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Article

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ASEAN economic growth, trade openness and banking-sector depth: The nexus

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Abstract

This paper investigated the linkages between banking sector depth, trade openness, and economic growth using a panel data set covering the ASEAN regional forum countries for the period 1961–2012. Using our multivariate framework, we first found that all the variables were integrated of order one and were cointegrated. Our panel-data estimation procedures offered more robust estimates than previous studies by utilizing variations between countries as well as variations over time. The results of this study indicated a general long-run equilibrium relationship among trade openness, banking sector depth and economic growth as well as a short-run relationship between these variables. Policy recommendations include those that will promote greater banking sector development as well as increased trade openness.

JEL classification: O16; O43; E44; E31

Keywords: Trade openness; Banking sector depth; Economic growth; Granger causality; ASEAN regional forum countries

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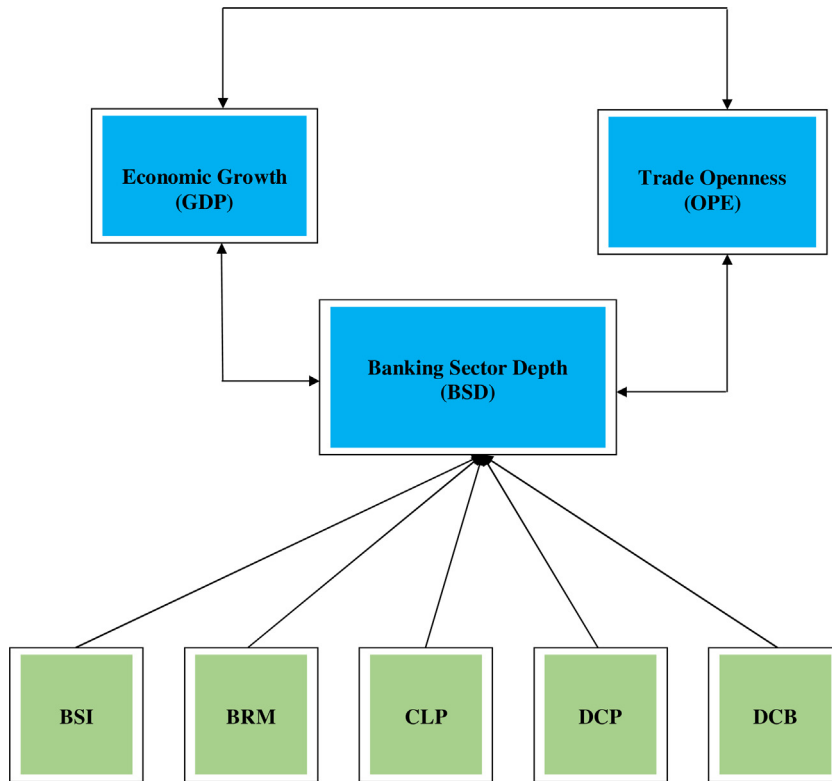
1. Introduction

It has long been recognized that trade openness has an important bearing on economic growth (Coe and Helpman, 1995; Barro and Sala-i-Martin, 1995; Romer, 1998). Moreover, the case for fostering depth in the financial sector of a nation¹ for the sake of fostering its economic growth is propounded in a litany of articles using different measures of financial depth (Shahbaz, 2012; Bojanic, 2012; Gries et al., 2009; Levine, 2003; Shan et al., 2001; Blackburn and Hung,

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¹ 'Depth' in the financial sector captures the dimensions of higher quantity, improved quality, and enhanced efficiency of financial services – all in relation to national income to allow for different levels of country needs and development. Of course, the financial sector may be defined in different ways (see below).



Note: BSD has five different measures: BSI, BRM, CLP, DCP, and DCB. See Table 3 for their definitions.

Fig. 1. Conceptual framework of the possible causal patterns between economic growth, banking sector depth, and trade openness.

1998). Financial sector depth itself may be linked to trade openness. Thus, financial sector depth may affect economic growth both directly through the usual expenditure channels and indirectly through its effect on trade openness.

The endogenous growth theory as articulated by Levine (2005) and others stresses that financial sector depth is key in fostering long-run economic growth since it facilitates efficient inter-temporal allocation of resources, capital accumulation and technological innovation. King and Levine (1993) in particular underscore the beneficial effects on investment and growth from the existence of sound financial markets. However, as Barro and Sala-i-Martin (1995) assert, the development of these markets is endogenous since they are a regular part of the process of economic growth. Thus, while financial depth may lead to economic growth, the latter may itself lead to further financial depth. Similarly, financial depth can be linked to trade openness.

Since the concept of financial sector depth is fairly broad and can include both banking sector and stock market depth, in this paper we concentrate on one variable, namely banking sector depth. Thus, we explore the causal linkages between economic growth, trade openness, and banking sector depth. The symmetrical representation of the relationship between banking sector depth, trade openness, and economic growth is presented in Fig. 1.

Prior to the present study, many studies have investigated the causal relationship between these variables in a bivariate setting (see the next section) for different countries or regions. The present paper extends previous studies by examining the nature of the causal link among all three variables using panel co-integration and causality tests. In addition, a group of countries that have been neglected in previous research, namely the ASEAN Regional Forum (ARF) countries, are used in the present study. Our advanced panel-data estimation methods allow for more robust estimates by utilizing variations between countries as well as variation over time. We found interesting and relevant causal links among the variables, derived inter alia from the use of more sophisticated econometric techniques.

The remainder of this paper is organized as follows: Section 2 provides an overview on two stands of the economic growth literature: one examining the relationship between financial sector development and economic growth and the

other exploring the nexus between trade openness and economic growth. This section also motivates our study by pointing out the unique contributions of the present study. Section 3 describes the variables in more detail and outlines the data source used in the analysis. Section 4 describes the methodology and this is followed by a section describing the results. The final section contains a summary and the policy implications of our results.

2. Literature survey and motivations for the study

Previous researchers have delved extensively on the relationship between financial sector depth and economic growth, defining financial sector depth as banking sector depth, stock market depth, or a combination of the two. Despite a sizable body of literature on this subject, which includes studies of different countries, the direction of the causal effect across the two variables has been inconclusive (King and Levine, 1993). It remains open to question whether financial depth drives economic growth or whether economic growth drives financial depth. Of course, there is also the possibility that the two variables are mutually causal. Thus, we review the studies and the hypotheses from these studies next. The first of these hypotheses, the financial depth-led growth hypothesis, suggests that financial depth is a necessary pre-condition to economic growth (Schumpeter, 1911). Hence, the causality runs from financial depth to economic growth. The proponents of this hypothesis maintain that financial depth induces economic growth by facilitating resources for productivity improvement. For example, Hsueh et al. (2013), Bojanic (2012), Chaiechi (2012), Jalil et al. (2010), Kar et al. (2011), Wu et al. (2010), Abu-Bader and Abu-Qarn (2008), Ang (2008), Naceur and Ghazouani (2007), Boulila and Trabelsi (2004), Christopoulos and Tsionas (2004), Calderon and Liu (2003), Al-Yousif (2002), Levine (1997), Thornton (1994), Bencivenga and Smith (1991), and Greenwood and Jovanovic (1990) advance results in support of this hypothesis.

A second proposition, the growth-led financial depth hypothesis, suggests that causality runs from economic growth to financial depth. Supporters of this hypothesis suggest that financial depth plays only a minor role in economic growth and that it is merely a by-product or an outcome of growth in the real side of the economy (Kar et al., 2011; Odhiambo, 2010; Gries et al., 2009; Panopoulou, 2009; Ang, 2008; Ang and McKibbin, 2007; Liang and Teng, 2006; Demetriades and Hussein, 1996; Ireland, 1994). The idea is that, when an economy matures, additional demand for financial services emerge in the economy. Accordingly, as the real side of the economy grows, the financial depth improves further, thereby increasing opportunities for financial markets.

The third proposition is the feedback hypothesis, suggesting that economic growth and financial depth can complement and reinforce each other. The argument in favour of the bidirectional causality is that financial depth is indispensable to economic growth and economic growth inevitably requires a certain level of financial depth (Wolde-Rufael, 2009; Lee and Chang, 2009; Dritsakis and Adamopoulos, 2004; Al-Yousif, 2002; Craigwell et al., 2001; Ahmed and Ansari, 1998; Greenwood and Smith, 1997; Demetriades and Hussein, 1996).

Table 1 provides a synopsis of research on the causal nexus between financial depth and economic growth.

There is also a body of literature relating to the direction of causality between economic growth and trade openness. Analogously to the previous strand of the literature, three possible hypotheses are offered and tested.

The first of these hypotheses, the trade-led growth hypothesis, suggests that trade openness is a necessary pre-condition to economic growth (see, for instance, Bojanic, 2012; Yavari and Mohseni, 2012; Muhammad et al., 2012). Thus, the causality runs from trade openness to economic growth. The proponents of this hypothesis maintain that trade openness induce economic growth by facilitating resources and technology movements across the borders (see, for example, Shahbaz, 2012; Romer, 1998).

A second proposition, the growth-led trade hypothesis, suggests that causality runs instead from economic growth to trade openness. Supporters of this hypothesis suggest that trade openness plays only a minor role in economic growth and that it is merely a by-product or an outcome of growth in the real side of the economy (see, for instance, Shahbaz, 2012; Bajwa and Siddiqi, 2011; Konya, 2006; Reizman et al., 1996). The idea is that, when an economy matures, additional demand for goods and services emerge in the economy. Thus, the dearth of openness in the developing countries indicates a lack of demand for goods and services.

The third proposition is the feedback hypothesis suggesting that economic growth and trade openness can complement and reinforce each other, making trade openness and economic growth mutually causal. The argument in favour of the bidirectional causality is that trade openness is indispensable to economic growth and economic growth inevitably facilitates further opportunities for trade through specialization (see, for instance, Tang and Chea, 2013; Awokuse, 2006; Konya, 2006; Din, 2004; Xu, 1996).

Table 1
Summary of studies on the causal nexus between financial sector depth and economic growth.

Study	Method of study	Study area	Period of study
Case 1: studies supporting SLH			
Hsueh et al. (2013)	1	Ten Asian countries	1980–2007
Bojanic (2012)	4	Bolivia	1940–2010
Chaiechi (2012)	4	South Korea, Hong Kong, UK	1990–2006
Kar et al. (2011)	4	15 MENA countries	1980–2007
Wu et al. (2010)	4	European Union	1976–2005
Abu-Bader and Abu-Qarn (2008)	2	Egypt	1960–2001
Ang (2008)	4	Malaysia	1960–2003
Naceur and Ghazouani (2007)	4	MENA region	1979–2003
Calderon and Liu (2003)	4	109 countries	1960–1994
Case 2: Studies supporting DFH			
Kar et al. (2011)	4	15 MENA countries	1980–2007
Odhiambo (2008)	2	Kenya	1969–2005
Ang and McKibbin (2007)	4	Malaysia	1960–2001
Liang and Teng (2006)	4	China	1952–2001
Case 3: Studies supporting FBH			
Wolde-Rufael (2009)	3	Kenya	1966–2005
Craigwell et al. (2001)	4	Barbados	1974–1998
Ahmed and Ansari (1998)	4	India, Pakistan, Sri Lanka	1973–1991

Note 1: Supply leading hypothesis (SLH): if there is unidirectional causality from an indicator of financial sector depth (FSD) to economic growth (GDP); demand following hypothesis (DFH): if there is presence of unidirectional causality from GDP to FSD; feedback hypothesis (FBH): if there is bidirectional causality between FSD and GDP.

Note 2: The definition of financial sector depth varies across studies.

Note 3: 1: Bivariate Granger causality; 2: Trivariate Granger causality; 3: Quadivariate Granger causality; 4: Multivariate Granger causality.

Table 2 provides a synopsis of research on the causal nexus between trade openness and economic growth.

In common with many other studies in this literature, we define financial depth as depth in the banking sector. There are four unique contributions that this study will make towards the existing body of knowledge. First, unlike the previous studies, we consider the causal relationship between three, not two variables. In doing so, we meld two strands of the literature linking economic growth to two other pertinent variables. Second, we use a large sample of ARF countries, both developed and developing, over a long and recent span of time (1961–2012). As Tables 1 and 2 reveal, this group of countries have thus far not been studied in this literature. Third, we employ sophisticated econometrics – and certainly empirical approaches heretofore not adopted in the literature – to answer questions concerning the nature of the causal relationship between the three variables. In particular, we use cointegration and error-correction with unrestricted dynamic techniques to justify the presence of contemporaneous relationships between the variables. Fourth, we use impulse response function analysis to ascertain the responsiveness to shocks in the variables.

3. Variables and data structure

As several previous researchers have commented (see, for instance, Abu-Bader and Abu-Qarn, 2008; Naceur and Ghazouani, 2007; Beck and Levine, 2004; Rousseau and Wachtel, 1998; Levine and Zervos, 1998), banking sector depth cannot be captured by a single measure. Our study utilizes five measures for banking sector depth, namely broad money supply in relation to national income (BRM), claims on the private sector in relation to national income (CLP), domestic credit to the private sector in relation to national income (DCP), domestic credit provided by the banking sector in relation to national income (DCB), and banking sector depth index (BSI). The latter index is derived from the other measures using principal component analysis (see Appendix A for the methodology). We adopt the World Bank definition of the first four measures and elaborate on them in Table 3. This table also defines the other variables used in this study.

Data in relation to all these variables are obtained from the *World Development Indicators*, published by the World Bank. Fig. 2 shows the conceptual framework of the possible causal patterns between the variables. Furthermore, as

Table 2
Summary of studies on the causal nexus between trade openness and economic growth.

Study	Method of study	Study area	Period of study
Case 1: Studies Supporting SLH			
Shahbaz (2012)	3	Pakistan	1971–2011
Bojanic (2012)	2	Bolivia	1940–2010
Hossain (2011)	3	NICs	1971–2007
Gries et al. (2009)	3	16 SSA countries	1960–2003
Chanderan and Munusamy (2009)	3	Malaysia	1970–2003
Konya (2006)	2	24 OECD countries	1960–1997
Anwar and Sampath (2000)	1	97 countries	1960–1992
Xu (1996)	1	32 DCs	1960–1990
Riezman et al. (1996)	1	126 countries	1950–1990
Van de Berg and Schmidt (1994)	1	16 LACs	1980–2007
Nandi (1991)		India	1960–1985
Case 2: Studies Supporting DFH			
Shahbaz (2012)	3	Pakistan	1971–2011
Jayanthakumaran and Verma (2008)	1	ASEAN 5	1967–2005
Konya (2006)	2	24 OECD countries	1960–1997
Riezman et al. (1996)	1	126 countries	1950–1990
Case 3: Studies Supporting FBH			
Tang and Chea (2013)	1	Cambodia	1972–2008
Awokuse (2006)	3	Argentina, Colombia, Peru	1993–2002
Konya (2006)	2	24 OECD countries	1960–1997
Clarke and Ralhan (2005)	3	5DCs	1960–2003
Din (2004)		5SACs	1960–2002
Ekanayake (1999)	1	8 ADCs	1960–1997
Xu (1996)	1	32 DCs	1960–1990
Bhat (1995)	1	India	1950–1993
Van de Berg and Schmidt (1994)	1	16 LACs	1980–2007
Bahmani-Oskooee et al. (1991)	1	20 DCs	1951–1987

Note 1: Supply-leading hypothesis (SLH): if unidirectional causality is present from trade openness to economic growth; demand-following hypothesis (DFH): if unidirectional causality from economic growth to trade openness is present; and feedback hypothesis (FBH): if bidirectional causality between trade openness and economic growth is present.

Note 2: 1: Bivariate Granger Causality; 2: Trivariate Granger Causality; and 3: Multivariate Granger Causality.

Note 3: NACs: Northeast Asian Countries; EEC: Eastern European Countries; LACs: Latin American Countries; GCT: Granger Causality Test; MST: Modified Sims Test; DCs: Developing Countries; ACs: Asian Countries; SSA: Sub-Saharan African countries; and SACs: South Asian Countries.

is evident from Fig. 1, banking sector depth can be represented by one of our four identified indicators, as well as the composite index, BSI. Since using all the four indicators in the same equation would lead to multicollinearity, we use each one separately (see below).

Our empirical analysis is based on a panel of 25 ARF countries, namely Brunei, Burma, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam, Australia, Canada, China, India, Japan, New Zealand, Korean Republic, Russian Federation, the United States, Papua New Guinea, Mongolia, Pakistan, East Timor, Bangladesh, and Sri Lanka, over the period 1960–2012. The countries are selected on the basis of data availability. We require complete and continuous time series on the variables for a time span of 53 years. The variables used are transformed to their natural logarithm forms for our estimations so that their first differences approach the growth rates. Table 4 provides the descriptive statistics and their correlations for the economic growth, trade openness and the indicators of banking sector depth.

We can see that there is considerable variation across the countries. The correlation coefficients in Table 4 suggest that, as hypothesized, four indicators of banking sector depth (BRM, CLP, DCP, and DCB) are highly correlated with each other and are statistically significant at the 1% level. This means that multicollinearity would be a problem if we were to use them all simultaneously in studying the causal relation between banking sector depth, economic growth, and trade openness. Hence, we proceed by examining the nexus between trade openness, economic growth, using

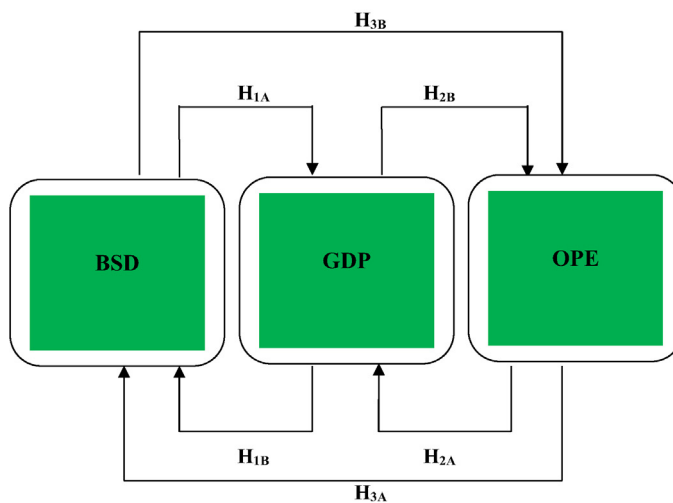
Table 3
Variables definition.

Variables	Definition
BSI	Composite index of banking sector depth: This is derived using four indicators: broad money supply, claims on private sector, domestic credit to the private sector, and domestic credit provided by the banking sector. The index is derived using principal component analysis (see Appendix A). The four indicators are defined below.
BRM	Broad money supply: This is broad money expressed as a percentage of gross domestic product. Broad money is the sum of currency outside banks; demand and term deposits, including foreign currency deposits of resident sectors (other than the central bank); certificates of deposit and commercial paper.
CLP	Claims on the private sector: This is claims on central government which include loans to central government institutions (net of deposits) – expressed as a percentage of gross domestic product.
DCP	Domestic credit to the private sector: This credit is expressed as a percentage of gross domestic product. The credit refers to financial resources provided to the private sector, such as through loans, purchases of non-equity securities, and trade credits and other accounts receivable, that establish a claim for payment.
DCB	Domestic credit provided by the banking sector: This credit is expressed as a percentage of gross domestic product. Domestic credit provided by the banking sector includes all credit to various sectors on a gross basis, with the exception of credit to the central government, which is net. The banking sector includes monetary authorities and deposit money banks, as well as other banking institutions such as mortgage and building loan associations.
OPE	Trade openness: Total volume of trade (exports plus imports) as a percentage of gross domestic product.
GDP	Growth rate of per capita income (in percentage): Income is defined as gross domestic product. This is our measure of economic growth.

Note 1: All monetary measures are in real US dollars.

Note 2: Variables above are defined in the World Development Indicators, published by the World Bank.

Note 3: We use the natural log of these variables in our estimation. Summary statistics on these variables appears in [Table 4](#).



Note 1: GDP is economic growth, BSD is banking sector depth, and OPE is trade openness. BSD has five different measures. A more detailed definition of the variables appears in the text.

Note 2: H_{1A}: BSD Granger-causes GDP; H_{1B}: GDP Granger-causes BSD; H_{2A}: OPE Granger-causes GDP; H_{2B}: GDP Granger-causes OPE; H_{3A}: OPE Granger-causes BSD; and H_{3B}: BSD Granger-causes OPE.

Note 3: Possible Granger causal relationships between any two variables are tested in the presence of the other two variables.

Fig. 2. Proposed model and hypotheses.

Table 4
The descriptive statistics and correlations for the variables.

Variables	GDP	BSI	BRM	CLP	DCP	DCB	OPE
Mean	1.25	0.08	1.82	1.78	1.77	1.87	1.8
Median	1.26	0.12	1.82	1.78	1.87	1.86	1.77
Maximum	1.49	0.64	2.38	2.26	2.36	2.53	2.66
Minimum	-0.15	-0.84	1.21	-0.19	0.71	0.86	1.17
Stand. dev.	0.12	0.28	0.25	0.13	0.36	0.31	0.32
Skewness	-5.08	-0.15	0.09	-7.89	-0.39	-0.11	0.52
Kurtosis	47.9	2.4	2.56	11.7	2.18	2.74	2.99
JB	36.3	7.8	3.89	22.9	21.9	1.97	18.3
Correlations							
GDP	1	-0.03	0.02	0.13**	-0.01	-0.08	0.06
BSI		1	0.94*	-0.06	0.98*	0.97*	0.02
BRM			1	-0.14**	0.89*	0.88*	0.13**
CLP				1	-0.03	-0.15**	0.08
DCP					1	0.93*	0.05
DCB						1	-0.13**
OPE							1

Note 1: Stand. Dev.: Standard Deviation; and JB: Jarque Bera statistics.

Note 2: BSI: Composite index of banking sector depth; BRM: Broad money supply; CLP: Claims on the private sector; DCP: Domestic credit to the private sector; DCB: Domestic credit provided by the banking sector; OPE: Trade openness; and GDP: Growth rate of per capita income.

Note 3: Variables as defined in Table 3.

Note 4: Values reported here are the natural logs of the variables in Table 3. Natural log forms are used in our estimation.

Note 5: *: The significance levels at the 1%; and **: The significance levels at the 10%.

each of the four financial sector development indicators, separately. We also utilize the composite index BSI which combines all four indicators of banking sector depth into one aggregate measure.

4. Econometric modelling and estimation strategy

To examine the long-run causal relationship between per capita economic growth (GDP), banking sector depth (BSD), and trade openness in the economy (OPE), we estimate three dynamic panel regressions using pooled data on the 25 countries. Following Holtz-Eakin et al.'s (1988) procedure, the three regressions are

$$\Delta GDP_{it} = \eta_{1j} + \sum_{k=1}^p \alpha_{1ik} \Delta GDP_{it-k} + \sum_{k=1}^q \beta_{1ik} \Delta BSD_{it-k} + \sum_{k=1}^r \delta_{1ik} \Delta OPE_{it-k} + \lambda_{1i} ECT_{1it-1} + \varepsilon_{1it} \quad (1)$$

$$H_0 : \beta_{1ik} = 0 ; \delta_{1ik} = 0 ; \lambda_{1i} = 0 \quad \text{for } k = 1, 2, \dots, p/q/r$$

$$H_1 : \beta_{1ik} \neq 0 ; \delta_{1ik} \neq 0 ; \lambda_{1i} \neq 0 \quad \text{for at least one } k$$

$$\Delta BSD_{it} = \eta_{2j} + \sum_{k=1}^p \alpha_{2ik} \Delta BSD_{it-k} + \sum_{k=1}^q \beta_{2ik} \Delta GDP_{it-k} + \sum_{k=1}^r \delta_{2ik} \Delta OPE_{it-k} + \lambda_{2i} ECT_{2it-1} + \varepsilon_{2it} \quad (2)$$

$$H_0 : \beta_{2ik} = 0 ; \delta_{2ik} = 0 ; \lambda_{2i} = 0 \quad \text{for } k = 1, 2, \dots, p/q/r$$

$$H_1 : \beta_{2ik} \neq 0 ; \delta_{2ik} \neq 0 ; \lambda_{2i} \neq 0 \quad \text{for at least one } k$$

$$\Delta OPE_{it} = \eta_{3j} + \sum_{k=1}^p \alpha_{3ik} \Delta OPE_{it-k} + \sum_{k=1}^q \beta_{3ik} \Delta BSD_{it-k} + \sum_{k=1}^r \delta_{3ik} \Delta GDP_{it-k} + \lambda_{3i} ECT_{3it-1} + \varepsilon_{3it} \quad (3)$$

Table 5

The summary of the hypotheses tested in this study.

Causal flow	Restrictions
BSD \Rightarrow GDP	$\beta_{1ik} \neq 0; \lambda_{1i} \neq 0$
GDP \Rightarrow BSD	$\beta_{2ik} \neq 0; \lambda_{2i} \neq 0$
OPE \Rightarrow GDP	$\delta_{1ik} \neq 0; \lambda_{1i} \neq 0$
GDP \Rightarrow OPE	$\delta_{3ik} \neq 0; \lambda_{3i} \neq 0$
BSD \Rightarrow OPE	$\delta_{2ik} \neq 0; \lambda_{2i} \neq 0$
OPE \Rightarrow BSD	$\beta_{3ik} \neq 0; \lambda_{3i} \neq 0$

Note 1: BSD is banking sector depth and is defined in terms of BSI, BRM, CLP, DCP, or DCB.

Note 2: BSI: Composite index of banking sector depth; BRM: Broad money supply; CLP: Claims on the private sector; DCP: Domestic credit to the private sector; DCB: Domestic credit provided by the banking sector; OPE: Trade openness; and GDP: Growth rate of per capita income.

Note 3: Variables are defined under Table 3.

$$H_0 : \beta_{3ik} = 0; \delta_{3ik} = 0; \lambda_{3i} = 0 \quad \text{for } k = 1, 2, \dots, p/q/r$$

$$H_1 : \beta_{3ik} \neq 0; \delta_{3ik} \neq 0; \lambda_{3i} \neq 0 \quad \text{for at least one } k$$

where

Δ is a first-difference operator applied to the variables;

p , q , and r are lag lengths;

i represents country i in the panel ($i = 1, 2, \dots, N$);

t denotes the year in the panel ($t = 1, 2, \dots, T$);

BSD has five measures and is defined as BSI, BRM, CLP, DCP, or DCB.

ECT is the error-correction term which is derived from the cointegration equation;

ε_{it} is a normally-distributed random-error term for all i and t with a zero mean and a finite heterogeneous variance.

One can look for both short-run and long-run causal relationships among the variables. Short-run causal relationships are measured by F-statistics and the significance of the lagged changes in the independent variables. The long-run causal relationships are measured by the significance of t-tests of the lagged ECTs. The ECTs represent the long-run dynamics, akin to an equilibrium process, while differenced variables represent short-run dynamics between the variables.

Based on Eqs. (1)–(3), Table 5 presents summary of possible hypotheses concerning the causal nexus between BSD, trade openness, and economic growth.

The above econometric specification, as presented in Eqs. (1)–(3), is meaningful if the time-series variables are integrated of order one [denoted by $I(1)$] and are cointegrated. If the variables are $I(1)$ and not cointegrated, the ECT component will be removed in the estimation process. Thus, before the estimation process is performed, we checked the order of integration and of cointegration among the variables. We employed the Levin-Lin-Chu (LLC) panel unit root test (Levin et al., 2002) and Pedroni panel co-integration test (Pedroni, 1999) to check for $I(1)$ and cointegration between each BSD indicator, trade openness, and economic growth. A brief discussion on these two techniques is conducted below.

4.1. Testing for unit roots

The study deploys the Levin-Lin-Chu test (LLC) to ascertain unit roots (i.e., the orders of integration), where a time-series variable attains stationarity (Levin et al., 2002). The test is commonly used; it is akin to the conventional augmented Dickey-Fuller (ADF) test and allows for heterogeneity of the intercepts across members of the panel. The test involves estimation of the following regression equation:

$$\Delta Y_t = \mu_i + \gamma_i Y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta Y_{it-j} + \lambda_i t + \varepsilon_{it} \quad (4)$$

where

Δ is the first difference filter;

$i = 1, 2, \dots, N$ represents the country in the panel;

$t = 1, 2, \dots, T$ represents the year in the panel;

Y_{it} is the series for country i in year t ;

μ_i represents country-specific effects;

p_i is the number of lags selected for the ADF regression;

ε_{it} is an independently and normally distributed random error with a zero mean and a finite heterogeneous variance (σ_i^2).

The model allows for fixed effects, unit-specific time trends, and common time effects. The coefficient β_j of the lagged dependent variable is restricted to be homogenous across all the countries of the panel. Hence, the null hypothesis of non-stationarity is stated as

$$H_0: \gamma_i = 0 \text{ tested against the alternative } H_A: \gamma_i = \gamma < 0 \text{ for all } i \tag{5}$$

where the fixed effect in Eq. (4) is based on the usual t-statistics. Finally,

$$t_\gamma = \frac{\hat{\gamma}}{s.e(\hat{\gamma})} \tag{6}$$

where γ is restricted by being kept identical across countries under both null and the alternate hypotheses.

4.2. Testing for cointegration

The cointegration test is applied to ascertain the presence of long-run equilibrium relationship among the variables. If the difference between two non-stationary series is itself stationary, then the two series are cointegrated. If two or more series are co-integrated, then we can interpret that the variables in these series as being in a long run equilibrium relationship. The lack of cointegration, on the other hand, suggests that the variables have no long-run relationship; so, in principle, they can move arbitrarily far from one another.

When a collection of time-series observations becomes stationary only after being first-differenced, the individual time series might have linear combinations that are stationary before any differencing. Such collections of series are generally termed to be ‘cointegrated’ (Engle and Granger, 1987; Granger, 1988).

If the integration of ‘order one’ is implied, the next step is to employ cointegration analysis in order to establish whether there exists a long-run relationship among the set of such possibly ‘integrated’ variables. In such investigations, Johansen’s Vector Auto Regression (VAR) test of cointegration is usually employed (Johansen, 1988). The VAR is a systemic approach to check for co-integration, allowing for the determination of up to r linearly independent cointegrating vectors ($r \leq g - 1$, where g is the number of variables tested for cointegration). The estimated cointegration equation is of the following form:

$$Y_{it} = \beta_{i0} + \beta_{i1}X_{i1t} + \beta_{i2}X_{i2t} + \dots + \beta_{ik}X_{ikt} + \varepsilon_{it} \tag{7}$$

This equation may be re-written as:

$$\varepsilon_{it} = Y_{it} - (\beta_{i0} + \beta_{i1}X_{i1t} + \beta_{i2}X_{i2t} + \dots + \beta_{ik}X_{ikt}) \tag{8}$$

with the co-integration vector defined as:

$$[1 - \beta_{i0} - \beta_{i1} - \beta_{i2} \dots - \beta_{ik}] \tag{9}$$

We note that, as set up by Johansen (1988), the above test cannot deal with a panel setting. Thus, we use an enhancement, the Pedroni (1999) panel cointegration test, in order to test for the existence of cointegration among the variables. The Pedroni panel cointegration test is applied to the following time-series panel regression set-up:

$$Y_{i,t} = \alpha_i + \sum_{j=1}^{p_i} \beta_{ji} X_{jit} + \varepsilon_{it} \tag{10}$$

$$\varepsilon_{it} = \rho_i \varepsilon_{i(t-1)} + w_{it} \tag{11}$$

where Y_{it} and X_{jit} are the observable variables; ε_{it} represents the disturbance term from the panel regression; α_i allows for the possibility of country-specific fixed effects and the coefficients β_{ji} allow for variation across individual countries. The null hypothesis of no co-integration of the pooled (within-dimension) estimation is:

$$H_0: \rho_i = 1 \text{ for all } i \text{ against } H_1: \rho_i = \rho < 1. \quad (12)$$

Under the first hypothesis, the within-dimensional estimation assumes a common value for ρ_i ($= \rho$). In sum, this procedure excludes any additional source of heterogeneity between individual country members of the panel. The null hypothesis of no cointegration of the pooled (between-dimensions) estimation is expressed as

$$H_0: \rho_i = 1 \text{ for all } i \text{ against } H_1: \rho_i < 1. \quad (13)$$

Under the alternative hypothesis, the between-dimensions estimation does not assume a common value for ρ_i . It thus allows for an additional source of possible heterogeneity across individual country members of the panel.

Pedroni (1999) suggested two types of tests to determine the existence of heterogeneity of the cointegration vector. First is a test which uses the within-dimension approach (i.e., a panel test). It uses four statistics which are panel ν -statistic, panel ρ -statistic, panel PP-statistic, and panel ADF-statistic. These statistics pool the autoregressive coefficients across different panel members for the unit root tests to be performed on the estimated residuals. Second is a test which is based on the between-dimensions approach (a group test). It includes three statistics: a group ρ -statistic, a group PP-statistic, and a group ADF-statistic. These statistics are based on estimators that simply average the individually-estimated autoregressive coefficients for each panel member. Next, the heterogeneous panel and heterogeneous group mean panel cointegration statistics are calculated as detailed fully in Pedroni (2000).

All seven statistics assume the existence of an asymptotically-standard normal distribution given by the respective panel/group cointegration statistic. The panel ν is a one-sided test where large positive values would reject the null hypothesis of no cointegration. The other remaining statistics diverge to negative infinity, which means that large negative values also reject the null hypothesis. Each of these tests is able to accommodate country-specific short-run dynamics, country-specific fixed effects and deterministic trends, as well as country-specific slope coefficients (Pedroni, 2004).

It should be noted that, prior to estimation, the researcher needs to specify the number of lag lengths. This is a crucial step because the causality test results may depend sensitively on the lag structure. Too few lags mean that some important variables are omitted from the model and such a specification error will usually cause bias in the retained regression coefficients, leading to misleading conclusions. On the other hand, too many lags will waste observations and thus increase the standard errors of the estimated coefficients, making the results less reliable.

There is no simple rule for deciding the maximum lag length, though there are formal model specification criteria that one can rely on. Ideally, the lag structure is allowed to vary across countries, variables, and equation systems. However, for a relative large panel like ours, this would increase the computational burden substantially. For this reason, under each system we allow different maximum lag lengths for the three variables, but we do not allow them to vary across countries. We estimate each equation accordingly and choose the combination of lags which minimizes the standard Akaike Information Criterion and Schwartz Bayesian Information Criterion.

5. Empirical results and discussion

The presentations of the empirical results are presented in three stages: first, we present evidence on the nature of stationarity of the time series variables; second, we show evidence of cointegration among these variables; and third, we comment on the direction of Granger causality between the cointegrated variables. The estimation process involves examining five different cases. Each case adopts a different BSD indicator. Model 1 describes the causal nexus between GDP, OPE, and BSI. Models 2–5 use BRM, CLP, DCP, and DCB instead of BSI, respectively.

The results are shown in Tables 6–9. They indicate that all the variables are integrated of order one (i.e., they become stationary after first differencing – see Table 6 as well as being cointegrated – see Table 7).

The existence of I (1) and cointegration among these variables imply the possibility of Granger causality among them. Hence, we perform a causality test, using a vector error-correction model (VECM) and utilizing Eqs. (1)–(3), the results of which are shown in Table 9. This table reports the panel Granger causality test results for both the long run, as represented by the significance of lagged error-correction term, and the short run, as represented by the significance of the F-statistic.

Table 6
Results of unit roots tests.

Variables	Level	LLC	ADF	PP	Inferences
GDP	LD	0.8	19.1	23.9	I(1)
	FD	−21.0*	372.2*	468.9*	
	LE	1.54	46.2	35.2	
BSI	FD	−12.2*	201.7*	327.7*	I(1)
	LE	5.23	4.4	3.64	
BRM	FD	−10.1*	156.7*	271.7*	I(1)
	LE	−0.46	22	35.1	
CLP	FD	−20.3*	362.2*	493.5*	I(1)
	LE	3.96	8.02	6.92	
DCP	FD	−9.16*	151.7*	239.5*	I(1)
	LE	5.46	7.06	5.99	
DCB	FD	−11.5*	192.4*	302.4*	I(1)
	LE	2.91	10.8	7.76	
OPE	FD	−11.6*	194.5*	312.3*	I(1)

Note 1: BSI: Composite index of banking sector depth; BRM: Broad money supply; CLP: Claims on the private sector; DCP: Domestic credit to the private sector; DCB: Domestic credit provided by the banking sector; OPE: Trade openness; and GDP: Growth rate of per capita income.

Note 2: Variables shown above are defined in Table 3.

Note 3: LD: indicates level data; and FD: indicates first difference data.

Note 4: The Levine-Lin-Chu (LLC), ADF, and PP are test statistics are reported at no intercept and trend.

Note 5: * indicates statistical significance at 1%; and I(1) indicates integration of order one.

5.1. Long-run causality

From Table 8, in Models 1–5, when Δ GDP serves as the dependent variable, the lagged error-correction term is statistically significant at the one per cent level. This implies that GDP tends to converge to its long-run equilibrium path in response to changes in its regressors. The significance of the ECT_{-1} coefficient in the Δ GDP equation in each of the five models confirms the existence of long-run equilibrium between GDP and its determinants which are trade openness and various measures of BSD. In other words, we can generally conclude that trade openness and banking sector depth Granger-cause economic growth in the long run.

The lagged error-correction term in the Δ OPE equation under Table 9 is not statistically significant in any of the five models. Hence, there is no long-run causality from GDP and our indicators of BSD to trade openness. Finally, as is evident from the statistical insignificance of the ECT_{-1} coefficient in the Δ BSD equation in all the five models, economic growth and trade openness do not cause banking sector depth. In other words, there is no long-run causality flowing from OPE and GDP to BSD.

5.2. Short-run causality

From Table 8, in Model 1 we find existence of bidirectional causality between economic growth and trade openness [$GDP \Leftrightarrow OPE$] and economic growth and the banking sector depth index [$GDP \Leftrightarrow BSD$].

In Model 2 we discover the existence of bidirectional causality between economic growth and trade openness [$GDP \Leftrightarrow OPE$] and economic growth and broad money supply [$GDP \Leftrightarrow BRM$]. In addition, we also find unidirectional causality from broad money supply to trade openness [$BRM \Rightarrow OPE$].

In Model 3 we demonstrate the existence of bidirectional causality between economic growth and trade openness [$GDP \Leftrightarrow OPE$]. Moreover, we find the unidirectional causality from claims on the private sector to economic growth [$CLP \Rightarrow GDP$], and from trade openness to claims on the private sector [$OPE \Rightarrow CLP$].

In Model 4 we show the existence of bidirectional causality between economic growth and trade openness [$GDP \Leftrightarrow OPE$] and economic growth and domestic credit to the private sector [$GDP \Leftrightarrow DCP$].

In Model 5 we uncover the existence of bidirectional causality between economic growth and trade openness [$GDP \Leftrightarrow OPE$] and a unidirectional causality from domestic credit provided by the banking sector to trade openness [$DCB \Rightarrow OPE$].

The above findings are summarized in Table 9.

Table 7
Results of cointegration tests.

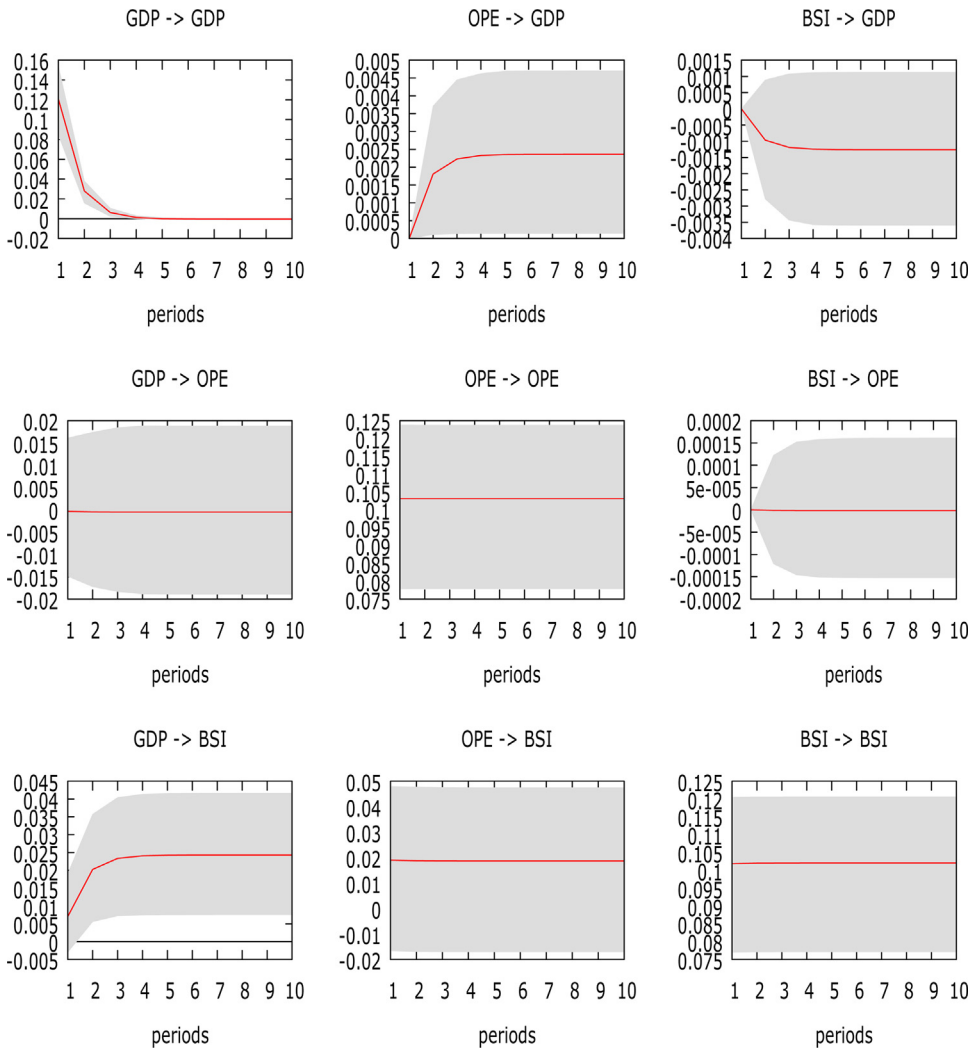
Test statistics	No deterministic intercept or trend		Deterministic intercept and trend	
Model 1: GDP, OPE, BSI				
Panel v- statistics	−0.41	[0.66]	−2.76	[0.99]
Panel ρ - statistics	−6.04	[0.00]	−2.72	[0.00]
Panel PP- statistics	−8.7	[0.00]	−11.5	[0.00]
Panel ADF- statistics	−5.46	[0.00]	−7.66	[0.00]
Group ρ - statistics	3.09	[0.00]	−0.07	[0.53]
Group PP- statistics	−10.3	[0.00]	−12.2	[0.00]
Group ADF- statistics	−7.19	[0.00]	−6.28	[0.00]
Model 2: GDP, OPE, BRM				
Panel v- statistics	0.58	[0.28]	−1.15	[0.02]
Panel ρ - statistics	−4.2	[0.00]	−1.84	[0.00]
Panel PP- statistics	−6.87	[0.00]	−9.48	[0.00]
Panel ADF- statistics	−3.88	[0.00]	−6.68	[0.00]
Group ρ - statistics	−2.07	[0.00]	−0.09	[0.00]
Group PP- statistics	−9.53	[0.00]	−12.3	[0.00]
Group ADF- statistics	−5.95	[0.00]	−6.68	[0.00]
Model 3: GDP, OPE, CLP				
Panel v- statistics	−0.39	[0.99]	−3.79	[1.99]
Panel ρ - statistics	−8.07	[0.00]	−1.27	[0.01]
Panel PP- statistics	−10.3	[0.00]	−9.18	[0.00]
Panel ADF- statistics	−6.27	[0.00]	−7.37	[0.00]
Group ρ - statistics	−5.1	[0.00]	−0.63	[0.20]
Group PP- statistics	−11.6	[0.00]	−14.6	[0.00]
Group ADF- statistics	−6.34	[0.00]	−6.73	[0.00]
Model 4: GDP, OPE, DCP				
Panel v- statistics	0.88	[0.01]	−1.19	[0.88]
Panel ρ - statistics	−5.93	[0.00]	−1.75	[0.04]
Panel PP- statistics	−8.4	[0.00]	−10.6	[0.39]
Panel ADF- statistics	−4.64	[0.00]	−7.08	[0.87]
Group ρ - statistics	−2.05	[0.20]	−0.12	[0.45]
Group PP- statistics	−8.49	[0.10]	−12.3	[0.48]
Group ADF- statistics	−5.51	[0.01]	−6.4	[0.92]
Model 5: GDP, OPE, DCB				
Panel v- statistics	−0.19	[0.57]	−2.73	[0.99]
Panel ρ - statistics	−4.28	[0.00]	−1.2	[0.11]
Panel PP- statistics	−6.49	[0.00]	−11.3	[0.00]
Panel ADF- statistics	−3.58	[0.00]	−7.96	[0.00]
Group ρ - statistics	−2.36	[0.00]	−0.11	[0.00]
Group PP- statistics	−8.44	[0.00]	−14.3	[0.00]
Group ADF- statistics	−5.42	[0.00]	−7.43	[0.00]

Note 1: BSI: Composite index of banking sector depth; BRM: Broad money supply; CLP: Claims on the private sector; DCP: Domestic credit to the private sector; DCB: Domestic credit provided by the banking sector; OPE: Trade openness; and GDP: Growth rate of per capita income.

Note 2: Variables shown above are defined in Table 3.

Note 3: Figures in square brackets are probability levels indicating significance.

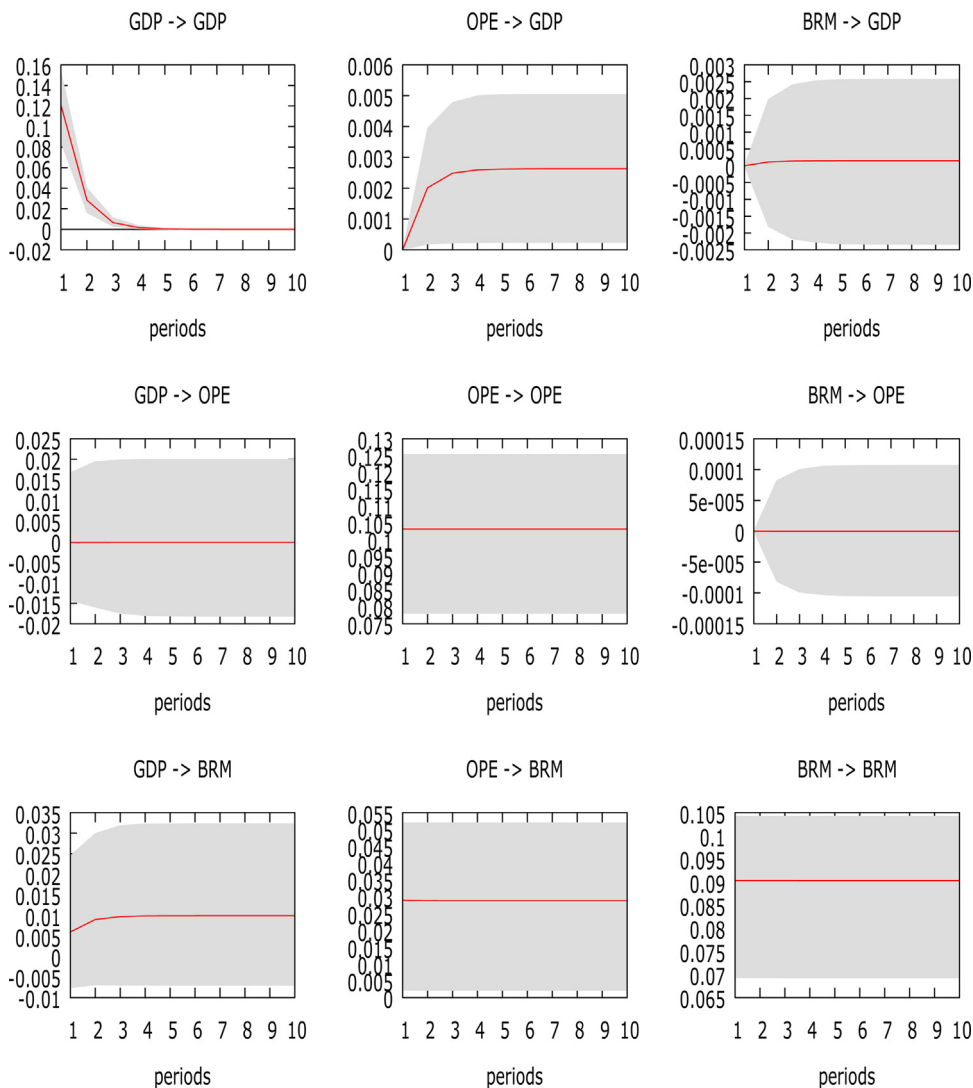
The above discussion gives a snapshot of the statistical significance of historical changes; however, it does not indicate whether or not any particular series responds to perturbations or unexpected changes (i.e., the shocks) in another series. Hence, we deploy generalized impulse response functions (GIRFs) to address this shortcoming. The use of GIRFs is to trace the effect of a one-off shock to one of the innovations on the current and future values of the endogenous variables. The key importance of the GIRFs are that the responses are invariant to any re-ordering of the variables in the VECM and, as orthogonality is not imposed, it allows for meaningful interpretation of the initial impact response of each variable to shocks to any other variables. In brief, the GRIFs provide more robust results than the orthogonalized method (Ewing et al., 2007). However, the significance of the impulse response is largely



Note: GDP: Growth rate of per capita income; BSI: Composite index of banking sector depth; OPE: Trade openness.

Fig. 3. Plot of generalized impulse functions for GDP, OPE, and BSI.

determined by the use of confidence bands (Christiano et al., 2005; Runkle, 1987). The shaded area represents the confidence bands; when the horizontal line in the GIRFs falls between confidence bands, the impulse responses are not statistically significant. In other words, the null hypothesis of “no effects of a particular shock” on the specific variable cannot be rejected. The Figs. 3–7 display the GRIFs of the five VAR models. Our discussion of the impulse response functions centers on the responses of banking sector depth (BSI, BRM, CLP, DCP, and DCB), trade openness, and per capita economic growth to their own and other shocks. For comparative analysis, we reported the GRIFs to one-standard-error confidence bands (roughly equal to 95% confidence bands) and the responses were very similar to those which we obtained using Cholesky-one-standard innovation (Christiano et al., 2005). This analysis provided additional support for our results and in particular the notion that there is a stable long-run equilibrium relationship between the variables.



Note: GDP: Growth rate of per capita income; BRM: Broad money supply; OPE: Trade openness.

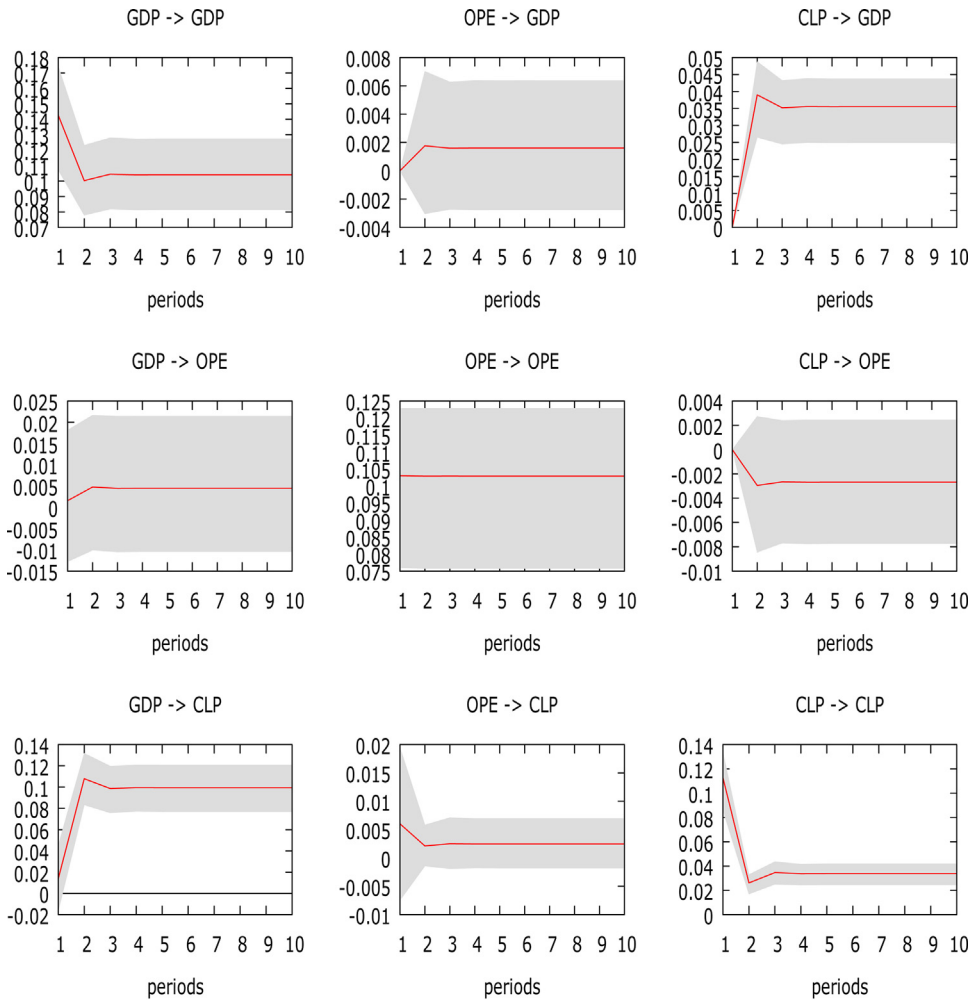
Fig. 4. Plot of generalized impulse functions for GDP, OPE, and BRM.

6. Conclusion and policy implications

Our study used sophisticated panel cointegration and causality tests — estimation procedures that have not hitherto been used in this literature. We first established that there was a general long-run equilibrium relationship among trade openness, banking sector depth and economic growth, but the nature of the causal relationship was complex in that trade openness and various measures of banking sector depth Granger-cause economic growth in the long run without the possibility of reverse causality. At the same time, our short-run causality results revealed a wide range of short-run adjustment dynamics between the variables, including the possibility of feedback causality between them in several instances.

These results demonstrated that future studies on economic growth that do not simultaneously consider trade openness and measures of banking sector depth will offer biased or misguided results.

On the policy front, decision makers in the ARF countries wishing to encourage economic growth in the long run should seek to develop their banking sectors and to promote free trade policies. More specifically, the development of the banking sector should not only make the banking sector more assessable to users that currently do not have



Note: GDP: Growth rate of per capita income; CLP: Claims on the private sector; OPE: Trade openness.

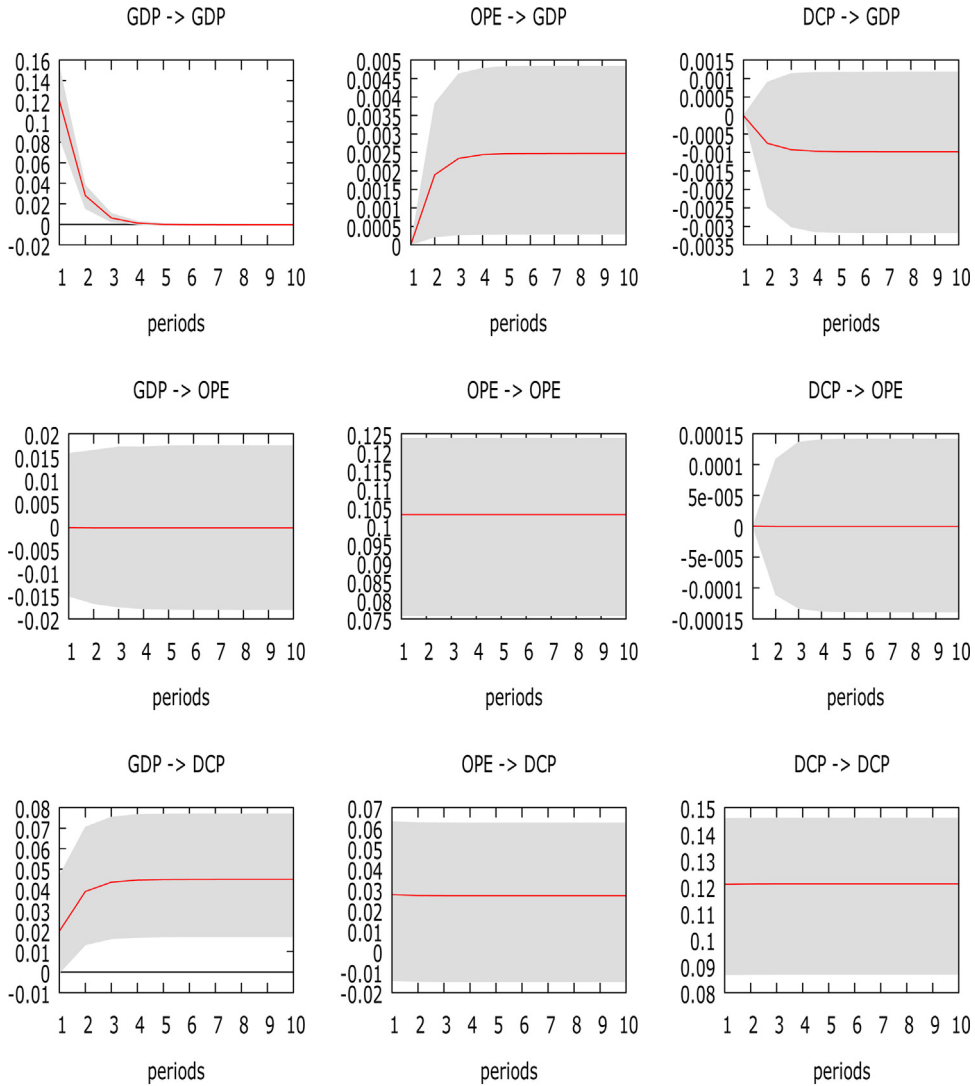
Fig. 5. Plot of generalized impulse functions for GDP, OPE, and CLP.

access to the banking sector, but put regulations (and regulators) in place that will ensure the financial stability of the banking sector and the guarding of depositors’ money within the banking industry. Regarding free trade policies, whilst government departments or trade missions that concentrate specifically on promoting trade openness should be established, they must also be empowered to explore and implement trade policies that will enhance trade openness whilst at the same time stimulating economic growth of the country.

Appendix A. Principal component analysis

Including various indicators of banking sector depth in the same equation would lead to multicollinearity. Thus, we bring the four indicators of BSD together by employing Principal Component Analysis (PCA). The PCA transforms the data into new variables (i.e., the principal components) that are not correlated.

The use of PCA to construct indexes similar to ours is well-documented in papers using panel data (Herwartz and Walle, 2014; Menyah et al., 2014). To be clear, PCA is a special case of the more general method of factor analysis. The approach entails several steps: construction of a data matrix, creation of standardized variables, calculation of a correlation matrix, determination of eigen values (to rank principal components) and eigenvectors, selection of PCs (based on stopping rules), and interpretation of results (Hosseini and Kaneko, 2011). The intent behind PCA is to



Note: GDP: Growth rate of per capita income; DCP: Domestic credit to the private sector; OPE: Trade openness.

Fig. 6. Plot of generalized impulse functions for GDP, OPE, and DCP.

transform the original set of variables into a smaller set of linear combinations that account for most of the variance of the original set. The aim is to construct from a set of variables, X_j 's ($j = 1, \dots, n$) new variables (P_i) called 'principal components', which are linear combinations of the X 's. Representing it mathematically,

$$\begin{aligned}
 P_1 &= a_{11}X_1 + \dots + a_{1n}X_n \\
 &\vdots \\
 P_m &= a_{m1}X_1 + \dots + a_{mn}X_n
 \end{aligned}
 \tag{14}$$

Here, $P = [P_1, \dots, P_m]$ are principal components; $A = [a_{ij}]$ for $i = (1, \dots, m)$; and $j = (1, \dots, n)$ are component loadings; and $X = [X_1, \dots, X_n]$ are original variables. The component loads are the weights showing the variance contribution of principal components to variables. Since the principal components are selected orthogonal to each other, a_{ij} weights are proportional to correlation coefficient between variables and principal components.

Table 8
Results of Granger causality test.

Dependent variable		Independent variables		ECT ₋₁ coefficient
Model 1: VECM with GDP, OPE, BSI				
	Δ GDP	Δ OPE	Δ BSI	ECT ₋₁
Δ GDP	–	3.93** [0.05]	0.67 [0.77]	–0.72* (–9.82)
Δ OPE	18.8* [0.00]	–	9.06* [0.00]	–0.02 (–0.12)
Δ BSI	0.07 [0.76]	3.85** [0.05]	–	0.08 –2.84
Model 2: VECM with GDP, OPE, BRM				
	Δ GDP	Δ OPE	Δ BRM	ECT ₋₁
Δ GDP	–	3.83*** [0.10]	3.86*** [0.10]	–0.72* (–9.70)
Δ OPE	16.9* [0.00]	–	12.10* [0.00]	0.01 –0.33
Δ BRM	3.96*** [0.10]	2.66 [0.26]	–	0.04 –1.79
Model 3: VECM with GDP, OPE, CLP				
	Δ GDP	Δ OPE	Δ CLP	ECT ₋₁
Δ GDP	–	5.65* [0.00]	15.6* [0.53]	–0.32* (–3.57)
Δ OPE	13.4* [0.00]	–	0.93 [0.63]	–0.01 (–0.52)
Δ CLP	2.25 [0.32]	27.9* [0.00]	–	0.66 –9.79
Model 4: VECM with GDP, OPE, DCP				
	Δ GDP	Δ OPE	Δ DCP	ECT ₋₁
Δ GDP	–	3.29*** [0.10]	0.16 [0.92]	–0.72* (–9.16)
Δ OPE	20.1* [0.00]	–	6.40* [0.00]	–0.01 (–0.14)
Δ DCP	2.94 [0.22]	8.34** [0.02]	–	0.12 –3.64
Model 5: VECM with GDP, OPE, DCB				
	Δ GDP	Δ OPE	Δ DCB	ECT ₋₁
Δ GDP	–	2.82 [0.20]	0.43 [0.80]	–0.73* (–9.86)
Δ OPE	15.9* [0.00]	–	9.11* [0.01]	0.01 –0.37
Δ DCB	1.57 [0.45]	0.42 [0.80]	–	0.05 –1.58

Note 1: BSI: Composite index of banking sector depth; BRM: Broad money supply; CLP: Claims on the private sector; DCP: Domestic credit to the private sector; DCB: Domestic credit provided by the banking sector; OPE: Trade openness; and GDP: Growth rate of per capita income.

Note 2: Variables shown above are defined in Table 3.

Note 3: VECM: vector error correction model; ECT: error-correction term.

Note 4: * indicates significance at 1% level; ** indicates significance at 5% level; *** indicates significance at 10% level.

Note 5: Values in square brackets represent probabilities for F-statistics.

Note 6: Values in parentheses represent *t*-statistics.

Note 7: Basis for the determination of long-run causality lies in the significance of the lagged ECT coefficient.

The first principal component (P_1) is determined as the linear combination of X_1, \dots, X_n provided that the variance contribution is at a maximum. The second principal component (P_2), independent from the first principal component, is determined so as to provide a maximum contribution to total variance left after the variance explained by the first principal component. Analogously, the third and the other principal components are determined as to provide the

Table 9

Summary of short-run Granger causality between banking sector depth, trade openness, and economic growth in the ARF countries.

Causal Relationships Tested in the Model	Direction of Relationships Observed in Model 1	Direction of Relationships Observed in Model 2	Direction of Relationships Observed in Model 3	Direction of Relationships Observed in Model 4	Direction of Relationships Observed in Model 5
OPE vs. GDP	OPE \Leftrightarrow GDP**	OPE \Leftrightarrow GDP**	OPE \Leftrightarrow GDP**	OPE \Leftrightarrow GDP**	OPE \Leftrightarrow GDP**
BSD vs. GDP	NA	BRM \Rightarrow OPE*	CLP \Rightarrow GDP*	NA	NA
OPE vs. BSD	OPE \Leftrightarrow BSI**	OPE \Leftrightarrow BRM**	OPE \Rightarrow CLP*	OPE \Leftrightarrow DCP**	DCB \Rightarrow OPE*

Note 1: BSD is banking sector depth and is defined in terms of BSI, BRM, CLP, DCP, or DCB.

Note 2: BSI: Composite index of banking sector depth; BRM: Broad money supply; CLP: Claims on the private sector; DCP: Domestic credit to the private sector; DCB: Domestic credit provided by the banking sector; OPE: Trade openness; and GDP: Growth rate of per capita income.

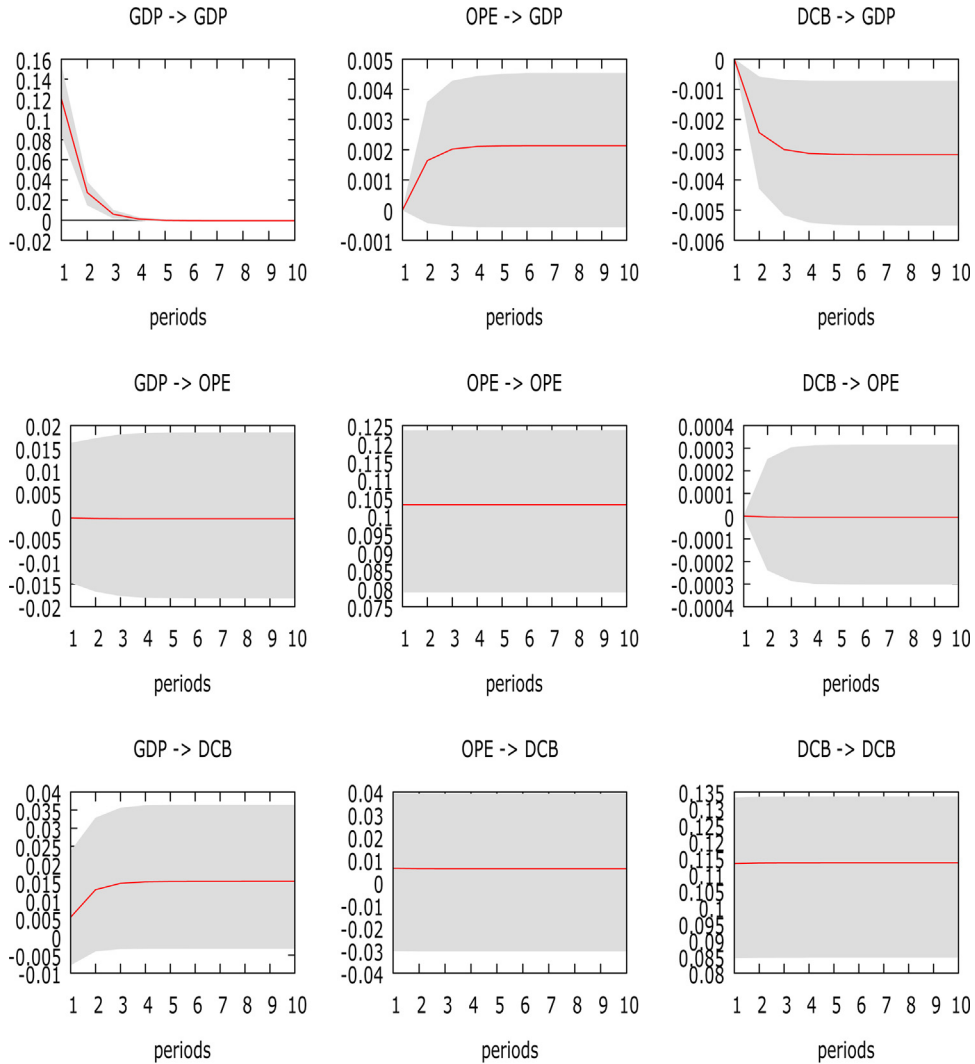
Note 3: Variables shown above are defined in Table 3.

Note 4: \Rightarrow : unidirectional causality; and \Leftrightarrow : Bidirectional causality.

Note 5: *: Supports the supply-leading hypothesis; **: Supports the feedback hypothesis.

maximum contribution to the remaining variance and independent from each other. The aim here is to determine a_{ij} coefficients providing the linear combinations of variables based on the specified conditions.

It should be noted here that the method of principal components could be applied by using the original values of the X_j 's, by their deviations from their means, or by the standardized variables. The present study, however, adopts the latter procedure, as it is assumed to be more general and can be applied to variables measured in different units. It is important to note that the values of the principal components will be different depending on the way in which the variables are used (original values, deviations, or standardized values). The coefficients a 's, called loadings, are chosen in such a way that the constructed principal components satisfy two conditions: (a) principal components are uncorrelated (orthogonal), and (b) the first principal component P_1 absorbs and accounts for the maximum possible proportion of total variation in the set of all X 's. Furthermore, principal component absorbs the maximum of the remaining variation in the X 's (after allowing for the variation accounted for by the first principal component) and so on. There are different rules to define a high magnitude known as stopping rules. Here, variance explained criteria are implemented based on the rule of keeping enough principal components to account for 90% of the variation (Hosseini



Note: GDP: Growth rate of per capita income; DCB: Domestic credit provided by the banking sector; OPE: Trade openness.

Fig. 7. Plot of generalized impulse functions for GDP, OPE, and DCB.

and Kaneko, 2011). The following equation is utilized to create BSI, our composite index for banking sector depth using the four indicators that are summarized under Table 3.

$$BSI = \sum_{i=1}^4 a_{ij} \frac{X_{ij}}{Sd(X_i)} \tag{15}$$

Where,

- BSI: Composite index for banking sector depth;
- a_{ij} is the factor loads for BSD indicators;
- SD is the standard deviation of BSD indicators;
- $i = 1-4$ represents the indicators of BSD;
- $j = 1-25$ represents the corresponding country;
- X_{ij} is the value of BSD indicator i for country j .

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