Kasetsart Journal of Social Sciences 43 (2022) 19–30

Kasetsart Journal of Social Sciences

journal homepage: http://kjss.kasetsart.org

Legal independent central bank and exchange rate

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Article Info

Article history:
Received 2 February 2021
Revised 5 April 2021
Accepted 14 April 2021
Available online 31 January 2022

Keywords:
CBI,
economic activity,
exchange rate,
mean group estimation,
panel VAR

Abstract

This study developed a new solution for the heterogeneity responses of exchange rate and economic activity in relation to central bank independence shocks in developing countries. It used quarterly time series panels of 26 developing countries for the period 1991Q1–2019Q4. The analysis was based on a panel Vector Autoregressive estimation. The results revealed that CBI required up to a year to cause an appreciation in the exchange rate. We also concluded that exchange rate had an essential role to play in monetary policy transmission, to the extent that a change in CBI affected the domestic currency, thereby influencing private consumption and investment. This study was different from the existing literatures from several perspectives. First, by performing pool ability tests on the effect of CBI on domestic currency, this study showed that the pooling assumption in the panel data did not hold, and hence the model was biased. Second, we performed a mean-group estimation to the panel VAR as a solution to heterogeneity problem. Third, by dividing the sample countries into three poolable sub-groups, the results showed that CBI produced appreciation of the exchange rate for group 1 but depreciation of the exchange rate for group 2. For group 3, CBI strengthened the exchange rate after 6 quarters of the shock.

Introduction

Major research revealed that central bank independence (hereafter, CBI) is a main factor on price stability (Agoba, Abor, Osei, & Sa-Aadu, 2017). However, according to Nurbayev (2018), assigning price stability as a main objective of CBI may have a negative consequence on domestic currency stability. The main reason for this negative effect is because under international capital mobility, policymakers encounter a trade-off between exchange rate stability and domestic monetary independence. Moreover, Governments in developing countries have the ability to manipulate exchange rate depreciation to win elections. However, if the central bank is fully credible and free from government interference, this may limit the government on such manipulation.

Developing countries should pay more attention regarding exchange rate depreciation because it may have an impact on macroeconomic stability (Habib, Mileva, & Stracca, 2017). Some countries in Asia, such as Indonesia, Thailand and South Korea, experienced a financial crisis in 1997 due to depreciation of the exchange rate. Thus, those countries increased their credibility and autonomy of their central banks to create stable domestic currencies (Eichler & Littke, 2018).

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https://doi.org/10.34044/j.kjss.2022.43.1.03
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Furthermore, the exchange rate has an important role in the stability of macroeconomics because the exchange rate is an essential factor affecting the export and import price (Latief & Lefen, 2018). Thus, the exchange rate influences imported goods prices in domestic market and domestic goods in foreign markets. Consequently, changes in the exchange rate may lead to a significant effect on domestic inflation, particularly in small open countries, affecting public consumption and investment (Kandil, 2015).

The role of CBI to affect exchange rate can be explained as follow: central bank reform (change in the degree of CBI) will alter the public's expectation of inflation. Then, if the public perception of inflation changes, the exchange rate should also change due to the sensitivity related to inflation. This means that the exchange rate contains information pertaining to future inflation. A few papers have focused on central bank reform over the financial asset prices. Kuttner and Posen (2010) and Moser and Dreher (2010) documented the changes of the central bank's governor and their relationship to the exchange rate.

The contribution of this paper adds empirical research by linking the relationship among CBI, exchange rate, consumption and investment. In this paper, the interaction between CBI, domestic currency and economic activity was examined by fitting a panel VAR estimation on quarterly data spanning the periods 1991Q1 and 2016Q4. Subsequently, the pooling assumption of the model was tested by applying the Chow and Roy-Zellner tests. It was established that the models contained heterogeneity among the samples; thus, we applied a mean-group estimation for the panel VAR by averaging all of the individual VAR coefficients. The samples were divided into three subgroups to make a poolable group. Subsequently, the subsamples and the full sample were compared in regard to the link between CBI, domestic currency, consumption and investment.

Literature Review

The effect of monetary policy on exchange rate has become one of the most interesting research topics in macroeconomic policy over the last two decades. Moser and Dreher (2010) examined the effect of changing the governor of the central bank on the foreign exchange market, domestic stock market and sovereign bond spreads based on a data set for 20 emerging countries over the period 1992 to 2006. Consequently, asset price should change to the extent of their sensitivity to inflation. Their results showed that changing the governor of the central bank has a negative effect on the financial market. The reasons why investors respond negatively is because the new governor of the central bank apparently suffers from a systemic credibility problem.

Eichler and Littke (2018) investigated the effect of CBI on exchange rate volatility using panel data for 62 economies from 1998 to 2010. They reported that a conservative and independent central bank will reduce the public's uncertainty about the central bank's policy objective, thus reduce the volatility of inflation expectation, finally creating a pronounced stabilising effect on exchange rate volatility. They also revealed that exchange rate volatility depends on price flexibility in the goods market, central bank preferences for price stability and the interest rate sensitivity related to money demand. They established strong empirical evidence that an increase in independent central banks decreases exchange rate volatility.

The relationship between asset price and economic activity varies depending on financial structure. Assenmacher-Wesche and Gerlach (2008) studied the response of asset prices (property price and equity price), inflation and real activity to interest rate policy shocks for a panel of 17 OECD countries using quarterly data for the period 1986 to 2006. By way of performed individual VAR, they discovered that inflation and output growth respond better to interest rate shock than property and equity shock. Furthermore, their study applied a mean group estimator for panel VAR, which split the sample into two groups based on financial structure. They concluded that the interest rate shock has a positive effect on housing price and increase real economic activity. However, for equity price, monetary policy shock reduces the equity price. Panel VAR analysis of different subgroups of countries reveals that the effect of interest rate on housing price seems influenced by financial structure.

Methodology

Data

This paper used data from 26 developing countries (Argentina, Bolivia, Honduras, Guatemala, Uruguay, Venezuela, Suriname, Trinidad and Tobago, Mexico, Paraguay, Nicaragua, Egypt, Ethiopia, Ghana, Kenya, Zambia, Mauritania, Morocco, South Africa, Tunisia, Turkey, Indonesia, Malaysia, Thailand, Pakistan and Philippines) having changes in CBI and applying flexible

exchange rate regime. The dataset consisted of 4 variables: CBI, exchange rate, consumption and investment. Quarterly data from the years 1991 quarter 1 to 2019 quarter 4 were used.

The data relating to the CBI index were legal variable aggregate weighted obtained from Garriga's (2016) data set because it was the newest and most comprehensive CBI data set. The index was between 0 and 1, with higher values denoting greater CBI for the legal index. The role of asset prices was represented by the exchange rate. The domestic currency in terms of natural logarithm was used. Exchange rate is the bilateral currency of each country's sample against the U.S. dollar (USD). This paper used household consumption and investment following Claessens and Kose (2017). The reason why this paper used total consumption and investment is because consumption is the largest share of output, while investment is the most volatile component of output. Household consumption data is the private consumption expenditure. The data were retrieved from the IFS of the IMF. Investment was measured as gross fixed capital formation taken from the IFS of the IMF. Consumption and investment were in terms of natural logarithm. The data that were presented annually were interpolated into quarterly data.

Methodology

Our Panel VAR model included four endogenous variables: exchange rate (ER), CBI, household consumption (Cons), and investment (Inv), thus our Panel VAR models (Equation 1–4) were:

$$ER_{it} = \alpha_{1,i} + \sum_{j=1}^{k} a_{1,j}\, ER_{i,t-j} + \sum_{j=1}^{k} b_{1,j}\, CBI_{i,t-j} + \sum_{j=1}^{k} c_{1,j}\, Cons_{i,t-j} + \sum_{j=1}^{k} d_{1,j}\, Inv_{i,t-j} + U_{1,it} \quad (1)$$

$$CBI_{it} = \alpha_{2,i} + \sum_{j=1}^{k} a_{2,j}\, ER_{i,t-j} + \sum_{j=1}^{k} b_{2,j}\, CBI_{i,t-j} + \sum_{j=1}^{k} c_{2,j}\, Cons_{i,t-j} + \sum_{j=1}^{k} d_{2,j}\, Inv_{i,t-j} + U_{2,it} \quad (2)$$

$$Cons_{it} = \alpha_{3,i} + \sum_{j=1}^{k} a_{3,j}\, ER_{i,t-j} + \sum_{j=1}^{k} b_{3,j}\, CBI_{i,t-j} + \sum_{j=1}^{k} c_{3,j}\, Cons_{i,t-j} + \sum_{j=1}^{k} d_{3,j}\, Inv_{i,t-j} + U_{3,it} \quad (3)$$

$$Inv_{it} = \alpha_{4,i} + \sum_{j=1}^{k} a_{4,j}\, ER_{i,t-j} + \sum_{j=1}^{k} b_{4,j}\, CBI_{i,t-j} + \sum_{j=1}^{k} c_{4,j}\, Cons_{i,t-j} + \sum_{j=1}^{k} d_{4,j}\, Inv_{i,t-j} + U_{4,it} \quad (4)$$

Results and Discussion

Summary Statistics

The descriptive statistics in Table 1 show that during the period 1991 Q1 to 2019 Q4, the average bilateral exchange rate logarithm was 2.3724, with the minimum -5.7386 and the maximum 9.5361. The average CBI degree was 0.5404 with the lowest 0.1886 and the highest 0.9512. The average private consumption, in terms of logarithm, was 12.1945 with the range between 4.1735 and 21.3359. Finally, investment had an average of 11.5065 with the lowest 3.0725 and the highest 22.1196.

Panel Unit Root Tests

This paper used three panel unit root tests, LLC, Breitung and IPS panel unit root tests, to check the stationary series of the CBI, exchange rate, consumption and investment. Regarding the LLC, IPS and Breitung tests, the null hypothesis was nonstationary. LLC and Breitung tests assumed a common autoregressive parameter for all panels; each individual series was stationary. IPS test assumed the individual unit root (some of the individual series were stationary). The optimal lag length was automatically selected by means of Schwarz Info Criterion. This chapter used individual intercept and trend in panel unit root tests.

Table 2 represents the result of the panel unit root test at level. The result illustrated that the null hypothesis was rejected for all variables at the 5 percent level of significance. Rejecting the null hypothesis means that those variables were I (0).

Lag Length Criteria

The model in Equations (1–4) was estimated to examine the interrelationship between CBI, exchange rate, consumption and investment by applying a panel VAR. For full sample and group 3, lag 2 was selected as the optimal lag. Meanwhile, the optimal lag was lag 3 for group 1 and group 2. Those selected lag were based on the Akaike information criterion which are revealed in Table 3.

Full Sample Countries Panel VAR

First, the model was estimated to examine the interrelationship between CBI, exchange rate and economic activity by applying panel VAR. Lag 2 was selected as the optimal lag based on Akaike information criterion. The results are presented in Table 4.

Table 1 reveals the summary statistics of the data

Variable	Mean	*SD*	Min.	Max
Ln Exchange Rate	2.3724	2.3086	-5.7386	9.5361
CBI	0.5405	0.1886	0.1345	0.9512
Ln Consumption	12.1945	2.7550	4.1735	21.3359
Ln Investment	11.5065	2.9870	3.0725	22.1196

Note: Test Period: 1991.1–2019.4. All variables - with the exception of the CBI degree - in logs.

Table 2 Panel Unit Root Tests

Variable	LLC	Breitung	IPS
ln Exchange Rate	-4.3490***	1.7727	-2.6921***
CBI	-2.9180***	-2.1609**	-2.0782**
Ln Consumption	-3.7550***	2.0605	-0.5044
Ln Investment	-3.4058***	2.0101	-1.6551**

Note: All variables - with the exception of the CBI degree - in logs *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Critical values: 1%: -2.33; 5%: -1.65; 10%: -1.28.

Table 3 VAR Lag Selection Criteria

Lags	Full Sample	Group 1	Group 2	Group 3
0	10.0227	9.36157	6.3628	10.0536
1	-11.6558	-13.8891	-13.7670	-11.0274
2	-12.3951*	-15.0995	-15.1868	-11.6374*
3	-12.3630	-15.1347*	-15.2080*	-11.5931
4	-12.3362	-15.0983	-15.1483	-11.5532

Note: The superscripts * indicate a lag order selected by Akaike information criterion (AIC).

Table 4 PVAR Regression

Variable	Exchange Rate	CBI	Consumption	Investment
Exchange Rate (-1)	1.2973***	-0.0319***	0.1423***	0.0545***
	(0.0184)	(0.0087)	(0.0283)	(0.0111)
Exchange Rate (-2)	-0.3013***	0.0321***	-0.1457***	-0.0552***
	(0.0183)	(0.0087)	(0.0282)	(0.0111)
CBI (-1)	0.0139	0.9856***	-0.0175	-0.0066
	(0.0411)	(0.0194)	(0.0631)	(0.0248)
CBI (-2)	-0.0200	-0.0009	0.0189	0.0102
	(0.0410)	(0.0194)	(0.0630)	(0.0248)
Consumption (-1)	0.0166	0.0070	1.0087***	0.0191***
	(0.0126)	(0.0059)	(0.0194)	(0.0076)
Consumption (-2)	-0.0161	-0.0077	-0.0136	-0.0165***
	(0.0126)	(0.0060)	(0.0194)	(0.0076)
Investment (-1)	0.0718***	0.0239**	0.2697***	1.6565***
	(0.0225)	(0.0106)	(0.0346)	(0.0136)
Investment (-2)	-0.0714***	-0.0233**	-0.2648***	-0.6594***
	(0.0224)	(0.0106)	(0.0345)	(0.0136)
C	0.0130	0.0109***	0.0321***	0.0106**
	(0.0085)	(0.0040)	(0.0130)	(0.0051)

Note: Standard errors are in parentheses.
*$p < .1$; **$p < .05$; ***$p < .01$.

Table 4 presents that exchange rate is positively influenced by its own first lag and significant at 1 percent with coefficient 1.2973. This implies that exchange rate of previous quarter leads to depreciate exchange rate while second lag of exchange rate has negative effect on exchange rate at 1 percent significance, with coefficient -0.3013. Investment lag one has positive effect on exchange rate while lag two investment has negative effect on exchange rate with coefficient around 0.07. Exchange rate lag one has negative effect on CBI, but lag two exchange rate has positive effect with coefficient about 0.03. Only CBI lag one has positive and significant effect on CBI, with coefficient 0.9856. Consumption is influenced positively by exchange rate lag one but negatively by second lag of exchange rate; likewise, investment lag one has positive effect on consumption but investment lag two has negative effect on consumption. Investment is influenced positively by exchange rate lag one, consumption lag one and investment lag one with coefficient 0.0545, 0.0191 and 1.6565, respectively. By contrast, for exchange rate lag two, consumption lag two and investment lag two have negative effect on investment. Overall, the effect of CBI on exchange rate and economic activities did not exist. However, the opposite effect of exchange rate was found on consumption and investment. Exchange rate lag one has positive effect on consumption and investment, but exchange rate lag two has negative effect on consumption and investment.

The panel VAR models in Equations 1–4 were estimated in pooled least squared (POLS). The POLS estimator is known to be potentially biased if the coefficients on the explanatory variables differ across countries. We ran the Chow and Roy-Zellner tests proposed by Baltagi (2008) to investigate the heterogeneity coefficients in the model. The null hypothesis confirmed that the coefficients were the same for all country samples while the alternative hypothesis showed the coefficients differed all cross-countries. The Chow and Roy-Zellner tests showed that the null hypothesis was rejected. This result implies that coefficients in the panel VAR model contain cross country heterogeneity. Therefore, one way to solve the heterogeneity problem is to perform the mean-group estimation procedure proposed by Pesaran and Smith (1995). It has been used in previous studies, such as Assenmacher-Wesche and Gerlach (2008), to obtain cross-sectional average responses. In particular, let $y_{kl}^{(i)}$ *be a h x* 1 *vector* containing the responses of variable l to an impulse in variable k over periods for country i. The MG responses of variable l to an impulse in variable k over h periods are calculated by averaging the individual country's coefficients and it is showed in Equation (5).

$$MG_{kl} = \frac{1}{N} \sum_{1}^{N} \gamma_{kl}^{(i)} \quad (5)$$

It was difficult to interpret the coefficient of VAR; hence, we focused the analysis on Impulse Response Function (IRF). In Figure 1, the IRF was displayed over 20 quarters for a one standard deviation shock implied by the panel VAR regression using the mean-group estimator. The focus was on the domestic currency response to CBI shock, consumption and investment responses to the domestic currency, consumption and investment responses to CBI shocks. The response of the domestic currency to shock of CBI was positive in the beginning, after the shock. This finding indicates that in the short-run, the CBI shock depreciates the exchange rate. After the central bank reform shock, it took six quarters for the exchange rate to begin to appreciate, with the highest effect around 0.58 percent in period 20. The evidence of the delayed overshooting puzzle of the influence of monetary policy on the domestic currency was confirmed, in which shock monetary policy requires time to appreciate the domestic currency, as prior studies such as Anaya, Hachula, and Offermanns (2017) demonstrated.

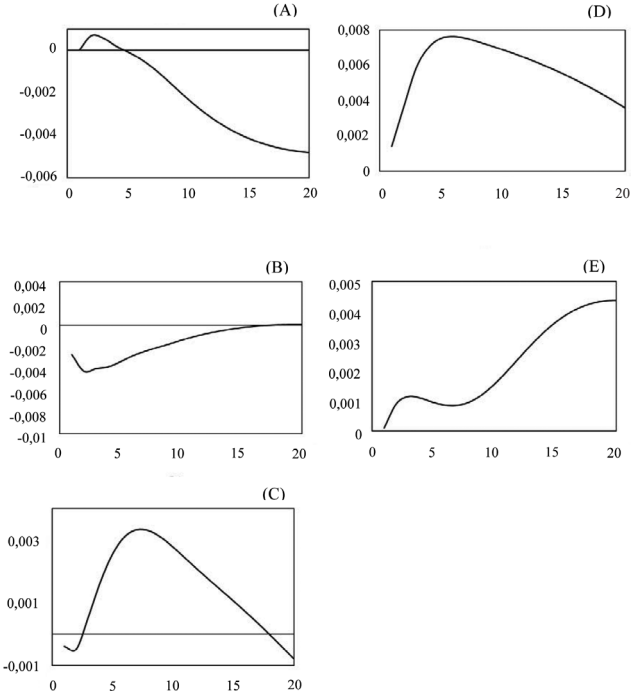

Figure 1 Impulse response function mean group estimation (A) Response of Exchange Rate to CBI, (B) Response of Consumption to CBI, (C) Response of Investment to CBI, (D) Response of Consumption to Exchange Rate, (E) Response of Investment to Exchange Rate.
Note: This estimation only averages the coefficient but not for confidence interval.

The response of consumption to a shock of the domestic currency was positive and reached the peak of about 0.69 percent at quarter 7 prior to falling in the following quarter. This implies that the depreciation of the domestic currency increases consumption, which is in line with the international real business cycle model. Our finding was in line with Kandil (2015), who found a positive link between consumption and domestic currency in emerging economies. The positive response to and consumption shock also showed in investment, where shock one standard deviation domestic currency increased 0.21 percent consumption at quarter four. This result denotes that depreciation of the exchange rate increases investment because it reduces investment cost and hence, attracts new investment. Latief and Lefen (2018) concluded that depreciation improves foreign direct investment. A one percentage point to the degree of CBI shock led to a fall in consumption by 0.27 percent in the first quarter and reached the minimum around 0.44 percent at quarter 2. From period 3 onwards, the impulse response turned back and reached the initial value at quarter 17. This finding could possibly initiate greater CBI followed by the tightening of monetary policy, for instance, reducing the supply of money to decrease inflation, although it also reduces private consumption. Shock one standard deviation in CBI increased investment and reached the peak of around 0.33 percent in quarter 7. Subsequently, the impact fell to the initial value at period 18. This result is in line with our expectation that a higher degree of CBI attracts investment.

Variance Decomposition

This session discusses the forecast error variance decompositions which disclose the contributions of the variables to the variation of one variable, as reported in Table 5. Panel 1 of Table 5 reveals that approximately 95.5 percent of the variance of the errors in forecasting the exchange rate came from innovations to the exchange rate itself at the 4-quarter horizon; the contribution of innovations to the exchange rate dropped to around 71 percent at a 20-quarter horizon. The second largest contribution came from CBI and reached over 10 percent at the 20-quarter horizon. Innovations to consumption and investment made a small contribution to variance in errors in forecasting the exchange rate.

Table 5 Forecast error variance decompositions

Period	Exchange Rate	CBI	Consumption	Investment
Forecasting Exchange Rate				
4	95.5573	1.7704	1.1519	1.5202
8	86.1522	4.4440	3.7057	5.6979
12	79.2689	7.1358	5.4770	8.1182
16	74.5350	9.1775	7.0903	9.1970
20	71.0128	10.4824	8.6717	9.8329
Forecasting CBI				
4	3.2491	93.9349	2.1445	0.6714
8	9.2098	83.2188	5.5808	1.9904
12	13.4531	76.5960	6.7544	3.1963
16	15.8101	72.6234	7.3386	4.2277
20	17.0955	70.0082	7.8597	5.0365
Forecasting Consumption				
4	6.8046	4.8279	85.0986	3.2687
8	10.9290	6.3834	73.9580	8.7294
12	13.8712	7.7769	64.4866	13.8651
16	15.8802	9.1736	58.4469	16.4991
20	17.1744	10.4686	54.6726	17.6842
Forecasting Investment				
4	5.7748	4.6715	13.8347	75.7188
8	9.5272	6.7563	18.4218	65.2945
12	13.0612	8.3453	21.6108	56.9826
16	16.0477	9.5483	23.5625	50.8414
20	17.9136	10.4947	24.8209	46.7707

Note: Each row shows the percentage of the variance of the error in forecasting the variable mentioned in the title of the table, at each forecasting horizon (in quarters) given in the first column.

In panel 3 in Table 5, it is evidence that consumption explains above 85 percent of the forecast error variance of the consumption at the 4-quarter horizon, though the contribution dropped continuously to roughly 54 percent at the 20-quarter. The importance of innovations to the exchange rate contributed approximately 7 percent in the 4-quarter then increased to around 17 percent in period 20.

The last panel in Table 5 explains that the importance of investment decreased with the increase in the forecast horizon. The investment contributed approximately 76 percent of the variance of the error in forecasting the investment at the 4-quarter horizon then fell to around 47 percent at the 20-quarter horizon. The contribution of the exchange rate innovations to forecast the increase in investment was from just below 6 percent in quarter 4 to around 18 percent at quarter 20. The innovation of consumption made a sizeable contribution to the forecast error variance of the investment, practically 25 percent at period 20.

Sub-Sample Analysis

The sample of countries was then divided into three groups to make our subsamples poolable. The first group included Guatemala, Morocco, Paraguay, Thailand, Malaysia and Trinidad and Tobago. The second group covered 5 countries: Tunisia, Uruguay, Pakistan, the Philippines and Egypt. The third group consisted of 15 countries: Mexico, Honduras, Mauritania, Suriname, Argentina, Ghana, Kenya, South Africa, Turkey, Zambia, Bolivia, Ethiopia, Nicaragua, Venezuela and Indonesia. The subgroups were selected for the reason that they were poolable. To do that, the researcher tried to make a combination of countries manually in a group then applied the polability test. After the poolable groups were found, the same criterions among the countries for each subgroup were found. This technique is a contribution of this paper in that a poolable groups based on econometric method exist.

First, a Panel VAR regression for subsample group 1 was performed. To check the presence of heterogeneity across countries, the Chow and Roy-Zellner tests were applied for pooling assumption. The results of the poolability test showed that the null hypothesis was not rejected. This signified that the panel was poolable, and there was no heterogeneity among the countries sample. The impulse response function for group 1 could now be presented. Initially, it was seen that the effect of central bank reform shock was negative in relation to the domestic currency. This finding was in line with our expectation that higher CBI affects the appreciation of the domestic currency. In response to a shock to the degree of CBI, the domestic currency level appreciated by 0.18 percent in the third quarter. From period four onwards, the response increased to reach the initial value. Shock one standard deviation exchange rate produced lower consumption and reached the minimum at period four at 0.12 percent while the direction changed the following quarter. The negative response was also shown by investment to the domestic currency shock. This result signified that the depreciation of domestic currency led to lower investment. Finally, it was perceived that the effect of CBI shock increases economic activity, both consumption and investment. Consumption responded positively to CBI shock after quarter two and increased over time. The investment response to CBI shock was positive and the coefficient was roughly 0.03 percent in the first period. The response increased gradually and reached the peak, roughly 0.28 percent, at period 20.

Next, Figure 2, we moved to the second group. After applying the panel VAR regression, the presence of heterogeneity across countries was checked by applying the Chow and Roy-Zellner tests for pooling assumption. The results of the poolability tests demonstrated that the null hypothesis was not rejected. This implied that the panel was poolable and there was no heterogeneity among the countries sample.

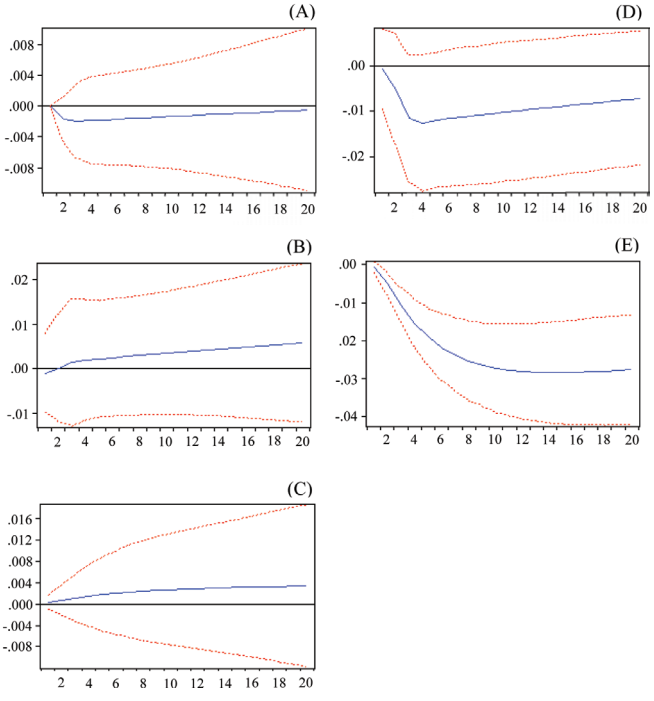

Figure 2 Impulse responses function group 1: (A) Response of Exchange Rate to CBI, (B) Response of Consumption to CBI, (C) Response of Investment to CBI, (D) Response of Consumption to Exchange Rate, (E) Response of Investment to Exchange Rate

Figure 3 describes that shock one standard deviation of CBI caused an increase in the domestic currency and reached the peak, approximately 0.27 percent, at period 5, after which the response fell to the original level. The result revealed that greater CBI produced depreciation in the domestic currency. This confirmed the existence of the exchange rate puzzle for this group. The negative response of consumption to a shock of the domestic currency began in period 2 and reached the minimum at period 6, about 0.30 percent. From quarter 7 onwards, the response climbed to reach the initial value. In contrast, the investment response to one standard deviation shock of exchange rate was negative from the first period, and reached the trough by 0.32 percent at period 5. Subsequently, the response rose and reached the initial value. This evidence implied that the depreciation (appreciation) exchange rate led to lower (higher) consumption and investment. Finally, the effect of CBI on economic activity via the domestic currency was analysed. In response to a shock of CBI, the consumption response was negative for all periods. This may have well been caused by the strong effect of the depreciation exchange rate due to CBI, therefore, generating higher imported goods. Therefore, private consumption dropped. Conversely, shock positive CBI led to increased investment until period 6. This implied that higher CBI together with the depreciation in the domestic currency attracted investors in the short-run.

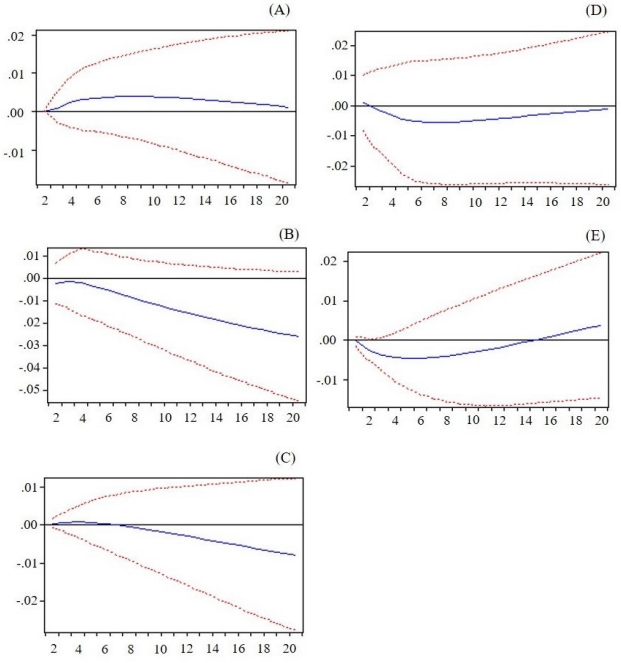

Figure 3 Impulse responses function group 2: (A) Response of Exchange Rate to CBI, (B) Response of Consumption to CBI, (C) Response of Investment to CBI, (D) Response of Consumption to Exchange Rate, (E) Response of Investment to Exchange Rate

Finally, we moved to the last group. The Panel VAR regression on the model was applied, then the presence of heterogeneity across countries was verified using the Chow and Roy-Zellner tests for pooling assumption. The results of the poolability tests showed that the null hypothesis was rejected. This result showed that the panel was not poolable and there was heterogeneity among the countries sample. In this part, the mean-group estimation was applied by averaging the coefficient for the 15 countries sample.

Figure 4 presents the result of IRF's using the mean-group estimation for 15 countries. Shock a one-unit innovation to the degree of CBI on the exchange rate was positive at the first 3-periods and reached the peak at 0.24 percent in period 3. Subsequently, the response fell to the initial value at period 6 and remained negative until the end of period 20. This finding signified that CBI created depreciation in the short-run but generated appreciation in the long-run. In this group, the delayed overshooting puzzle of the exchange rate due to changes in monetary policy is shown. The shock a one-unit innovation exchange rate increased consumption and reached the peak of about 1.54 percent at period 8. This group demonstrated that the depreciation exchange rate affected higher real economic activity. These findings confirmed the international business cycle model prediction of the positive relationship between the domestic currency and consumption. Shock a one-unit innovation exchange rate affected higher investment, roughly 1 percent at period 6. This indicated that the depreciation exchange rate generated lower cost for investment; thus, it increased the investment. The response of consumption to CBI shock was negative, reaching the minimum at period 6. After that, the response remained steady. This negative effect might have been caused by the strong influence of the depreciation exchange rate. The negative investment response to CBI shock was seen in the first 2 periods. After periods 2 to 11, the investment response to CBI shock was positive. From period 12 onwards, the investment response was negative. Investment response fluctuation was found due to higher CBI.

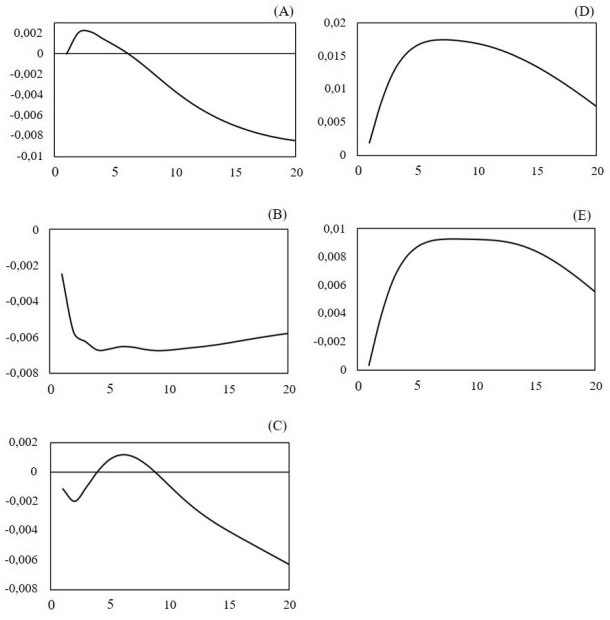

Figure 4 Impulse responses function group 3: (A) Response of Exchange Rate to CBI, (B) Response of Consumption to CBI, (C) Response of Investment to CBI, (D) Response of Consumption to Exchange Rate, (E) Response of Investment to Exchange Rate
Note: This estimation only averages the coefficient but not for confidence interval.

Comparison Sub-Sample Group

In this section, the interaction between CBI, exchange rate, consumption and investment in various sub-samples was analysed: full sample, group 1, group 2 and group 3. We compare the impulse response of the exchange rate to the shock of CBI in three different groups samples and the average for the full sample. Interestingly, the response to the shock varied in each group. From the Figure 1–4, it is apparent that a one-unit shock in CBI negatively affected the exchange rate in the first group. However, the positive effect was shown for groups two, three and also for the full sample countries, even though after a certain period the effect was negative. The magnitude of the maximum impact of one percentage point change in the degree of CBI on the exchange rate varied between -0.2 percent and 0.4 percent, averaging around 0.1 percent across the countries examined. The maximum impact was achieved at period 2 for the full sample, group 1 and group 3; however, for group 2 it was in period 8.

Various economic features of developing countries were found as the main factors that can describe the different results among groups. First, classification of the exchange rate measured by Ilzetzki, Reinhart, and Rogoff (2019) was applied. A higher number meant a more flexible exchange rate arrangement. The three groups had different degrees of exchange rate flexibility. Group 1 had the lowest flexibility of the exchange rate; the average group members in group 1 were applying de facto crawling peg. Group 2 had moderate exchange rate flexibility; a number of countries were using the crawling band exchange rate arrangement. Group 3 had the highest degree; certain countries adopted the manage floating exchange rate. Theoretically, the peg currency arrangement may have resulted in exchange rate puzzling (Kim & Lim, 2018). In the 1990s, most developing countries applied the peg exchange rate system to limit speculation, provide a stable system for traders and investors, and prevent market adjustments when a currency undervalued. However, this system creates an unreal currency or currency manipulation. Independent central banks commonly followed by changing the exchange rate system from the peg to the floating exchange rate system. In the short-run, the exchange rate will adjust to the market value. Therefore, the domestic currency will be depreciated as it is undervalued. However, in the long-run, central bank reforms could lower the domestic currency depreciation. This implies that under CBI, monetary policy is predictable, generating lower exchange rate uncertainty. This finding is relevant with Eichler and Littke (2018), who concluded that central bank reforms are associated with reduced domestic currency uncertainty and lower average depreciation in the long-run.

According to Davis and Presno (2017), the link between the exchange rate and monetary policy was based on perfect capital mobility. When capital mobility is highly controlled, the increase in CBI degree may not affect capital flows and the exchange rate. We established that the degree of capital control restrictions was different for the three subgroups, resulting in different monetary transmission effects on the exchange rate. The results for group 1, which had the lowest capital control restriction, were compatible with theoretical expectations that higher CBI leads to lower inflation expectation and hence, will appreciate the exchange rate. The “overshooting” theory developed by Dornbusch (1976) predicted that in the long-run, the domestic currency should initially overshoot to respond to monetary policy shock. Thus, an overshooting domestic currency occurred in this group. Previous empirical results support this finding as, for instance, with Alessi and Kerssenfischer (2019), who ascertained an appreciation domestic currency to monetary policy shocks. In contrast, the exchange rate puzzle was demonstrated by group 2, where monetary

policy shock affected domestic currency depreciation. In this group, capital mobility restriction was high. The previous result presented by Inoue and Rossi (2019) strengthened this finding. According to Kim and Lim (2018), exchange rate puzzle occurs in countries with strong restricted capital mobility. Hence, the change in monetary policy may not influence the exchange rate. The result for group 3 and the full sample group added the existence of the "delayed overshooting" puzzle previously documented by Scholl and Uhlig (2008). Group 3 had moderate capital mobility restriction. Capasso, Napolitano, and Jiménez (2019) found that the exchange rate overshoots were the long-run effect of monetary policy shock, though it occurs one to three years after the shocks.

Gantman and Dabós (2018) stated that there is a close relationship between trade openness and exchange rate. The trade openness is defined as a ration export and import divided by GDP. When the domestic exchange rate appreciates it leads to an increase in domestic good and services compared to foreign goods and services; thus, the aggregate demand decreases. However, an appreciating exchange rate means foreign goods and services become less expensive, and therefore increases imports. According to Gantman and Dabós (2018), the higher trade openness generates higher fluctuation in the exchange rate. This paper found that group 1 had high trade openness degree, for example Malaysia (175%), Thailand (112%) and Paraguay (97%). Group 2 had low openness countries such as Pakistan (33%), Uruguay (46%) and Egypt (48%). Group 3 had moderate trade openness countries including Indonesia (55%), Kenya (55%), Bolivia (60%) and Zambia (66%).

Robustness Check

Panel GMM estimation

In order to ensure that the estimation in the model was accurate and robust, this study ran Generalize Method of Movement (GMM) estimation. This estimation also deals with endogeneity problem in the model.

The results in Table 6 show CBI had a negative and significant effect on exchange rate for full sample, groups 1 and 3. However, CBI had a positive and significant effect on exchange rate for group 2. This paper added capital control restriction to see whether that variable had a significant effect on exchange rate. The result showed that capital control had a positive and significant effect on exchange rate for full sample, groups 1 and 2, but a negative and significant effect on exchange rate for group 3.

Panel cointegration test

As seen in Table 7, at this stage, we ran a panel cointegration test to investigate the long-run equilibrium relationship in order to establish the presence of convergence among the exchange rate, CBI, consumption and investment. The Kao panel cointegration test was performed to examine the equilibrium relationship among the investigated variables. The result of Kao cointegration test revealed that the null hypothesis of no cointegration was rejected at 1 percent of full sample, groups 1, 2 and 3. This result implied that there was a long-run equilibrium among the exchange rate, CBI, consumption and investment.

Table 6 Panel GMM estimation

Variable	Full Sample		Group 1		Group 2		Group 3	
ER (-1)	0.7934***	0.7142***	0.9398***	0.9280***	0.9366****	0.9201***	0.6984***	0.6438***
	(0.01456)	(0.0114)	(0.0081)	(0.0088)	(0.0110)	(0.0116)	(0.0151)	(0.0144)
CBI	-0.1184***	0.2397***	-0.0930**	-0.1239***	0.0910**	-0.1018*	-0.0830**	0.1991***
	(0.0436)	(0.0377)	(0.0419)	(0.0427)	(0.0457)	(0.0616)	(0.0382)	(0.0425)
CONS	0.1602***	0.1882***	-0.0235***	-0.0138*	0.0467***	0.0417***	0.0614**	0.0243
	(0.0216)	(0.0115)	(0.0071)	(0.0076)	(0.0152)	(0.0151)	(0.0315)	(0.0265)
INV	-0.1141***	-0.1301***	0.0365***	0.0278***	-0.0395**	-0.0295*	0.0116	0.0740***
	(0.0179)	(0.0191)	(0.0094)	(0.0097)	(0.0164)	(0.0164)	(0.0224)	(0.0191)
Capital Control		0.0381*		0.0687***		0.0765***		-0.4513***
		(0.0214)		(0.0188)		(0.0181)		(0.0502)
AR (1)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
AR (2)	0.1105	0.1981	0.1291	0.1782	0.1305	0.1622	0.1430	0.1867

Note: Dependent variable is exchange rate. *$p < .1$; **$p < .05$; ***$p < .01$. Standard errors are in parentheses. Critical values: 1% : 2.576; 5%: 1.960; 10% : 1.645.

Table 7 Kao Panel Cointegration Test

Test Statistic	Full Sample		Group 1		Group 2		Group 3	
	t-Stat	Prob.	t-Stat	Prob.	t-Stat	Prob.	t-Stat	Prob.
ADF	-5.0116	.0000	-2.1129	.0000	-1.8083	.0000	Test	.0000
Residual Variance	0.0045		0.0014		0.0021		0.0063	
HAC Variance	0.0072		0.0023		0.0043		0.0090	

Conclusion

We established that the negative response of the exchange rate to CBI shock was delayed; it took around 5 quarters to appreciate exchange rate. The effect of the exchange rate on both consumption and investment was positive, which implied that depreciation in the exchange rate created higher consumption and investment. We determined that CBI had a contradictory effect on real activity, a negative effect on consumption but a positive effect on investment. We then split our sample into three groups to create homogeneous subsamples. Results showed that CBI produced appreciation of the exchange rate for group 1 but depreciation of the exchange rate for group 2. For group 3, CBI strengthened the exchange rate after 6 quarters of the shock. Meanwhile, the response of economic activity to the exchange rate also varied for all three groups. We found a negative response for both consumption and investment to the exchange rate for groups 1 and 2. However, for group 3 we found the opposite result, which was that depreciation would increase both consumption and investment. Finally, the CBI link to real activity via the exchange rate channel can be explained as follows. Higher CBI degree increased consumption and investment only occurred in low inflation countries (group 1). In contrast, CBI caused lower consumption and investment for countries with moderate and high inflation (groups 2 and 3).

The findings of this paper show that policymakers in developing countries need to pay more attention to improve their credibility in the international financial market in order to attract capital; a higher degree of CBI reflects more transparency and credibility, thus attracting more investment. However, the effect of CBI on attracting capital depends on global financial factors, such as capital restriction. Lower capital restriction reduces capital costs, increases investment and boosts economic growth, thereby, generating an appreciation in exchange rate. Our results show that for countries with low capital control, a higher CBI has a positive impact on appreciation of the exchange rate. These findings suggest that developing countries have gradually removed restrictions on capital inflow such as taxes.

Conflict of Interest

There is no conflict of interest.

References

Agoba, A. M., Abor, J., Osei, K. A., & Sa-Aadu, J. (2017). Central bank independence and inflation in Africa: The role of financial systems and institutional quality. *Central Bank Review*, *17*(4), 131–146. doi: 10.1016/j.cbrev.2017.11.001

Alessi, L., & Kerssenfischer, M. (2019). The response of asset prices to monetary policy shocks: Stronger than thought. *Journal of Applied Econometrics*, *34*(5), 661–672. doi: 10.1002/jae.2706

Anaya, P., Hachula, M., & Offermanns, C. J. (2017). Spillovers of US unconventional monetary policy to emerging markets: The role of capital flows. *Journal of International Money and Finance*, *73*, 275–295. doi: 10.1016/j.jimonfin.2017.02.008

Assenmacher-Wesche, K., & Gerlach, S. (2008). *Financial structure and the impact of monetary policy on asset prices*. Zürich, Switzerland: Swiss National Bank.

Baltagi, B. (2008). *Econometric analysis of panel data*. Chichester, UK: John Wiley & Sons.

Capasso, S., Napolitano, O., & Jiménez, A. L. V. (2019). The long-run interrelationship between exchange rate and interest rate: The case of Mexico. *Journal of Economic Studies*, *46*(7), 1380–1397. doi: 10.1108/JES-04-2019-0176

Claessens, S., & Kose, M. A. (2017). *Asset prices and macroeconomic outcomes: A survey*. Washington, DC: The World Bank.

Davis, J. S., & Presno, I. (2017). Capital controls and monetary policy autonomy in a small open economy. *Journal of Monetary Economics*, *85*, 114–130. doi: 10.1016/j.jmoneco.2016.11.008

Dornbusch, R. (1976). Expectations and exchange rate dynamics. *Journal of Political Economy*, *84*(6), 1161–1176. Retrieved from https://www.jstor.org/stable/1831272

Eichler, S., & Littke, H. C. (2018). Central bank transparency and the volatility of exchange rates. *Journal of International Money and Finance*, *89*, 23–49. doi: 10.1016/j.jimonfin.2018.07.006

Gantman, E. R., & Dabós, M. P. (2018). Does trade openness influence the real effective exchange rate? New evidence from panel time-series. *Series*, *9*(1), 91–113. doi: 10.1007/s13209-017-0168-7

Garriga, A. C. (2016). Central bank independence in the world: A new data set. *International Interactions*, *42*(5), 849–868. doi:10.1080/03050629.2016.1188813

Habib, M. M., Mileva, E., & Stracca, L. (2017). The real exchange rate and economic growth: Revisiting the case using external instruments. *Journal of International Money and Finance*, *73*, 386–398. doi: 10.1016/j.jimonfin.2017.02.014

Inoue, A., & Rossi, B. (2019). The effects of conventional and unconventional monetary policy on exchange rates. *Journal of International Economics*, *118*, 419–447. doi: 10.1016/j.jinteco.2019.01.015

Ilzetzki, E., Reinhart, C. M., & Rogoff, K. S. (2019). Exchange arrangements entering the twenty-first century: Which anchor will hold? *The Quarterly Journal of Economics*, *134*(2), 599–646. doi: 10.1093/qje/qjy033

Kandil, M. (2015). On the benefits of nominal appreciations: Contrasting evidence across developed and developing countries. *Borsa Istanbul Review*, *15*(4), 223–236. doi: 10.1016/j.bir.2015.06.003

Kim, S., & Lim, K. (2018). Effects of monetary policy shocks on exchange rate in small open Economies. *Journal of Macroeconomics*, *56*, 324–339. doi: 10.1016/j.jmacro.2018.04.008

Latief, R., & Lefen, L. (2018). The effect of exchange rate volatility on international trade and foreign direct investment (FDI) in developing countries along "one belt and one road". *International Journal of Financial Studies*, *6*(4), 86. doi: 10.3390/ijfs6040086

Moser, C., & Dreher, A. (2010). Do markets care about central bank governor changes? Evidence from emerging markets. *Journal of Money, Credit and Banking*, *42*(8), 1589–1612. doi:10.1111/j.1538-4616.2010.00355.x

Nurbayev, D. (2018). The rule of law, central bank independence and price stability. *Journal of Institutional Economics*, *14*(4), 659–687. doi: 10.1017/S1744137417000261

Pesaran, M. H., & Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics*, *68*(1), 79–113. doi: 10.1016/0304-4076(94)01644-F