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Capital Flows, Measures and Effectiveness of Monetary Sterilization Policies in the Selected Emerging Market Economies

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ABSTRACT

Sterilization policies aim to prevent the overvaluation of the national currency due to high capital inflows and the resulting inflationary effects from increased money supply. Emerging Market Economies (EMEs) faced instability from large capital inflows during the 1990s and 2000s, leading to the adoption of sterilization policies. With this motivation, this paper examines the extent and effectiveness of sterilization measures in 13 EMEs for the period 2005Q1-2021Q4. While the extent of sterilization measures is analyzed using the Instrumental Variables GMM technique, the effectiveness of these policies against different types of capital inflows is investigated using quantile regression analysis. The use of the Instrumental Variables GMM technique contributes methodologically to the literature as it produces more precise and robust results. In investigating the effectiveness of sterilization policies, in addition to the general types of capital inflows, gross portfolio equity and portfolio debt inflows and alternative definitions of capital inflows (gross debt and equity-based) make important contributions to the economic literature. The GMM results indicate the existence of partial sterilization and suggest that full sterilization was not implemented to reduce economic costs and promote domestic economic stability. Quantile regression analysis reveals that sterilization measures are particularly effective against short-term private capital inflows.

Keywords: International Private Capital Flows, Monetary Policy, Sterilization Coefficient, International Reserves.

JEL Classification Codes: C30, E50, E52, E58, F30

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INTRODUCTION

Signals of sudden stops in capital flows in EMEs were most evident in the Mexican (1994), East Asian (1997) and Russian (1998) crises (Calvo et al., 2004, p. 16). With the complete lifting of capital account controls in the 1990s, these economies witnessed large inflows of short-term capital (such as bank loans and portfolio investments). However, the initial benefits of the large amounts of foreign capital flowing into these economies in terms of financing deficits and boosting investment levels and growth rates eventually reversed and led to crises (e.g. the 1994/1995 Mexican (Tequila) Crisis, the 1997/1998 East Asian Crisis, the 1998 Russian Crisis and the 1999 Brazilian Crisis). The adverse consequences of the crises have revealed the harms of uncontrolled liberalization of foreign capital flows in these economies. Therefore, the crises brought about debates on whether high capital inflows are beneficial for the economies of the countries and the issue of imposing a restriction on capital flows rather than removing all barriers to capital flows came to the agenda. In fact, the debate has centered on whether restrictions on capital inflows and outflows can prevent possible crises or, if they cannot prevent these possible crises, whether they can eliminate the negative (adverse) effects of crises.

Emerging economies are believed to have learned an important lesson from the financial crises of the 1990s. It is argued that these economies have increased their international reserves as a way of hedging against sudden stops in capital inflows and significant shifts in their balance of payments. It is argued that the efforts of these countries to build better macroeconomic policies and strong reserve stocks were able to mitigate the effects of the 2008/2009 crisis and that this strategy also reduced the likelihood of a crisis (Mendoza, 2010, p. 2).

The 1997/1998 East Asian financial crisis caused a shift in countries' attitudes towards the accumulation of exchange reserves, resulting in increased demand for international reserves. There are a number of reasons for the change in the way international reserves are viewed.

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The fact that these countries used mainly speculative hot money inflows to finance their high current account deficits is seen among the important reasons that triggered the crisis. Moreover, the economies of the region continued to accumulate reserves as a precautionary measure to avoid a recurrence of the severe currency crises of 1997/1998, and hence a shortage of international liquidity resulting from sudden stops in capital inflows. This behavior was also a consequence of the distrust of the International Monetary Fund (IMF) (Park and Estrada, 2009). However, the crisis led to significant declines in production and investment volumes, collapses in credit supply and, for some regional economies, banking crises (Aizenman and Lee, 2007, p. 1; Cheung and Qian, 2009, p. 1; Filardo et al., 2010, p. 24)[1].

Given the underdeveloped financial systems of many EMEs, excessive reserve accumulation entails risks and costs for the domestic economy[2]. Excessive reserve accumulation may hinder the accumulation of assets other than foreign exchange that can contribute positively to the long-run growth of the economy (Cook and Yetman, 2012, p. 31). This implies that policy authorities would be willing to bear the opportunity cost of choosing to hold a certain level of foreign exchange reserves over assets with higher returns. Moreover, the accumulation of reserves may have crowding out effects on domestic investment (Mahraddika, 2019, p. 40).

Grilli and Milesi-Ferretti (1995) argue that there are some reasons to be concerned about the effects of large capital inflows on recipient economies, such as loss of competitiveness in exporting sectors, the deepening effects of real appreciation on current account deficits, or sudden reversals in capital inflows. Given these potential problems, Grilli and Milesi-Ferretti (1995) emphasize the need for recipient economies to take some precautions against the potential costs and argue that there are reasons why countries may find it useful to impose some restrictions on capital account transactions (capital controls). As a matter of fact, many Latin American and East Asian countries resorted to sterilization measures in order to reduce the pressures on real appreciation due to increased capital inflows in the 1990-1994 period (Frankel and Okongwu, 1996, p. 3).

Sterilization policy, which is an indirect monetary policy measure, refers to the interventions of monetary authorities in the foreign exchange market in order to prevent overvaluation of the national currency due to high capital inflows (Reinhart and Reinhart, 1998, p. 94). However, central banks resort to sterilization policy in order to prevent excessive monetary growth due to the fear that an increase in the money supply corresponding to the accumulation of reserves would lead to hyperinflation. In particular, central banks can neutralize the effects that may arise by ensuring that the market absorbs the liquidity glut caused by capital inflows through the issuance of commercial paper. Indeed, Calvo (1996) and Montiel (1999) argued that sterilization policy is a common macroeconomic stabilization policy to be implemented in the face of high capital inflows (Calvo, 1991 p. 921; Montiel, 1999, p. 14).

Sterilization policy has been a common policy response to excessive capital inflows for many emerging market economies. Chile, for example, tried to prevent the instability caused by large capital inflows in 1990-91 with a sterilization policy. Similarly, countries such as Colombia, Indonesia, Korea, Malaysia, Mexico, Thailand and the Philippines have also used sterilization policy extensively to prevent the adverse effects of significant increases in foreign reserves on the domestic economy. However, there is an important debate in the literature on the effectiveness and desirability of these monetary policy measures (Corbo and Hernandez, 1996, p. 74).

The experience of many countries in the 1990s showed that sterilization policies can be useful if they are a temporary monetary tightening measure. Hence, sterilization measures would lead to higher interest rates, which in turn would lead to more foreign capital entering the country due to perfect capital liberalization. These new capital flows would offset the effect of sterilization on domestic interest rates, rendering the policy ineffective. However, if there is a restriction on capital flows, the sterilization policy may be partially effective (Reinhart and Reinhart, 1998; Garcia, 2007). Therefore, although sterilization measures partially prevent the negative effects of large short-term capital inflows on macro aggregates, it is questioned whether they are effective enough to completely prevent crises caused by these negative effects.

The aim of this study is to understand how the sterilization coefficient works for 13 EMEs in the face of different types of foreign capital inflows for the period

[1] International reserve stocks have increased significantly, especially since 1998. The propensity to hold reserves has been much higher mainly in emerging markets. International Monetary Fund data show that reserves increased nearly 4-fold from 1998 to the 2008 crisis. The data show that this trend has continued in the aftermath of the global financial crisis (Mendoza, 2010, p. 2; IMF, 2014).

[2] These risks and costs generally include inflationary pressures, overinvestment, asset bubbles, difficulties in the conduct of monetary policy, large capital losses on central bank balance sheets, costs of sterilizing excessive monetary expansion, risks of credit misallocation by domestic banks, and segmentation of the public debt market (European Central Bank, 2006, p. 16-17)

2005Q1-2021Q4 and to investigate the effectiveness of sterilization policies for these countries. In this framework, our study seeks answers to the questions of whether the extent of sterilization measures (the degree of sterilization coefficients) in offsetting the macroeconomic effects of domestic monetary expansion resulting from foreign exchange intervention in emerging market economies varies across countries and periods. Additionally, our study aims to determine to what extent the sterilization policy is effective against foreign capital inflows and whether the degree of effectiveness differs according to the types of capital flows.

Our study makes various contributions to the related literature. In the study, instrumental variables GMM analysis technique is used to estimate sterilization coefficients for individual EMEs. The instrumental variables GMM method is more effective in dealing with endogeneity problems than the Two-Stage Least Squares (2SLS) method, which is mostly used in the related literature for estimating sterilization coefficients. However, the economic effects of sterilization measures may occur simultaneously or with a time lag. Thus, the effects of both immediate and past interventions on economic variables in future periods (in the long run) can be better assessed. In this framework, the instrumental variable GMM method provides significant advantages in terms of better capturing such dynamic effects. On the other hand, the sterilization coefficients for the periodically selected EMEs are investigated by using Recursive Estimation with current data sets. In this way, it is possible to examine how and in what direction the sterilization coefficients change across countries and to evaluate the effects of economic conditions by taking into account the financial stress periods that the EMEs have been exposed to since the mid-2000s. Finally, the effectiveness of sterilization measures for different types of foreign capital inflows for the panel group is investigated with fixed effect panel quantile regression analysis. Thus, quantile regression analysis makes it possible to reveal which type of sterilization measures are effective in restricting or encouraging capital inflows under different time periods and economic conditions.

The general organization of the study is as follows; After the introduction, Section 2 presents the results of empirical research on the effectiveness of sterilization policies in EMEs. Section 3 introduces the countries used in the analysis, their datasets, and the method of analysis. Section 4 presents the empirical results, and the paper concludes with a final section containing evaluations and policy recommendations.

EMPIRICAL LITERATURE

There are empirical studies in the literature investigating the effectiveness of sterilization policy. Cavoli (2007), one of these studies, investigated the relationship between international capital mobility and sterilization measures using monthly data for 5 selected East Asian countries for the period 1990-1997 within the framework of 2SLS procedure and VAR method. The study emphasizes that sterilization measures are more effective and applicable only in the case of limited capital mobility.

Cavoli (2017) investigated the possible determinants of sterilization policy for the period 1994-2012 using panel Ordinary Least Squares (OLS) analysis and concluded that reserve flows may be more effective for central banks to resort to sterilization measures. The findings suggest that private capital inflows of different maturities have indirect effects on sterilization decisions. On the other hand, the main motivation for these decisions is the changes in local interest rates.

Another study in the empirical literature on the effectiveness of sterilization measures is Arya et al. (2020). The authors investigated the relationship between monetary sterilization measures and foreign capital inflows using panel least squares and panel quantile regression analysis for 28 EMEs from Asia and Latin America for the period 1990-2013. As a result of the analyses, they found that sterilization measures cause the local interest rate to rise, thereby encouraging more FDI and portfolio inflows into the country.

Some empirical studies in the literature investigate the extent to which central banks in emerging market economies resort to sterilization measures. Cavoli and Rajan (2006), one of these studies, investigate the degree of monetary sterilization for five selected Asian countries using OLS estimation of a single equation model for the period 1990-1997 before the Asian crisis, and find that the coefficient of sterilization is -1.11 for Korea, -1.05 for Thailand, -0.77 for Indonesia, -0.94 for Malaysia and -0.98 for the Philippines. Similarly, Aizenman and Glick (2009) estimated the coefficient values for China, Brazil, Malaysia, Thailand, Argentina, Singapore, India, South Korea and Mexico as -0.78, -0.77, -0.93, -0.86, -0.96, -0.82, -0.96, -0.93 and -0.98, respectively, using quarterly data for 9 selected emerging market economies for the period 1985-2007. Kwack (2001), using the same methodology for 7 Asian countries for the period 1985-1996, finds the sterilization coefficient values as -0.99 for Indonesia, Malaysia and Singapore, -0.97 for Korea,

-0.94 for Philippines and Taiwan and -0.81 for Thailand. Kwack (2001) found the sterilization coefficient as -0.94 in his OLS estimation for the panel group[3].

Among the studies investigating the effectiveness of sterilization policy in China, Wang et al. (2021) used the ordinary OLS method to measure the degree of sterilization measures using monthly data for the period 2000-2017 and found the coefficient of sterilization to be -1.027 and -0.917. On the other hand, Takagi and Esaka (2001), using the classical OLS method with quarterly data for the 1987-1997 period for 5 emerging Asian countries, concluded that the sterilization policy yielded significant results only in the Philippines and the coefficient value was -0.11. Siklos (2000), in his study investigating the coefficient of sterilization for Hungary with monthly data for the period 1992-1997, found the coefficient value to be -1. These values indicated full sterilization practices for the periods in question.

Khemraj and Pasha (2011) investigated the size of the sterilization coefficient for 8 Caribbean countries using quarterly data for the period 1993-2008 with the OLS method and found the coefficient values as -0.62 for Bahamas, -0.83 for Barbados, -0.83 for Belize, 0.18 for Eastern Caribbean Currency Union Countries (ECCU), -1.03 for Guyana, -0.16, -0.50 and -0.70 for Trinidad and Tobago, Jamaica and Suriname respectively. On the other hand, Kim (1995) investigated the degree of sterilization for Korea through GLS and 2SLS methods with quarterly data for the period 1980-1994. Accordingly, while the coefficient of sterilization is found to be -0.64 in the estimation with the GLS method, this value is found to be -0.56 for the 2SLS method.

Celasun (2000) determined the sterilization coefficient as -0.37 with the 2SLS method using monthly data for Türkiye for the period 1990-1996. Similarly, Emir et al. (2000) estimated the sterilization coefficient in the case of Türkiye with 2SLS using data for the period 1990-1999. As a result of the estimation, it is concluded that a more effective sterilization policy was pursued in the 1995-1999 period (-0.88) compared to the 1990-1993 sub-period (-0.54). Altınkemer (1998), on the other hand, obtained the sterilization coefficient before and after the 1994 crisis as -1.04 and 0.93, respectively, as a result of his estimation with the classical OLS method.

Moreno (1996) investigated the degree of sterilization measures taken by monetary authorities in response to a shock in foreign assets by following a 4-variable VAR analysis procedure using monthly data for Korea and Taiwan for the period 1981-1994. The impulse-response analysis findings show that monetary authorities in Korea react more strongly to unexpected increases in foreign assets by reducing domestic assets, and hence the degree of sterilization is higher in Korea than in Taiwan[4]. Using VAR analysis for the Czech Republic, Christensen (2004) estimated the sterilization coefficient as -0.11.

Nakibullah (2011) used the 2SLS method using quarterly data for the period 1990-2009 for a sample of 6 oil exporter countries and found the sterilization coefficients as -1.03 for Bahrain, -1.01 for Kuwait, -0.97 for Oman, -0.38 for Qatar, -1.01 for Saudi Arabia and -0.39 for the United Arab Emirates (UAE). Similarly, Hassan et al. (2013), using the Seemingly Unrelated Regression method, found -0.84 for Bahrain, -0.52 for Kuwait, -0.81 for Oman, -0.75 for Qatar, -0.96 for Saudi Arabia and -0.17 for the UAE. Ljubaj et al. (2010), on the other hand, determined the sterilization coefficient as -0.81 for Croatia using the 2SLS method using monthly data for the period 2000-2009.

In the literature, there are also studies estimating the sterilization coefficient for country groups using panel data analysis techniques. Cavoli (2017), one of these studies, investigated the determinants of sterilization using panel OLS analysis method using 1994-2012 quarterly data. As a result of the estimation, the coefficient of sterilization was calculated as -0.91 for Korea, 0.89 for the Philippines, 0.89 for Thailand, 0.93 for Thailand, 0.99 for Singapore, 1.01 for Indonesia and 1.02 for Malaysia. Aizenman and Glick (2009) investigate whether the sterilization measures taken by monetary authorities against reserve inflows and different types of foreign capital flows are effective or not for the period 1980-2007 using OLS analysis method. According to the findings of the analysis, they revealed that during the sample period, selected Asian and Latin American countries increased sterilization measures due to rising inflationary concerns in the face of foreign reserve inflows. They also found that sterilization measures increased more in response to domestic monetary effects caused by short-term speculative capital inflows other than FDI inflows.

[3] A sterilization coefficient of “-1” implies that changes in foreign exchange reserves are fully sterilized and therefore changes in net foreign assets will not affect the monetary base. On the other hand, a coefficient value of “0” would reflect a situation where the effects of reserve changes on the monetary base are not sterilized at all. A coefficient value between -1 and 0 indicates partial sterilization (Aizenman ve Glick, 2009, p. 781-782).

[4] However, an important drawback of the VAR model is the assumption that the variables in the model are symmetrically endogenous. In the calculation of the degree of sterilization, the lagged values of the NDA and NFA variables are taken into account in standard VAR-based models due to the problem of defining the model form, and in the absence of any model restrictions, the estimated values of the effects of the variables in the current period cannot be obtained (Ouyang et al., 2010, p. 958).

Cardarelli et al. (2010) argue that high values of the sterilization index coinciding with the period when capital inflows increased indicate that policy makers aggressively increased sterilization measures. However, it was determined that the index values decreased in later periods. The authors suggest this is because policymakers have become more aware of the cost implications of implementing additional sterilization measures.

DATA SET AND METHODOLOGY

In this section of the study, the magnitude of sterilization coefficients and changes in these coefficients over time are investigated for 13 selected emerging market economies[5]. Variables, their descriptions, measurement methods, and data source information are presented in Table A1. The expected sign for the sterilization coefficient, which is our main focus of interest, should be negative. This coefficient indicates the response of net domestic assets (NDA) to changes in net foreign assets (NFA) or the degree of domestic monetary sterilization of central banks in response to increases in foreign currency assets (Meng et al., 2018, p. 26).

The monetary policy reaction function includes many variables that are likely to affect monetary policy. However, the impact mechanism of these variables on the central bank's domestic assets emerges in different ways. In this framework, taking into account the relevant empirical literature, the coefficients of the following variables are expected to be negative: money multiplier (see Zhang, 2010), real effective exchange rate (see Ouyang et al., 2008), foreign interest rate (see Zhang, 2010, Ouyang et al., 2008), inflation and cyclical income (see Wang et al., 2021).

Various methods are used in the literature to estimate the monetary policy response function. Among these econometric methods, OLS method may lead to biased and inconsistent estimation results. The reason for the possible bias problem in the estimation results is due to the fact that the NFA variable in the response function is endogenous. In this framework, an increase in domestic assets is expected to be offset by a decrease in foreign reserves. In this case, changes in NDA and NFA are expected to be in a simultaneous relationship. In this framework, the functioning mechanism of the sterilization policy can be represented by the simultaneous equations proposed by Kouri and Porter (1974) as follows;

$$\Delta NDA = \alpha + \beta \, \Delta \, NFA + \gamma X_2 + v \qquad (1)$$

$$\Delta NFA = b + \beta \, \Delta \, NDA + c X_1 + u \qquad (2)$$

When the central bank aims to sterilize the monetary effects of reserve inflows, domestic loans will be an endogenous variable in the model when domestic loans show simultaneous changes in response to changes in foreign assets. In this case, the error term in the domestic credit equation will be related to foreign assets, and the error term in the foreign assets equation will be related to domestic credits (Emir et al., 2000, pp. 14-15). However, the main question here is the direction in which the OLS estimators of the sterilization coefficient will deviate. Roubini (1988) shows in a simple mathematical form that the deviation will be towards -1. Therefore, a much smaller negative deviation of the sterilization coefficient in the OLS estimator would lead to misinterpretations as an indicator of significant sterilization measures. The same would be true for the values of the equalization coefficient (Roubini, 1988, pp. 7-9).

On the other hand, the Generalized Method of Moments (GMM) has some important advantages compared to traditional estimation methods. If the 2SLS method is used to estimate an over-specified model, the procedure of reducing the instrumental variables in the model should be followed. However, such a reduction is not necessary for the GMM approach with instrumental variables. With this method, all instrumental variables can be used.

On the other hand, instrumental variable GMM estimations for time series are performed with robust standard errors. Since instrumental variable GMM estimates will differ in over-specified equations, estimation with robust standard errors will be more efficient and consistent than 2SLS estimation. For this reason, in this study, instrumental variables GMM estimations are performed with the HAC standard errors used by Newey-West, thus increasing the reliability of the estimates by obtaining more accurate and robust standard errors in the presence of statistical problems such as heteroskedasticity and autocorrelation (Baum et al., 2003, pp. 14-15). Moreover, if statistical problems such as autocorrelation and heteroskedasticity prevail in the model, the 2SLS estimator will not be asymptotically efficient. In such a case, the GMM estimator will be more efficient (Söderbom, 2009, p. 24).

[5] These countries: Brazil, Chile, Colombia, Czech Republic, Hungary, Hungary, Indonesia, Mexico, Mexico, Poland, Poland, Russia, South Africa, South Africa, Thailand and Türkiye. The 13 EMEs analyzed in the analysis are included in the emerging markets category in the classification of the MSCI Emerging Markets Index. The lack of data for some of the countries in this scope for certain years necessitated the analysis to be conducted with 13 countries. In addition, these countries included in the analysis are countries with relatively higher foreign capital inflows compared to other emerging market economies.

Testing the validity of the instrumental variables, in other words, testing whether the instrumental variables are correlated with the error terms is of great importance for the consistency of the estimation results. Therefore, checking the overidentification restriction will reveal that the model specification is correct and the orthogonality conditions are met. Therefore, in the GMM framework, we check for over-identification restrictions using the J test statistic of Hansen (1982). This test statistic represents the value of the objective function of the efficient GMM estimator. If the null hypothesis is rejected, it means that the orthogonality conditions for the use of instruments in the model are not fulfilled. This implies that the GMM specification may not be appropriate because the instruments were incorrectly excluded from the regression. The opposite would be true for the alternative hypothesis (Baum et al., 2003, pp. 15-16).

EMPIRICAL RESULTS

Estimation of the degree of sterilization is attempted to be obtained by time series analysis for each EME, using data for the period 2005q1-2021q4. Although the coefficient values calculated for the entire analysis period are important in terms of revealing the extent to which these countries resorted to sterilization measures, they prevent a full assessment of policy responses. This limitation arises from the challenge of measuring the magnitude of sterilization over different periods. For this reason, recursive estimation method is applied to measure the degree of monetary responses of central banks of selected EMEs to foreign reserve increases.

In the econometrics literature, spurious regression in time series analysis arises especially when the series have a unit root process. In time series analysis, if the series contain unit roots, ignoring stationarity causes the analysis to produce unreliable results (Baltagi, 2001, p. 611). Unit root tests, specifically the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, were conducted to determine the stationarity of the time series. Based on the estimation results, it was found that all variables belonging to other countries were stationary at the level, except for the cyclical income of Russia, which showed non-stationarity in the ADF unit root test. However, the PP test shows that the cyclical income variable is stationary at level. Therefore, considering the advantages of the PP test (see Verbeek, 2008, p. 306; Leybourne and Newbold, 1999, p. 51), this variable is included in the analysis with its level values. These results are presented in Table A2 and Table A3 in Appendix A.

The Lagrange Multiplier (LM) test of Breusch and Pagan (1980), the Cross Section Dependent (CD) and Cross Section Dependent LM (CD_{LM}) tests introduced by Pesaran (2004) and the Bias-Adjustment LM (LM_{adj}) test of Pesaran et al. (2008) were used to check the cross-sectional dependence of the data sets of the panel units (countries). In this framework, the test results for horizontal cross-section dependence are presented in Table A4 in Appendix A. The results indicate the validity of horizontal cross-section dependence.

In this study, the CADF (Cross-sectionally ADF) test developed by Pesaran (2007), which considers horizontal cross-sectional dependence and serial correlation in the residuals, is used for panel unit root analysis. In this framework, the null hypothesis of the CADF test will imply the existence of a unit root. In this framework, CIPS test results reveal that the series are stationary at level (Table A5).

The lagged values of Costant, $\Delta \mathrm{NFA}$, $\Delta \mathrm{NDA}$, $\Delta \mathrm{mm_t}$,$\Delta \mathrm{r_t}$, $\mathrm{Y_{t-1}}$, $\mathrm{P_{t-1}}$, $\Delta \mathrm{G_t}$ and $\Delta \mathrm{REER_t}$ are used as instrumental variables in the analyses conducted using instrumental variables estimation methods[6]. Thus, the dynamic structure of the model and the exogeneity assumptions, which state that the instrumental variables should be uncorrelated with the error term, are taken into account. As a matter of fact, the results of Hansen's J test, which is used to test the exogeneity of the instrumental variables, support the exogeneity assumption by having high probability values. These results reveal the validity of the instrumental variables considered in the model and the reliability of the forecasts (see Table 1 and Table 2).

As a result of the estimation of the monetary policy reaction function for the entire sample period, changes in reserves are an important indicator in arriving at the sterilization coefficient values for countries. However, there are many factors that may affect the monetary policy decisions of central banks. As a matter of fact, these factors that may have an impact on the policy decision are included as control variables in the response function. In this framework, the analysis findings for individual countries are presented in Table 1. For the entire sample period, the degree of sterilization is found to be quite high for some of the selected EMEs and at or close to full and/or extreme sterilization for some other countries.

[6] Fair (1997) suggests that lagged values of both dependent and explanatory variables should be considered in the list of instrumental variables for better model estimation and to avoid endogeneity problems. Indeed, Hassan et al., (2013), Nakibullah (2011) and Nwogwugwu et al., (2020) followed a similar method in the selection of instrumental variables in the calculation of sterilization coefficients.

Table 1: GMM Estimation Results for Monetary Policy Response Function for Time Series (2005Q1-2021Q4)

	Türkiye (2005Q1-2021Q4)	**Brazil (2005Q1-2021Q4)**	**Chile (2005Q1-2021Q4)**	**Colombia (2005Q1-2021Q4)**	**Czech Republic (2005Q1-2021Q4)**	**Hungary (2005Q1-2021Q4)**
$\Delta\mathrm{NFA}$	-0.9220449	-0.8760012	-0.864181	-0.8338346	-0.8430646	-1.02484
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\Delta\mathrm{mm}_t$	-0.9798526	-0.9207934	-1.28549	-0.8567811	-0.7890832	-0.7933574
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\Delta\mathrm{r}_f$	-0.0104577	-0.0061174	0.025526	-0.0024644	0.0033484	-0.0042678
	(0.266)	(0.241)	(0.186)	(0.313)	(-0.0106877)	(0.637)
Y_{t-1}	-0.0868247	-0.1002652	0.699720	0.0740975	0.097941	-0.1407381
	(0.334)	(0.078)	(0.000)	(0.013)	(0.099)	(0.259)
P_{t-1}	0.3941059	0.4297184	-0.079861	0.1728303	0.0834862	0.031706
	(0.084)	(0.038)	(0.891)	(0.534)	(0.827)	(0.948)
$\Delta\mathrm{G}_t$	0.1302546	0.4871293	0.249853	-0.0827776	1.266039	0.5075101
	(0.497)	(0.283)	(0.362)	(0.274)	(0.395)	(0.032)
$\Delta\mathrm{REER}_t$	-0.303967	-0.0050095	-0.513682	-0.1063564	-0.038662	-0.3364357
	(0.004)	(0.857)	(0.033)	(0.000)	(0.633)	(0.000)
Costant	0.0267965	0.0191306	0.007266	0.0210349	0.0125061	0.0158654
	(0.000)	(0.000)	(0.200)	(0.000)	(0.001)	(.0061765)
Wald chi2	483.21	3649.18	2710.77	2925.17	417.88	2589.08
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R^2	0.93	0.97	0.96	0.94	0.92	0.98
Hansen-J	3.0359	6.4572	4.1591	3.9312	2.9821	3.8908
Statistic	(0.8043)	(0.3740)	(0.6552)	(0.6860)	(0.8111)	(0.6914)
Endogeneity	0.5308	0.8837	0.8837	0.4977	0.0501	0.0974
	(0.4663)	(0.3472)	(0.6552)	(0.4805)	(0.8229)	(0.7550)

Continuation of Table 1.

	Indonesia (2005Q1-2021Q4)	**Poland (2005Q1-2021Q4)**	**Russia (2005Q1-2021Q3)**	**South Africa (2005Q1-2021Q4)**	**South Korea (2005Q1-2021Q4)**	**Mexico (2005Q1-2021Q4)**	**Thailand (2005Q1-2021Q4)**
$\Delta\mathrm{NFA}$	-0.985362	-0.9923113	-0.9250243	-.9148763	-1.005284	-0.9894354	-0.8393146
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\Delta\mathrm{mm}_t$	-0.9807175	-0.9544943	-0.8224464	-.6426803	-.9661008	-0.6811224	-0.07562
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\Delta\mathrm{r}_f$	0.001281	-0.015164	0.0073698	.0002804	-0.0095012	0.0025839	-0.0018224
	(0.826)	(0.000)	(0.265)	(0.926)	(0.000)	(0.315)	(0.689)
Y_{t-1}	0.2902556	0.0960143	-0.0091361	-.1368322	-0.1132483	-0.084677	0.0006384
	(0.005)	(0.026)	(0.953)	(0.011)	(0.076)	(0.004)	(0.345)
P_{t-1}	0.1877429	-0.0114789	0.3651185	0.8113304	-0.3091097	0.2000502	0.0826476
	(0.029)	(0.956)	(0.023)	(0.000)	(0.038)	(0.162)	(0.640)
$\Delta\mathrm{G}_t$	0.3342574	0.5892139	1.661465	0.0198796	0.3077826	0.3944413	0.1251289
	(0.002)	(0.009)	(0.003)	(0.902)	(0.024)	(0.013)	(0.324)
$\Delta\mathrm{REER}_t$	-0.0075735	-0.1076642	-0.1751167	-0.0376642	0.019529	-.1274729	-0.1231863
	(0.876)	(0.132)	(0.000)	(0.271)	(0.630)	(0.000)	(0.244)
Costant	0.022475	0.0178504	0.0223157	0.0098284	0.0163605	0.0217999	0.0141944
	(0.000)	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)
Wald chi2	5129.79	5678.28	1641.85	3434.67	145289.22	6092.12	330.35
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.0000)	(0.000)
R^2	0.97	0.98	0.97	0.98	0.99	0.98	0.95
Hansen-J	5.9220	4.9155	9.49942	5.24596	2.7884	5.3031	2.0106
Statistic	(0.4320)	(0.5547)	(0.1474)	(0.5127)	(0.8349)	(0.5056)	(0.9187)
Endogeneity	1.50252	0.1432	0.051426	0.3883	2.78842	0.00076	5.3405
	(0.2203)	(0.7051)	(0.8206)	(0.5332)	(0.8349)	(0.9780)	(0.0208)

Note: Values in parentheses denote probability values. Since real GDP data for Russia for 2021q4 is missing, the analysis period covers the period 2005q1-2021q3.

Table 2. Panel Two-Stage Least Square Results for the Monetary Policy Response Function (2005Q1-2021Q4)

EMERGING MARKET ECONOMIES (2005Q1-2021Q3)	
ΔNFA	-0.8702
	(0.000)***
Δmm_t	-0.4677
	(0.086)*
Δr_f	0.0012
	(0.820)
Y_{t-1}	-0.0046
	(0.212)
P_{t-1}	-0.1979
	(0.371)
ΔG_t	0.0314
	(0.842)
$\Delta REER_t$	-0.1436
	(0.144)
Fixed	**0.0223**
	(0.000)* **
Number of Observations	**845**
Wald X^2 Statistics	**3236.32**
	(0.000)
R^2	**0.82**
Hansen J Statistic	**5.385**
	[0.4954]

Note: Values in parentheses denote probability values. Since real GDP data for Russia for 2021q4 is missing, the analysis period covers the period 2005q1-2021q3.

Accordingly, the coefficient values of -0.92 and -0.96 for Türkiye and South Africa, respectively, are very close to full sterilization (-1). For Mexico (-0.98), Poland (-0.99) and Indonesia (-0.99), the coefficient values are almost close to full sterilization. Full sterilization for Korea (-1.00) and partial over-sterilization for Hungary (-1.02). On the other hand, partial sterilization is observed for the Czech Republic (-0.84), Brazil (-0.88), Thailand (-0.84), Russia (-0.86), Colombia (-0.83) and Chile (-0.86). Although these results are highly statistically significant, they suggest that the selected EMEs have adopted a significant sterilization policy in order to prevent the monetary effects of reserve accumulation (Table 1). The sterilization coefficient for the panel group was determined as -0.87 (Table 2).

Upon analyzing the control variables, it is evident that the money multiplier variable has a significantly greater impact than the other variables. This suggests that a rise in the money multiplier (mm) would be strongly offset by a fall in the NDA. As a result, an expansion in the money supply will prompt central banks to adopt contractionary monetary policy in response to its effects.

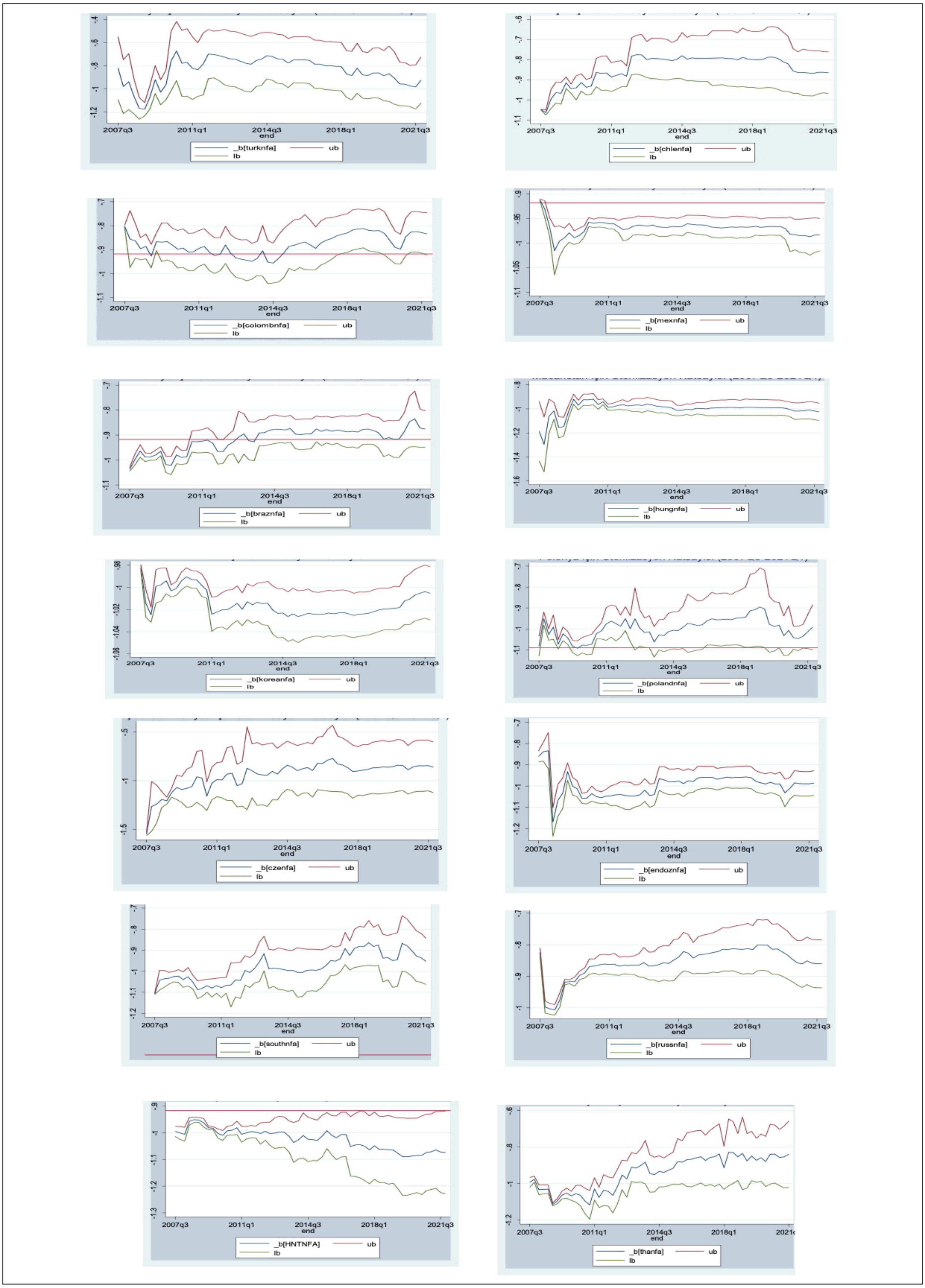
The only statistically significant contractionary effects on NDA from increases in the foreign interest rate were found in the Czech Republic, Poland, and South Korea. Moreover, the coefficient sign of this variable is negative in line with expectations. Accordingly, for many EMEs, increases in foreign interest rates lead to a deepening of macro instability as foreign capital flows to the source country with the expectation of lower risk but higher interest yields and worsens the balance of payments of the countries they leave. In this situation, emerging market central banks opt for a tight monetary policy such as a reduction in the NDA to mitigate indirect negative effects.

Increases in the value of the national currency (increases in the REER) make countries' export goods more expensive, leading to a loss of their relative competitive advantage in international trade. This price effect may cause deterioration in the current account balance and lead to a contraction in foreign reserves. These developments lead to the emergence of expectations of a decline in the value of the country's currency and a deterioration in the balance of payments, causing the central banks of the EMEs to resort to contractionary monetary policy measures (reductions in the NDA). In this framework, the coefficient sign of the variable for Türkiye, Chile, Colombia, Hungary, Russia and Mexico is negative as expected.

The coefficient signs and statistical significance of cyclical income[7], government expenditures and inflation variables differ for many EMEs. While the coefficient sign for all three variables is expected to be negative

[7] Although the data sets obtained by scaling the cyclical income variable with the trend values of real GDP and its deviations from the trend value following the studies of Wang et al. (2019) were used, the coefficient values did not change significantly in the analysis findings.

Chart 1: Sterilization Coefficients (2007Q3-2021Q4) for periodically selected EMEs, Recursive Estimation



Note: ub and lb denote 95% confidence intervals, respectively. The sterilization coefficient values obtained for each period are based on the instrumental variable GMM analysis technique for time series. Newey-West HAC correction is applied to resist autocorrelation and variance problems. Since the analysis period consists of quarterly data, a lag of 4 periods is considered for the correction.

economically, the opposite is true for some countries. Possible reasons for insignificant coefficients and incorrect signs of these two variables exist. First, the NDA, which is the dependent variable in the monetary policy response function, may be more volatile than inflation and cyclical income variables. In fact, the series of the other two variables are more stationary (Ouyang et al., 2008, p. 189). On the other hand, the positive relationship between the increase in net domestic assets and cyclical income may be the result of the central banks' increasing domestic liquidity during the expansionary phases of economic activity. However, all these may differ depending on the economic conjuncture. For example, central banks may adopt expansionary monetary and fiscal policies during periods of slowdown in economic activity. On the contrary, they may pursue tighter economic policies during periods of economic recovery (Ouyang and Rajan, 2011, p. 2022). In addition, depending on the economic situation, some countries may pursue pro-inflationary policies instead of implementing anti-inflationary monetary measures. Due to the economic crises in the world, countries may turn to expansionary monetary and fiscal practices to prevent contraction in economic activities (such as the 2008 global financial crisis, COVID 19 crisis) (Nakibullah, 2011, pp. 149-150).

On the other hand, an recursive estimation was performed to examine the change in sterilization over time and the results based on this estimation are presented in Chart 1[8]. Following the crises in the mid-1990s, the intensity of sterilization has increased in most EMEs, especially after 2002, in order to prevent the possible monetary effects of foreign reserve accumulation behaviors with periods of excessive international capital inflows. The degree of sterilization is found to have declined significantly for some of the EMEs during the 2008 crisis and 2009, when the effects of the crisis deepened, while it has increased for some EMEs and remained stable for others. During these periods, countries also suffered significant losses in their foreign exchange reserves. However, in some countries, sterilization measures have also increased during periods of financial stress in order to limit severe fluctuations in exchange rates, reduce inflationary pressures, balance capital inflows and outflows by preventing sudden capital flight, and ensure exchange rate stability.

Note: ub and lb denote 95% confidence intervals, respectively. The sterilization coefficient values obtained for each period are based on the instrumental variable GMM analysis technique for time series. Newey-West HAC correction is applied to resist autocorrelation and variance problems. Since the analysis period consists of quarterly data, a lag of 4 periods is considered for the correction.

Chart 2[9] shows the historical development of the exchange rate pressure index for selected EMEs. This index is generally regarded as an important indicator of exchange rate depreciation and international reserve depletion. This index is a crucial indicator of central banks' actions to sell foreign currency in order to safeguard the value of the national currency against depreciation due to currency crises in emerging economies. In this case, a positive index value would indicate a depreciation of the national currency and a decrease in reserve accumulation. A negative index value would indicate the opposite (Gupta and Sengupta, 2014, pp. 13-14).

The trend of the exchange rate pressure index during periods of financial stress, when capital inflows decline and even face the threat of a sudden stop, exhibits characteristics that can be considered common for the majority of the selected EMEs. In fact, the index shows a downward trend during the 2002-2007 period, when there was a surge in international capital inflows. However, upward trends are observed in the index during periods of financial stress, such as the 2008/2009 financial crisis, the Taper Tantrum phase in 2013, which indicated that tighter monetary policy would be implemented, the 2010 Euro debt crisis, the deterioration in China's economic outlook in 2015 due to disruptions in financial market functioning (Das et. al., 2022, p. 27) and declines in growth expectations (Ahmed and Zlate, 2017, p. 135), the 2017-2018 years and the COVID 19 crisis[10].

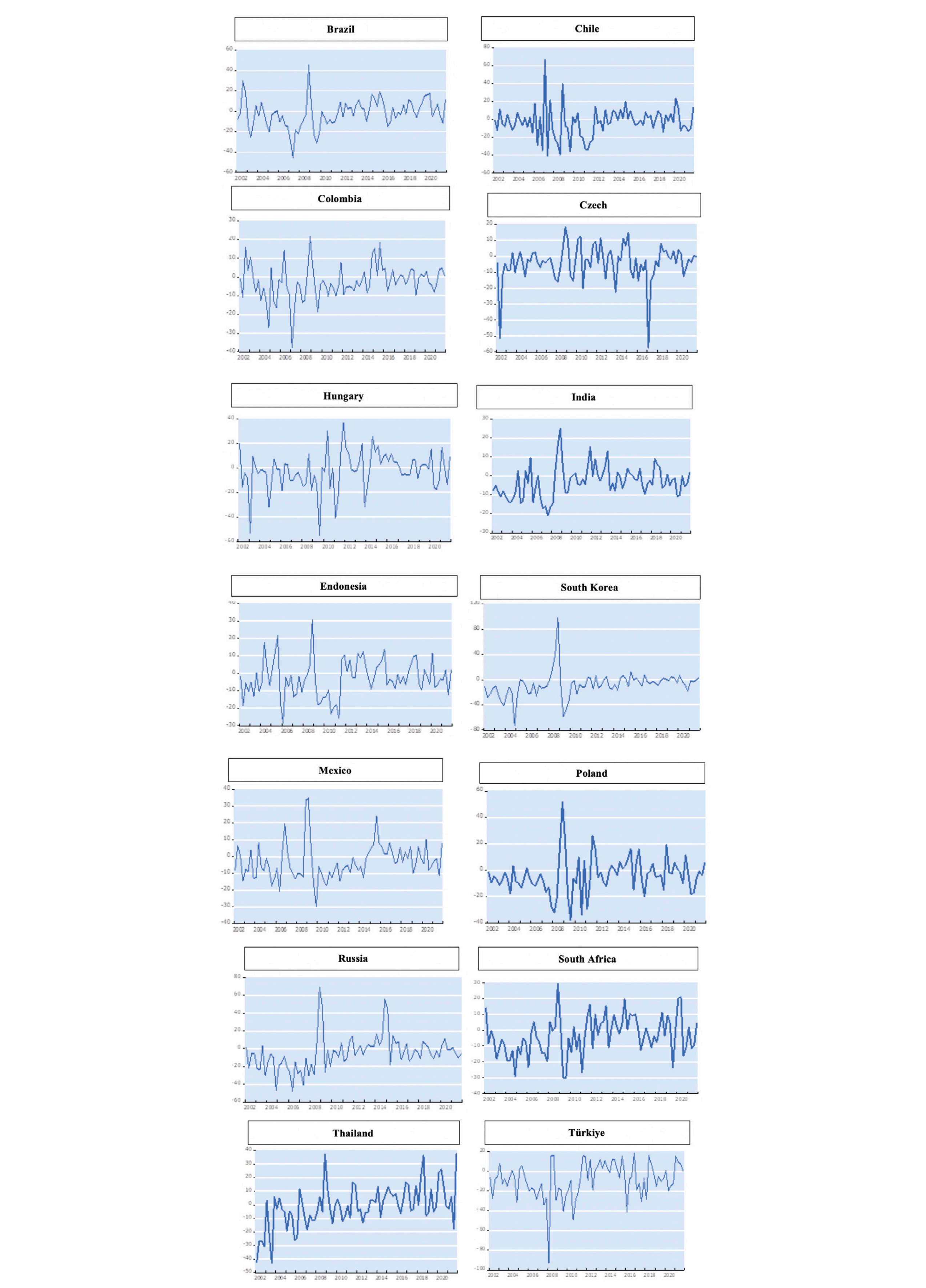
It is of great importance to determine how central banks respond to different types of capital inflows in terms of increasing or decreasing sterilization measures. In the related empirical literature, some studies have tried to investigate whether the willingness of central banks to engage in further sterilization efforts in the face of long- and/or short-term foreign capital inflows varies

[8] Countries are, from left to right, Türkiye, Chile, Colombia, Mexico, Brazil, Hungary, South Korea, Poland, Czech Republic, Indonesia, South Africa, Russia, India, Thailand.

[9] The exchange rate pressure index is calculated using the formula $\frac{\Delta e_{i,t}}{e_{i,t-1}} - \frac{\Delta IR_{i,t}}{M_{i,t-1}/e_{i,t-1}}$ following Aizenman et al. (2012). In this formula, $e_{i,t}$, denotes the nominal exchange rate of country i at time t, which is the value of foreign currency (dollar) in terms of national currency, $\Delta IR_{i,t}$ denotes countries' reserves in dollars excluding gold, and $M_{i,t}$ denotes the monetary base in dollars. International reserves are normalized by the monetary base in period t-1 (lagged by 1 quarter) (pp. 5-6).

[10] For detailed information see Martin et. al., 2020, p. 21; Hördahl and Shim, 2020, p. 1-2; Beirne et. al., 2021, p. 504-505.

Chart 2. Exchange Rate Pressure Index



Note: ub and lb denote 95% confidence intervals, respectively. The sterilization coefficient values obtained for each period are based on the instrumental variable GMM analysis technique for time series. Newey-West HAC correction is applied to resist autocorrelation and variance problems. Since the analysis period consists of quarterly data, a lag of 4 periods is considered for the correction.

across the components of capital flows (Aizenman and Glick, 2009; Arya et al., 2020; Yang, 2016). Some of these studies (e.g., Arya et al., 2020) investigate to what extent and in which direction the sterilization interventions of the central banks of the EMEs affect different types of capital inflows.

This study investigates the degree of sterilization measures at different quantile levels for all components of gross private capital inflows. With the findings obtained from different quantile levels through this method, it will be possible to determine more clearly which type of capital inflows policymakers aim to affect. Indeed, since the effects of international capital flows on financial stability differ at low, medium or high quantile levels, it is crucial for policymakers to develop appropriate strategies to determine the extent of sterilization to limit the effects of capital flows.

Linear statistical models such as the classical least squares regression method calculate the effects of explanatory variables on the average value of the dependent (explained) variable (Binder and Coad, 2011, p. 278). Therefore, linear modeling techniques of this type produce average estimates (Konstantopoulos et al., 2019, pp. 883-884). However, focusing on average effects causes the important features underlying the relationships between variables to be ignored. Moreover, in order for the OLS method to produce unbiased estimates, special assumptions such as normal distribution of errors, homoscedasticity and absence of autocorrelation problems should be met. If one or more of these assumptions are not valid, the estimation findings of this method will produce biased results that are not reliable.

Unlike traditional linear regression analysis, quantile regression analysis has predictive power for all conditional quantile functions instead of the conditional mean function. While the presence of variance in classical regression analysis exposes the estimation results to reliability problems, quantile regression analysis overcomes this problem. Quantile regression can provide complete information about the relationships between the dependent variable and independent (explanatory) variables across the entire conditional distribution and does not impose any distributional condition on the error term (John and Nduka, 2009, p. 61).

Quantile regression, first introduced to the literature with the contributions of Koenker and Baset (1978), enables the estimation of conditional quantile functions where the quantiles of the conditional distribution of the response variable (dependent variable) are functions of the observed explanatory variables (Koenker and Hallock, 2001, p. 143). Accordingly, the general form of the quantile regression model is as follows;

$$y_{it} = x'_{it}\beta_\theta + u_{\theta_{it}} \quad \text{and} \quad Quant_\theta(y_{it}|x_{it}) = x'_{it}\beta_\theta \quad j = 1, \ldots, p \tag{3}$$

In Equation 3, y_{it} denotes the dependent variable, x_{it} , denotes the vector of explanatory variables, β denotes the parameters to be estimated and denotes the residuals vector. $Quant_\theta(y_{it}|x_{it})$, represents the th conditional quantile of y_{it} for given x_{it}.

The quantile regression analysis method is robust to outliers and heavy distributions. However, this analysis method does not take unobserved heterogeneity into account. However, the panel fixed effects quantile regression method provides an important advantage in that it consideration unobserved individual heterogeneity. For this purpose, we consider the fixed-effects Method of Moments Quantile Regression introduced to the literature by Machado and Santos Silva (2019). This method makes it possible for individual effects to affect the entire conditional distribution. Although quantile regression methods have been developed in the literature to overcome the incidental parameter problem of individual effect quantile regressions, the calculation methods of these methods are difficult and complex and are based on overly restrictive assumptions about how fixed effects affect quantiles at different levels. However, the fixed-effects quantile regression method developed by Machado and Santos Silva (2019) provides significant advantages in terms of computational simplicity even when there are multiple endogenous explanatory variables and the model is nonlinear (Machado and Silva, 2019, pp. 145-146). In this framework, the quantile regression approach of Machado and Santos Silva (2019) is aimed at estimating the conditional quantiles $Q_\gamma(\tau|X)$ of the model whose conditional distribution is location scale. Accordingly;

$$Y_{it} = \alpha_i + X'_{it}\beta + \sigma\left(\delta_i + Z'_{it}\gamma\right)U_{it} \tag{4}$$

In the equation, Y is the dependent variable, X is the explanatory variable, $\Pr\{\delta_i + Z'_{it}\gamma > 0\} = 1$ probability, $(\alpha, \beta', \delta, \gamma')'$ unknown parameters, Z is the vector k of differentiable transformations of known components of X through the element l given by $Z_l = Z_l(X), l = 1, \ldots, k$, U_{it} denotes the unobserved random variable, $U(\alpha_i, \delta_i)$ parameters denote fixed effects for individual i with $i=1,\ldots n$. In this framework, based on Equation 3, the conditional quantile of the dependent variable will be shown in the following form;

$$Q_{\gamma}(\tau|X_{it}) = (\alpha_i + \delta_i q(\tau)) + X_{it}^{'}\beta + Z_{it}^{'}\gamma q(\tau) \quad (5)$$

In Equation 5, $X_{it}^{'}$ denotes the vector of explanatory variables and $\alpha_i(\tau) \equiv \alpha_i + \delta_i q(\tau)$ denotes the scalar coefficient of fixed effects in the quantile τ with respect to individual i. The fixed effects quantile regression method of Machado and Santos Silva (2019) differs from the usual fixed effects method in that the distributional effects are not location shifted. In other words, the distributional effect captures the effects of time-invariant individual characteristics that allow for different effects in different regions of Y. $\int_0^1 q(\tau)d\tau = 0$ can be interpreted as the average effect of α_i for individual i if it is valid. For the solution of the optimization problem;

$$\min_q \sum_i \sum_t p_{\tau}\left(\widehat{R}_{it} - \left(\hat{\delta}_i + Z_{it}^{'}\widehat{\gamma}\right)q\right) \quad (6)$$

Based on Equation 6, $p_{\tau}(A) = (\tau - 1)AI(A \leq 0) + \tau AI\{A > 0\}$ denotes the control function (Machado and Santos Silva, 2019, pp. 147-148).

On the other hand, a linear quantile regression model that captures individual differences (heterogeneity) in order to examine varying effects at different quantile levels independent of average effects is shown in the following form;

$$Q_{Y_{it}}(\tau|\alpha_i, X_{it}) = \alpha_i + \beta_1 x_{it} + \mu_{it} \quad (7)$$

In the above equation, i represents country and t represents time, α is the fixed effect at the quantile level τ for unit i and μ is the error term. In addition, Y is the dependent variable and x is the main explanatory variables. Therefore, the dependent variable is the sterilization coefficients and the independent variables are the different components of gross capital inflows (as a share of GDP).

Quantile regression analysis findings are presented in Table 3, Table 4 and Table 5. In our quantile regression analysis, low percentiles indicate periods of economic and financial stress when capital inflows are relatively low, while high percentiles indicate periods when capital inflows increase and the economic and financial environment improves. The analysis also includes the exchange rate pressure index and investigates how central banks' sterilization measures change during periods of increased or decreased exchange rate interventions. In this framework, the findings of the analysis show that at low quantile levels, sterilization measures are reduced in the face of low-volume increases in aggregate portfolio inflows. Low capital inflows can significantly reduce the possibility of destabilization by causing severe fluctuations in exchange rates. Thus, policymakers may have less need for sterilization measures to maintain exchange rate stability and ensure stability in financial markets. On the other hand, low volumes of capital inflows can reduce the risk of excessive appreciation of the national currency and thus reduce the level of domestic money supply and inflationary pressures to a large extent. Moreover, in EMEs growing based on short-term capital inflows, policymakers may resort to less sterilization measures to stimulate the economy in the face of the growth-weakening effects of low-volume portfolio inflows. However, towards the median quantile level, the coefficient values for gross portfolio inflows become increasingly negative. These results suggest that sterilization measures are resorted to more as the volume of portfolio inflows increases. After the median quantile level, the findings for this capital type lose their statistical significance (Table 3).

On the other hand, sterilization measures against the possible macroeconomic effects of other investment inflows, a subcomponent of gross total capital inflows, are found to increase, including at low quantile levels. Gross other investment inflows are more volatile and can be withdrawn more rapidly than other subcomponents of gross capital inflows. With these characteristics, gross other investment inflows may disrupt economic balances and increase financial instability, which may lead policymakers to expand the scope of sterilization.

At the higher quantile levels of 55th and 60th quantiles, the coefficient magnitude for other investment inflows is 1.19 and 1.14, respectively. However, it is observed that the sterilization responses to increases in the volume of inflows of this type of capital decreases towards higher quantiles (e.g., at quantiles 65 and 70, the coefficient values are 1.08 and 1.02, respectively) (Table 3). This may be due to the level in the size of the volume of inflows of some types of capital. Indeed, after the 2008 crisis, the volume of capital inflows did not reach the level of pre-crisis periods. Post-crisis inflows periodically experienced significant contractions. The expansionary monetary policies implemented by the central banks of emerging economies in order to stimulate economic activity that contracted due to increased foreign exchange needs and falling demand during periods of stress may have weakened the response of emerging economies' central banks to inflationary tendencies to some extent. All these are indicators that sterilization policies depend on changing economic conditions and countries' political preferences.

At higher quantiles, no significant results were found for the coefficients of the different components of gross inflows and the EMP index. Table 4 presents the estimation results for the central bank's sterilization responses to gross portfolio equity and debt inflows, which are the main components of gross portfolio investment. Initially, we find that increases in portfolio equity inflows at low quantile levels reduce sterilization measures. Again, the coefficient sign for gross other investment inflows is jointly positive. This result suggests that EMEs central banks try to sterilize the more volatile types of foreign capital inflows. At higher quantile levels (e.g., quantiles 55 and 60), the central bank's sterilization responses to gross other investment inflows are significant and consistent with economic expectations, but these effects gradually diminish. At later quantiles, all components of capital inflows are found to be statistically insignificant.

Table 3. Quantile Regression Analysis of Sterilization Responses to Different Types of Gross Capital Inflows

Quantiles		*Explanatory Variables*			
		Gross FDI Inflows	**Gross Total Portfolio Inflows**	**Gross Other Investment Inflows**	**Exchange Rate Pressure Index (EMP)**
Low Quantile Levels	**0.1**	0.2447 (1.9012)	-2.9683 (1.3492)**	1.7154 (0.7999)**	0.0090 (0.0399)
	0.15	0.0421 (1.6963)	-2.6636 (1.2045)**	1.6401 (0.7137)**	0.0071 (0.0357)
	0.2	-0.1251 (1.5388)	-2.4122 (1.0929)**	1.5781 (0.6474)**	0.0055 (0.0323)
	0.25	-0.2486 (1.4317)	-2.2265 (1.0174)**	1.5322 (0.6023)***	0.0044 (0.0300)
	0.3	-0.3893 (1.3217)	-2.0149 (0.9404)**	1.4799 (0.5560)***	0.0030 (0.0278)
	0.35	-0.5067 (1.2421)	-1.8383 (0.8848)**	1.4364 (0.5225)***	0.0019 (0.0261)
	0.4	-0.6587 (1.1599)	-1.6098 (0.8286)**	1.3799 (0.4879)***	0.0005 (0.0243)
	0.45	-0.8176 (1.1032)	-1.3708 (0.7894)*	1.3209 (0.4639)***	-0.0009 (0.0232)
Median Quantile	**0.5**	-1.0236 (1.0820)	-1.0609 (0.7747)	1.2444 (0.4550)***	-0.0029 (0.0227)
Higher Quantile Levels	**0.55**	-1.1728 (1.1057)	-0.8351 (0.7909)	1.1886 (0.4650)***	-0.0043 (0.0232)
	0.6	-1.3140 (1.1557)	-0.6242 (0.8249)	1.1366 (0.4861)***	-0.0057 (0.0243)
	0.65	-1.4581 (1.2324)	-0.4076 (0.8794)	1.0831 (0.5184)**	-0.0070 (0.0259)
	0.7	-1.6169 (1.3406)	-0.1687 (0.9553)	1.0241 (0.5639)*	-0.0085 (0.0182)
	0.75	-1.8072 (1.4961)	0.1175 (1.0651)	0.9534 (0.6293)	-0.0103 (0.0314)
	0.8	-2.0164 (1.6899)	0.4320 (1.2014)	0.8757 (0.7110)	-0.0123 (0.0355)
	0.85	-2.2052 (1.8795)	0.7159 (1.3339)	0.8057 (0.7908)	-0.0140 (0.0395)
	0.9	-2.3836 (2.0685)	0.9843 (1.4671)	0.7394 (0.8704)	-0.0157 (0.0435)
	0.95	-2.6547 (2.3694)	1.3919 (1.6832)	0.6387 (0.9969)	-0.0183 (0.0498)

Note: The dependent variable is the sterilization coefficient. Values in parentheses indicate t statistics. * indicates statistical significance at 10% level, ** at 5% level and *** at 1% level.

Table 4. Quantile Regression Analysis of Sterilization Responses to Different Types of Gross Capital Inflows

		Quantiles	*Explanatory Variables*				
			Gross FDI Inflows	Gross Portfolio Equity Inflows	Gross Portfolio Debt Inflows	Gross Other Investment Inflows	Exchange Rate Pressure Index (EMP)
Dependent Variable Sterilization (STER)	Low Quantile Levels	0.1	-0.0521 (1.9965)	-8.9198 (4.2772)**	-0.7538 (1.4652)	1.7963 (0.8974)**	0.0048 (0.0400)
		0.15	0.1972 (1.7865)	-8.0566 (3.8290)**	-0.7086 (1.3111)	1.7260 (0.9031)**	0.0035 (0.0358)
		0.2	-0.3216 (1.6245)	-7.3169 (3.4837)**	-0.6699 (1.1922)	1.6659 (0.7303)**	0.0024 (0.0326)
		0.25	-0.4148 (1.5174)	-6.7621 (3.2586)**	-0.6409 (1.1135)	1.6207 (0.6822)***	0.0016 (0.0304)
		0.3	-0.5400 (1.3980)	-6.0177 (3.0059)**	-0.6019 (1.0259)	1.5601 (0.6287)***	0.0005 (0.0280)
		0.35	-0.6366 (1.3297)	-5.4431 (2.8641)**	-0.5718 (0.9756)	1.5133 (0.5980)***	-0.0003 (0.0266)
		0.4	-0.7517 (1.2802)	-4.7586 (2.7650)*	-0.5359 (0.9391)	1.4577 (0.5758)***	-0.0013 (0.0257)
		0.45	-0.8745 (1.2698)	-4.0281 (2.7449)	-0.4977 (0.9313)	1.3982 (0.5712)***	-0.0024 (0.0254)
	Median Quantile	0.5	-1.0473 (1.3302)	-3.0008 (2.8739)	-0.4440 (0.9757)	1.3146 (0.5984)**	-0.0039 (0.0267)
	Higher Quantile Levels	0.55	-1.1738 (1.4242)	-2.2486 (3.0700)	-0.4046 (1.0449)	1.2534 (0.6405)**	-0.0049 (0.0285)
		0.6	-1.2923 (1.5433)	-1.5432 (3.3182)	-0.3677 (1.1324)	1.1960 (0.6939)*	-0.0059 (0.0309)
		0.65	-1.3940 (1.6646)	-0.9385 (3.5773)	-0.3360 (1.2214)	1.1468 (0.7485)	-0.0069 (0.0334)
		0.7	-1.5222 (1.8366)	-0.1762 (3.9419)	-0.2961 (1.3478)	1.0848 (0.8257)	-0.0079 (0.0368)
		0.75	-1.6774 (2.0666)	0.7471 (4.4316)	-0.2478 (1.5166)	1.0097 (0.9290)	-0.0093 (0.0414)
		0.8	-1.8466 (2.3364)	1.7536 (5.0056)	-0.1951 (1.7147)	0.9278 (1.0502)	-0.0108 (0.0468)
		0.85	-1.9749 (2.5503)	2.5167 (5.4563)	-0.1551 (1.8718)	0.8657 (1.1462)	-0.0119 (0.0511)
		0.9	-2.1478 (2.8480)	3.5444 (6.0897)	-0.1014 (2.0904)	0.7821 (1.2799)	-0.0134 (0.0571)
		0.95	-2.3603 (3.2256)	4.8088 (6.9069)	-0.0352 (2.3673)	0.6792 (1.4498)	-0.0153 (0.0647)

Note: The dependent variable is the sterilization coefficient. Values in parentheses indicate t statistics. * indicates statistical significance at 10% level, ** at 5% level and *** at 1% level.

Findings on sterilization responses to gross equity-based and debt-based capital inflows are presented in Table 5. When the estimation results are evaluated, it can be said that the findings are in line with economic expectations. However, these responses are found to be positive and significant only for gross debt-based capital inflows (at the 10% significance level for all statistically significant quantiles). According to the estimation results, it is observed that the coefficient values decrease gradually, albeit slightly, from the 45th quantile to the 50th and 55th quantiles. This situation points to the possibility that the volume of foreign capital inflows to EMEs has gradually weakened due to the impact of global-based shocks. In fact, these developments cause the global economic outlook to deteriorate and foreign investors to become more risk-sensitive, thereby reducing the likelihood of large-scale capital inflows. In the higher quantiles, the findings for both types of capital inflows are statistically insignificant.

Table 5. Quantile Regression Analysis of Sterilization Responses to Different Types of Gross Capital Inflows

		Quantiles	*Explanatory Variables*		
			Gross Equity Based Capital Inflows	**Gross Debt-Based Capital Inflows**	**Exchange Rate Pressure Index (EMP)**
Dependent Variable Sterilization (STER)	**Low Quantile Levels**	**0.1**	-2.7491 (1.8986)	0.8352 (0.8038)	0.0184 (0.0395)
		0.15	-2.5603 (1.7153)	0.8261 (0.7260)	0.0162 (0.0357)
		0.2	-2.3825 (1.5536)	0.8176 (0.6576)	0.0142 (0.0323)
		0.25	-2.2642 (1.4542)	0.8119 (0.6154)	0.0128 (0.0302)
		0.3	-2.0994 (1.3296)	0.8039 (0.5624)	0.0109 (0.0276)
		0.35	-1.9978 (1.2632)	0.7991 (0.5339)	0.0097 (0.0263)
		0.4	-1.8542 (1.1846)	0.7922 (0.5004)	0.0081 (0.0246)
		0.45	-1.6437 (1.1094)	0.7821 (0.4683)*	0.0056 (0.0230)
	Median Quantile	**0.5**	-1.4338 (1.0909)	0.7719 (0.4602)*	0.0032 (0.0226)
	Higher Quantile Levels	**0.55**	-1.2818 (1.1133)	0.7647 (0.4701)*	0.0014 (0.0231)
		0.6	-1.1232 (1.1685)	0.7571 (0.4937)	-0.0004 (0.0243)
		0.65	-0.9850 (1.2400)	0.7504 (0.5239)	-0.0019 (0.0258)
		0.7	-0.8234 (1.3455)	0.7427 (0.5687)	-0.0039 (0.0279)
		0.75	-0.5949 (1.5258)	0.7317 (0.6452)	-0.0065 (0.0317)
		0.8	-0.4213 (1.6805)	0.7233 (0.7109)	-0.0085 (0.0349)
		0.85	-0.2245 (1.8692)	0.7139 (0.7912)	-0.0108 (0.0389)
		0.9	-0.0422 (2.0534)	0.7051 (0.8695)	-0.0129 (0.0427)
		0.95	0.2411 (2.3555)	0.6915 (0.9966)	-0.0162 (0.0489)

Note: The dependent variable is the sterilization coefficient. Values in parentheses indicate t statistics. * indicates statistical significance at 10% level, ** at 5% level and *** at 1% level.

CONCLUSION AND RECOMMENDATIONS

Measuring policy responses to sterilization in the face of gross capital inflows and their different components is of great importance for balancing the effects of international capital flows and ensuring economic stability. However, these responses may differ depending on the composition and size of capital inflows. Therefore, this study investigates the effectiveness of sterilization measures against inflows of gross total capital and their components through quantile regression analysis using recent data sets. In this framework, the quantile regression analysis method is used to determine in which direction and at what levels sterilization measures will respond to low or large volumes of foreign capital inflows at different quantile levels. Thus, it is possible to determine the responses of sterilization measures depending on the type of capital inflows and to evaluate these responses at different levels. Moreover, non-linear relationships between capital inflows and sterilization measures are valid. In this respect, quantile regression analysis provides great advantages in modeling non-linear relationships between variables and developing appropriate economic policies. Therefore, policymakers can make and implement better decisions by taking into account the types of capital inflows and their effects on the differentiated economy and the shocks they may cause.

The inclusion of instrumental variable GMM estimation in the calculation of the sterilization coefficient is another important contribution of this study to the literature. In addition, our study takes into account all financial stress periods since the 2008 crisis and takes into account the recent data sets and the sample period in a way to reveal the monetary policy actions of the central banks of the countries. In this framework, the GMM method with instrumental variables is a more efficient estimator of both over- and under-specified models than the 2SLS method, which is the method mostly used in the literature. It also provides a more flexible framework in terms of generating more efficient and successful solutions to more complex endogeneity problems such as missing instrumental variables. In this respect, we initially calculate the levels of monetary policy responses of the EMEs to changes in net foreign assets by obtaining sterilization coefficients for each EME. The findings of the analysis with the time series-based instrumental variable GMM estimator show that the coefficient values are high for most of the EMEs over the sample period. For the panel group, the sterilization coefficient was found to be -0.87. These results suggest that policymakers have generally pursued the objectives of reducing exchange rate volatility and inflationary pressures and stabilizing financial markets by reducing financial risks.

On the other hand, the overall quantile regression analysis findings suggest that among different types of foreign capital inflows, EMEs policymakers try to sterilize other types of capital inflows, especially those with shorter maturity and volatile characteristics, mainly banking flows. Moreover, we find that sterilization measures are reduced in the face of gross portfolio equity inflows at lower quantile levels. Indeed, given the relatively more stable nature of portfolio equity investments, such as long-term foreign capital inflows, and their long-term contribution to the economy, the negative relationship is in line with expectations. Considering that lower quantile levels represent periods when risk is lower and capital inflows are relatively more limited, it can be said that the findings are in line with expectations as sterilization measures are less. As a matter of fact, the pressure of lower volume capital inflows on the exchange rate is limited and excessive volatility is much less pronounced depending on the type of capital inflows. Therefore, it can be stated that sterilization policy would not be a primary requirement for exchange rate stability as well as economic stability. Moreover, the empirical findings show that gross portfolio equity-based capital flows are less volatile than gross portfolio debt flows and hence may have less destabilizing effects on the economy and hence may be less prone to sterilization measures.

As a result, policymakers may increase their sterilization efforts to ensure economic and financial stability by taking into account the periods when exchange rate fluctuations and financial volatility are more severe and pronounced. Moreover, the size of sterilization measures may differ due to different factors. Therefore, more balanced and flexible sterilization measures should be considered according to the type and amount of capital inflows as well as economic conditions.

Finally, the time period considered in the study to investigate the scope and effectiveness of sterilization measures is of great importance as it takes into account the effects of recent global financial crises and serious economic events such as pandemics. However, constraints on the availability of data for EMEs led to the limited number of countries analyzed and the number of countries analyzed. Therefore, in addition to extending the time period within the framework of this research, it would be of great importance to consider other emerging economies or regions in order to generalize the results.

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APPENDİX

Appendix A.

Table A1. Definition and Measurement Method of the Variables Used in the Empirical Analysis

Variables	Definition	Measurement	Source
$\Delta\mathrm{NDA}$	Change in Net Domestic Assets	The difference between the ratio of the change in the monetary base (Monetary Base-MB-) to the monetary base at time t and the change in NFA excluding the valuation effect: $\left(\frac{\Delta \mathbf{MB_t}}{\mathbf{MB_t}} - \mathbf{\Delta NFA}_{\mathbf{t}}\right)$	IMF
$\Delta\mathrm{NFA}$	Change in Net Foreign Assets	**Change in NFA excluding revaluation effect:** $\left[NFA_t - NFA_{t-1}\left(\frac{e_t}{e_{t-1}}\right)\right]/MonetaryBase$	IMF
NFA	Net Foreign Assets	The difference between dollar-denominated foreign reserves excluding gold multiplied by the nominal dollar exchange rate and foreign liabilities: $\boldsymbol{Reserves(R)} \times \boldsymbol{NominalDollarExchangeRate(e)} - \mathrm{ForeignExchangeLiabilities}(\boldsymbol{DY}) = \boldsymbol{NFA}$	IMF
$\Delta\mathrm{mm_t}$	Money Multiplier	Quarter-on-quarter logarithmic change in the ratio of broad money supply to monetary base	IMF
$\Delta\mathrm{r_t}$	Federal Effective Funds Rate	Change in the US federal funds rate compared to the previous quarter	Federal Reserve Economic Data (FRED)
$\mathrm{Y_{t-1}}$	Cyclical Income	Deviations from trend values calculated using current real GDP and its H-P filter	IMF
$\mathrm{P_{t-1}}$	Inflation Rate	Logarithmic difference in the Consumer Price Index (CPI) compared to the previous quarter	IMF
$\Delta\mathrm{G_t}$	Change in Public Expenditures	Ratio of quarter-on-quarter change in public expenditures to monetary base	IMF
$\Delta\mathrm{REER_t}$	Change in Real Effective Exchange Rate	Quarter-on-quarter logarithmic change in CPI-based REER	Bruegel Database (2022)

Table A2. Estimation Results of ADF and PP Unit Root Tests for Individual Countries

	Türkiye (2005q1-2021q4)		**Brazil (2005q1-2021q4)**		**Chile (2005q1-2021q4)**		**Colombia (2005q1-2021q4)**		**Czech Republic (2005q1-2021q4)**		**Indonesia (2005q1-2021q4)**	
	ADF	**PP**	**ADF**	**PP**	**ADF**	**PP**	**ADF**	**PP**	**ADF**	**PP**	**ADF**	**PP**
$\Delta\mathrm{NDA}$	-7.675 (0.000)	-7.861 (0.000)	-6.187 (0.000)	-6.329 (0.000)	-9.694 (0.000)	-9.560 (0.000)	-7.621 (0.000)	-7.628 (0.000)	-10.64 (0.000)	-11.02 (0.000)	-7.407 (0.000)	-7.380 (0.000)
$\Delta\mathrm{NFA}$	-5.716 (0.000)	-5.824 (0.000)	-4.970 (0.000)	-5.070 (0.000)	-10.38 (0.000)	-10.14 (0.000)	-7.288 (0.000)	-7.342 (0.000)	-7.703 (0.000	-7.724 (0.000)	-5.762 (0.000)	-5.821 (0.000)
$\Delta\mathrm{mm_t}$	-8.684 (0.000)	-8.682 (0.000)	-6.397 (0.000)	-6.538 (0.000)	-7.017 (0.000)	-7.079 (0.000)	-13.42 (0.000)	-12.48 (0.000)	-7.094 (0.000)	-7.200 (0.000)	-8.721 (0.000)	-8.947 (0.000)
$\Delta\mathrm{r_t}$	-3.724 (0.003)	-4.157 (0.000)	-4.189 (0.000)	-4.157 (0.000)	-4.189 (0.000)	-4.157 (0.000)	-4.189 (0.000)	-4.157 (0.000)	-4.189 (0.000)	-4.157 (0.000)	-4.189 (0.000)	-4.157 (0.000)
$\mathrm{Y_{t-1}}$	-4.189 (0.000)	-3.813 (0.002)	-3.763 (0.003)	-3.833 (0.002)	-3.295 (0.015)	-3.572 (0.006)	-4.426 (0.000)	-4.386 (0.000)	-3.291 (0.015)	-3.408 (0.010)	-4.118 (0.000)	-4.124 (0.000)
$\mathrm{P_{t-1}}$	-5.309 (0.000)	-5.375 (0.000)	-4.324 (0.000)	-4.169 (0.000)	-5.094 (0.000)	-5.021 (0.000)	-3.724 (0.003)	-3.791 (0.000)	-4.270 (0.000)	-4.415 (0.000)	-6.076 (0.000)	-6.167 (0.000)
$\Delta\mathrm{G_t}$	-8.761 (0.000)	-9.514 (0.000)	-12.80 (0.000)	-11.91 (0.000)	-8.886 (0.000)	-8.856 (0.000)	-78.35 (0.000)	-116.1 (0.000)	-6.778 (0.000)	-6.945 (0.000)	-11.70 (0.000)	-12.33 (0.000)
$\Delta\mathrm{REER_t}$	-8.358 (0.000)	-8.357 (0.000)	-5.809 (0.000)	-5.723 (0.000)	-6.419 (0.000)	-6.288 (0.000)	-6.976 (0.000)	-6.914 (0.000)	-6.000 (0.000)	-5.918 (0.000)	-6.386 (0.000)	-6.269 (0.000)

Table A3. Estimation Results of ADF and PP Unit Root Tests for Individual Countries

	Poland (2005Q1-2021Q4)		Russia (2005Q1-2021Q3)		South Africa (2005Q1-2021Q4)		South Korea (2005Q1-2021Q4)		Mexico (2005Q1-2021Q4)		Thailand (2005Q1-2021Q4)	
	ADF	**PP**	**ADF**	**PP**	**ADF**	**PP**	**ADF**	**PP**	**ADF**	**PP**	**ADF**	**PP**
$\Delta\mathrm{NDA}$	-10.733 (0.000)	-10.496 (0.000)	-5.460 (0.000)	-5.407 (0.000)	-7.580 (0.000)	-7.602 (0.000)	-7.454 (0.000)	-7.488 (0.000)	-4.482 (0.000)	-4.489 (0.000)	-8.164 (0.000)	-8.166 (0.000)
$\Delta\mathrm{NFA}$	-8.543 (0.000)	-8.542 (0.000)	-4.915 (0.000)	-4.873 (0.000)	-7.189 (0.000)	-7.225 (0.000)	-7.792 (0.000)	-7.859 (0.000)	-4.711 (0.000)	-4.677 (0.000)	-8.514 (0.000)	-8.507 (0.000)
$\Delta\mathrm{mm_t}$	-13.409 (0.000)	-15.519 (0.000)	-7.549 (0.000)	-7.575 (0.000)	-10.063 (0.000)	-10.107 (0.000)	-10.768 (0.000)	-13.137 (0.000)	-7.782 (0.000)	-7.836 (0.000)	-12.125 (0.000)	-12.433 (0.000)
$\Delta\mathrm{r_t}$	-4.189 (0.000)	-4.157 (0.000)	-4.156 (0.000)	-4.124 (0.000)	-4.189 (0.000)	-4.157 (0.000)	-4.189 (0.000)	-4.157 (0.000)	-4.189 (0.000)	-4.157 (0.000)	-4.156 (0.000)	-4.124 (0.00)
$\mathrm{Y_{t-1}}$	-4.584 (0.000)	-4.659 (0.000)	-5.527 (0.000)	-5.691 (0.000)	-6.099 (0.000)	-6.095 (0.0009	-3.576 (0.006)	-3.846 (0.000)	-5.060 (0.000)	-5.050 (0.000)	-4.264 (0.000)	-4.349 (0.000)
$\mathrm{P_{t-1}}$	-3.735 (0.003)	-3.725 (0.003)	-4.266 (0.000)	-4.269 (0.000)	-5.018 (0.000)	-5.070 (0.000)	-5.221 (0.000)	-5.366 (0.000)	-6.818 (0.000)	-6.976 (0.000)	-6.233 (0.000)	-6.222 (0.000)
$\Delta\mathrm{G_t}$	-8.457 (0.000)	-8.545 (0.000)	-6.859 (0.000)	-6.898 (0.000)	-3.940 (0.001)	-3.991 (0.001)	-6.191 (0.000)	-6.358 (0.000)	-6.470 (0.000)	-6.395 (0.000)	-9.071 (0.000)	-9.431 (0.000)
$\Delta\mathrm{REER_t}$	-6.500 (0.000)	-6.377 (0.000)	-9.120 (0.000)	-9.137 (0.000)	-6.958 (0.000)	-6.892 (0.000)	-6.710 (0.000)	-6.745 (0.000)	-7.794 (0.000)	-7.804 (0.000)	-5.377 (0.000)	-5.312 (0.000)

Table A4. Horizontal Cross-Sectional Dependence Test for Panel Data.

Tests	Statistics	Probability Value
LM	**155.2**	**0.000**
LM adj*	**24.92**	**0.000**
LM CD*	**6.847**	**0.000**

Table A5. Panel Unit Root Analysis

$\Delta\mathrm{NDA}$	-5.5182
$\Delta\mathrm{NFA}$	-5.2840
$\Delta\mathrm{mm_t}$	-6.1765
$\mathrm{Y_{t-1}}$	-2.5067
$\mathrm{P_{t-1}}$	-3.3694
$\Delta\mathrm{G_t}$	-4.2729
$\Delta\mathrm{REER_t}$	-6.0338
CIPS Critical Values	-2.48 -2.28 -2.17

Note: "Federal Effective Funds Rate", one of the variables used in the analysis for the panel group countries, is the covariate. Since this variable is used by taking its change compared to the previous quarter, CIPS test results could not be obtained. Since the change values of the variable are close to zero, it is accepted that it meets the characteristics of stationarity and it is included in the analysis with its level values. However, it was found that there were no significant differences in the test results when the variable was included in the analysis in its first difference.