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Article

Supply shocks and monetary policy responses in emerging economies

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journal homepage: www.elsevier.com/locate/latabSupply shocks and monetary policy responses in emerging economies[☆]José Antonio Ocampo^a, Jair Ojeda-Joya^{b,*}^a Minister of Finance and Public Credit of Colombia, on a leave of absence from public service from his position as Professor at the School of International and Public Affairs, Columbia University, and Chair of the United Nations Committee for Development Policy^b Senior Research Economist, Banco de la República, Carrera 7 # 14-78, piso 11, Bogotá, Colombia

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ABSTRACT

Supply shocks bring about important dilemmas for monetary policy in emerging economies. We compute monetary policy responses to supply shocks using quarterly data and a Bayesian panel VAR for 24 emerging economies during the period 2004–2019. In this framework, we identify supply shocks as unexpected and temporary total factor productivity innovations which are orthogonal to demand related shocks. We highlight three results from this econometric exercise. First, monetary policy is, in average, procyclical in emerging economies after temporary supply shocks. Second, monetary policy is more procyclical in fixed than in flexible exchange-rate regimes. Third, monetary policy is more procyclical in economies with a higher degree of financial openness. The latter result is a central dilemma for emerging economies during supply shocks, since it implies that financial openness prevents less procyclical monetary policy reactions due to the trade-off between exchange rate and income volatility.

1. Introduction

The emerging market monetary policy dilemma, as identified by Végh et al. (2017), is more evident when central banks should decide between stimulating the economy and stabilizing inflation in response to negative and temporary shocks. If the central bank decides to reduce inflation, it will implement a procyclical monetary policy that will likely worsen the shock's effect on economic activity. Supply shocks, as opposed to demand shocks, are those most likely associated with this dilemma because these usually induce opposite-sign effects on inflation and economic activity. Examples of these kinds of shocks are climate-related temporary events, which may imply negative productivity effects—mainly in agriculture—and may lead to price increases (Brainard, 2019). Other examples are temporary supply-chain disruptions, oil-price shocks, and macroeconomic policies in developed economies.

We compute monetary policy responses to temporary and unexpected supply shocks by using the quarterly data of 24 emerging economies for 2004–2019. Our main goal is to understand better the determinants of procyclical monetary-policy responses in emerging economies. We estimate supply shocks by computing transitory Total Factor Productivity (TFP) innovations and then controlling for aggregate demand indicators. It is important to note that supply shocks in this paper are temporary and, therefore, not defined

[☆] The findings, recommendations, interpretations, and conclusions expressed in this paper do not necessarily reflect the official view of Banco de la República (the Central Bank of Colombia) or the Ministry of Finance and Public Credit of Colombia. We thank Mauricio Villamizar, Cedric Tille, Frank Westermann, Miguel Sarmiento and two anonymous referees for their useful comments. The authors have no competing interests to declare.

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by their permanent effects on economic activity, which contrasts the approach by [Blanchard and Quah \(1989\)](#). We do not focus only on terms of trade shocks, as we include more shocks that are general and explicitly control their demand-side determinants.¹

We estimate impulse-response functions from a Bayesian Panel VAR that identifies monetary policy and supply shocks. For the identification of monetary policy, we follow [Kim \(2003\)](#) and [Anzuini et al. \(2013\)](#) by constructing interest-rate reactions that are lagged with respect to macroeconomic shocks, such as innovations in the real quantity of money (M2). These assumptions are convenient for our estimations because they recognize that central banks take time to evaluate the macroeconomic environment and make monetary policy decisions. On the other hand, these assumptions guarantee that TFP shocks are unrelated to contemporaneous movements of the domestic real interest rate.²

This framework introduces an alternative approach to analyze the cyclicity of monetary policy, including a dynamic framework, policy identification, and supply shocks, which are unexpected and temporary. The literature on this topic originates from the contribution by [Kaminsky et al. \(2005\)](#), who detected procyclical monetary and fiscal policies in emerging economies. Our approach contributes to this literature by focusing on the careful identification of supply shocks within a Bayesian Panel VAR framework and by detecting a new institutional driver of procyclical monetary policy across emerging economies: the degree of financial openness.

A positive supply shock would appreciate the exchange rate, and this would reduce inflation. Therefore, the central banks need to determine the trade-off between lower inflation and stronger economic activity. A similar trade-off with opposite signs occurs in the case of a negative supply shock. If the exchange-rate regime is flexible, the central bank can react with a countercyclical monetary policy to smooth the effect on economic activity. However, in the case of less flexible exchange-rate regimes, the central bank needs to apply a procyclical monetary policy to stabilize the exchange rate. Therefore, a higher degree of exchange-rate flexibility is important to deal with this monetary-policy dilemma. In addition, this role is exacerbated in the case of countries with higher degrees of financial openness because their exchange rates are more sensitive to supply shocks and the implied inflationary effects are more intense. Note that this monetary policy dilemma does not occur in the case of demand shocks because, in this case, inflation and economic activity react in the same direction.

Our econometric exercises first show that monetary policy tends to be more procyclical in emerging economies, compared to developed economies, after temporary supply shocks. This result is in line with the original findings by [Kaminsky et al. \(2005\)](#), and more recently confirmed by [Végh et al. \(2017\)](#), regarding the monetary policy dilemma in developing economies. Second, monetary policy is more procyclical in economies with fixed exchange-rate regimes. This is partial evidence of the traditional trilemma, in which regimes that are more flexible allow more independent monetary policy without necessarily imposing restrictions on international capital flows ([Obstfeld et al., 2005, 2019](#)).

The third result is that monetary-policy responses to supply shocks tend to be less procyclical in economies with low financial openness. This result holds under two alternative definitions of financial openness, and it is compatible with the monetary policy dilemma in emerging economies, as described by [Végh et al. \(2017\)](#). In this dilemma, central banks face a difficult choice between defending the currency and smoothing fluctuations in economic activity, especially during negative supply shocks. The third result is also coherent with the hypothesis about balance-of-payment dominance in emerging economies ([Ocampo, 2016](#)), in which financially open economies are vulnerable to external shocks with important implications for the policy-making process. This finding is also consistent with recent empirical evidence about how capital-account regulations improve monetary policy independence in emerging economies, see [Erten et al. \(2021\)](#) for a literature review. These results should be interpreted as showing average behaviors across groups of countries and during the analysis period 2004–2019.³

This paper is organized in the following way. After this introduction, [Section 2](#) describes a brief review of related literature. [Section 3](#) looks at the data. [Section 4](#) explains the econometric methodology. [Section 5](#) describes the empirical results, and finally, the last section includes concluding comments.

2. Related literature

The article by [Kaminsky et al. \(2005\)](#) is pivotal for the analysis of this topic because it describes the relationship between macroeconomic policy and the economic cycle of 104 economies. Its main finding is about monetary and fiscal policies being either countercyclical or acyclical in developed countries, but the policies are procyclical in developing economies. This finding is partially revised by [Frankel et al. \(2013\)](#) and [Végh and Vuletin \(2013, 2014\)](#), who describe the so-called policy graduation that occurs when previous procyclical economic policies become countercyclical in certain emerging economies. Their results show that, starting in 2000, a sizeable portion of these economies have graduated in monetary and fiscal policies. [McGettigan et al. \(2013\)](#), as well as [Thornton and Vasilakis \(2016\)](#), show that the implementation of inflation targeting has helped in this process by reducing output volatility and inflation.

[Kaminsky et al. \(2005\)](#) also analyze the relation between the external sector and macroeconomic policymaking. They find that capital flows in the developing world are positively correlated with expansive fiscal and monetary policies, thus exacerbating such

¹ Additionally, empirical estimations in [Uribe and Schmitt-Grohé \(2017, chapter 8\)](#) show that terms-of-trade shocks play only a modest role in generating aggregate fluctuations in emerging and poor economies, these shocks explain between 10% and 14% of the output variance, depending on the econometric model.

² We assume the natural interest rate to remain constant after the supply shock, as this shock is only temporary and does not have any long-term effects.

³ Although this period includes the presence of the Great Financial Crisis, excluding such crises would excessively limit the sample size of our time series, which is needed for a proper estimation of the panel VAR.

procyclical behavior. [Araujo et al. \(2017\)](#) find that capital inflows are highly procyclical and persistent for low-income economies and get even more procyclical as these countries become wealthier. Such behavior imposes an important constraint for the implementation of countercyclical macroeconomic policies. Similarly, [Ocampo \(2016\)](#) identifies the prevalence of balance-of-payments dominance in the process of policymaking in developing economies due to the strong effects of external shocks on interest rate spreads and exchange rates. One of the reasons for this dominance is the dismantling of several external-sector policy instruments during economic liberalization reforms adopted throughout the past four decades.

The behavior of the exchange rate is also important because it translates external shocks to the domestic economic cycle. [Cordella and Gupta \(2015\)](#) find evidence that procyclical monetary policies are correlated with procyclical exchange rate reactions, implying real appreciations during good times. This result resembles the fear of floating in developing economies, as described by [Calvo and Reinhart \(2002\)](#). In such cases, the monetary authority capacity to perform countercyclical policy can be hindered by exchange-rate devaluations in times of massive capital outflows. In view of this result, [Frankel \(2017\)](#) proposes a semi-fixed exchange rate regime for countries where commodity exports are a crucial part of the income. Such a regime would imply that currencies would be pegged to their most relevant external currencies and to the price of their main commodity exports. Finally, [Végh et al. \(2017\)](#) study monetary policy responses to terms of trade shocks and analyze the institutional features that determine procyclical monetary policy reactions in emerging economies.

Our paper contributes to this literature by computing monetary-policy responses to identified temporary supply shocks in emerging economies. These kinds of shocks potentially generate important policy trade-offs related to controlling the volatility of the exchange rate versus economic activity. Our econometric approach consists of Bayesian panel VAR estimations, which simultaneously identify supply shocks and monetary policy reactions. We apply this framework to compute monetary policy responses for alternative exchange-rate regimes and financial openness degrees in emerging economies. We analyze these results in detail to learn more about the determinants of the cyclicity of monetary policy.

3. Data description

We use quarterly data from 24 emerging economies with good availability of macroeconomic data. For each country, we collect six macroeconomic variables from 2004Q1 to 2019Q2: TFP, public consumption, household consumption, real money balances (M2), real effective exchange rate, and real monetary policy rate.⁴ The selection of countries in our sample follows [Ilzetzki et al. \(2013\)](#), and it is driven by the availability of quarterly GDP and consumption data during the analysis period. Table A4 in the appendix shows the list of emerging economies included in the estimation and their classifications. We also use data for 21 developed economies (Table A3) to perform an initial estimation and to compare results with emerging economies.

TFP data are computed country by country using quarterly GDP and total employment growth rates as reported by the International Monetary Fund (IMF) and by national offices of statistics. As the estimation period is relatively short, we assume a constant rate of capital growth that is recovered with the intercept of the regression, assuming a Cobb-Douglas production function. We need a uniform methodology to estimate TFP for all 44 economies in the entire sample of countries. For some emerging economies, it is difficult to find quarterly estimations of the growth rate of the capital stock or the time varying utilization rate of the existing capital stock. Therefore, we use a methodology for TFP estimation that is feasible and uniform across all countries.

Data for public and household consumption are retrieved from the national accounts in each country. The quantity of money in the economy (M2) is deflated with the consumer price index. For the Real Effective Exchange Rate (REER), we retrieve the indicator computed with the International Monetary Fund's (IMF) methodology, in which an increase implies a real appreciation of each currency vis-a-vis its main trading partners. Finally, our real interest rate indicator is computed using the nominal policy rate and the observed consumer inflation rate. For most countries, the relevant policy rate was easy to identify and was retrieved from Central Bank's statistics. For some countries, the policy rate was less clear, and we used instead interbank rates.

We use the real interest rate as our indicator of monetary policy for two main reasons. First, because we have a panel of heterogeneous countries with different inflation rates, using the real interest rate is a way to normalize these differences among countries. Second, changes of the real interest rate are a measure of the monetary policy stance changes, assuming a relatively constant natural interest rate ([Laubach and Williams, 2003](#)). As we are more interested in the monetary policy stance changes, the real interest rate is a more accurate indicator on this regard. Performing estimations with the nominal interest rate leads to biased results because economies with higher inflation rates would have a higher weight on the average behavior of the panel. Additionally, as inflation is included as a deflator of most variables, it is not necessary to include it as an additional variable in the exercise.

All the data have good quality and easy access because they are retrieved from International Financial Statistics (IFS), OECD, Eurostat, national statistical agencies, and central banks. To correct for non-stationarity, we compute quarterly growth rates for all variables except real interest rates. In the Appendix, we show results about panel unit root tests, according to [Im et al. \(2003\)](#) for all six variables (Tables A1 and A2).

The set of emerging economies is divided into flexible and fixed exchange rate regimes using the classification by [Reinhart and Rogoff \(2004\)](#) and updated with the information from the International Monetary Fund (IMF) until 2019. Fixed-rate episodes are defined by legal tenders, hard pegs, crawling pegs, bands, and monetary unions. All other cases are classified as flexible regimes.

⁴ There are high volatility events between 2000 and 2003 for a significant number of emerging economies; thus, this period is not included.

In this sense, all economies in our sample have a well-defined exchange rate regime during the analysis period, see classification in Table A4 of the Appendix.⁵

We use two alternative indicators about the degree of financial openness in each economy to split our set of economies into high and low openness. First, Chinn and Ito (2006) developed an indicator, which is defined as the principal component of several measurements, about the intensity of restrictions on international transactions in each economy. Second, we use the sum of external assets and liabilities in each economy, as a percentage of GDP and as an indicator of the accumulated importance of international financial integration in each economy. Lane and Milesi-Ferreti (2008) use similar indicators to study the determinants of financial globalization. We use the median of each financial openness indicator across countries during the analysis period to divide the set of emerging economies into two subsets: high and low financial openness, see classification in Table A4 of the Appendix.⁶

4. Econometric methodology

An important challenge in this study is the proper simultaneous identification of the supply shocks and monetary policy responses within the Bayesian Panel Vector Auto Regression. Following Blanchard and Perotti (2002), a key identification assumption is that policy decisions take time (a quarter) to respond to innovations in other macroeconomic variables, including GDP. Additionally, following Kim (2003) and Anzuini et al. (2013), we control for money demand shocks by allowing the quantity of money to react contemporaneously to TFP shocks. Instead, monetary policy rates take at least one quarter to react to these supply shocks due to the time that monetary authorities need to evaluate the macroeconomic data and to confirm the nature of the shock.

We use the Cholesky decomposition to perform such identification. The variables are included in the following order: government consumption, monetary policy rate, TFP, household consumption, real money balances (M2), and real exchange rate. This ordering implies that the real exchange rate reacts contemporaneously to shocks from the system's remaining variables. In addition, fiscal and monetary policy indicators are those with the most sluggish reaction to macroeconomic shocks.

The reasons for selecting those variables for our panel study are as follows. Government and household consumption and real money balances are chosen as aggregate demand controls. This is to ensure that TFP shocks correspond to supply shocks only. The real exchange rate is chosen as a control for external demand shocks to improve the identification of the monetary policy reaction and to study its reaction to the supply shock.⁷ The real policy rate is our monetary policy indicator. Finally, TFP is our main shock variable. We do not assume that TFP is an exogenous variable because it is an important component of GDP, which is potentially affected by macroeconomic policies.

Policy variables are ordered first in the Cholesky decomposition, as these are assumed to react with a lag to macroeconomic shocks. Following Ilzetzki et al. (2013), government consumption decisions are ordered first because they tend to react with a lag to macroeconomic news. Then, following Kim (2003) and Anzuini et al. (2013), the monetary policy rate also reacts with a lag to macroeconomic shocks, except for government consumption shocks. The reason for this specific ordering is that fiscal policy decisions usually take longer to be approved and implemented, as they are subject to public and sometimes congressional debate. In contrast, monetary policy decisions are usually made directly by an independent board of economists as soon as they analyze and understand the current macroeconomic shocks. TFP is next in the ordering; this is a supply-side variable that is immediately affected by macroeconomic policy shocks but not by demand shocks. Next, there are controls for demand-related shocks. Household consumption is assumed to react immediately to policy and TFP shocks, but as it implies consumption planning by households, it does not immediately react to money demand or real exchange rate shocks.

The variables that immediately react to most macroeconomic shocks are money demand and the real exchange rate. These variables depend on financial decisions by market agents and, therefore, are assumed to react quickly to economic news. Our original ordering implies that the real exchange rate reacts contemporaneously to money-demand shocks but not the other way around. We computed impulse-response function using both alternative orderings, and the results are similar because both variables are only controls for demand-related shocks.

We estimate the following Panel VAR system:

$$Y_{it} = A_1 Y_{it-1} + A_2 Y_{it-2} + \dots + A_p Y_{it-p} + u_i + e_{it} \quad i = 1, \dots, N \quad t = 1, \dots, T. \quad (1)$$

This is a homogeneous panel VAR of order p , with k dependent variables and with country-specific fixed effects. The vector Y_{it} contains the six variables for country i at quarter t . The fixed effects are shown in the k -vector u_i . Idiosyncratic errors for each country and quarter are contained in the k -vector e_{it} . We want to estimate the $(k \times k)$ matrices of coefficients A_1, A_2, \dots, A_p . The errors are assumed to be zero-mean and serially uncorrelated.

⁵ There are a few economies with mild reforms on their exchange-rate policies, for example, Argentina, Malaysia, and Peru. However, we need a unique classification for the entire period, and these countries remained in the group of fixed regimes reflecting their policies during most of the study period.

⁶ We compute the average financial openness indicator for each country during the analysis period. Although we acknowledge that, in some countries, there were changes during the period, we prefer to work with the average in order to obtain a unique country classification as a first approach to the subject.

⁷ We do not try to use terms of trade as an indicator of external shocks because it is exogenous. Therefore, it may not react to financial or uncertainty shocks. In addition, the real exchange rate allows controlling for external uncertainty shocks according to evidence described by papers such as Beckmann and Czudaj (2017) and Kido (2016).

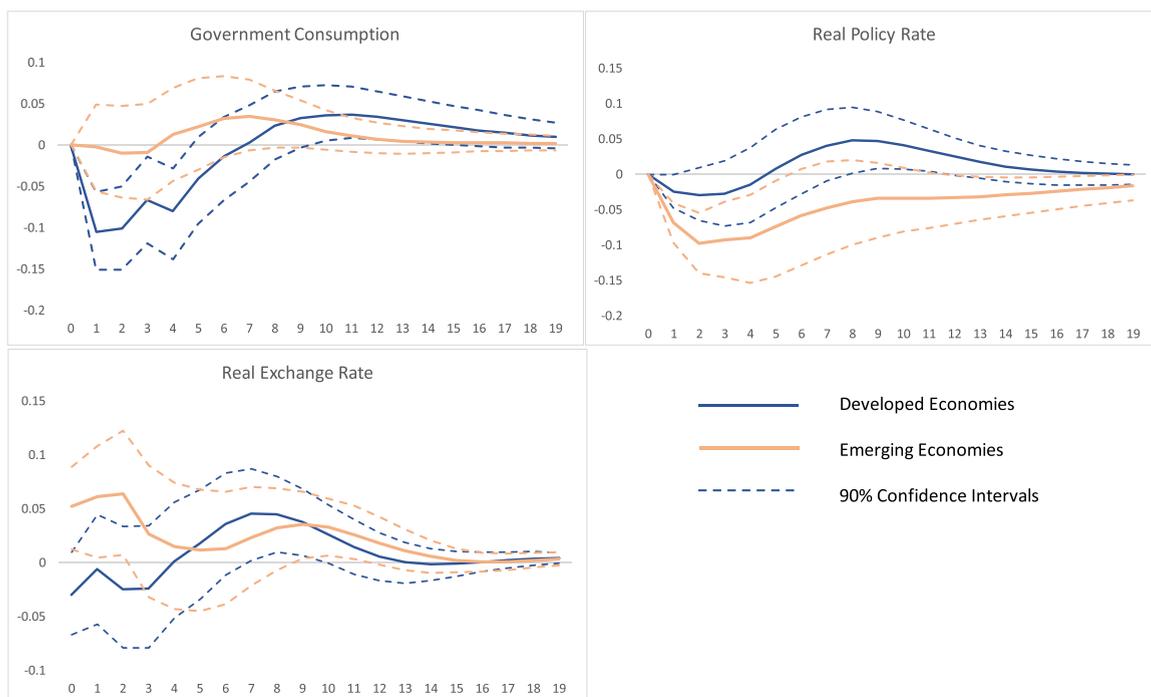


Fig. 1. Macroeconomic Responses to a 1 Standard-Deviation Supply Shock – Developed versus Emerging Economies.

We use the Bayesian Estimation, Analysis, and Regression (BEAR) toolbox (Version 4.2) to perform these estimations. The European Central Bank developed the toolbox, and it is fully described by Dieppe et al. (2016). We choose to use the pooled estimator to draw inferences with alternative groups of economies and to compare their results. In this case, a normal-Wishart estimation strategy is adopted, in which the prior for the matrices of coefficients is multivariate normal. Previously to the estimation, we normalize all the data country-by-country to control for heterogeneities in the dispersion of the variables. Therefore, all our results are expressed in standard deviation units.

5. Empirical results

Our empirical results consist mostly of the analysis of impulse-response functions (IRF) to temporary and unexpected supply shocks for alternative groups of economies. In every figure, we show the IRF of the following variables: real interest rates, government consumption, and real exchange rates. We interpret the IRF for the real interest rate as the monetary-policy response to positive supply shocks, assuming symmetric responses in the case of negative shocks. The response of government consumption is an imperfect indicator of fiscal policy because it does not include the reaction of public investment due to data limitations. The IRF of the real exchange rate is an indicator of the external vulnerability to supply shocks. In the Appendix, Figures A1 to A8 show the responses of all the system’s variables, including the TFP shock itself. As data are quarterly, we use four lags for all panels ($p = 4$) to capture the autocorrelation structure of all the system variables appropriately.

5.1. Advanced versus emerging economies

Once the panel VAR is estimated, it is possible to compute the implied responses to supply shocks. Fig. 1 shows monetary-policy responses to a 1 standard deviation TFP shock. We perform this estimation with data from 21 developed economies and 24 emerging economies, as described in Section 3. Our key indicator of monetary policy is the real policy rate because it shows changes in the monetary policy rate in excess of the movements in inflation. Following Kaminsky et al. (2005), we also compare the reactions of public consumption and the real exchange rate, as these are helpful to understand better the overall macroeconomic implications of the supply shock.

Fig. 1 shows a procyclical monetary-policy reaction in the average emerging economy during the analysis period (2004–2019). As the supply shock is positive, a reduction of the real interest rate reinforces the effect of the initial shock on economic activity.⁸ This result is in line with the monetary policy dilemma in emerging economies, as described by Végh et al. (2017). The estimated

⁸ In this econometric model, the interpretation of policy reactions is symmetric. That is, in the case of a negative supply shock a procyclical monetary policy implies increases of the real interest rate.

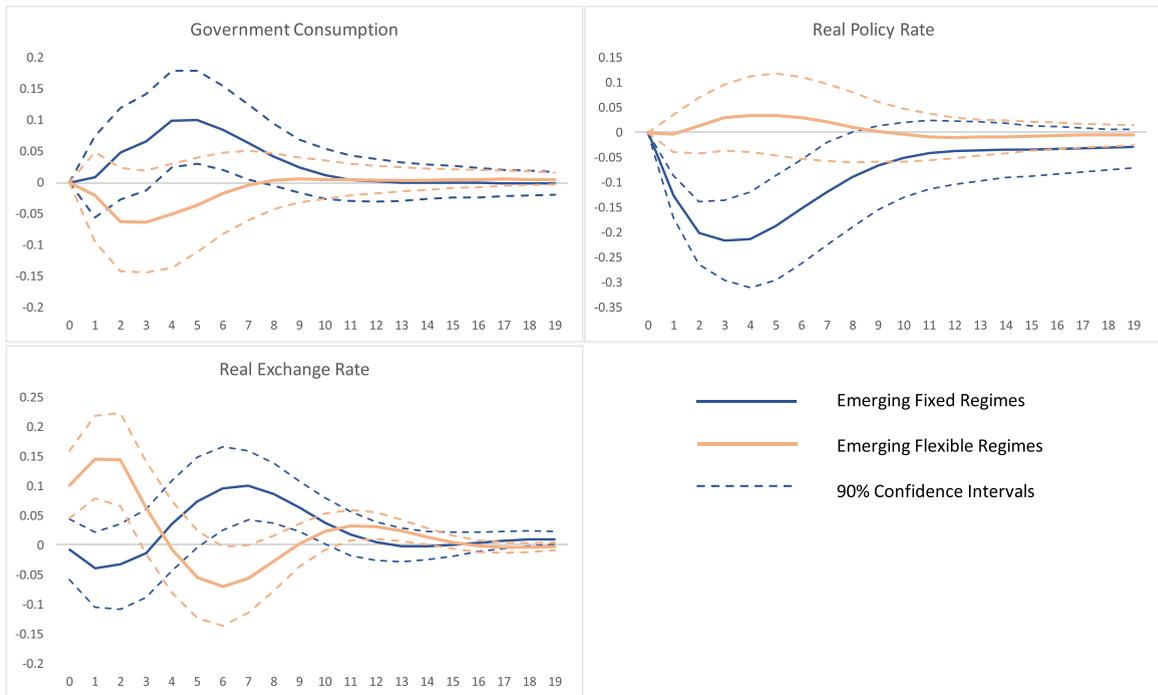


Fig. 2. Macroeconomic Responses to a 1 Standard-Deviation Supply Shock – Fixed Versus Flexible Regimes in Emerging Economies.

reduction of real interest rates remains significantly different from zero for about six quarters. Understanding some of the reasons for this procyclical reaction is an important goal of this paper. Fig. 1 also shows that, in the average developed economy, the reaction of monetary policy is slightly procyclical but not significantly different from zero. The lack of countercyclical reaction in developed economies is likely related to the already low interest rates predominant in several advanced economies before the Global Financial Crisis (GFC).

Another result in Fig. 1 is that, although government consumption is countercyclical to supply shocks in developed economies, it is acyclical in emerging economies, which is consistent with the original findings in Kaminsky et al. (2005). Additionally, although the Real Exchange Rate (RER) tends to appreciate in the short-term for emerging economies, this reaction is not statistically significant in developed economies.⁹ As described by Ocampo (2016), this result is consistent with the hypothesis of balance-of-payment dominance in emerging economies, in which their external sectors are very vulnerable to external shocks. The corresponding impulse-response figures for all variables in the system are presented in Figures A1 and A2 in the Appendix, and these include confidence intervals.

5.2. Fixed versus flexible exchange-rate regimes in emerging economies

In this subsection, we study whether monetary-policy responses in emerging economies depend on the exchange-rate regime. The classification of regimes is described in Section 2 and in Table A4 in the Appendix. Fig. 2 shows that, although the monetary-policy response is highly procyclical in fixed-regime economies, it is acyclical in flexible regimes. This result is consistent with the monetary-policy trilemma, in which fixed regimes lose monetary-policy maneuverability because they are committed to maintaining nominal or real exchange-rate targets (Obstfeld et al., 2019). As expected, there is a short-run RER appreciation in flexible regimes due to the supply shock. In contrast, the initial RER response is non-significant in fixed-regime economies due to the procyclical monetary policy response. This result is consistent with McGettigan et al. (2013), as well as with Thornton and Vasilakis (2016), who show that adopting inflation targeting—implying flexible exchange rates—leads to more countercyclical monetary policies.

Another interesting result in Fig. 2 is that the reaction of government consumption is procyclical in fixed regimes and acyclical in flexible regimes. The corresponding impulse-response figures for all system variables are presented in Figures A3 and A4 in the Appendix, and these include confidence intervals.

5.3. High versus low financial openness

Fig. 2 shows that the presence of fixed exchange-rate regimes is an important determinant of procyclical monetary policy responses to supply shocks. In this subsection, we analyze whether different degrees of financial openness can also partially explain

⁹ An increase of the real exchange rate, in this database, denotes an appreciation of the domestic currency vis-à-vis its main trade partners.

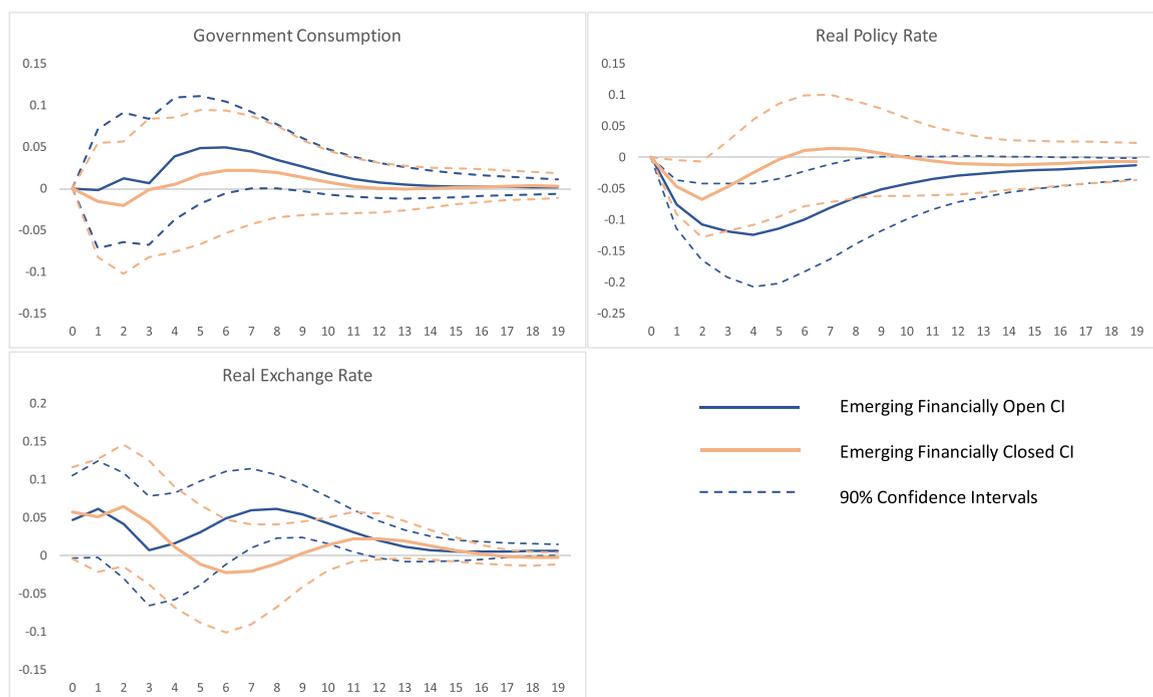


Fig. 3. Macroeconomic Responses to a 1 Standard-Deviation Supply Shock – Financially Open Versus Closed Emerging Economies According to Index by Chinn and Ito (2006).

the cyclicity of monetary policy. As mentioned in Section 3, we use two alternative approaches to measuring financial openness: the index developed by Chinn and Ito (2006) and the indicator used by Lane and Milesi-Ferreti (2008). We use these indicators to split our set of emerging economies between those financially open and closed. This classification is presented on Table A4 in the Appendix.

Fig. 3 shows results for financial openness according to Chinn and Ito's (2006) indicator. The impulse-response graphs show that monetary policy reactions are more procyclical in financially open economies, compared to closed ones. In open economies, the real interest reaction remains significantly below zero for 10 quarters. In contrast, this reaction is notably less pronounced in financially closed economies. However, these responses are not significantly different from each other because the confidence intervals overlap.¹⁰ Still, this result is consistent with literature on the greater vulnerability of the external sector in financially open emerging economies (Ocampo, 2016). In these economies, central banks have a more difficult choice between a volatile exchange rate and economic activity after the supply shock.

Fig. 3 also shows that the shock's effect on the exchange rate is more persistent in financially open economies. In addition, the reaction of government consumption to the supply shock does not vary much with the financial openness degree. The corresponding impulse-response figures for all variables in the system are presented in Figures A5 and A6 in the Appendix, and these include confidence intervals.

Fig. 4 shows results for financial openness according to the indicator suggested by Lane and Milesi-Ferreti (2008). The results are similar to those described in Fig. 3. The estimated monetary policy reaction in financially open economies is procyclical. Meanwhile, the reaction in closed economies is also procyclical, but with lower magnitude and less statistically significant. Therefore, these results are robust to the definition of financial openness. The corresponding impulse-response figures for all variables in the system are presented in Figures A7 and A8 in the Appendix, and these include confidence intervals.

5.5. Quantitative analysis of monetary policy reactions

Table 1 describes the size of the monetary policy responses to a one standard-deviation temporary supply shock in each group of countries. We express these responses in units of standard deviations of the real interest rate and compare these across country groups and along different horizons after the shock. We use this unit of measurement for all countries to control for heterogeneous volatility across economies.

¹⁰ Although impulse response functions include cumulated uncertainty from parameter estimations. Single parameters estimated with panel regressions show significantly different reactions. These results are available by request.



Fig. 4. Macroeconomic Responses to a 1 Standard-Deviation Supply Shock – Financially Open Versus Closed Emerging Economies According to the Indicator by Lane and Milesi-Ferreti (2008).

Table 1

Monetary policy reactions on different horizons. real interest rate responses to a 1 standard-deviation supply shock.

Group	5th quarter	10th quarter	15th quarter
1. Developed	0.007	0.042**	0.007
2. Emerging	-0.074**	-0.034	-0.027**
3. Fixed Regime	-0.188**	-0.050	-0.034
4. Flexible Regime	0.034	-0.004	-0.007
5. Open (C&I) ¹	-0.115**	-0.042	-0.021
6. Closed (C&I) ¹	-0.003	-0.001	-0.011
7. Open (LMF) ²	-0.120**	-0.061**	-0.031**
8. Closed (LMF) ²	-0.017	0.006	-0.005

** Indicates 90% significance1/ Financial openness indicator according to Chinn and Ito (2006)2/ Financial openness indicator according to Lane and Milesi-Ferreti (2008)Notes: All responses are expressed in standard deviations. Rows 3–8 correspond to emerging economies.

Five quarters after the shock, the emerging economy group with fixed exchange-rate regimes has the most procyclical monetary-policy response, with an average standard deviation of 19%. Ten quarters after the shock, the most procyclical response belongs to the group of financially open emerging economies, in accordance with Lane and Milesi-Ferreti’s (2008) indicator. This response amounts to a standard deviation of 6%. This same group has the most procyclical response 15 quarters after the shock. Meanwhile, the only countercyclical response is found for the developed economy group, 10 quarters after the shock. Therefore, Table 1 shows that, although procyclical responses are stronger in fixed regimes, these have a shorter duration. In contrast, these procyclical responses in financially open economies are less intense but have a longer duration. Meanwhile, monetary policy responses in financially closed economies are procyclical but non-significant. These results confirm the importance of the degree of financial openness for the cyclicity of monetary policy responses in emerging economies.

Table 2 describes the variance decomposition of the real interest rate 16 quarters after the supply shock. This exercise is performed with the Forecast Error Variance Decomposition (FEVD) approach, as described in Lütkepohl (2006). We compute the cumulative contributions of all the shocks in the system during 16 quarters to produce the variance of real interest rates in the same horizon.

Table 2
Variance decomposition of real policy rate fluctuations 16 quarters after the supply shock.

Group	Government consumption	Total factor productivity	Household consumption	Real money balances	Real exchange rate
1. Developed	1.02	0.81	2.15	1.89	0.81
2. Emerging	1.96	1.25	0.38	5.62	0.47
3. Fixed Regime	4.84	4.93	1.57	7.28	0.51
4. Flexible Regime	1.03	0.46	0.72	2.38	0.89
5. Open (C&I) ¹	2.17	3.04	0.57	6.26	0.66
6. Closed (C&I) ¹	1.22	0.64	0.61	4.60	1.19
7. Open (LMF) ²	4.29	3.29	0.55	7.25	1.12
8. Closed (LMF) ²	2.23	0.78	0.58	5.85	0.41

1/ Financial openness indicator according to [Chinn and Ito \(2006\)](#).

2/ Financial openness indicator according to [Lane and Milesi-Ferreti \(2008\)](#).

Notes: All responses are expressed percentage points. Rows 2–8 correspond to emerging economies.

This period is long enough for all the transmission mechanisms in the system to develop. [Table 2](#) shows that the most important determinants of interest-rate fluctuations in developed economies are household consumption shocks. In contrast, for all emerging economies (Rows 2 to 8), the most important determinants are real money shocks. This result follows from the higher observed macroeconomic volatility in emerging economies, which leads to highly fluctuating money-demand shocks. [Table 2](#) also shows that the second most important determinant of interest rates in emerging economies are government consumption shocks. This result is likely related to the typically procyclical government responses in these economies, which trigger additional monetary-policy reactions by central banks.

If we compare emerging economies with different degrees of financial openness in [Table 2](#), it is interesting to note that supply shocks (TFP) explain a larger proportion of the interest rate fluctuations in financially open economies. This result is in line with the hypothesis of balance-of-payment dominance in emerging economies, as external vulnerabilities lead to more frequent monetary policy decisions in open economies.

6. Concluding comments

In this document, we use an alternative methodology to analyze monetary-policy responses to unexpected and temporary supply shocks. We perform Bayesian Panel VAR estimations that allow for the identification of these supply shocks by controlling for demand-related variables. Then, we identify and compute the implied monetary-policy responses using the Cholesky ordering and controlling for demand, as well as real exchange rate shocks. This framework is applied to study monetary-policy reactions across levels of development, exchange-rate regimes, and financial openness degrees. Our results show that monetary-policy is more procyclical in financially open emerging economies with fixed exchange-rate regimes.

Although our results should be interpreted as average outcomes for groups of emerging economies, we detect a concern about the design of monetary policy in financially open economies that is in line with related literature. These results are consistent with the hypothesis of balance-of-payment dominance due to the external-sector effects of supply shocks in economies with relatively high degrees of financial openness. In this case, the high pass-through degree of external shocks to the real exchange rate leads to procyclical monetary policies ([Ocampo, 2016](#)). Some scholars have proposed the development of multilateral cooperation institutions that support emerging economies to improve the cyclicity of their monetary-policy responses ([Ocampo, 2017](#), p. 269). In addition, [Rey \(2015\)](#) and others have proposed the adoption of macroprudential measures to help smooth the potential domestic effects of external financial shocks.

Finally, future research should focus on detecting nonlinearities on the relation between financial openness degree and monetary policy. In addition, the use of macroeconomic modelling is essential to make welfare analyses and to compute optimal monetary-policy responses under imperfect financial markets. A four-way disaggregation of exchange regimes and financial openness degrees is an interesting extension that requires the inclusion of a higher number of countries to prevent panel estimations with too few economies.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Figs. A1–A8, Tables A1–A4.

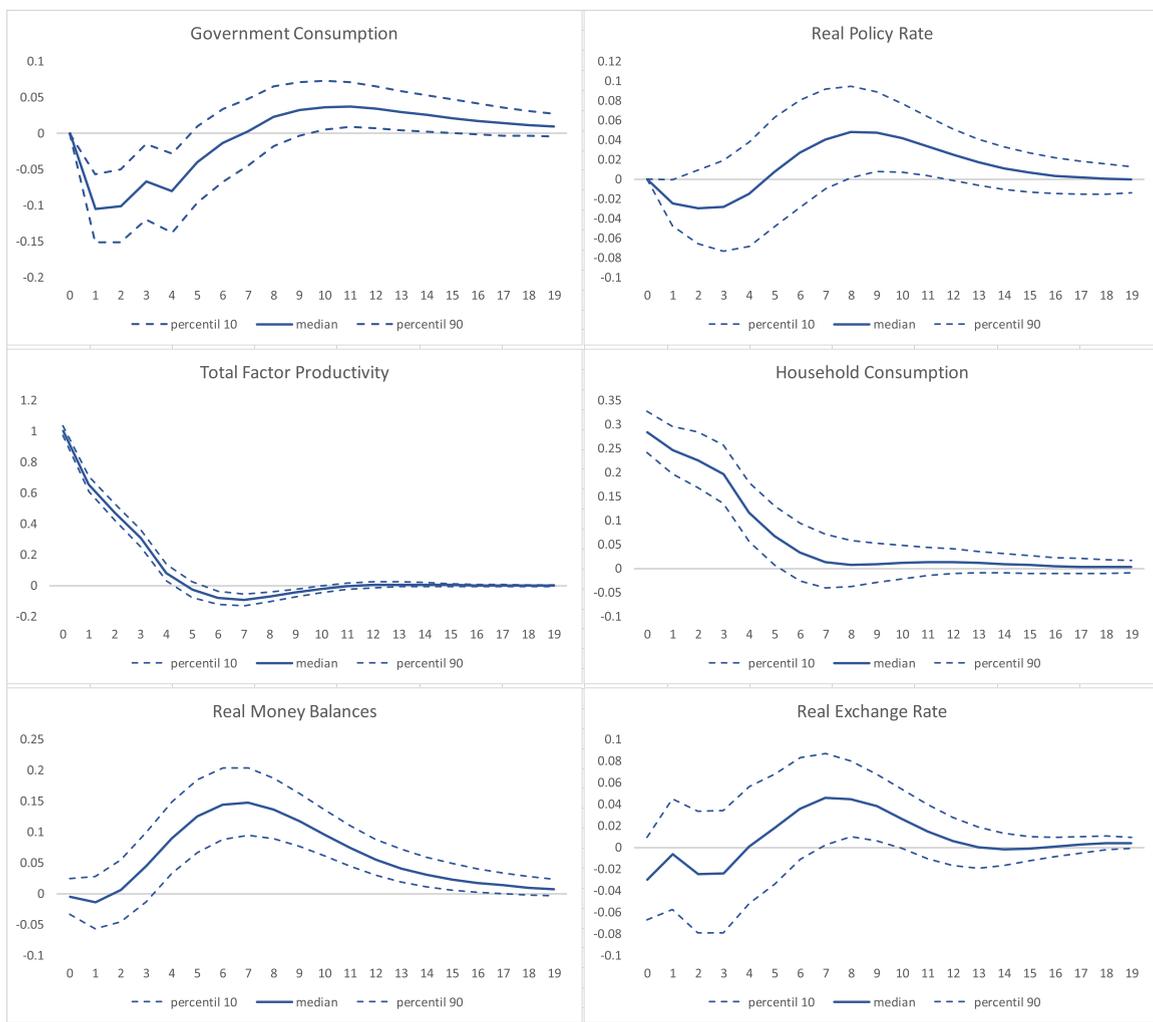


Fig. A1. Impulse-Response Functions in Developed Economies 2004Q1–2019Q2. One Standard-Deviation TFP Shock Note: 90% confidence intervals.

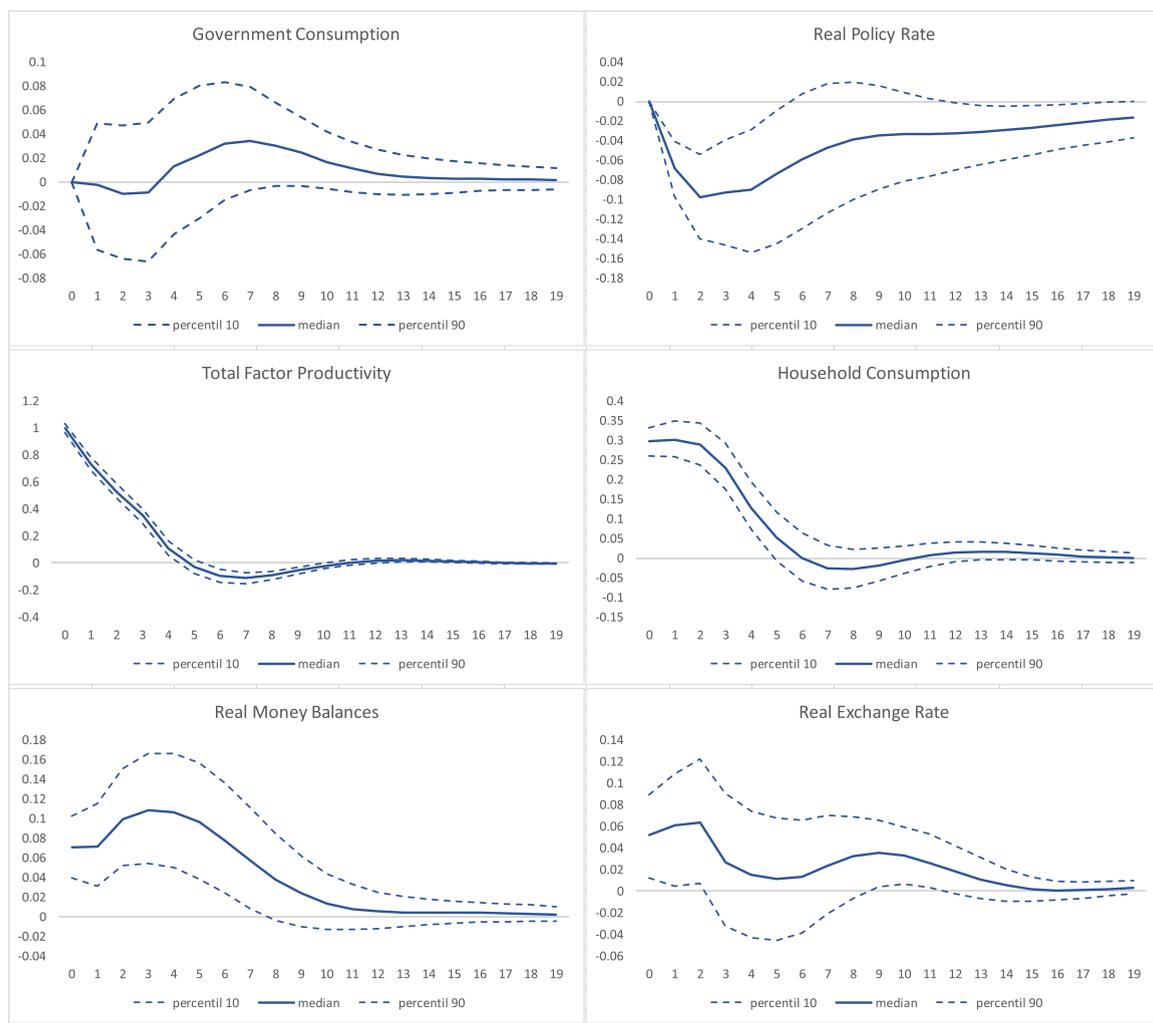


Fig. A2. Impulse-Response Functions in Emerging Economies 2004Q1–2019Q2. One Standard-Deviation TFP Shock. Note: 90% confidence intervals.

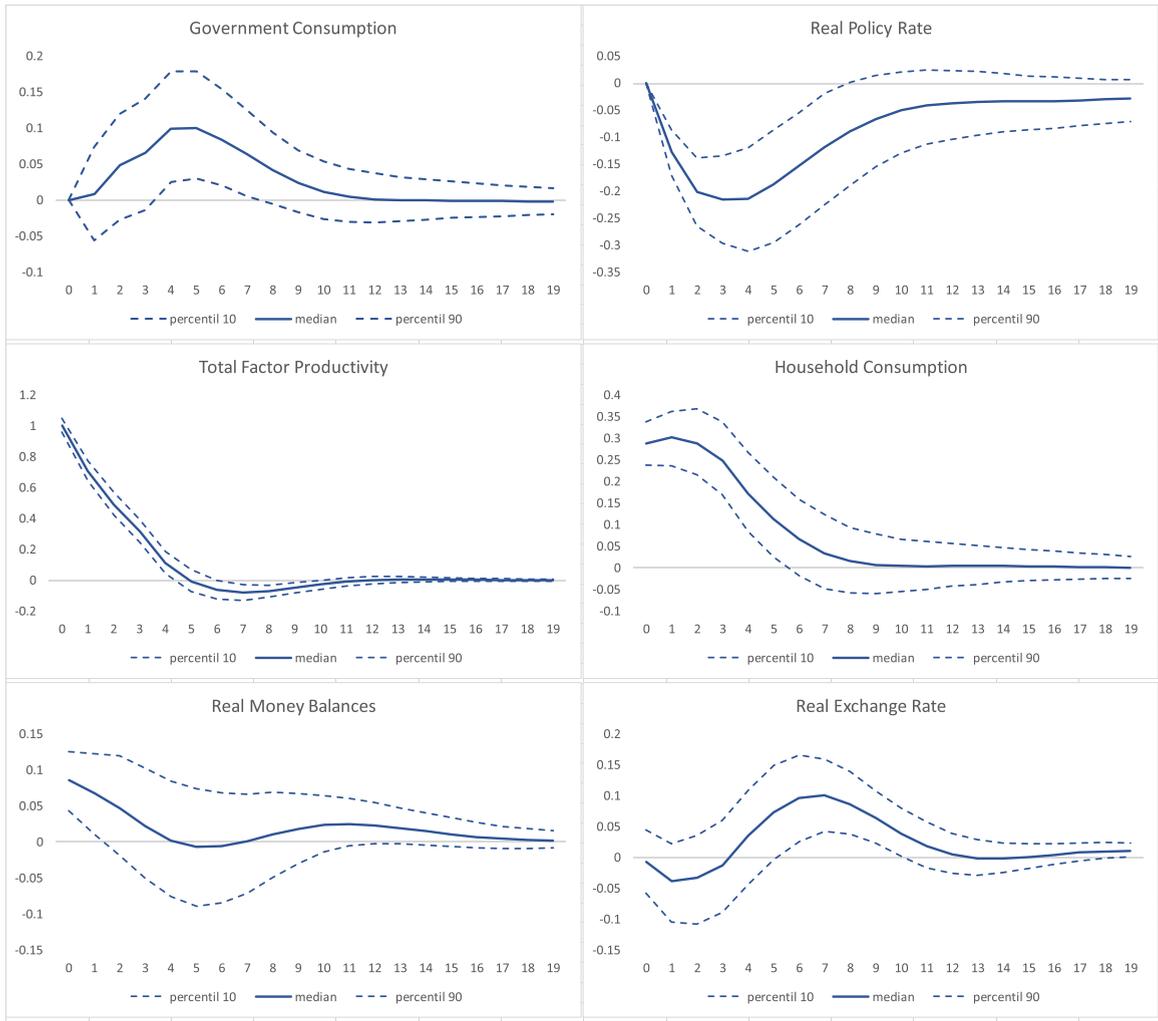


Fig. A3. Impulse-Response Functions in Emerging Economies with Fixed Exchange Rates 2004Q1–2019Q2. One Standard-Deviation TFP Shock. Note: 90% confidence intervals.

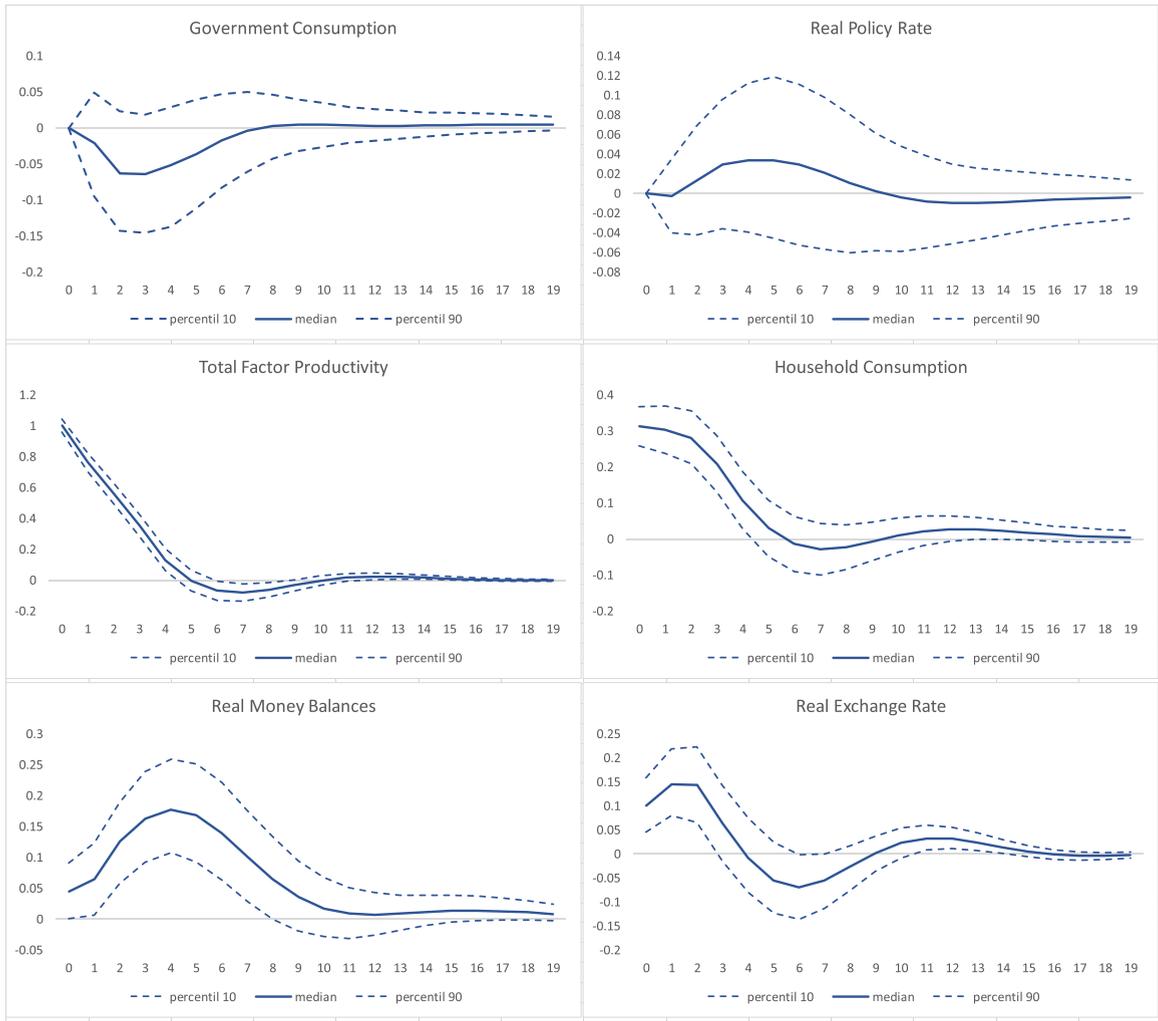


Fig. A4. Impulse-Response Functions in Emerging Economies with Flexible Exchange Rates 2004Q1–2019Q2. One Standard-Deviation TFP Shock. Note: 90% confidence intervals.

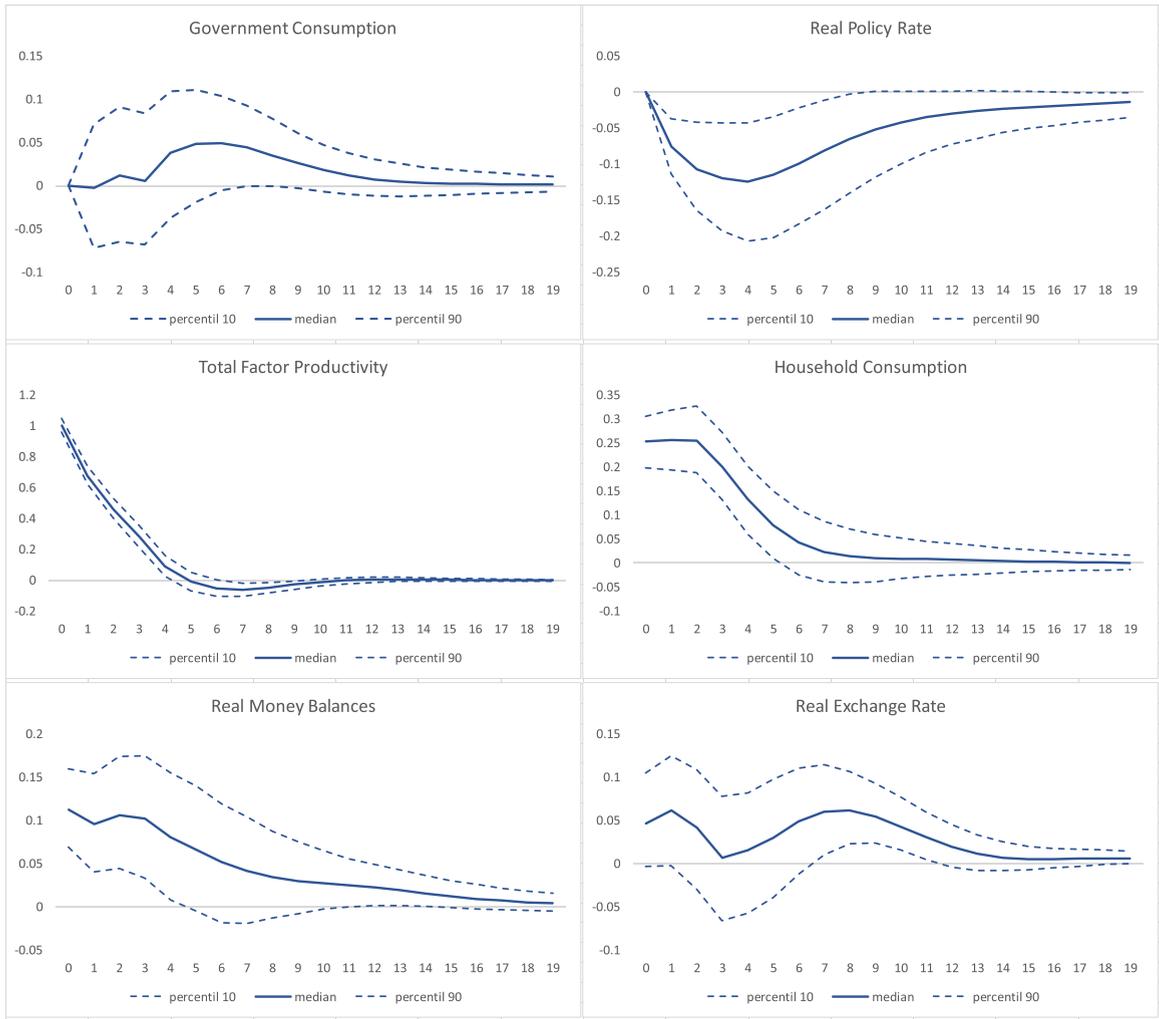


Fig. A5. Impulse-Response Functions in Financially Open Emerging Economies According to Chinn and Ito (2006). One Standard-Deviation TFP Shock. Note: 90% confidence intervals.

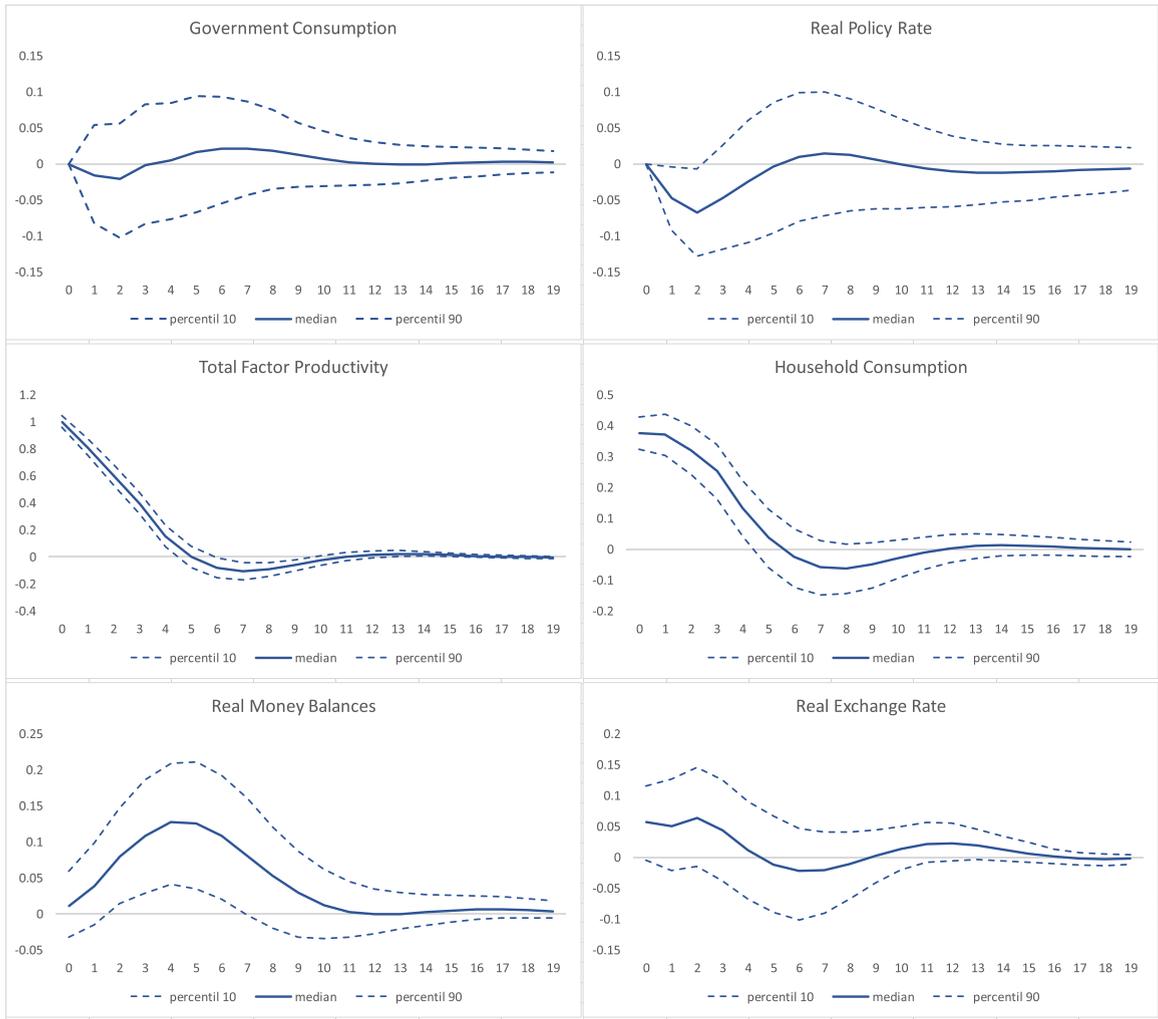


Fig. A6. Impulse-Response Functions in Financially Closed Emerging Economies According to Chinn and Ito (2006). One Standard-Deviation TFP Shock. Note: 90% confidence intervals.

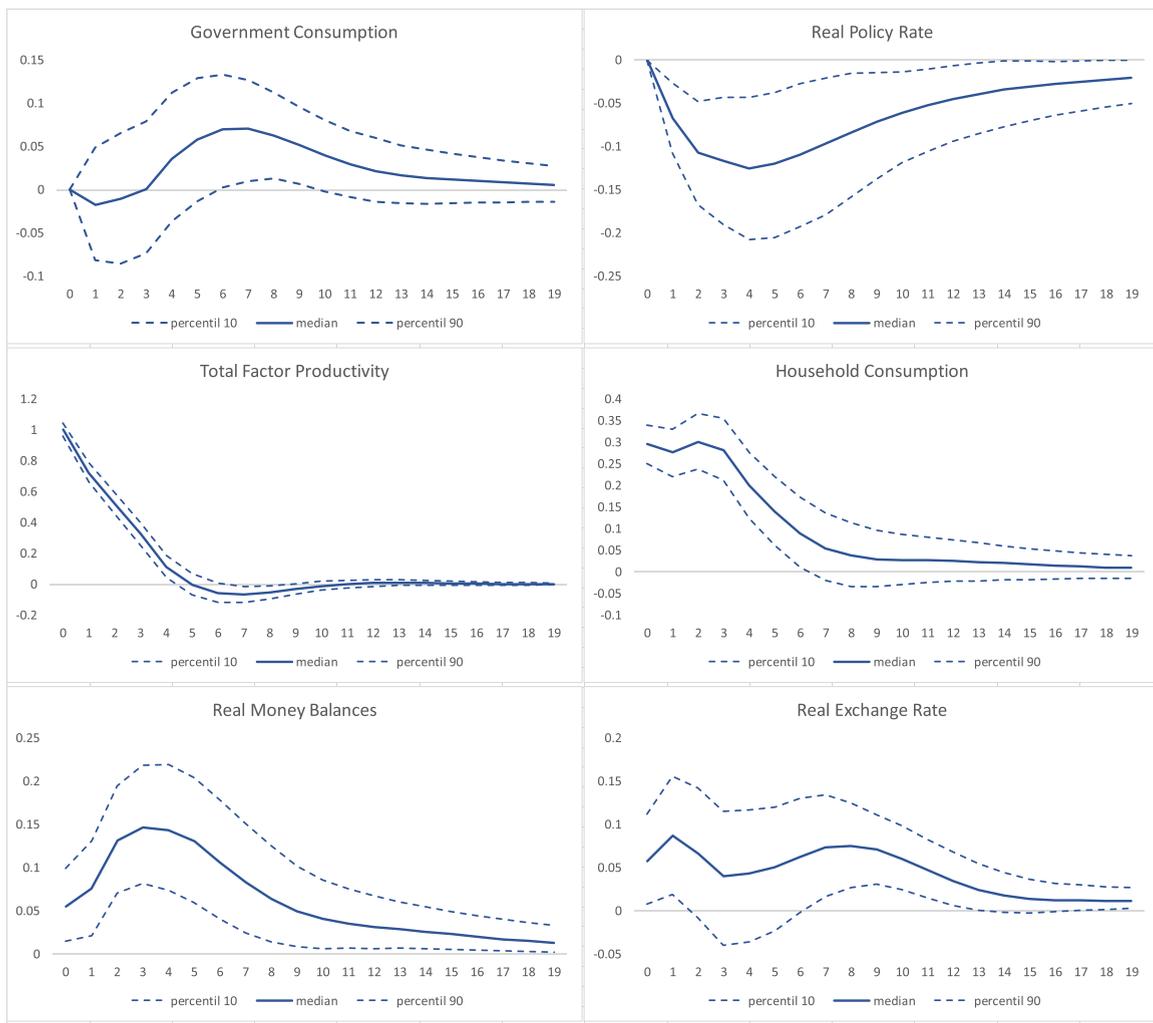


Fig. A7. Impulse-Response Functions in Financially Open Emerging Economies According to Lane and Milesi-Ferreti (2008). One Standard-Deviation TFP Shock. Note: 90% confidence intervals.

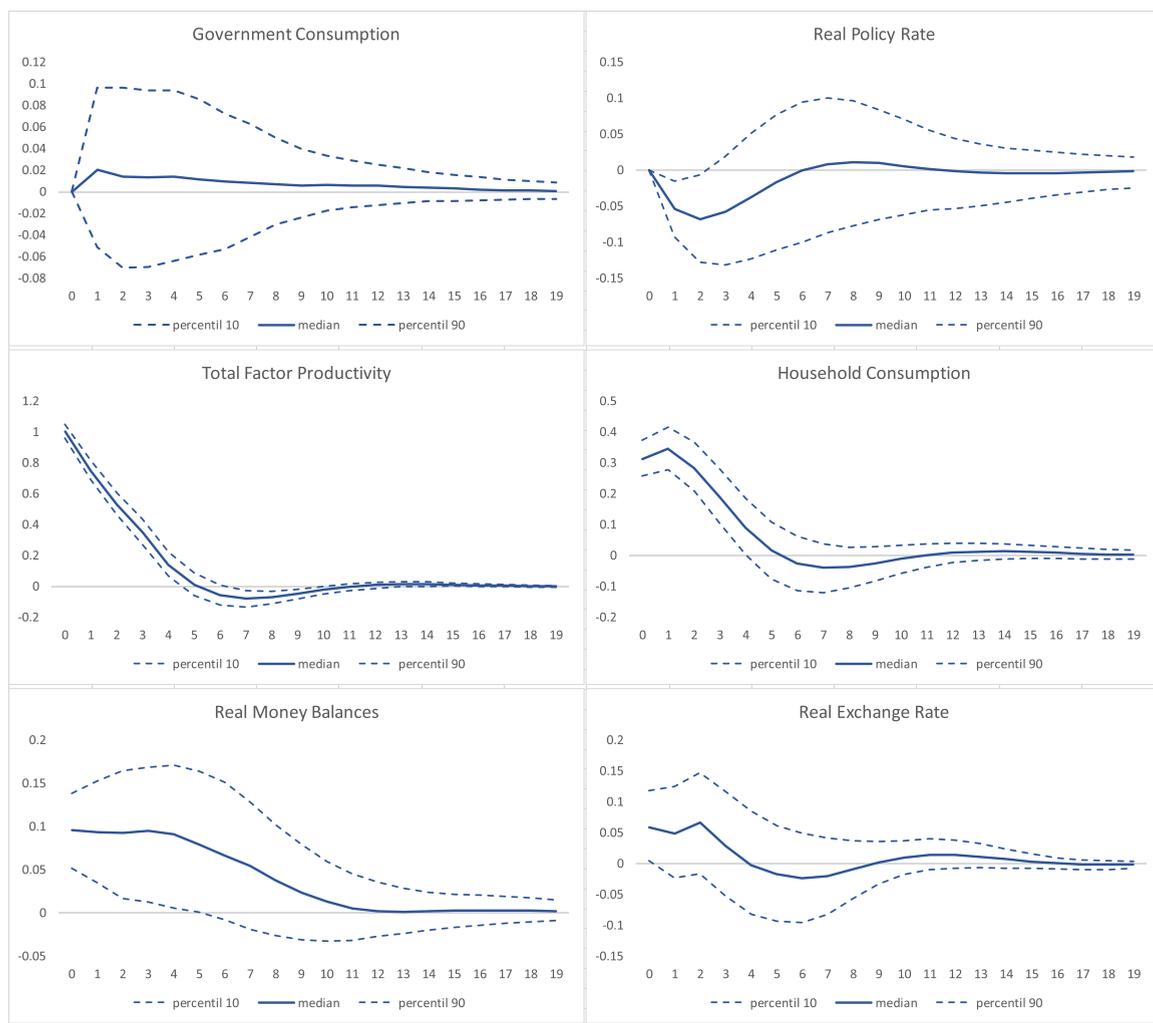


Fig. A8. Impulse-Response Functions in Financially Closed Emerging Economies According to Lane and Milesi-Ferreti (2008). One Standard-Deviation TFP Shock.

Table A1

Panel unit root tests – developed economies test by Im et al. (2003) Null: All panels contain unit roots.

Panel	W-t-bar	P-value
Gov.	-8.64	0.00
Consumption	-3.79	0.00
Real Policy Rate	-11.87	0.00
Total Factor Productivity	-7.96	0.00
Household Consumption	-3.02	0.00
Real Money Balances	-9.64	0.00
Real Exchange Rate		

Note: All variables in log difference, except for real policy rate. Bayesian information criterion is used to select the optimal number of lags.

Table A2

Panel unit root tests – emerging economies Test by Im et al. (2003) Null: All panels contain unit roots.

Panel	W-t-bar	P-value
Gov.	-14.10	0.00
Consumption		
Real Policy Rate	-8.90	0.00
Total Factor	-10.88	0.00
Productivity		
Household	-7.59	0.00
Consumption		
Real Money	-5.57	0.00
Balances		
Real Exchange	-8.94	0.00
Rate		

Note: All variables in log difference, except for real policy rate. Bayesian information criterion is used to select the optimal number of lags.

Table A3

List of developed economies.

Australia	Germany	Norway
Austria	Greece	Portugal
Belgium	Iceland	Slovenia
Canada	Ireland	Spain
Denmark	Israel	Sweden
Finland	Italy	United Kingdom
France	Netherlands	United States

Source: Data Description (Section 2).

Table A4

Classification table for emerging economies.

#	Country	Fixed	Flexible	Fin. Open C&I	Fin. Open LMF
1	Argentina	1	0	0	0
2	Brazil	0	1	0	0
3	Botswana	0	1	1	0
4	Bulgaria	1	0	1	1
5	Chile	0	1	1	1
6	Colombia	0	1	0	0
7	Croatia	1	0	0	1
8	Czech Republic	0	1	1	1
9	Ecuador	1	0	0	0
10	Estonia	1	0	1	1
11	El Salvador	1	0	1	0
12	Hungary	0	1	1	1
13	Latvia	1	0	1	1
14	Lithuania	1	0	1	0
15	Malaysia	1	0	0	1
16	Mexico	0	1	0	0
17	Peru	1	0	1	0
18	Poland	0	1	0	0
19	Romania	0	1	1	0
20	South Africa	0	1	0	1
21	Slovakia	1	0	0	1
22	Thailand	0	1	0	1
23	Turkey	0	1	0	0
24	Uruguay	0	1	1	1
	Number	11	13	12	12

Source: Data Description (Section 2).

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