index; FS = firm size; ROA = return on assets; FL = corporate financial leverage; LIQD = liquidity; CEM = cement industry = 1 if the company is in the cement industrial sector, otherwise 0; FP = fuel and power industry = 1 if the company is in the fuel and power industrial sector, otherwise 0; JUTE = jute industry = 1 if the company is in the jute industrial sector, otherwise 0; PHARM = pharmaceuticals and chemical industry = 1 if the company is in the pharmaceuticals and chemical industrial sector, otherwise 0; TAN = tannery industry = 1 if the company is in the tannery industrial sector, otherwise 0; AT = auditor type = 1 if audit firms link with Big 4, otherwise 0; and ϵ_i = error terms. To reduce the impact of outliers, we winsorize all continuous variables at 1 percent and 99 percent.

7. Results and Discussion

7.1. Aggregated Disclosure Index of Financial Risks

Figure 1 shows the distribution of total disclosure indices during the study period of 2010 to 2015 for the 48 sample companies. The deep yellow line indicates the average total disclosure index of

the sample. On average, the overall financial risk disclosure index is 0.44 during the study period of 2010 to 2015. The analysis of the distribution of the total disclosure indices for the 48 companies in the sample, for the period, shows that more than 56 percent of companies (27) have a lower index value than the average and the balance, about 44 percent of companies (21), have a higher index than the average value. The result indicates that despite compulsion with the introduction of BFRS-10, in 2010, most of the listed manufacturing companies have yet to disclose financial risk consistently and uniformly.

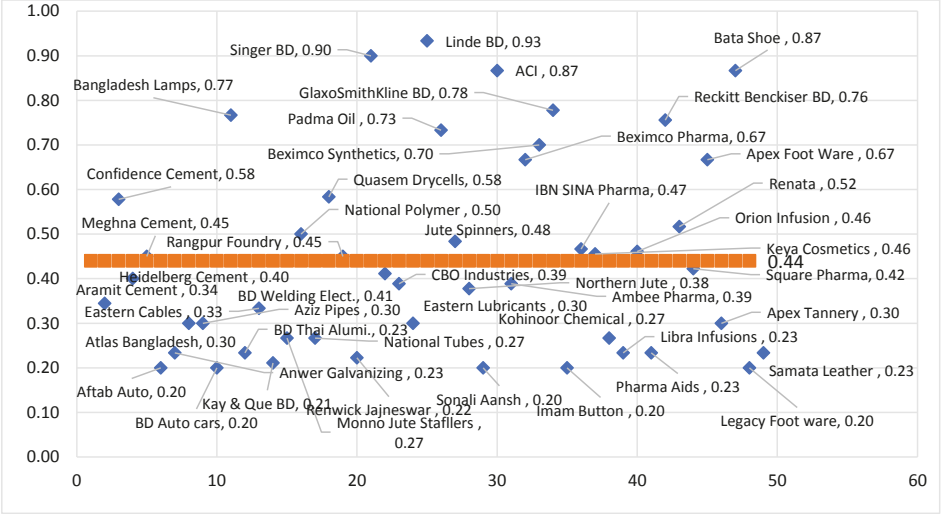

Figure 1. Distribution of overall financial risk disclosure indices during study period for each company in the sample.

7.2. Specific Disclosure Indices of Financial Risks: Analysis of Level

The analysis of levels of the disclosure indices relating to specific financial risks for each sample company is illustrated in Figure 2. The sample 48 companies are placed along the x-axis, and the accumulated level of financial risk for the five disclosure indices is on the y-axis. From the analysis of the graph, it is clear that financial risk disclosure is treated in heterogeneous ways by the companies. Levels of the individual indices show no common practice among the companies. This observed relatively heterogeneous practice of disclosing financial risk is important to the institutional settings of emerging economies and markets such as Bangladesh, because audited annual financial reports are the primary source of information for investors. Thus, more uniform and standardized financial risk disclosures enhance comparability of such disclosures and should be value-relevant to investors.

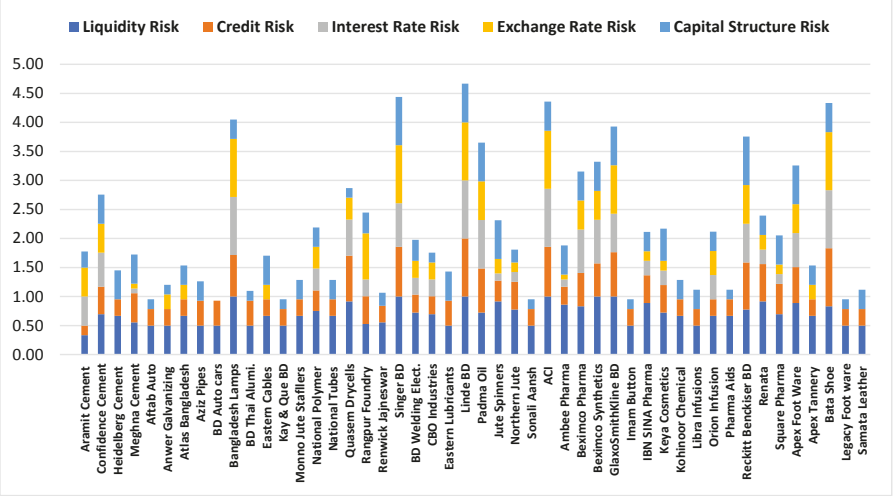

Figure 2. Accumulation of disclosure indices for individual financial risk during the study period of 2010 to 2015 for each company.

7.3. Specific Disclosure Indices of Financial Risks: Analysis of Composition

The analysis of the composition of the disclosure indices regarding specific financial risks for each individual company in the sample is illustrated in Figure 3. The sample companies are placed along the x-axis, and the percentage level of financial risk for the five disclosure indices is on the y-axis. Like level, the composition of aggregated value of financial risk disclosure shows no common practice among the companies with some diversity in disclosing financial risks.

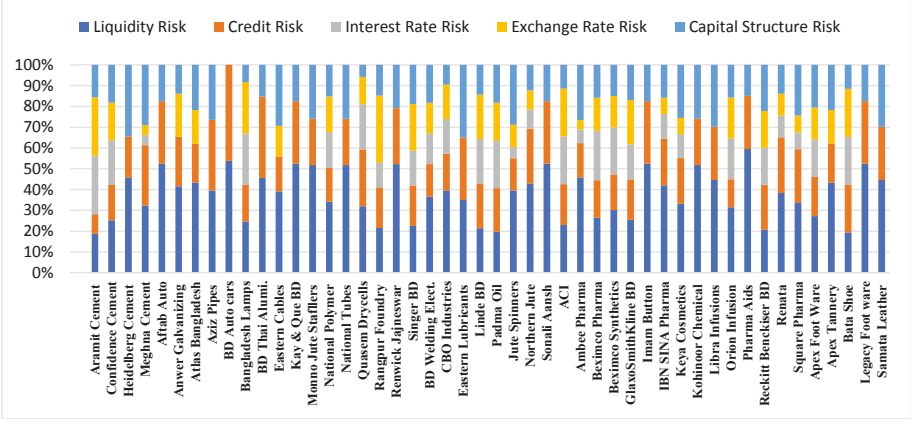

Figure 3. Composition of the disclosure indices for individual financial risks during the study period of 2010 to 2015 for each company.

7.4. Univariate Analysis

Table 3 presents the correlation matrix showing the relationship between each of the independent variables and the dependent variable. The dependent variable financial risk disclosure index is strongly

related to auditor type and firm size, and moderately correlated to financial performance (ROA), but it is weakly related to other independent variables. All possible correlations among the independent variables are given in the correlation matrix. Our standard is to look for a correlation that exceeds an absolute value of ±70. None of the independent variables are strongly correlated with each other. This indicates that multi-collinearity is not likely.

Table 3. Correlation matrix. DR—disclosure risk; CEM—cement industry; TAN—tannery industry; PC—Pharmaceuticals and Chemical industry; ENG—Engineering industry; FP—fuel and power industry and other variables as defined previously.

Variables	FRDI	DR	ROA	FS	LIQD	AT	CEM	ENG	FP	Jute	PC	TAN
FRDI	1											
DR	−0.07	1										
ROA	0.38 **	−0.28 **	1									
FS	0.52 **	−0.29 **	0.25 **	1								
LIQD	0.07	−0.51 **	0.22 **	0.19 **	1							
AT	0.65 **	−0.001	0.47 **	0.49 **	0.09	1						
CEM	0.000	0.024	0.07	0.19 **	−0.07	0.03	1					
ENG	−0.21 **	0.01	−0.12 *	−0.23 **	0.12 *	−0.25 **	−0.21 **	1				
FP	0.16 **	−0.02	0.06	0.06	−0.03	0.16 **	−0.10	−0.24 **	1			
Jute	−0.07	0.20 **	−0.10	0.03	−0.20 **	−0.07	0.73 **	−0.29 **	−0.14 *	1		
PC	0.14 *	−0.09	0.18 **	0.28 **	−0.17 **	0.11	0.37 **	−0.57 **	−0.28 **	0.15 *	1	
TAN	0.01	−0.03	0.07	0.13 *	0.18 **	0.15 *	0.63 **	−0.34 **	−0.16 **	0.41 **	0.05	1

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

7.5. Multivariate Analysis

Table 4 presents the results of our regression model. The adjusted R^2 measuring the strength of the relationship between the set of independent variables and dependent variable is 47.3 percent, which indicates that independent variables are relevant in predicting FRDI. The Durbin–Watson statistic is between 1 and 3, indicating that the errors in regression are independent. The computed F is 26.808, and hence supports our hypotheses. The standardized coefficient on size is 0.290 and is positively significant at the 1% level, suggesting the firm size is positively and significantly associated with the level of financial risk disclosure. The confidence on financial performance is 0.116 and positively significant at the 5% level. The coefficient on financial leverage is 0.036 positive, but statistically insignificant. The coefficient on the type of auditor is 0.449 and positive and significant at the 1% level. Coefficients of industry types are not statistically significant. These results suggest that larger companies, more profitable companies, and companies audited by Big 4 firms provide more financial risk disclosures. One possible explanation is that the bigger the firm, and the higher the profitability, the higher the level of resources available, particularly in developing countries, and thus the higher the level of disclosure produced.

Table 4. The Level of Financial Disclosure and Firm Financial Attributes.

Model	Unstandardized Coefficients		Standardized Coefficients	*t*-Value	Sig.
	B	Std. Error	Beta		
Constant	0.036	0.076		0.478	0.633
Firm Size	0.042	0.008	0.290	5.241 ***	0.000
Financial performance	0.306	0.138	0.116	2.212 **	0.028
Financial Leverage	0.030	0.046	0.036	0.651	0.516
Liquidity	−0.003	0.012	−0.013	−0.233	0.816
Cement Industrial Sector	−0.073	0.076	−0.085	−0.969	0.333
Fuel and Power Industrial Sector	0.049	0.038	0.063	1.298 *	0.195
Jute Industrial Sector	0.030	0.046	0.045	0.656	0.513
Pharmaceuticals and Chemical Industrial Sector	0.016	0.027	0.033	0.596	0.552

Table 4. *Cont.*

Model	Unstandardized Coefficients		Standardized Coefficients	*t*-Value	Sig.
	B	Std. Error	Beta		
Tannery Industrial Sector	−0.033	0.038	−0.054	−0.855	0.393
Type of Audit Firm	0.263	0.035	0.449	7.590 ***	0.000
Adj. R^2			0.473		

This table presents the results from a regression of the level of financial risk disclosure and firms financial attributes. The dependent variable is the level of financial risk disclosure (FRDI). The independent variables are firm size, financial performance, leverage, liquidity, and industry classifications. This table presents results from OLS (Ordinary Least Squares) regression of the level of FRDI on financial attributes. The definitions of all other variables are reported in Table 1. Standard errors are clustered at the firm level, and *t*-statistics are reported in the related column. Significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

8. Conclusions and Limitations

This study examines the level of financial risk disclosure of publicly traded manufacturing companies by investigating the association between the level of financial risk disclosure and firm specific characteristics. The results of the content analysis show that the sample companies treat financial risk disclosure in heterogeneous and less standardized manners. Although compliance with BFRS-7 requires that public companies uniformly disclose financial risk, our results show that there is no common practice in this regard. Thus, a more uniform and standardized financial risk disclosure can improve corporate disclosure in compliance with BFRS-7 and enhance comparability of financial risk disclosure. The results also confirm that the companies tend to provide more information on liquidity risk and less information about interest rate risk and currency risk.

The regression results show that firm size, financial performance, and auditor type are positively and significantly associated with the level of financial risk disclosure in annual reports. These results are consistent with those of various previous empirical studies worldwide (Amran et al. 2008; Das et al. 2015; Linsley and Shrives 2006). The results suggest that firm size, performance, and auditor type are the main determinants of risk disclosure and are the driving factors for the selected companies to increase the level of financial risk disclosure. The results reveal that financial leverage, liquidity, and industry type have no association with the level of financial risk disclosure, which are consistent with findings of prior studies (e.g., Alsaeed 2006). As a result, these characteristics have no relevance to disclosing financial risk of the publicly traded manufacturing companies. Our results contribute to the business and accounting literature by providing an initial understanding of financial risk disclosure practices in Bangladesh, where the risk disclosure practice is still in an early stage.

There are, however, several limitations of this study. First, the study focuses on 30 selected disclosure items. Moreover, the choice of the items does not reflect their level of importance as perceived by financial information users and the coding approach is subject to coder bias. Second, the un-weighted or binary approach is used to measure the level of financial risk disclosure, which may not reflect the quality of financial risk disclosure. Third, the study is confined to one country in emerging markets and economies. Fourth, the information regarding risk can be provided in sources other than annual reports. Finally, a potential endogenous concern may exist in our analysis given the sample size in relation with the estimated coefficients. Thus, the results and their policy, practical, and research implications should be interpreted with caution, considering these potential limitations. Future research should address financial risk disclosure in other developing countries and investigate both the quality and quantity of financial risk disclosure.

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Article

Value-at-Risk for South-East Asian Stock Markets: Stochastic Volatility vs. GARCH

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Abstract: This study compares the performance of several methods to calculate the Value-at-Risk of the six main ASEAN stock markets. We use filtered historical simulations, GARCH models, and stochastic volatility models. The out-of-sample performance is analyzed by various backtesting procedures. We find that simpler models fail to produce sufficient Value-at-Risk forecasts, which appears to stem from several econometric properties of the return distributions. With stochastic volatility models, we obtain better Value-at-Risk forecasts compared to GARCH. The quality varies over forecasting horizons and across markets. This indicates that, despite a regional proximity and homogeneity of the markets, index volatilities are driven by different factors.

Keywords: ASEAN; GARCH; stochastic volatility; Value-at-Risk

JEL Classification: C58; F37; G15; G17

1. Introduction

The members of the Association of Southeast Asian Nations (ASEAN)[1] already produce 3.43% of the worldwide Gross Domestic Product (GDP) in 2016 and even the economically smaller countries such as Vietnam are on the rise. The ASEAN-6[2] have an annual GDP growth from 2016 to 2017 of 4.91% and share 4.48% of the world's average annual GDP growth of 3.6%.[3]

However, the crisis of Asian markets in 1997 shows that investors have to accept other risks than those in industrialized and developed western economies. The Asian crisis is characterized by an unparalleled contagion throughout the markets and extreme market and currency movements. While this crisis has almost only regional macroeconomic effects, consequences and lessons from it are drawn globally (Hunter et al. 1999). Another example for very high contagion in these markets are disruptions in the wake of the global financial crisis beginning in 2007, as Asian emerging markets do not offer diversification potential (Kenourgios and Dimitriou 2015).

During times of crises as well as during more moderate times of daily business, investors and portfolio managers face the challenge to properly estimate and model dispersion in market prices,

1 The ASEAN consists of ten countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam.
2 ASEAN-6 are the six biggest contributor to GDP of the ASEAN region, i.e., Indonesia, Thailand, Philippines, Singapore, Malaysia, and Vietnam.
3 Own calculations based on data.worldbank.org and www.imf.org.

formalized in its volatility or variance. Depending on the trading position, financial risk has to be determined for the long and short position. While the long trading position (e.g., having bought an asset to sell it at a later point) is concerned with falling prices or negative returns, the short trading position (e.g., short-selling an asset, i.e., borrow an asset and directly sell, to re-buy it at a later point to give it back to the owner) faces rising prices or positive returns (Giot and Laurent 2003). This is of particular importance if asymmetric distributions, such as the Skewed Student's-*t* distribution, are found to provide a better resemblance of the empirical price return distribution than symmetric distributions like the Normal or Student's-*t* distribution. In this work, we use the Value-at-Risk (VaR) as a measure for financial risk, which is determined by the volatility of an investment. Albeit the fact that VaR has been replaced by Expected Shortfall as the main tool to determine the minimum capital requirements for banks under the Basel framework, VaR is still in place for backtesting the internally used risk models (Basel Committee on Banking Supervision 2016). Here, we incorporate two competing classes of volatility models. Within the framework of Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models (Bollerslev 1986; Engle 1982), we model volatility conditional on its past. This allows for including volatility clusters with periods of high and low market movements. In the next step, the Asymmetric Power ARCH (Ding et al. 1993) is applied to account to asymmetric news impact on volatility. Another so-called stylized fact is the long lasting dependence of shocks in a time series known as long memory. The Fractionally Integrated GARCH (FIGARCH, (Baillie et al. 1996)) model is able to depict this pattern. The Fractionally Integrated Asymmetric Power ARCH (FIAPARCH) of Tse (1998) combines both long memory and asymmetry. The second class of models is based on the stochastic volatility (SV) model introduced by Taylor (1986). In addition to the standard SV model, we implement specifications that are able to depict the leverage effect as well as heavy tails. We use both classes to forecast the volatility over specific horizons based on estimates of a training window. With these variance forecasts, we then predict the VaR. These VaR predictions are evaluated and compared over different markets against standard approaches such as the non-parametric Historical Simulation (HS).

In this work, we focus on six major ASEAN stock market indices. Given the regional proximity and general similarity of these markets, we aim to understand if this also yields comparable variance properties. This would imply that methods of modeling and forecasting volatility as well as the VaR have comparable performances across the markets and that these markets could be grouped. While there is a plethora of literature on variance modeling for commodities, stock markets, and exchange rates of developed countries, academic advances on Asian stock indices and their comparison is relatively sparse. Walther (2017) identifies a sufficient performance of GARCH with a symmetric Student's-*t* distribution as well as FIAPARCH with a skewed Student's-*t* distribution in terms of variance and VaR forecasting for Vietnamese stock indices. Brooks and Persand (2003) show that asymmetric approaches work well to forecast the VaR for the Singapore and Thailand equity indices. So and Yu (2006) use different GARCH models to estimate the VaR in twelve different stock markets including Indonesia, Malaysia, Thailand, and Singapore. Su and Knowles (2006) perform a VaR analysis of Mixture Normal models on stock indices including Malaysia, Singapore, and Thailand. Lastly, McMillan and Kambouroudis (2009) and Sharma and Vipul (2015) provide large studies of different equity indices (including many ASEAN countries) for VaR forecasting.

Our results suggest that the volatility structures in the ASEAN markets is heterogeneous and include various so-called stylized facts. Hence, we observe that more sophisticated models provide better forecasts than standard approaches. However, given the different dynamics in the markets, we cannot conclude with one explicit model choice over all ASEAN equity markets.

The remainder of the paper is structured as follows: Section 2 presents methods of estimation of the volatility and forecasting and assessing the VaR. Section 3 provides the data basis. Section 4 presents the results and their discussion. Section 5 provides the conclusions.

2. Methodology

2.1. Estimating Volatility

We incorporate two alternatives to calculate the daily volatility. The first model belongs to the family of Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models originating from Engle (1982). Within the GARCH framework, the process for returns r_t is formulated as

$$\begin{aligned} r_t &= \mu + \varepsilon_t, \\ \varepsilon_t &= \sqrt{h_t} z_t, \end{aligned}$$

where μ denotes the mean, the conditional variance is defined as $h_t = \mathbb{V}(r_t | \mathcal{F}_{t-1})$, and the random variable z_t follows a Skewed Student's-t distribution[4] with $z_t \sim \mathrm{SkSt}_{\nu,\xi}(0,1)$ i.i.d. for all $t = 1, \ldots, n$ (Hansen 1994). Here, $\mathcal{F}_{t-1}$ is a sigma algebra containing all past information of returns and conditional volatilities up to time $t-1$.

The distributional parameter for the Skewed Student's-t distribution, the degrees-of-freedom ν and the skewness ξ, are estimated along with the model parameters. For the conditional variance h_t, we consider the GARCH(1,1) specification of Bollerslev (1986), which reads:

$$h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1}. \tag{1}$$

A well-known characteristic of volatility is the negative correlation with returns, also known as the leverage effect (Black 1976; Christie 1982). In order to cope with this stylized fact, we implement the Asymmetric Power ARCH (APARCH, (Ding et al. 1993)), which is defined as:

$$h_t^{\frac{\delta}{2}} = \omega + \alpha \left(|\varepsilon_{t-1}| - \gamma \varepsilon_{t-1} \right)^{\delta} + \beta h_{t-1}^{\frac{\delta}{2}}, \tag{2}$$

where $\gamma \in (-1, 1)$ refers to the leverage parameter indicating whether negative or positive shocks have a larger impact on the daily volatility. For example, an estimated $\gamma > 0$ reveals that negative residuals increase the conditional volatility more than their positive equivalents, which is of particular interest for shocks.

We include the Fractionally Integrated GARCH (FIGARCH, (Baillie et al. 1996)) to cover the long memory effect. The standard FIGARCH(1,d,1) reads:

$$\begin{aligned} h_t &= \frac{\omega}{1-\beta} + \left(1 - \frac{(1-\phi L)(1-L)^d}{1-\beta L} \right) \varepsilon_t^2 \\ &= \frac{\omega}{1-\beta} + \sum_{i=1}^{\infty} \lambda_i \varepsilon_{t-i}^2, \end{aligned} \tag{3}$$

where

$$\begin{aligned} \lambda_1 &= \phi - \beta - d, \\ \lambda_i &= \beta \lambda_{i-1} + \left(\frac{i-1-d}{i} - \phi_1 \right) \left(\frac{(i-2-d)!}{i!(1-d)!} \right), \end{aligned} \tag{4}$$

[4] The assumption of Skewed Student's-t distributed errors is justified in the Data section.

with the long memory parameter d and the lag operator L. To combine the leverage and the long memory effect, Tse (1998) proposed the Fractionally Integrated APARCH (FIAPARCH):

$$\begin{aligned} h_t^{\frac{\delta}{2}} &= \frac{\omega}{1-\beta_1} + \left(1 - \frac{(1-\phi_1 L)(1-L)^d}{1-\beta_1 L}\right)(|\varepsilon_t| - \gamma\varepsilon_t)^\delta, \\ &= \frac{\omega}{1-\beta_1} + \sum_{i=1}^{\infty} \lambda_i (|\varepsilon_{t-i}| - \gamma\varepsilon_{t-i})^\delta. \end{aligned} \tag{5}$$

Note that the ARCH(∞) representation in Equations (3) and (5) is carried out using the fast fractional differencing method of Klein and Walther (2017) with truncation lag 5000. All GARCH-type models introduced above are estimated with maximum-likelihood estimations (MLE), ensuring that non-negativity and stationarity conditions, if applicable, hold for each model. All parameter estimates and robust standard errors following Bollerslev and Wooldridge (1992) are available upon request.

As an alternative to the GARCH framework, we also consider the stochastic volatility framework. Stochastic volatility models belong to the family of state-space models (Sarkka 2013, ch. 4). The standard stochastic volatility (SV) model is introduced by Taylor (1986) as

$$r_t = \mu + \sqrt{h_t} z_t, \tag{6}$$

$$\log h_t = \alpha + \beta \log h_{t-1} + \sigma\eta_t, \tag{7}$$

$$\begin{pmatrix} z_t \\ \eta_t \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}\right) \text{ i.i.d. } t = 1, \ldots, n. \tag{8}$$

The SV model contains two noise processes, $\{z_t\}_t$ and $\{\eta_t\}_t$, respectively accounting for the return shocks and the volatility shocks. In the SV model above, $\{z_t\}_t$ and $\{\eta_t\}_t$ are independent.

Harvey and Shephard (1996) introduce a more general setting where the noise processes $\{z_t\}_t$ and $\{\eta_t\}_t$ are correlated as

$$\begin{pmatrix} z_t \\ \eta_{t+1} \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\right),$$

instead of being independent as in Equation (8). The correlation coefficient ρ accounts for the leverage effect, defined as the negative correlation between shocks on return and volatility (i.e., $\rho < 0$). This model is called the asymmetric SV model or SV-leverage (SV-L) model.

We consider a third stochastic volatility model where the return shocks $\{z_t\}_t$ follow Student's t-distribution with ν degrees of freedom. It allows more extreme observations than with Gaussian return shocks as the Student's t-distribution has heavier tails. The volatility shocks $\{\eta_t\}_t$ follow the standard Gaussian distribution. In this model, z_t and η_t are independent. It is referred to as the SV-t model.

We end up with three different stochastic volatility models: the SV model (Gaussian and independent shocks), the SV-L model (Gaussian and correlated shocks), and the SV-t model (t-distributed return shock, Gaussian volatility shock, independent shocks). In the three models, the parameters are estimated by Bayesian inference using the Markov Chain Monte Carlo (MCMC) sampling algorithms from Chan and Grant (2016).[5]

Lastly, we consider the RiskMetrics approach, the historical simulation, as well as the semi-parametric filtered historical simulation, which we explain in detail in the next subsection.

[5] We are thankful to Joshua Chan for providing the MatLab (MathWorks, Natick, Massachusetts, United States) code for estimating the stochastic volatility models on his personal webpage joshuachan.org.

2.2. Value-at-Risk Forecasting and Backtesting

One of the most important financial risk measures is the Value-at-Risk. The VaR is usually defined as a specific loss, which is not exceeded for a given probability (e.g., $(1-a)\%$).

When using GARCH models, the k-days ahead VaR forecast is simply derived by a k-steps forecast of the variance based on the estimated parameters at time T, $\widehat{h}_{T+k} = \mathbb{E}\left(h_{T+k}|\mathcal{F}_T\right)$, which is then applied in the general VaR calculation scheme, yielding

$$\widehat{\mathrm{VaR}}_{T+k} = \widehat{\mu}_{T+k} + \sqrt{\widehat{h}_{T+k}} Q_a\left(\widehat{\nu}, \widehat{\xi}\right),$$

where $\widehat{\mu}_{T+k}$ is the estimated mean, $\widehat{h}_{T+k}$ is the estimated conditional variance, and $\widehat{\nu}$ and $\widehat{\xi}$ are the estimated distributional parameters from the training set $1, \ldots, T$. $Q_a\left(\nu, \xi\right)$ denotes the a quantile function of the Skewed Student's-t distribution with degrees-of-freedom parameter ν and skewness ξ. Note that we only forecast the variance. Hence, in the VaR forecast, the quantile function depends on the estimated insample parameters, which are not forecasted separately. The calculation of the forecasted variance depends on the specific GARCH model. In this sense, there exists a closed form solution for the GARCH(1,1) k-days ahead forecast while, for the APARCH, FIGARCH, and FIAPARCH, the forecasts are calculated iteratively.[6]

With stochastic volatility (SV, SV-L, SV-t) models, we approximate the conditional distribution of the returns at the forecast horizon given the observed returns non-parametrically, i.e., the conditional distribution of r_{T+k} given $r_1, \ldots, r_T$. We use particle filtering, a sequential Monte Carlo algorithm for state-space models (Sarkka 2013, chp. 7). The particle filter approximates the conditional distribution of the volatility h_T given the returns $r_1, \ldots, r_T$ in the form of a sample of so-called "particles". This sample is propagated k times according to the volatility dynamics (Equation (7)), which is the same in the three stochastic volatility models. Then, from the volatility sample at time $T+k$, a return sample is generated according to the return model (Equation (6)). We compute the VaR by taking the empirical quantiles of this return sample.

For the RiskMetrics approach (Longerstaey and Spencer 1996)—also known as Exponentially Weighted Moving Average (EWMA)—we use the standard GARCH-like case with fixed parameters $\omega = 0.00$, $\alpha = 0.06$, and $\beta = 0.94$ for Equation (1). Since the RiskMetrics model is not stationary, we use the estimate $\widehat{h}_T$ for all k-days ahead forecasts.

Lastly, we derive VaR forecast non-parametrically by the Historical Simulation (HS) and the semi-parametric Filtered Historical Simulation (FHS). The former method takes the past 250 returns as possible scenarios of a future return distribution and the VaR is calculated from the empirical a-quantile of the past returns, i.e.,

$$\widehat{\mathrm{VaR}}_{T+k} = Q_a(\{r_t\}_{t=T-249}^{T}).$$

For the FHS, we follow Barone-Adesi et al. (1999). The technique combines the aforementioned GARCH and HS. To calculate the VaR, we estimate the parameters for a GARCH model with Skewed Student's-t innovations over the whole insample. From the parameters, we derive a k-days ahead volatility forecast. Moreover, we calculate the empirical a-quantile from the most recent 250 standardized and centered GARCH residuals. The volatility forecast is then multiplied with the empirical quantile to estimate the VaR:

$$\widehat{\mathrm{VaR}}_{T+k} = \widehat{\mu}_{T+k} + \sqrt{\widehat{h}_{T+k}} Q_a(\{\widetilde{z}_t\}_{t=T-249}^{T}),$$

[6] An outline of forecasting conditional variance can be found in Klein and Walther (2016) and Walther (2017) for example.

where

$$\widetilde{z}_t = \frac{r_t - \widehat{\mu}}{\sqrt{\widehat{h}_t}}$$

is the standardized and centered GARCH residual.

To evaluate the quality of the VaR forecasts for the different models and classes, we use four different VaR tests: the regulatory traffic light test, the conditional coverage test, the multi-level unconditional coverage test, and the loss function based comparison. In what follows, we refer to VaR violations or exceptions for the cases, where $r_{T+k} < \widehat{\mathrm{VaR}}_{T+k}$ for the long trading position and where $r_{T+k} > \widehat{\mathrm{VaR}}_{T+k}$ for the short trading position.

The Basel traffic light backtest (Basel Committee on Banking Supervision 2016) sorts VaR test results in three different zones. The test uses the 1-day ahead $a = 1\%$ VaR for the last 250 trading days. A model is considered in the *green zone*, if four or less VaR violations occurred in that period. The *yellow zone* includes models yielding between five and nine exceptions. Lastly, the *red zone* covers all models with more than nine violations. The idea behind this color scheme is that the yellow zone is a buffer area for models that violate the VaR too often due to "bad luck" (type I error). Thus, banks only have to adjust their calculated minimum capital requirements by a fixed factor. However, models in the red zone are not allowed to be used; instead, the standard approach of the Basel framework has to be employed. Here, we calculate the traffic light test on a rolling time frame over the whole out-of-sample period and report how many days each model appears in the green, the yellow, or the red zone, respectively. Doing so, we gain a regulatory perspective of the results of the VaR forecasts.

In order to account for possible clustering of VaR violations, we include the conditional coverage test proposed by Christoffersen (1998). The test combines the unconditional coverage test with a test for the independence of VaR exceptions. Independence is assumed if the VaR violations do not follow a first order Markov chain. Thus, the test procedure penalizes models not only for an undesirable amount of violations, but also for not adjusting quickly after an exception occurred. Unfortunately, the test only evaluates a certain quantile and not the whole tail of the distribution.

The multi-level coverage test of Pérignon and Smith (2008) resembles a joint unconditional coverage test for three VaR levels at $a = 1\%$, 2.5%, and 5%. Thus, the test is able to evaluate the whole tail in one single test. The test compares the actual coverage ratio (number of VaR violations to length of observation period) with the preferred one (i.e., the VaR level a) based on a likelihood ratio test. Hence, only the absolute number of VaR violations is important to that test and it penalizes too conservative models as well as too optimistic models. However, the test is not designed to cope with clustering of VaR violations.

The outcome of the two presented backtests can only decided whether a particular model pass the requirements of being in the admired VaR coverage zone and not having clustered violations. Nevertheless, the backtests cannot be used to compare the VaR forecasts among a given set of models. Therefore, we incorporate a loss function based comparison. Here, we follow the idea of Angelidis and Degiannakis (2007). The authors suggest a two-stage approach: (1) all models are tested with a backtest such as the conditional coverage test; and (2) for the models that pass this test, the following VaR loss function suggested by Lopez (1998) is used:

$$L_{T+k} = \begin{cases} 1 + \left(r_{T+k} - \widehat{\mathrm{VaR}}_{T+k}\right)^2, & \text{if } r_{T+k} < \widehat{\mathrm{VaR}}_{T+k}, \\ 0, & \text{if } r_{T+k} \geq \widehat{\mathrm{VaR}}_{T+k}. \end{cases}$$

The results of the loss functions for each model are compared with the Superior Predictive Ability test by Hansen (2005). We deviate from this procedure by using the Model Confidence Set (MCS, (Hansen et al. 2011)) in place of the Superior Predictive Ability test. The MCS yields a set of models of equally predictive ability. Thus, this procedure allows us to directly compare those models that pass the first-stage backtests.

3. Data

For our analysis of the main ASEAN financial markets, we include six country stock market indices. We choose the Indonesian Jakarta Stock Exchange Composite Index (JCI), the Kuala Lumpur Stock Exchange (KLSE) of Malaysia, the Philippines Stock Exchange PSEI Index (PCOMP), the Stock Exchange of Thailand (SET), the Singapore Strait's Time Index (STI), and the Vietnam Ho Chi Minh Stock Index (VNI). Hence, we exclude the smaller stock markets of Myanmar, Cambodia, Laos, and Brunei from our analysis. The data is retrieved from Bloomberg in USD denominations for the period from 1 July 2006 to 30 June 2017. The period is chosen such that we obtain an equal number of observations of around $n = 2700$ for all indices accounting for individual holidays. We note that the VNI has some zero volume trading days before our chosen period. We calculate the daily returns of the stock indices by logarithmic price differences. For the forecasting exercise, we use the in-sample data from 1 July 2006 to 30 June 2017. This leaves us with an out-of-sample period from 1 July 2006 to 30 June 2017 and six years of 1-, 5-, and 20-days ahead forecasts for each index.

Descriptive statistics, provided in Table 1, show evidence that the empirical distributions of the index returns are of leptokurtic shape, indicated by an increased excess kurtosis. The JCI has the highest kurtosis of 12.54 while the VNI features the lowest at 4.46. Moreover, all return series are skewed to the left; the series' distributions have large negative returns with a higher probability compared to their positive counterpart. In comparison to indices of developed countries and global benchmarks, the empirical moments are quite extreme for indices, in particular the kurtosis, suggesting less diversification effects within each index. This highlights the relatively high risks associated with investing in these markets. In addition to the non-normal appearance of moments, we test for autocorrelation in the return series. The Ljung–Box (LB) test and the ARCH test both reject the hypothesis of no autocorrelation in the returns. The Augmented Dickey-Fuller (ADF) test rejects the hypothesis of a unit root in the return series. Based on these results, we assume the underlying distribution for the GARCH framework as Skewed Student's-t. This distribution choice over alternatives such as the Normal or symmetric Student's-t distribution ensures that we cover heavy tails and skewness found in the series, which impacts the parameter estimation and forecasting exercise. The series are depicted in Figure 1.

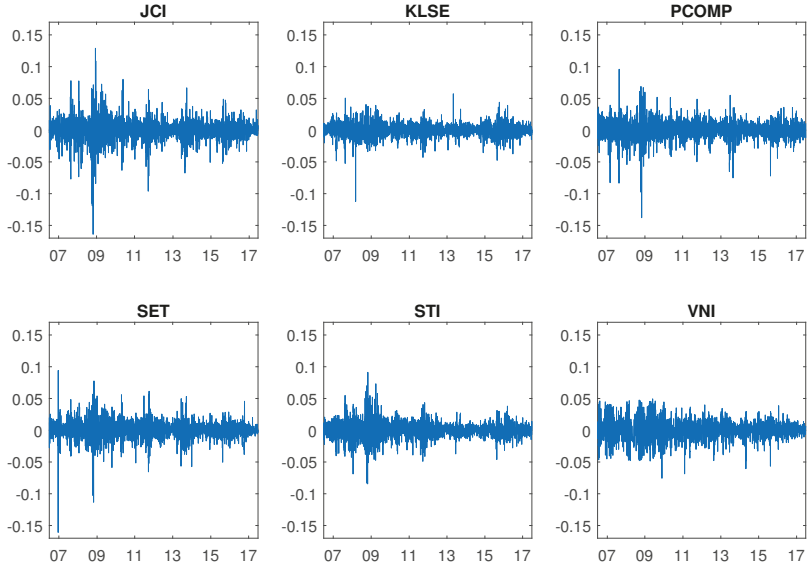

Figure 1. Log-returns for the period 1 July 2006–30 June 2017.

Table 1. Descriptive statistics of the log-returns for the six ASEAN stock indices in the period 1 July 2006–30 June 2017. Rejection of the null-hypothesis is displayed with asterisks (* 1% level of significance).

	Obs.	Mean	Min.	Max.	Std. Dev.	Skewn.	Kurtosis	LB(12)	ARCH(12)	ADF
JCI	2674	0.0413	−16.3976	12.8918	1.5024	−0.5791	12.5428	58.6283 *	414.1944 *	−46.7885 *
KLSE	2683	0.0493	−13.7896	9.5896	1.4425	−0.7345	10.2419	69.4031 *	354.3988 *	−45.7856 *
PCOMP	2709	0.0152	−11.2295	5.7262	1.0244	−0.5489	10.5371	34.8944 *	96.5796 *	−46.7559 *
SET	2687	0.0353	−16.0911	9.4139	1.3997	−0.9414	15.2982	41.0240 *	308.1694 *	−49.2268 *
STI	2761	0.0158	−8.4502	9.1221	1.2931	−0.1834	8.5997	51.0448 *	845.2581 *	−49.7627 *
VNI	2737	0.0027	−7.5612	4.9411	1.5211	−0.2330	4.4559	210.0781 *	604.1086 *	−40.7110 *

Note: Obs. is the number of observations, Min. and Max. are the minimum and maximum return in the sample, Std. Dev. is the standard deviation, LB(12) refers to the Ljung-Box test with 12 lags, ARCH(12) refers to the ARCH test for heteroskedasticity at 12 lags and ADF is the augmented Dickey-Fuller test.

4. Results and Discussion

In this section, we compare the VaR forecast results for the six ASEAN equity indices. Therefore, we first present the results for each index individually and compare the findings afterwards. For each model, we estimate 1-, 5-, and 20-days ahead predictions that correspond to forecasts a day, a week, and a month ahead. Note that we do not forecast the VaR for the whole period, but for a certain point in the future. The results are presented in Tables 2–7.

We start our analysis with the results from the Indonesian JCI (Table 2). The traffic light test does not find any of the models to be in the red zone. Moreover, we see that the GARCH is only present in the green zone, i.e., it never has no more than four violations in the whole out-of-sample for the long and the short trading position. However, the GARCH model does not pass the conditional coverage test by Christoffersen (1998) or the multilevel Pérignon and Smith (2008) test at any forecast horizon. There are a number of models that are able to depict the VaR at all quantiles under consideration for the 1-day ahead forecast on the long trading position: FHS, FIGARCH, SV, and SV-L, but only FIGARCH also shows the same ability on the short trading position. Its loss functions are satisfactory, but FIGARCH only belongs to the best performing models at the 2.5% quantile. The generally good performance of this model hints toward an elevated shock persistence in volatility. Regarding higher forecast horizon, it is only HS, which depicts good performance for all horizons on both trading sides with respect to the multilevel coverage test. The fact that HS is not able to pass the conditional coverage test may indicate that the model tends to build clustered violations, which is not covered by the multilevel coverage test.

The second equity index we analyze is the Malaysian KLSE (Table 3). Here, three models fail the regulatory traffic light test. While RiskMetrics has several days in the red zone of the long trading position, the HS and FHS models are included in the red zone for the short trading positions. Moreover, we observe some asymmetric behavior. RiskMetrics also completely fails to meet the criteria from the coverage test for the long trading position. However, it passes all tests for the short trading position. Almost the same behavior is observed for FIGARCH, with only exception for the 2.5% VaR of the conditional coverage test of Christoffersen (1998). On the long trading position, APARCH archives good results especially for 1-day ahead predictions. This suggests that both asymmetric news impact and long memory are present in this market's volatility, which is further underlined by the performance of FIAPARCH. All stochastic volatility models pass the multilevel coverage test for the long trading position.

Next, we compare the results from the Philippine PCOMP index (Table 4). No model appears in the red zone of the traffic light test and thus they could be used without being replaced by the regulator. Here, we find five complete failures of models regarding the two statistical coverage tests. Neither RiskMetrics for the long trading position, nor GARCH or any stochastic volatility specification for the short trading position pass any of the tests. In addition, the two asymmetric GARCH models seem to have problems with the specific dynamics of the PCOMP index. Both APARCH and FIAPARCH

perform very poorly with only a few passed tests. Generally, our model set does not include a clear candidate to be preferred in terms of VaR prediction performance. However, the HS and the FHS deliver the most promising results with respect to the multilevel test and the corresponding loss function results.

Table 2. Value-at-Risk backtest results for JCI returns.

Model	Traffic Light	Christoffersen (1998)									Pérignon and Smith (2008)		
		1%			2.5%			5%					
		1-Day	5-Days	20-Days	1-Day	5-Days	20-Days	1-Day	5-Days	20-Days	1-Day	5-Days	20-Days
long trading position													
EWMA/RiskMetrics	91/1120/0	–	–	–	–	–	–	–	–	–	–	–	–
Historical Simulation	755/456/0	–	–	–	–	–	–	–	–	–	0.2996	0.3007	0.3053
Filtered Historical Simulation	1211/0/0	**0.0740**	–	**0.0868**	**0.1526**	–	–	**0.2174**	–	–	0.2758	–	–
GARCH-SkSt	1211/0/0	–	–	–	–	–	–	–	–	–	–	–	–
APARCH-SkSt	1211/0/0	**0.0828**	–	–	–	–	–	–	–	–	**0.2469**	–	–
FIGARCH-SkSt	758/453/0	0.1047	–	–	**0.1635**	**0.1526**	–	0.2385	–	–	0.3075	0.3007	0.3173
FIAPARCH-SkSt	1173/38/0	**0.0828**	–	–	–	–	–	–	–	–	–	–	–
SV	653/558/0	0.1111	–	–	0.1813	–	–	**0.2297**	–	–	0.3130	0.2961	**0.2695**
SV-*t*	362/849/0	–	–	–	0.1696	**0.1571**	–	**0.2312**	–	–	0.3141	–	–
SV-L	627/584/0	0.1141	–	–	**0.1526**	–	–	**0.2205**	**0.2110**	–	0.2914	**0.2733**	–
short trading position													
EWMA/RiskMetrics	847/364/0	0.1110	–	–	**0.1655**	**0.1736**	–	**0.2126**	**0.2174**	**0.2174**	**0.2914**	–	–
Historical Simulation	961/250/0	**0.0979**	–	–	–	–	–	–	–	–	**0.2891**	**0.2891**	**0.2926**
Filtered Historical Simulation	946/265/0	**0.0907**	–	–	–	–	–	–	–	–	–	–	–
GARCH-SkSt	1211/0/0	–	–	–	–	–	–	–	–	–	–	–	–
APARCH-SkSt	1019/192/0	**0.0907**	**0.1047**	0.0944	–	–	**0.1434**	–	–	–	–	**0.2669**	–
FIGARCH-SkSt	926/285/0	0.1079	–	–	**0.1716**	–	–	0.2427	–	–	0.3162	–	–
FIAPARCH-SkSt	1025/186/0	**0.0907**	**0.0868**	**0.0828**	–	–	–	–	–	–	–	–	–
SV	1211/0/0	**0.0740**	–	–	–	–	–	–	–	–	–	–	–
SV-*t*	1211/0/0	**0.0785**	**0.0868**	–	–	–	–	–	–	–	–	–	–
SV-L	1152/59/0	**0.0785**	**0.0828**	–	–	–	–	–	–	–	–	–	–

Note: Numbers under the Basel traffic light test indicate the number of days in the green/yellow/red zone for a 250 rolling trading day window with 1-day ahead VaR forecasts at $a = 1\%$. For the Christoffersen (1998) test the 1-, 5-, and 20-days ahead forecasts results are reported for the $a = 1\%$, 2.5%, and 5% VaR. If a specific test does not reject the null hypothesis, we present the corresponding VaR loss function result. – indicates that the null hypothesis is rejected at least at 10% level of significance. Bold faced loss functions represent the inclusion in the Model Confidence Set (Hansen et al. 2011) with level of significant 10% and 10,000 bootstraps. The test by Pérignon and Smith (2008) is reported in a similar manner, except for the fact that the three VaR levels (1%, 2.5%, and 5%) are tested jointly.

Table 3. Value-at-Risk backtest results for KLSE returns.

Model	Traffic Light	Christoffersen (1998)									Pérignon and Smith (2008)		
		1%			2.5%			5%					
		1-Day	5-Days	20-Days	1-Day	5-Days	20-Days	1-Day	5-Days	20-Days	1-Day	5-Days	20-Days
long trading position													
EWMA/RiskMetrics	195/925/104	–	–	–	–	–	–	–	–	–	–	–	–
Historical Simulation	679/545/0	–	–	–	–	–	–	–	–	–	0.3159	0.3181	0.3234
Filtered Historical Simulation	569/655/0	**0.1136**	–	0.1074	–	**0.1519**	–	**0.2180**	–	–	0.3016	**0.2708**	–
GARCH-SkSt	974/250/0	**0.0864**	**0.0939**	**0.0903**	**0.1542**	–	**0.1474**	**0.2101**	–	–	**0.2745**	–	–
APARCH-SkSt	1034/190/0	**0.0903**	–	0.1009	0.1627	**0.1519**	–	**0.2117**	–	–	**0.2818**	**0.2842**	–
FIGARCH-SkSt	523/701/0	–	–	–	–	–	–	–	–	–	0.3337	–	–
FIAPARCH-SkSt	1139/85/0	**0.0864**	**0.1009**	**0.0782**	**0.1519**	–	–	–	–	–	–	–	–
SV	468/756/0	–	–	0.1009	0.1786	–	–	0.2316	–	–	0.3159	0.3039	**0.2695**
SV-*t*	670/554/0	–	–	–	0.1767	–	–	0.2374	–	–	0.3181	0.3170	**0.2794**
SV-L	750/474/0	–	–	–	0.1767	**0.1606**	–	0.2286	–	–	0.3105	0.2994	**0.2733**
short trading position													
EWMA/RiskMetrics	890/334/0	**0.1074**	0.1106	0.1194	**0.1497**	**0.1519**	**0.1668**	**0.2117**	**0.2117**	**0.2226**	**0.2806**	**0.2830**	**0.3027**
Historical Simulation	792/353/79	**0.1165**	–	–	**0.1648**	–	–	–	–	–	**0.3005**	**0.3072**	–
Filtered Historical Simulation	735/402/87	–	0.1194	–	–	–	–	0.2444	–	–	–	**0.3061**	–
GARCH-SkSt	969/255/0	**0.0940**	**0.0864**	**0.0864**	–	–	–	–	–	–	–	–	–
APARCH-SkSt	1046/178/0	**0.0940**	**0.0782**	**0.0824**	–	–	–	–	–	–	–	–	–
FIGARCH-SkSt	974/250/0	**0.0975**	**0.0975**	0.1106	**0.1648**	**0.1563**	–	0.2241	0.2241	**0.2286**	**0.2948**	**0.2902**	**0.3072**
FIAPARCH-SkSt	1059/165/0	**0.0824**	–	–	–	–	–	–	–	–	–	–	–
SV	1046/178/0	**0.0903**	**0.0824**	–	–	–	–	–	–	–	–	–	–
SV-*t*	1059/165/0	**0.0824**	**0.0782**	–	–	–	–	–	–	–	–	–	–
SV-L	1216/8/0	**0.0864**	**0.0737**	–	–	–	–	–	–	–	–	–	–

Note: Numbers under the Basel traffic light test indicate the number of days in the green/yellow/red zone for a 250 rolling trading day window with 1-day ahead VaR forecasts at $a = 1\%$. For the Christoffersen (1998) test the 1-, 5-, and 20-days ahead forecasts results are reported for the $a = 1\%$, 2.5%, and 5% VaR. If a specific test does not reject the null hypothesis, we present the corresponding VaR loss function result. – indicates that the null hypothesis is rejected at least at 10% level of significance. Bold faced loss functions represent the inclusion in the Model Confidence Set (Hansen et al. 2011) with level of significant 10% and 10,000 bootstraps. The test by Pérignon and Smith (2008) is reported in a similar manner, except for the fact that the three VaR levels (1%, 2.5%, and 5%) are tested jointly.

Table 4. Value-at-Risk backtest results for PCOMP returns.

Model	Traffic Light	Christoffersen (1998)									Pérignon and Smith (2008)		
		1%			2.5%			5%					
		1-Day	5-Days	20-Days	1-Day	5-Days	20-Days	1-Day	5-Days	20-Days	1-Day	5-Days	20-Days
long trading position													
EWMA/RiskMetrics	216/996/0	–	–	–	–	–	–	–	–	–	–	–	–
Historical Simulation	968/244/0	–	–	–	–	–	–	–	–	–	0.2972	0.3040	0.3107
Filtered Historical Simulation	1017/195/0	**0.0906**	–	–	0.1716	–	–	–	–	–	0.2972	**0.2719**	**0.2757**
GARCH-SkSt	1003/209/0	**0.0785**	–	–	–	–	–	–	–	–	–	–	–
APARCH-SkSt	1035/177/0	–	–	–	**0.1360**	–	–	**0.2044**	–	–	**0.2550**	–	–
FIGARCH-SkSt	554/658/0	0.1199	–	–	0.1775	–	–	–	–	–	0.3289	0.3340	–
FIAPARCH-SkSt	1043/169/0	**0.0785**	–	–	–	–	–	–	–	–	–	–	–
SV	661/551/0	0.1141	–	–	–	–	–	0.2384	–	–	0.3118	0.2890	–
SV-*t*	767/445/0	**0.1047**	–	–	–	–	–	0.2326	–	–	0.3051	0.2914	–
SV-L	916/296/0	**0.0979**	–	–	**0.1433**	–	–	0.2158	–	–	0.2769	**0.2732**	–
short trading position													
EWMA/RiskMetrics	983/229/0	**0.1013**	–	–	–	–	–	–	–	–	**0.2769**	–	–
Historical Simulation	717/495/0	–	–	–	–	–	–	–	–	–	**0.2960**	**0.3029**	–
Filtered Historical Simulation	613/599/0	**0.1199**	–	–	–	–	–	–	–	–	–	0.3161	–
GARCH-SkSt	1212/0/0	–	–	–	–	–	–	–	–	–	–	–	–
APARCH-SkSt	1109/103/0	–	–	–	–	–	–	–	–	–	–	–	–
FIGARCH-SkSt	1009/203/0	**0.0979**	–	–	–	**0.1696**	–	–	–	–	0.3051	**0.3073**	–
FIAPARCH-SkSt	1109/103/0	–	–	–	–	–	–	–	–	–	–	–	–
SV	1109/103/0	–	–	–	–	–	–	–	–	–	–	–	–
SV-*t*	1212/0/0	–	–	–	–	–	–	–	–	–	–	–	–
SV-L	1109/103/0	–	–	–	–	–	–	–	–	–	–	–	–

Note: Numbers under the Basel traffic light test indicate the number of days in the green/yellow/red zone for a 250 rolling trading day window with 1-day ahead VaR forecasts at $a = 1\%$. For the Christoffersen (1998) test the 1-, 5-, and 20-days ahead forecasts results are reported for the $a = 1\%$, 2.5%, and 5% VaR. If a specific test does not reject the null hypothesis, we present the corresponding VaR loss function result. – indicates that the null hypothesis is rejected at least at 10% level of significance. Bold faced loss functions represent the inclusion in the Model Confidence Set (Hansen et al. 2011) with level of significant 10% and 10,000 bootstraps. The test by Pérignon and Smith (2008) is reported in a similar manner, except for the fact that the three VaR levels (1%, 2.5%, and 5%) are tested jointly.

Table 5 presents the results from the VaR backtests for the SET, traded in Bangkok. From the traffic light test, it becomes apparent that RiskMetrics and FHS lead to several days in the red zone for the long trading position. The general result for SET is that most models can cope with the long trading position to some extend, but completely fail to depict the dynamics on the short trading position. The results from HS suggest that it can be used for 1-day ahead predictions for the long trading position. Even though it is not rejected by the unconditional coverage tests, it has problems to avoid clustering of the VaR violations. This behavior is illustrated in Figure 2. It shows the slow reaction to VaR violations on the short trading position and the overall good coverage for 1% VaR forecasts. Additionally, SV-*t* shows somewhat good performance on the long trading position, which is reflected in the fact that it passes all multilevel tests and belongs to the set of the best models for 5- and 20-days ahead. For both trading positions however, only FIAPARCH and HS have good results with respect to the multilevel test at least. Hence, we conclude that both asymmetry and long memory play an important role in the variance dynamics of SET, indicating that variance shocks have an extended persistence which is of asymmetric shape, however.

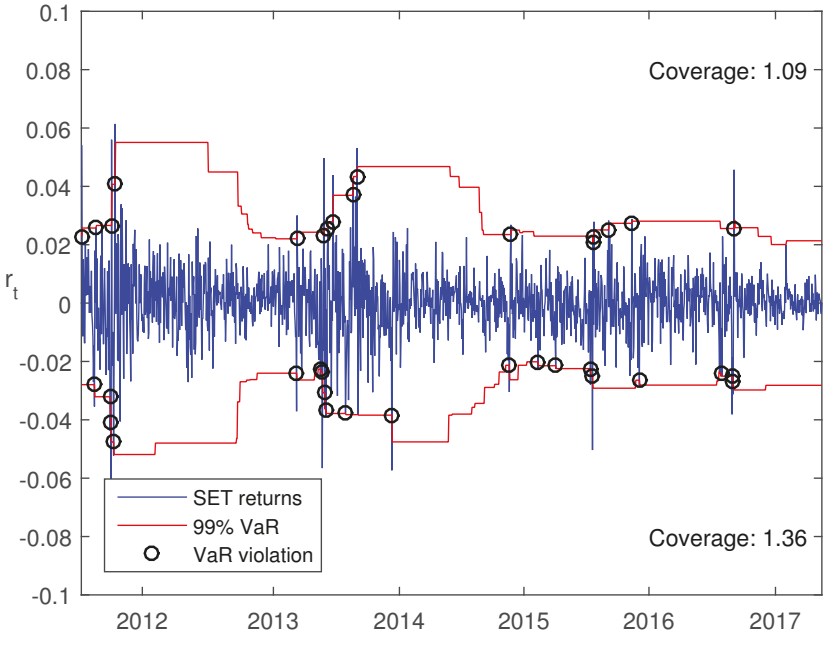

Figure 2. Value-at-Risk ($a = 1\%$) 1-day ahead forecast with Historical Simulation for the SET index.

The STI from Singapore provides interesting results. From Table 6, we find that RiskMetrics (long) and FHS (short) are included in the red zone of the Basel traffic light test. Consequently, the models would be replaced by the regulatory standard approach and the institution would be penalized with a higher factor on the minimum capital requirements accounting for the bad model choice. Interestingly, RiskMetrics shows a good performance on the short trading side, where it passes most of the tests. The worst results are achieved by the GARCH model, which fails all tests, even though it stays in the green zone over the whole out-of-sample period. The stochastic volatility models show good performance on the long trading position but cannot provide equally good results on the short trading

position. APARCH provides very good results for both trading positions regarding 1-day ahead forecasts, which indicates that asymmetries play an important role in the STI return structure.

Lastly, we compare the forecasting results for the Vietnamese equity index VNI (Table 7). Within our model set, which includes very widely used VaR estimation procedures, only the SV model provides an average to good performance. All other models are either in the red zone (RiskMetrics, FHS, FIGARCH) or fail most of the statistical coverage tests (GARCH, APARCH, FIAPARCH). The models in the red zone, however, are only included for one trading side. For the long trading position, FIGARCH and FHS provide good results from the coverage tests. The stochastic volatility models show very good performance for 1- and 5-days ahead predictions on the long trading position and belong to the model confidence set at every test they pass.

Finally, we compare all results from the six different equity indices of Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam. GARCH seems to be regulator's darling with respect to the traffic light characterization. Although popular, it fails almost all statistical coverage tests, while, for most indices, it is 100% of the time in the green zone of the traffic light test. This indicates that the model yields too conservative VaR forecast, which would result in particularly high minimum capital requirements. In addition, the very popular RiskMetrics model shows poor performance. McMillan and Kambouroudis (2009) concludes that the model only performs well in small markets and high VaR quantiles. Our findings suggest that the selected six markets in this paper may already be too big for the RiskMetrics approach. Interestingly, the HS is rarely rejected by the multilevel coverage test, i.e., regardless of the specific forecast horizon, it provides sufficient coverage ratios. However, it is not able to provide satisfying results for the conditional coverage test in all indices. This might be due to the slow adaption of shocks resulting in clustering of violations. The SV model specifications provide a framework with a good overall performance at all markets, but only on the long trading position. However, especially for shorter forecast horizons, the SV models belong to the model confidence sets.

Comparing the model performance for each index, we find evidence that the markets in our analyzed group are heterogeneous with respect to their volatility properties. For example, STI is dominated by asymmetric effects and long memory models are rejected by our coverage tests while, for the VNI, long memory models show a good forecasting performance and asymmetric models are rejected.

Table 5. Value-at-Risk backtest results for SET returns.

Model	Traffic Light	Christoffersen (1998)									Pérignon and Smith (2008)		
		1%			2.5%			5%					
		1-Day	5-Days	20-Days	1-Day	5-Days	20-Days	1-Day	5-Days	20-Days	1-Day	5-Days	20-Days
long trading position													
EWMA/RiskMetrics	387/738/95	–	–	–	–	–	–	0.2363	–	–	–	–	–
Historical Simulation	699/521/0	0.1167	–	–	0.1630	–	–	**0.2199**	–	**0.2260**	0.2975	**0.3032**	0.3032
Filtered Historical Simulation	814/345/61	0.1167	–	–	0.1650	–	–	0.2290	–	–	0.3054	–	–
GARCH-SkSt	1009/211/0	**0.0825**	–	–	–	–	–	–	–	–	–	–	–
APARCH-SkSt	978/242/0	**0.0904**	**0.0976**	**0.0865**	0.1521	**0.1453**	–	**0.2104**	–	–	0.2749	–	–
FIGARCH-SkSt	613/607/0	0.1224	–	–	–	–	–	–	–	**0.2245**	–	–	–
FIAPARCH-SkSt	1159/61/0	**0.0825**	**0.1076**	**0.0941**	**0.1381**	**0.1429**	–	**0.2071**	–	–	**0.2622**	–	**0.2557**
SV	620/600/0	0.1107	–	**0.0904**	0.1808	–	–	0.2391	–	–	0.3196	–	–
SV-*t*	732/488/0	0.1107	**0.1076**	**0.0904**	0.1826	**0.1566**	–	0.2475	–	–	0.3269	**0.2929**	**0.2583**
SV-L	1015/205/0	**0.0865**	**0.1076**	**0.0865**	0.1608	0.1587	–	0.2245	–	–	0.2894	**0.2858**	–
short trading position													
EWMA/RiskMetrics	629/591/0	–	–	–	–	–	–	–	–	–	–	–	–
Historical Simulation	760/460/0	–	–	–	–	–	–	–	–	–	**0.2798**	0.2798	**0.2858**
Filtered Historical Simulation	759/461/0	–	–	–	–	–	–	–	–	–	0.3196	**0.2648**	–
GARCH-SkSt	1018/202/0	–	–	–	–	–	–	–	–	–	–	–	–
APARCH-SkSt	1220/0/0	–	–	–	–	–	–	–	–	–	–	–	–
FIGARCH-SkSt	1043/177/0	–	–	–	–	–	–	–	–	–	**0.2774**	**0.2774**	–
FIAPARCH-SkSt	990/230/0	–	–	–	–	–	–	–	–	–	–	–	–
SV	1220/0/0	–	–	–	–	–	–	–	–	–	–	–	–
SV-*t*	1146/74/0	–	–	–	–	–	–	–	–	–	–	–	–
SV-L	1220/0/0	–	–	–	–	–	–	–	–	–	–	–	–

Note: Numbers under the Basel traffic light test indicate the number of days in the green/yellow/red zone for a 250 rolling trading day window with 1-day ahead VaR forecasts at $a = 1\%$. For the Christoffersen (1998) test the 1-, 5-, and 20-days ahead forecasts results are reported for the $a = 1\%$, 2.5%, and 5% VaR. If a specific test does not reject the null hypothesis, we present the corresponding VaR loss function result. – indicates that the null hypothesis is rejected at least at 10% level of significance. Bold faced loss functions represent the inclusion in the Model Confidence Set (Hansen et al. 2011) with level of significant 10% and 10,000 bootstraps. The test by Pérignon and Smith (2008) is reported in a similar manner, except for the fact that the three VaR levels (1%, 2.5%, and 5%) are tested jointly.

Table 6. Value-at-Risk backtest results for STI returns.

Model	Traffic Light	Christoffersen (1998)									Pérignon and Smith (2008)		
		1%			2.5%			5%					
		1-Day	5-Days	20-Days	1-Day	5-Days	20-Days	1-Day	5-Days	20-Days	1-Day	5-Days	20-Days
long trading position													
EWMA/RiskMetrics	234/1004/17	–	–	–	–	–	–	–	–	–	–	–	–
Historical Simulation	830/425/0	–	–	–	0.1710	–	–	–	–	–	0.2996	**0.2996**	0.3105
Filtered Historical Simulation	764/491/0	**0.0965**	–	–	**0.1651**	–	–	**0.2157**	–	–	**0.2883**	–	–
GARCH-SkSt	1255/0/0	–	–	–	–	–	–	–	–	–	–	–	–
APARCH-SkSt	895/360/0	**0.0893**	–	–	**0.1481**	–	–	**0.2014**	–	–	**0.2655**	–	–
FIGARCH-SkSt	628/627/0	–	–	–	–	–	–	–	–	–	0.3302	–	0.3137
FIAPARCH-SkSt	950/305/0	**0.0999**	–	–	**0.1436**	–	–	–	–	–	–	–	–
SV	747/508/0	–	–	**0.0855**	0.1768	–	**0.1436**	0.2419	–	–	0.3221	**0.3148**	0.2655
SV-*t*	608/647/0	–	–	–	0.1710	–	**0.1504**	0.2433	–	–	0.3221	**0.3105**	0.2741
SV-L	897/358/0	**0.1031**	–	–	**0.1569**	–	–	0.2173	–	–	0.2871	–	**0.2473**
short trading position													
EWMA/RiskMetrics	1036/219/0	0.1094	0.1153	–	**0.1691**	0.1710	0.1691	0.2203	0.2203	**0.2203**	0.2985	0.3018	–
Historical Simulation	729/526/0	**0.1094**	0.1124	0.1237	**0.1730**	–	–	–	–	–	0.2985	0.3007	–
Filtered Historical Simulation	809/387/59	0.1209	**0.0999**	0.1031	–	**0.1526**	0.1590	0.2391	–	–	0.3252	–	–
GARCH-SkSt	1255/0/0	–	–	–	–	–	–	–	–	–	–	–	–
APARCH-SkSt	1030/225/0	**0.0999**	**0.0965**	0.0999	**0.1526**	**0.1481**	**0.1389**	0.2111	**0.2047**	–	0.2789	**0.2704**	–
FIGARCH-SkSt	619/636/0	0.1237	–	–	–	–	0.1749	0.2277	0.2363	–	–	0.3221	**0.3116**
FIAPARCH-SkSt	958/297/0	**0.1031**	**0.0774**	–	**0.1459**	–	–	–	–	–	0.2680	–	–
SV	1237/18/0	**0.0855**	–	–	–	–	–	–	–	–	–	–	–
SV-*t*	1117/138/0	–	–	**0.0729**	–	–	–	**0.1997**	–	–	**0.2500**	–	–
SV-L	1255/0/0	**0.0774**	–	–	–	–	–	–	–	–	–	–	–

Note: Numbers under the Basel traffic light test indicate the number of days in the green/yellow/red zone for a 250 rolling trading day window with 1-day ahead VaR forecasts at $a = 1\%$. For the Christoffersen (1998) test the 1-, 5-, and 20-days ahead forecasts results are reported for the $a = 1\%$, 2.5%, and 5% VaR. If a specific test does not reject the null hypothesis, we present the corresponding VaR loss function result. – indicates that the null hypothesis is rejected at least at 10% level of significance. Bold faced loss functions represent the inclusion in the Model Confidence Set (Hansen et al. 2011) with level of significant 10% and 10,000 bootstraps. The test by Pérignon and Smith (2008) is reported in a similar manner, except for the fact that the three VaR levels (1%, 2.5%, and 5%) are tested jointly.

Table 7. Value-at-Risk backtest results for VNI returns.

Model	Traffic Light	Christoffersen (1998)									Pérignon and Smith (2008)		
		1%			2.5%			5%					
		1-Day	5-Days	20-Days	1-Day	5-Days	20-Days	1-Day	5-Days	20-Days	1-Day	5-Days	20-Days
long trading position													
EWMA/RiskMetrics	325/764/159	–	–	–	–	0.1809	–	0.2268	–	–	–	–	–
Historical Simulation	1122/126/0	**0.0731**	**0.0775**	**0.0731**	–	–	–	–	–	–	–	–	–
Filtered Historical Simulation	748/500/0	**0.0967**	–	–	**0.1529**	–	–	**0.2002**	–	–	**0.2699**	–	–
GARCH-SkSt	1248/0/0	–	–	–	–	–	–	–	–	–	–	–	–
APARCH-SkSt	872/376/0	**0.0857**	**0.0967**	–	–	–	–	–	–	–	–	–	–
FIGARCH-SkSt	782/466/0	0.1127	0.1212	0.1185	0.1791	0.1791	–	–	0.2253	**0.2253**	0.3155	0.3123	**0.3102**
FIAPARCH-SkSt	1036/212/0	**0.0775**	–	–	–	–	–	–	–	–	–	–	–
SV	864/384/0	**0.0967**	**0.0967**	–	**0.1392**	**0.1368**	–	**0.2068**	–	–	**0.2674**	–	–
SV-*t*	864/384/0	**0.0967**	**0.0817**	–	**0.1343**	**0.1343**	–	**0.2068**	**0.2002**	–	**0.2649**	**0.2546**	–
SV-L	929/319/0	**0.0967**	**0.0932**	–	**0.1507**	**0.1368**	–	**0.1968**	–	–	**0.2661**	–	–
short trading position													
EWMA/RiskMetrics	965/283/0	–	–	–	–	–	–	–	–	–	0.3025	0.3176	–
Historical Simulation	1072/176/0	**0.0857**	0.0857	**0.0817**	–	–	–	–	–	–	**0.2636**	**0.2598**	**0.2546**
Filtered Historical Simulation	845/384/19	**0.0967**	**0.0731**	–	**0.1485**	–	–	**0.2051**	–	–	**0.2711**	–	–
GARCH-SkSt	1248/0/0	–	–	–	–	–	–	–	–	–	–	–	–
APARCH-SkSt	1248/0/0	–	–	–	–	–	–	–	–	–	–	–	–
FIGARCH-SkSt	384/841/23	–	–	–	–	–	–	–	–	–	–	–	–
FIAPARCH-SkSt	1248/0/0	–	–	–	–	–	–	–	–	–	–	–	–
SV	1248/0/0	–	–	–	–	–	–	–	–	–	–	–	–
SV-*t*	1248/0/0	–	–	–	–	–	–	–	–	–	–	–	–
SV-L	1248/0/0	–	–	–	–	–	–	–	–	–	–	–	–

Note: Numbers under the Basel traffic light test indicate the number of days in the green/yellow/red zone for a 250 rolling trading day window with 1-day ahead VaR forecasts at $a = 1\%$. For the Christoffersen (1998) test the 1-, 5-, and 20-days ahead forecasts results are reported for the $a = 1\%$, 2.5%, and 5% VaR. If a specific test does not reject the null hypothesis, we present the corresponding VaR loss function result. – indicates that the null hypothesis is rejected at least at 10% level of significance. Bold faced loss functions represent the inclusion in the Model Confidence Set (Hansen et al. 2011) with level of significant 10% and 10,000 bootstraps. The test by Pérignon and Smith (2008) is reported in a similar manner, except for the fact that the three VaR levels (1%, 2.5%, and 5%) are tested jointly.

5. Conclusions

We compare the forecasting performance of different GARCH-type and Stochastic Volatility models as well as non- and semi-parametric approaches in terms of the widely-used Value-at-Risk measure. We obtain results that are not consistent across markets as well as trading positions. The results imply that, for the long and short trading positions, different forecasting methods should be implemented. Adding to this inconsistency, we find that, for different ASEAN stock indices, the model performances vary, indicating that the markets volatility might be driven by different factors. The simple GARCH and the RiskMetrics framework provide insufficient forecasts in terms of coverage and clustering. With only a few exceptions, the two models fail for all forecasting horizons and for all markets. This is a clear indication that the index volatilities should not be modeled by short memory and symmetric processes. Long memory models with or without asymmetric news impact, such as the FIGARCH, APARCH, or FIAPARCH, are potent alternatives.

Given the significant skewness in the empirical returns, skewed distributions driving the volatility processes are suggested. The Historical Simulation appears to be superior over its filtered extension and provides reasonably good results for the multilevel unconditional coverage test. With Stochastic Volatility models, we improve the quality of some forecasts. In general, we obtain better results for shorter horizons. In addition, there is no clear pattern in the failure rate of the unconditional and conditional coverage tests. Interestingly, for the stochastic volatility framework, we achieve a good overall VaR coverage, which is, however, clustered for most markets across the forecasting horizons. The clustering might be caused by periods of extreme market movements paired with only a minor reaction of the volatility models.

In summary, the results show that simple volatility models do not provide VaR forecasts of practical value and that more sophisticated models, which cover different stylized facts, are needed to properly quantify financial risk on the long and short side for ASEAN stock market indices. Moreover, we conclude that, despite their regional proximity and homogeneity of the markets, the stock index volatilities of the biggest ASEAN markets are driven by different factors. This needs to be addressed in further research.

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Author Contributions: Nam H. Nguyen and Paul Bui Quang implemented the Stochastic Volatility models and the corresponding Value-at-Risk estimation. Tony Klein and Thomas Walther jointly implemented and analyzed the GARCH models, carried out the backtests, and wrote the article.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

ASEAN	Association of Southeast Asian Nations
APARCH	Asymmetric Power Autoregressive Heteroskedasticity
GARCH	Generalized Autoregressive Heteroskedasticity
EWMA	Exponentially Weighted Moving Average
FHS	Filtered Historical Simulation
FIAPARCH	Fractionally Integrated Asymmetric Power Autoregressive Heteroskedasticity
FIGARCH	Fractionally Integrated Generalized Autoregressive Heteroskedasticity
HS	Historical Simulation
JCI	Jakarta Stock Exchange Composite Index

KLSE	Kuala Lumpur Stock Exchange
MCS	Model Confidence Set
PCOMP	Philippines Stock Exchange Index
SET	Stock Exchange of Thailand
STI	Singapore Strait's Time Index
SV	Stochastic Volatility
VaR	Value-at-Risk
VNI	Vietnam Ho Chi Minh Stock Index

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