4. THE MUNDELL-FLEMING TRILEMMA AND THE GLOBAL FINANCIAL CYCLE: AN EMPIRICAL TEST OF COMPETING HYPOTHESES

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Abstract

We use an innovative methodological approach to investigate the impact of financial globalization (the dilemma hypothesis), the accumulation of international reserves (the quadrilemma hypothesis) and foreign currency exposure (the original sin hypothesis) on the Mundell-Fleming trilemma. We use a dynamic panel threshold model with four regimes to investigate competing hypotheses within a single methodological framework. The results imply that there are significant differences between fixed and flexible exchange rate regimes at high levels of financial openness, and that countries are biased towards fixed exchange rates at high levels of foreign currency exposure. These empirical findings imply that the global financial cycle might be the result of a deliberate choice of exchange rate regime and not the result of the irrelevance of the exchange rate regime in financially globalized countries.

Keywords: Mundell-Fleming, Global Financial Cycle, Foreign Currency Exposure, Trilemma, Dilemma

JEL Classification: F15, F31, F41, E42

1. Introduction

This paper employs the original sin hypothesis (Eichengreen *et al.*, 2007) as an alternative theoretical explanation for the existence of the global financial cycle (GFC). To that end, we use an innovative methodological approach to simultaneously test for the original sin,

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dilemma (Rey, 2015) and quadrilemma (Aizenman *et al*., 2008) hypotheses using a dynamic panel threshold model with four regimes.

The conventional Mundell-Fleming trilemma hypothesis has long been a cornerstone of international macroeconomics. It implies that a country may simultaneously choose any two of the following three goals: monetary independence, exchange rate stability and financial integration. The theory says that if a country lets its exchange rate fluctuate freely, volatile capital flows should result in a relatively less volatile output than in the case of a fixed exchange rate. This means that the central bank can act counter-cyclically by changing interest rates independently. Furthermore, the flexible exchange rate serves as a "natural" defence against excessive capital inflows and domestic asset bubbles. This is because high capital inflows lead to the appreciation of the exchange rate, which makes it more expensive for foreign investors to buy domestic assets, which is what protects the economy from potentially disruptive excessive capital inflows, thus making output less volatile.

However, the standard trilemma hypothesis has recently been the subject of considerable debate. The emergence of the global financial cycle, which reflects widespread global co-movements in capital flows, asset prices, and credit growth across countries, has led Rey (2015) to suggest that financial globalization has transformed the trilemma into a dilemma, and argues that independent (counter-cyclical) monetary policies are possible only in the case of capital controls, regardless of the exchange rate regime. She finds that monetary policy in the US and the implied volatility of US Standard and Poor's 500 index options are major determinants of the global financial cycle, and that the cycle itself is fuelled by high levels of financial integration and financial openness globally. The implied consequence of the dilemma should be that output becomes more volatile as a result of volatile capital inflows even if the exchange rate is flexible.

On the other hand, Aizenman *et al.* (2008) have offered an alternative view of the trilemma hypothesis. Their hypothesis, often called a quadrilemma, emphasizes the importance of international reserves for the level of monetary policy sovereignty. They argue that higher monetary policy sovereignty in emerging small open economies could be achieved even if a country operates a fixed exchange rate, provided that it has accumulated high enough levels of international reserves. Aizenman *et al.* (2008) argue that, even in financially open countries, high international reserves create manoeuvre space for the central bank to act independently and counter-cyclically, as interest rates are less susceptible to external shocks.

The existence of the global financial cycle (GFC) is a stylized fact (Rey, 2015), but a theoretical explanation of the observed phenomenon is still open to debate. In this paper, we suggest an alternative explanation for the GFC based on the *original sin* hypothesis. Eichengreen *et al.* (2007) and Hausmann and Panizza (2011) have argued that the inability of countries to issue debt externally in domestic currency (original sin), together with the existence of a currency mismatch (higher foreign currency liabilities than assets), can interfere with the ability to conduct counter-cyclical monetary policy. This is a proposition which is compatible with the stylized fact that the majority of developing economies run pro-cyclical monetary policies (Vegh and Vuletin, 2012), and the fact that a group of emerging economies has managed to use international reserve accumulation in order to attain a higher level of monetary independence (the quadrilemma hypothesis of (Aizenman *et al*., 2008).[4]

[4] *Accumulation of international reserves can help countries to avoid a currency mismatch even if they have problems with issuing domestic currency denominated debt externally.*

According to the original sin hypothesis, the exchange rate regime matters for monetary policy, even in highly financially open countries. However, if a country suffers from both original sin and high foreign currency exposure, exchange rate depreciation entails strong negative valuation effects on domestic output. A depreciation of the exchange rate decreases the value of net assets expressed in the local currency. This negative valuation effect consequently decreases household consumption through the wealth effect (an increase in indebtedness), and decreases output. In extreme cases, it is even possible that a negative wealth effect dominates over the positive effect of monetary expansion on investments and net export, which results in upward-sloping IS curve. As a result, these countries often opt for a fixed exchange rate to avoid the negative wealth effects of exchange rate depreciation on output, which makes them more sensitive to the global financial cycle.

We argue that the accumulation of international reserves could increase the effectiveness of monetary policy, in effect confirming the quadrilemma hypothesis conclusion. However, the original quadrilemma hypothesis argues that higher levels of international reserves provide a higher degree of monetary independence. We offer an additional explanation, and argue that international reserve accumulation decreases foreign currency exposure and rotates the (dynamic) IS curve counter-clockwise. In essence, we argue that monetary policy can be effective if a country chooses a flexible exchange rate even if it is highly financially integrated. However, policymakers in these countries face a trade-off between counter-cyclical monetary policy and reducing the possibility of the negative valuation effects of exchange rate volatilities on the financial sector, consumption and output. In most cases, they choose the latter and fix the exchange rate, thus making them more susceptible and exposed to the global financial cycle.

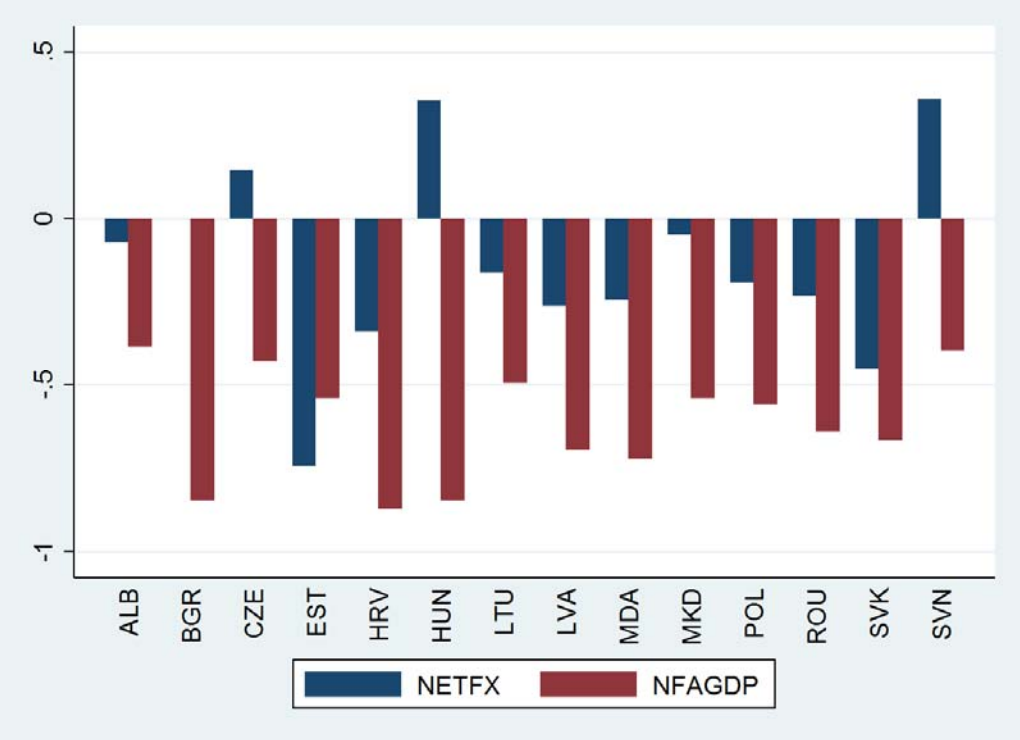
To test the aforementioned hypotheses within a single econometric framework, we employ dynamic panel threshold methodology to estimate the transmission of macroeconomic volatilities to output. We build upon the original sin literature and introduce net foreign currency exposure together with financial openness as an alternative measure of financial integration of emerging, developing and transition countries (or the negative side-effects of it). A similar approach was recently used by Georgiadis and Mehl (2015), who used two-stage regressions to estimate the impulse responses of net foreign currency exposure and net foreign assets to a positive EMU interest rate shock. In contrast to our study, the focus of their analysis was a group of EMU countries that have low foreign exchange exposure (more foreign currency denominated assets than liabilities), while we used a sample of 177 emerging, developing and transition countries that usually face opposite problems (they are more likely to have more liabilities than assets in foreign currency), as is evident from Figures 1 and 2.[5]

First, we estimate a classical two-regime threshold model with exchange rate stability as a threshold variable in order to investigate differences between exchange rate regimes over the entire sample. After that, we alternate the second threshold variable between financial openness (model 1), international reserves (model 2) and foreign currency exposure (model 3) in order to estimate the three separate models, each with four regimes.

[5] *The total number of countries entering the model is much larger than the one presented in Figures 1 and 2. For the sake of visibility and due to space issues, only selected groups of countries are shown in the Figures, to show their level of financial openness and net foreign currency exposure.*

Figure 1

Net Foreign Assets and Net Foreign Currency Exposure in Transition Countries in 2011 (Ratio to GDP)



Note: NETFX indicates the ratio of net foreign currency assets to GDP, NFAGDP indicates the net foreign assets to GDP ratio.

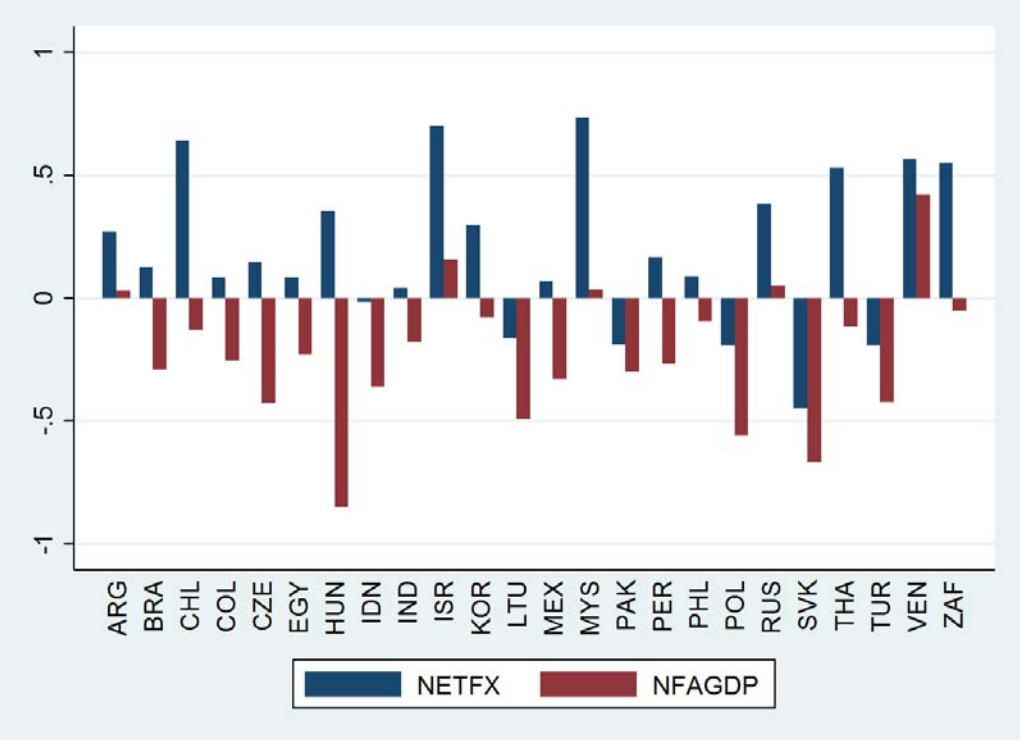
Source: Benetrix *et al.* (2015); Lane and Milesi-Ferretti (2007).

In model 1, we test the dilemma hypothesis, i.e. whether the choice of the exchange rate regime amongst financially open countries has an influence on the transmission of capital flow volatilities to output volatility. Model 2 tests the quadrilemma hypothesis. The model explores how the level of international reserves and the exchange rate regime have an influence on the aforementioned transmission of volatilities. Finally, model 3 tests the original sin hypothesis, i.e. whether the choice of the exchange rate regime and levels of foreign currency exposure impact on the intensity of volatility transmissions.

Our methodological approach is interesting because Rey (2015) and Aizenman *et al.* (2015) tests of dilemma vs. trilemma hypotheses were based on different methodologies, and had opposite results. Rey (2015) used the VAR methodology to estimate the impact of US interest rates and the VIX index on credit in emerging and developing countries, while Aizenman *et al.* (2015) used two-stage panel regressions to investigate the effects of exchange rate stability, *de jure* capital openness (and a vector of control variables) on the divergence between domestic and US interest rates.

Figure 2

Net Foreign Assets and Net Foreign Currency Exposure in Emerging Countries in 2011 (Ratio to GDP)



Note: NETFX indicates the ratio of net foreign currency assets to GDP, NFAGDP indicates the net foreign assets to GDP ratio.

Source: Benetrix *et al.* (2015); Lane and Milesi-Ferretti (2007).

Our methodological approach offers a single analytical framework to address the *dilemma vs. quadrilemma vs. original sin* hypotheses. Our research indicates that the choice of the exchange rate regime can reduce output volatility even in financially highly open economies, and that the Mundell-Fleming trilemma may not be as "dead" as it seemed. On the other hand, foreign exchange exposure influences the choice of the exchange rate regime at high levels of foreign currency exposure (more foreign currency liabilities than assets). Our results imply that the transmission of the global financial cycle might be a consequence of exchange rate regime choice in developing and emerging countries, and not only a consequence of financial globalization. The trade-off between output stability and exchange rate stability was confirmed in the case of countries with high net foreign currency exposure. The negative valuation effects of a potentially depreciating exchange rate seem to bear greater importance for policymakers than potential benefits from higher competitiveness and stronger net exports, which is why they are willing to keep the exchange rate stable at the price of more volatile domestic output.

The remainder of the paper is organized as follows: The next section summarizes the theory; Section 3 provides an overview of the methodology and discusses the data; Section 4 presents the results of various empirical models; and the final section summarizes the results.

2. Foreign Currency Exposure and the Effectiveness of Monetary Policy in an Open Economy

Meier (2013) is one of the rare papers that has allowed for international trading in foreign (multiple) assets in the standard New-Keynesian (NK) theoretical framework.[6] The model assumes that domestic and foreign households have domestic and foreign assets (bonds and equities) within the consumer budget constraint and that the domestic currency value of their portfolio is a function of the nominal exchange rate determined by the uncovered interest parity condition.

In such a setting, the slope of the dynamic IS curve is affected by the effect of the interest rate change on the value of consumer's portfolio in the following period. The interest rate change will create intertemporal substitution of consumption in the same way as in the basic New Keynesian model (rotation of a budget constraint due to substitution effect and shift due to income effect), but the effect of interest rate on the domestic currency value of the foreign currency denominated assets owned by domestic households will also induce an additional shift in the budget constraint (a wealth effect of the foreign currency denominated assets).

In the model, Meier (2013) assumes, due to technical reasons, that net foreign assets equal zero and concludes that changes in gross foreign assets do not affect the ability of monetary policy to affect output or inflation. We do not intend to develop a theoretical model, but we have highlighted the fact that the assumption of zero net foreign assets is not realistic and that a high absolute value of net foreign assets, and especially net foreign currency denominated assets, might be important in order to understand the effect of financial integration on the effectiveness of monetary policy (Figures 1 and 2).

Furthermore, even if we ignore empirical stylized facts about the long-term movements of net foreign assets, in the long-run the unbalanced growth model of open economies is a mainstream model (Turnovsky, 2009), which brings us back to the Feldstein-Horioka puzzle (Feldstein and Horioka, 1980) and the (il)logical behaviour of investment and savings across countries. Bearing this in mind, we have tried to highlight the importance of unbalanced growth on the global financial integration and focused on the foreign exchange exposures of small open economies in an unbalanced growth position.

The most intuitive way to understand the interference between the conventional understanding of the macroeconomic mechanism and foreign exchange rate exposure is to use the standard Mundell-Fleming model with wealth effects in a consumption function. Tobin and de Macedo (1979) derived a Mundell-Fleming model using a portfolio balance approach (Branson, 1977) in order to demonstrate that portfolio recomposition combined with negative foreign currency net assets (foreign currency liabilities > assets) results in peculiar comparative static. In contrast to their approach, we do not focus on valuation

[6] *The model was an extension of the Woodford (2007) approach to investigating the effects of the global integration of financial markets on the effectiveness of monetary policy.*

effects and money market equilibrium. Instead, we use wealth effects within the consumption function in order to derive an equally peculiar result in a simpler model.[7]

We can start with the basic demand relation $Y = C + I + G + N X$, where Y is GDP, C is final household expenditure, G is final government expenditure, I is fixed capital formation, and NX is net export (export X minus import X^*).

In order to incorporate the link between foreign currency exposure and GDP, it is necessary to incorporate wealth (W) in the consumption function $C = C(W, Y, T)$, where $C_W > 0$, $C_Y > 0$, $C_T < 0$. W represents the total net financial assets of the economy (assets minus liabilities) and T represents taxes.

For the rest of the economy, we can make standard assumptions. The investment function is defined as $I = I(r, Y) = I(i - \pi^e, Y)$, where $I_i < 0$, $I_{\pi^e} > 0$ and $I_Y > 0$. i is the nominal interest rate, π^e is the expected inflation rate, and r is the real interest rate.

The net export function is $NX = X(Y, Y^*, \varepsilon)$, where $NX_Y < 0$, $NX_{Y^*} > 0$, $NX_\varepsilon > 0$. Y^* is the GDP of the rest of the world, and ε is the real exchange rate defined as $\varepsilon \equiv EP^*/P$, where E is the nominal exchange rate (the price of foreign currency in terms of local currency), P is the domestic price level and P^* the foreign price level.

The next important assumption in order to understand the effect of foreign currency exposure on monetary policy is the interest parity condition. We define the nominal exchange rate as a function of the expected nominal exchange rate, domestic interest rate and foreign interest rate $E = E(E^e, i, i^*)$, where $E_{E^e} > 0$, $E_i < 0$ and $E_{i^*} > 0$.

The final assumption is that total (net) wealth $W \equiv EF/P + B/P$ is divided into domestic currency denominated net assets B and foreign currency denominated net assets F. Having in mind that all macroeconomic aggregates are expressed in the local currency, the domestic currency value of wealth W is a function of the nominal exchange rate $W = W(E)$.

An increase in the nominal exchange rate (depreciation) will increase the absolute value of foreign currency denominated assets and liabilities. If net foreign currency assets are positive, wealth will increase and depreciation will have a positive valuation effect on both wealth and consumption. Otherwise, if a country has more foreign currency liabilities than assets, depreciation will decrease wealth (increase indebtedness) and consumption.[8]

To formally prove this, we need to derive a typical Mundell-Fleming IS function with wealth effects:

$$Y = f\left(\frac{E(E^e, i^*, i)F}{P} + \frac{B}{P}, Y, T\right) + I(i - \pi^e, Y) + G + X(Y, Y^*, \frac{E(E^e, i^*, i)P^*}{P}) \quad (1)$$

The investment effect and the competitiveness effect operate in a traditional way, where monetary expansion leads to an economy-wide increase in the net present value of potential investment projects $I_i < 0$, boosting the demand for investment goods. If the Marshall-Lerner condition holds, depreciation increases net exports $NX_\varepsilon > 0 \times E_i < 0 = NX_i < 0$.

The novelty here is a new monetary transmission channel that affects consumption demand through the wealth effect. The sign of the partial derivation will depend on the foreign currency exposure (currency mismatch) within the portfolio. If the foreign currency exposure is equal to zero, the depreciation will not have any effects on wealth and consumption.

[7] *The derivation of the Mundell-Fleming model that follows is based on the approach of Rødseth (2000).*

[8] *Household liabilities on CHF mortgage loans in Eastern Europe during the appreciation of Swiss frank against the euro is the most vivid, although rather simplified, example of such a scenario.*

If foreign denominated net assets are larger than zero $F > 0$, monetary expansion will boost household consumption, and an increase in the exchange rate will increase the domestic currency value of net foreign currency assets. An increase in wealth will have positive effects on the consumption of households $W_E > 0 \rightarrow C_W > 0$.

On the other hand, if net foreign currency assets are negative $F < 0$ (high foreign currency exposure), an increase in the nominal exchange rate will increase the domestic currency value of external debt (decreasing the domestic currency value of wealth). If net foreign currency assets are negative (liabilities > assets), wealth $W \equiv -EF/P + B/P$ will be a negative function of the exchange rate $W_E < 0$. In such a scenario, depreciation will result in negative wealth effects and monetary expansion will lead to a decrease in household consumption.

If net foreign currency assets are negative $F < 0$ and low in absolute terms, changes in investment and net exports will dominate over wealth effects, and the effectiveness of monetary policy (the slope of the IS curve) will be smaller compared to the $F \geq 0$ scenario. On the other hand, if the value of foreign currency assets F is below a certain threshold (a certain level of indebtedness), wealth valuation effects can dominate over investment and net export changes, which will lead to a peculiar comparative static within the model (an upward sloping IS curve).[9]

2.1. The Role of International Reserves

As Eichengreen *et al.* (2007) have argued, the inability of countries to issue debt externally in domestic currency does not have to result in currency mismatch and foreign currency exposure ($F < 0$). If policymakers are willing to accumulate international reserves (assets denominated in foreign currency), countries will be able to avoid a clockwise rotation of the IS curve and foreign currency exposure. In other words, accumulation of international reserves can enable countries to avoid foreign currency exposure and run counter-cyclical monetary policy even if they suffer from original sin.

Furthermore, as Aizenman *et al.* (2008) have pointed out, according to *quadrilemma* hypothesis, accumulation of international reserves also provides a short run tool to boost the economy during recession, while keeping the exchange rate fixed. In both theoretical frameworks, an increase in international reserves should result in an ability to conduct counter-cyclical monetary policy. However, the impact of international reserves on monetary independence works through different monetary channels.

Therefore, we test both hypotheses independently with international reserves as the threshold variable for the quadrilemma hypothesis and foreign currency exposure as the threshold variable for the original sin hypothesis.

2.2. Dilemma vs. Original Sin

The basic intention of the dilemma hypothesis was to explain the existence of the GFC in a large sample of countries with heterogeneous exchange rate regimes. According to the hypothesis, fluctuations in asset prices are the cause and consequence of the pro-cyclicality of the financial leverage of global banks. Prolonged periods of loose monetary policy may reduce market uncertainty and funding costs, with a boost to asset prices. Rising asset prices might mask the fragile foundations of expanding global banks' balance sheets, since Value at Risk (VaR) constrained investors will build up leverage during expansion periods.

On top of that, global commercial banks are able to transmit monetary conditions from centre countries through cross-border capital flows, and influence the provision of global credit.

[9] *The pesofication during Argentinean 2001 crises is yet another example of monetary policy in the environment of high foreign currency exposure of the economy.*

Finally, receiving emerging and developing countries, especially if they are small open economies, might not be able to protect their domestic output cycle from the global financial cycle.

In order to prove the relevance of the dilemma hypothesis, Rey (2015) used the VAR model to estimate the impact of FED policy and the VIX index on credit in non-developed countries. Strong empirical evidence in favour of the GFC led to the conclusion that the choice of exchange rate regime is irrelevant and that capital controls are the only efficient instrument for counter-cyclical policy.

Nevertheless, the conclusion that the exchange rate regime does not matter is stated only as a possible explanation, and not as a result of an empirical investigation. The motivation behind our paper is to highlight a possible alternative explanation for the widespread existence of the GFC. According to the explanation that our paper promotes, exchange rate regimes are not irrelevant. Monetary policy is efficient, but foreign currency exposure discourages governments from conducting counter-cyclical monetary policy.

Bearing all this in mind, we focus on the volatility of the growth rate of net private foreign assets (the foreign assets minus foreign liabilities of countries) as a central variable that transmits international changes in monetary conditions, and explore the effect of changes in net foreign assets on the volatility of output.

Our empirical approach builds upon Aizenman *et al.* (2008) in many dimensions. However, we extend their empirical approach by replacing interaction terms with a multiple regime endogenous threshold model, and we employ *de facto* capital mobility as opposed to the *de jure* capital mobility index in order to capture materialized effects of capital flows in various regimes.

3. Methodology and Data

We employ a dynamic panel threshold methodology to estimate the transmission of macroeconomic volatilities to output, and to test the dilemma, quadrilemma and original sin hypotheses within a single econometric framework.

First, we endogenously estimate the model using the exchange rate stability index $ERS_{i,t}$ as the only threshold variable. The basic idea is to split the sample into regimes with low and high exchange rate stability and to determine potential differences in the estimated coefficients with respect to the exchange rate stability level.

The general form of the threshold dynamic panel data model is given as:

$$\sigma_{\Delta y_{i,t}} = \alpha_i + \begin{cases} \rho_1 \sigma_{\Delta y_{i,t-1}} + \beta_{11} \sigma_{\Delta nfa^p_{i,t}} + \beta'_{12} X_{i,t} + e_{1i,t} & if\ ERS_{i,t} \le \theta \\ \rho_2 \sigma_{\Delta y_{i,t-1}} + \beta_{21} \sigma_{\Delta nfa^p_{i,t}} + \beta'_{22} X_{i,t} + e_{2i,t} & if\ ERS_{i,t} \ge \theta \end{cases} \quad (2)$$

where: $\sigma_{\Delta y_{i,t-1}}$ is a five-year non-overlapping standard deviation of the per capita GDP growth rate in a local currency unit (LCU) (lower case letters denote natural logs), $\sigma_{\Delta nfa^p_{i,t}}$ is a five-year non-overlapping standard deviation of the growth rate of private net foreign assets,[10] which is the key variable of interest. $X_{i,t}$ is a vector of control variables. α_i is a cross-sectional

[10] *We define net private foreign assets as net foreign assets minus international reserves.*

fixed effect, $ERS_{i,t}$ is the exchange rate stability index (threshold variable), and θ is the value of the estimated threshold.

The vector of control variables $X_{i,t}$, contains between four and six variables: five-year non-overlapping standard deviation of the growth rate of international reserves $\sigma_{\Delta ir_{i,t}}$, five-year non-overlapping standard deviation of the growth rate of general government final consumption expenditure $\sigma_{\Delta g_{i,t}}$, five-year non-overlapping mean of the PPP GDP per capita level Y_{it}^{PPP}, an interaction term of US GDP and trade openness[11] as a proxy for the global business cycle Y^*, an index of monetary independence $MI_{i,t}$, and an index of exchange rate stability $ERS_{i,t}$.

In total, the threshold panel model in equation 2 has two regimes: a high volatility exchange rate regime below the threshold parameter $ERS_{i,t} \leq \theta$ and a low volatility exchange rate regime above the threshold parameter $ERS_{i,t} > \theta$.

Next, we estimate three separate models, each with four different regimes. Exchange rate stability is used as the first threshold variable in all models, while we alternate the second threshold variable between financial openness (model 1), international reserves (model 2) and foreign currency exposure (model 3).

In model 1, we test the dilemma hypothesis, *i.e.* whether the choice of the exchange rate regime amongst financially open countries has an influence on the transmission of macroeconomic volatilities to output volatility. Model 2 tests the quadrilemma hypothesis, where we test whether the level of international reserves and the exchange rate regime have an influence on the aforementioned transmission of volatilities. Finally, model 3 tests the original sin hypothesis, *i.e.* whether the choice of the exchange rate regime and levels of foreign currency exposure impact on the intensity of volatility transmissions.

We estimate the following dynamic panel threshold models:

$$\sigma_{\Delta y_{i,t}} = \alpha_i + \begin{cases} \rho_1 \sigma_{\Delta y_{i,t-1}} + \beta_{11} \sigma_{\Delta nfa_{i,t}^p} + \beta_{12}' X_{i,t} + e_{1i,t} & if\ ERS_{i,t} > \theta_1\ and\ q_{i,t} > \theta_2 \\ \rho_2 \sigma_{\Delta y_{i,t-1}} + \beta_{21} \sigma_{\Delta nfa_{i,t}^p} + \beta_{22}' X_{i,t} + e_{2i,t} & if\ ERS_{i,t} \leq \theta_1\ and\ q_{i,t} > \theta_2 \\ \rho_3 \sigma_{\Delta y_{i,t-1}} + \beta_{31} \sigma_{\Delta nfa_{i,t}^p} + \beta_{32}' X_{i,t} + e_{3i,t} & if\ ERS_{i,t} \leq \theta_1\ and\ q_{i,t} \leq \theta_2 \\ \rho_4 \sigma_{\Delta y_{i,t-1}} + \beta_{41} \sigma_{\Delta nfa_{i,t}^p} + \beta_{42}' X_{i,t} + e_{4i,t} & if\ ERS_{i,t} > \theta_1\ and\ q_{i,t} \leq \theta_2 \end{cases} \quad (3)$$

where we have exactly the same set of dependent, independent and control variables, but use two threshold variables simultaneously in each grid search: an index of exchange rate stability $ERS_{i,t}$ and an additional threshold variable $q_{i,t}$. We use $q_{i,t}$ to investigate how different levels of financial openness, international reserves and/or foreign exchange exposure affect output volatility in low and high stability exchange rate regimes.

A new approach with simultaneous estimations of two threshold parameters, one for each threshold variable, enables us to test the dilemma, quadrilemma and original sin hypotheses within a single empirical framework. The output of our estimating methodology results in four regimes. Within each of these regimes, it is possible to compare possible similarities or differences between the estimated coefficients over various exchange rate regimes and levels of financial integration and/or accumulated international reserves.

[11] *We define trade openness as the five-year non-overlapping mean of the ratio of the sum of exports and imports to GDP.*

The sample consists of 177 emerging, developing and transition countries, classified as such by the IMF's International Financial Statistics (IFS) database, meaning that 22 advanced countries have been excluded from the sample.[12] The data spans from 1970 to 2011. We use a fixed-effect panel estimator, and both threshold parameters are endogenously chosen to minimize root mean square error (RMSE) statistics. To avoid problems with autocorrelation, we use five-year non-overlapping time frequencies ($t = 5, ..., T$).

We use The World Bank (2016) as the source for GDP in constant local currency units (LCU), general government final consumption expenditure also in LCU, and the share of exports and imports in GDP. Local currency units are used whenever possible in order to address issues related to the Gerschenkron effect (Nuxoll, 1994).[13] The exchange rate stability index and monetary independence index are from Aizenman *et al.* (2008). PPP GDP and population data are from Feenstra *et al.* (2015), net foreign assets, foreign assets, foreign liabilities as well as international reserves data from Lane and Milesi-Ferretti (2007) and foreign currency exposure data are from Benetrix *et al.* (2015).

To construct a proxy for financial openness, we use a ratio of the sum of foreign assets and liabilities to GDP (Lane and Milesi-Ferretti, 2007). We express international reserves as a ratio to GDP (Lane and Milesi-Ferretti, 2007) and measure foreign currency exposure as a ratio of net foreign currency assets to GDP (Benetrix *et al*., 2015), which means that a decrease in the net foreign currency assets to GDP ratio represents an increase in foreign currency exposure.[14]

4. Results

Table 1 reports the results of the estimated equation 2. We estimated five different models with different combinations of independent variables. The exchange rate stability index $ERS_{i,t}$ was used as a threshold variable to split the sample into two regimes. An endogenous grid search was performed to minimise the RMSE and, depending on the model, a threshold value θ between 0.42 and 0.61 was selected.[15]

If we compare the estimated coefficients, it is possible to identify several differences between high and low exchange rate stability regimes. In the low exchange rate stability regime, the volatility of international reserves $\sigma_{\Delta ir_{i,t}}$ has a positive and highly significant effect on the volatility of the GDP growth rate. In the high exchange rate stability regime, the effect is negative, smaller and less significant. Furthermore, the volatility of government expenditures $\sigma_{\Delta gi,t}$ is positive and highly significant in the low stability regime, while it is sporadically significant and has a much smaller effect in the high stability regime.

[12] *We exclude EU-15 members, Norway, Switzerland, USA, Australia, Japan, New Zealand and Canada.*

[13] *According to Nuxoll (1994), there is no systematic relationship between PPP and LCU growth rates across countries. Therefore, he suggests using local currency units for growth rates and PPP GDP to make international comparisons.*

[14] *An increase in foreign currency liabilities is an increase in foreign currency exposure, while an increase in foreign currency assets represents a decrease in foreign currency exposure.*

[15] *Higher index values imply lower standard deviations of the nominal exchange rate of the respective country vis-a-vis the numeraire country (Aizenman et al., 2008).*

Table 1

Estimation of Equation 2 Using *ERS* as a Threshold Variable

	(1)	(2)	(3)	(4)	(5)
Regime 1 ($ERS_{i,t} \leq \theta$):					
$\sigma_{\Delta y}i,t-1$	0.433***	0.418***	0.364***	0.441***	0.367***
	(6.31)	(3.91)	(4.34)	(5.44)	(4.55)
$\sigma_{\Delta nfa}i,t$	-0.000	0.000	0.000	-0.000	0.000
	(-0.17)	(0.18)	(0.15)	(-0.34)	(0.28)
$\sigma_{\Delta ir}i,t$	0.006**	0.006***	0.007***		0.005**
	(2.40)	(3.83)	(5.18)		(2.33)
$\sigma_{\Delta g}i,t$	0.115***	0.118***	0.131***	0.115***	0.105***
	(3.92)	(3.00)	(4.91)	(4.31)	(4.45)
$M\,l_t$	0.007	-0.008			
	(0.54)	(-1.12)			
ERS_t	-0.040*		-0.011	-0.036***	
	(-1.95)		(-0.96)	(-2.90)	
Y_{it}^{PPP}	0.000	0.000	0.000	0.000	0.000
	(1.05)	(1.09)	(1.58)	(0.86)	(1.32)
Y_t^*	0.003**	0.003**	0.003***	0.005***	0.003**
	(2.38)	(2.08)	(2.90)	(3.88)	(2.55)
Regime 2 ($ERS_{i,t} > \theta$):					
$\sigma_{\Delta y}i,t-1$	0.130***	0.133**	0.146*	0.153**	0.156**
	(3.75)	(2.01)	(1.97)	(2.31)	(2.12)
$\sigma_{\Delta nfa}i,t$	-0.001	-0.001*	-0.001	-0.001	-0.001*
	(-1.50)	(-1.94)	(-1.53)	(-0.95)	(-1.79)
$\sigma_{\Delta ir}i,t$	-0.001**	-0.001**	-0.001**		-0.001**
	(-2.28)	(-2.28)	(-2.46)		(-2.05)
$\sigma_{\Delta g}i,t$	0.072***	0.073**	0.052	0.058	0.074*
	(4.69)	(2.09)	(1.41)	(1.45)	(1.84)
$M\,l_t$	-0.000	0.004			
	(-0.02)	(0.62)			
ERS_t	-0.000		0.007	-0.003	
	(-0.01)		(0.77)	(-0.41)	
Y_{it}^{PPP}	0.000	0.000*	0.000	0.000	0.000**
	(1.57)	(1.81)	(0.77)	(1.51)	(2.36)

	(1)	(2)	(3)	(4)	(5)
Y_t^*	0.005***	0.005***	0.005***	0.005***	0.005***
	(5.52)	(3.07)	(2.92)	(2.93)	(3.15)
$\alpha_{i,t}$	0.009	0.006	0.005	0.013*	0.005
	(1.38)	(1.11)	(0.71)	(1.76)	(0.90)
θ	0.419	0.419	0.609	0.463	0.609
N	676	676	716	716	731
RMSE	0.021	0.019	0.020	0.020	0.020
R^2	0.292	0.286	0.278	0.261	0.267
R^2_a	0.112	0.271	0.264	0.249	0.254

*Note: t statistics in parentheses, *, ** and *** indicate statistical significance at 10%, 5% and 1% respectively. θ is the endogenously estimated threshold value. The standard deviation of the GDP growth rate is a dependent variable, $\sigma_{\Delta y i,t-1}$ is a lag dependent variable, $\sigma_{\Delta nfa i,t}$ is the rolling standard deviation for net foreign assets minus international reserves, $\sigma_{\Delta ir i,t}$ is the rolling stand. dev. of international reserves, $\sigma_{\Delta g i,t}$ is the stand. dev. of the growth rate of government expenditure (all stand. dev. are 5 year rolling windows), MI_t is the monetary independence index, ERS_t is the exchange rate stability index, $Y^{PPP}_{i,t}$ is GDP per capita, and Y_t* is the interaction term of global GDP and trade openness.*

The persistence of the volatility of the GDP growth rate is two to three times higher in the low exchange rate stability regime, and the interaction term between openness and US GDP positively affects the volatility of the dependent variable in both regimes, but it is almost twice as strong in the high stability regime.

Such a finding is consistent with the theoretical expectation that countries with fixed exchange rate regimes (high stability regime) will be much more exposed to the global financial cycle. Contrary to the theoretical expectation of the dilemma hypothesis, the results imply that there are significant differences between fixed (high stability regime) and flexible (low stability regime) exchange rate regimes.

Nevertheless, this empirical proof should be treated with caution. The dilemma hypothesis uses financial integration as a variable that creates a macroeconomic framework in which the choice of the exchange rate regime does not protect countries from the global financial cycle. The results in Table 2 reveal the difference between low and high exchange rate stability regimes during the 1970-2011 period. Unfortunately, it is not obvious in the results how the effects of the choice of exchange rate regime change with higher levels of financial integration.

In order to solve this problem, we estimate equation 3 with two threshold variables and four regimes. Table 2 provides the results for models with two threshold variables.[16] In model 1, we use financial openness (measured as a ratio of the sum of foreign assets and foreign liabilities to GDP) together with exchange rate stability as a threshold variable.

As in the first model, we minimise RMSE through a grid search in order to endogenously select the threshold values for both threshold variables. In model 1, the grid search selected

[16] *Due to their statistical insignificance, we have excluded $MI_{i,t}$ and $ERS_{i,t}$ in the vector of the control variables in the estimation of equation 3.*

the threshold value θ_1 = 0.382 for exchange rate stability and θ_2 = 0.956 for financial openness. Above θ_1, the exchange rate is more stable and below it is more flexible (*ERS* = 1 implies a fixed exchange rate regime).

When it comes to financial openness, for values below θ_2 there is a regime with financially less open countries/years, and above it a regime with countries/years in which there was a high level of financial integration.[17] Keeping in mind the fact that foreign assets and liabilities are measured in terms of GDP, θ_2 = 0.956 implies that the threshold is in the vicinity of 100% of GDP.

Table 2

Estimation of Equation 3 Using Two Threshold Variables

	(1)		(2)		(3)	
Regime 1 ($ERS_{i,t} > \theta_1$ and $q_{i,t} > \theta_2$):						
$\sigma_{\Delta y i,t-1}$	0.104	(1.62)	0.027	(0.13)	0.240***	(3.09)
$\sigma_{\Delta nfa i,t}$	-0.002**	(-2.03)	-0.002	(-0.31)	0.000	(0.03)
$\sigma_{\Delta ir i,t}$	-0.001***	(-4.15)	0.048	(0.74)	0.003*	(1.68)
$\sigma_{\Delta g i,t}$	0.082**	(2.23)	0.091	(0.60)	0.061	(1.29)
Y^{PPP}	0.000***	(2.94)	0.000***	(3.97)	0.000***	(2.94)
Y_t^*	0.005***	(2.80)	0.003	(1.39)	0.004***	(4.79)
Regime 2 ($ERS_{i,t} \leq \theta_1$ and $q_{i,t} > \theta_2$):						
$\sigma_{\Delta y i,t-1}$	0.475***	(2.63)	0.499***	(2.91)	0.436***	(3.09)
$\sigma_{\Delta nfa i,t}$	-0.000*	(-1.86)	-0.006***	(-4.67)	0.004**	(2.48)
$\sigma_{\Delta ir i,t}$	0.002	(0.69)	0.000	(.)	0.010*	(1.75)
$\sigma_{\Delta g i,t}$	0.089	(1.55)	0.000	(.)	0.078**	(2.36)
Y^{PPP}	-0.000	(-0.23)	0.000*	(1.90)	-0.000	(-0.09)
Y_t^*	0.004	(1.39)	0.003**	(2.29)	0.002	(0.97)
Regime 3 ($ERS_{i,t} \leq \theta_1$ and $q_{i,t} \leq \theta_2$):						
$\sigma_{\Delta y i,t-1}$	0.370***	(3.73)	0.425***	(3.32)	0.250	(1.32)
$\sigma_{\Delta nfa i,t}$	0.000	(0.76)	-0.000	(-0.30)	0.000	(0.42)
$\sigma_{\Delta ir i,t}$	0.007	(1.01)	0.003	(1.15)	0.002	(0.55)
$\sigma_{\Delta g i,t}$	0.095***	(3.11)	0.091**	(2.02)	0.273	(1.25)
Y^{PPP}	-0.000	(-0.40)	-0.000	(-0.85)	-0.000	(-0.55)
Y_t^*	0.003	(0.94)	0.004*	(1.68)	0.003	(0.73)

[17] *We should bear in mind that the ratio of the sum of foreign assets and liabilities to GDP can be extremely high, while at the same time net foreign assets might be approximately equal to zero.*

	(1)		(2)		(3)	
Regime 4 ($ERS_{i,t} > \theta_1$ and $q_{i,t} \leq \theta_2$):						
$\sigma_{\Delta y i,t-1}$	0.303***	(5.37)	0.179**	(2.48)	0.117	(1.34)
$\sigma_{\Delta nfa i,t}$	-0.000	(-0.24)	-0.001	(-1.15)	-0.001**	(-2.52)
$\sigma_{\Delta ir i,t}$	-0.000	(-0.55)	-0.001**	(-2.28)	-0.001**	(-2.33)
$\sigma_{\Delta g i,t}$	0.089**	(2.41)	0.083**	(2.42)	0.079*	(1.70)
Y^{PPP}	-0.000	(-1.01)	0.000	(0.50)	0.000	(0.09)
Y_t^*	0.006**	(2.51)	0.005***	(3.11)	0.007**	(2.59)
$\alpha_{i,t}$	0.007	(1.19)	0.009	(1.55)	0.007*	(1.72)
N	731		731		731	
θ_2	0.956		0.609		0.382	
θ_1	0.382		0.369		0.382	
RMSE	0.019		0.020		0.019	
R^2	0.304		0.271		0.300	
R^2_a	0.280		0.248		0.277	

Note: *t statistics in parentheses, *, ** and *** indicate statistical significance at 10%, 5% and 1% respectively. θ_1 is the endogenously estimated threshold value for the threshold variable ERS_t and θ_2 is the estimated threshold value for the threshold variable $q_{i,t}$. In model 1, $q_{i,t}$ is financial openness, in model 2 international reserves and in model 3 foreign currency exposure. The standard deviation of the GDP growth rate is a dependent variable, $\sigma_{\Delta y i,t-1}$ is a lag dependent variable, $\sigma_{\Delta nfa i,t}$ is the rolling standard deviation for net foreign assets minus international reserves, $\sigma_{\Delta ir i,t}$ is the rolling stand. dev. of international reserves, $\sigma_{\Delta g i,t}$ is stand. dev. of the growth rate of government expenditure (all stand. dev. are 5-year rolling windows), Y^{PPP} is GDP per capita, and Y_t^* is the interaction term of global GDP and trade openness.*

Table 2 presents results for four regimes: (1) high stability and high integration, (2) low stability and high integration, (3) low stability and low integration, (4) high stability and low integration. In terms of the dilemma hypothesis, it is very interesting to compare regimes 1 and 2. Both regimes are above θ_2, which means that regimes 1 and 2 represent fixed (or high stability) and flexible exchange regimes in countries/years that were financially integrated (sum of foreign assets and liabilities over 95% of GDP).

In so-called financially integrated fixed exchange rate regime 1, all variables are significant with the exception of the lagged dependent variable. Both the changes in international reserves and net foreign assets decrease the volatility of the GDP growth rate. In addition, the volatility of government consumption, as well as the level of per capita GDP and the interaction term of trade openness have a significant and positive effect on the volatility of the GDP growth rate.

On the other hand, regime 2, which represents a flexible exchange rate regime, has a drastically different set of estimated coefficients. Only the lagged dependent variable is highly significant and the volatility of net foreign assets is marginally significant. Such a striking difference between regimes 1 and 2 obviously indicates that the choice of the level

of exchange rate stability (volatility) strongly affects the relationship between the volatility of macroeconomic policy tools and the volatility of GDP growth rate even in highly integrated economies.

Model 2 in Table 2 uses the ratio of international reserves to GDP to test the quadrilemma hypothesis. The estimated threshold value for model 2 is 0.60 for international reserves and 0.369 for exchange rate stability.

The differences between regimes 1 and 4 are of interest for the quadrilemma hypothesis. Regime 1 implies a high exchange rate stability and high level of international reserves, while regime 4 implies a low level of international reserves and a fixed exchange rate regime. According to the quadrilemma hypothesis, a higher level of international reserves should enable countries to use monetary policy even in a fixed exchange rate regime.

Therefore, countries/years in flexible exchange rate regimes (regimes 2 and 3), as well as observations in fixed exchange regime with a high level of international reserves (regime 1) should demonstrate proof of (higher) monetary independence and the efficient activity of monetary policy. On the other hand, in a fixed exchange regime with a low level of international reserves (regime 4), the behaviour of the economy should be different compared to the other three models.

The results only partially confirm our theoretical expectation. As expected, a fixed exchange rate regime with high international reserves shares more similarities with flexible exchange rate regimes, but the statistical significance of the estimated coefficients (or the lack of it) differs from our expectations. In regime 1, only the level of GDP per capita is a statistically significant variable, while there is a significant effect of government consumption (although pro-cyclical) and international reserves on the volatility of GDP growth rate at low levels of international reserves.

Net foreign currency assets are used as a secondary threshold variable in model 3. The basic idea is that there is a possibility that exposure to exchange rate changes and negative valuation wealth effects might induce policymakers to conduct pro-cyclical policies. Consequently, in such a group of countries, the number of observations in a regime with low exchange rate stability and negative foreign currency assets should be drastically smaller.

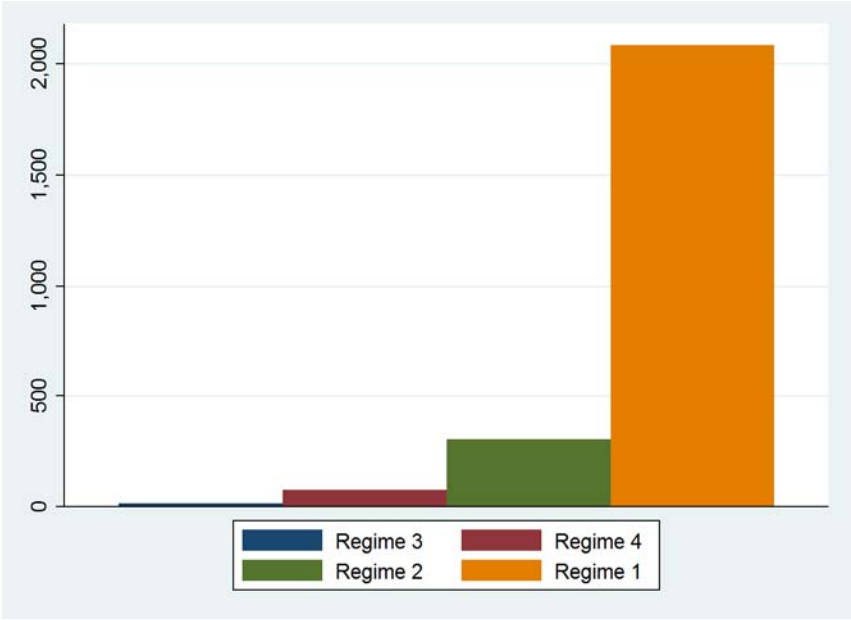
The estimated threshold values in model 3 are 0.382 for both threshold variables. In terms of foreign currency net assets, $\theta_2 = 0.382$ is interpreted as the difference between foreign currency denominated assets and liabilities in terms of GDP. Therefore, at the threshold, a 10% depreciation will increase the local currency value of net assets by 3.82% of GDP. Regimes 3 and 4 are in the focus of our analysis. Both regimes are below the ratio level of 0.382 of net foreign currency assets-to-GDP, and include countries with high foreign currency assets.[18]

Regime 3 does not have any significant variables, which is closely connected to the small number of observations in this regime (Figure 3), which confirms the theoretical expectation that exposed countries will avoid exchange rate fluctuations and predominantly choose fixed and/or high stability exchange rate regimes to minimize valuation effects. In regime 4, the volatility of net foreign assets, international reserves and government consumption are significant variables, together with the interaction term for real international shocks (trade openness). When it comes to estimated signs, international reserves are on average counter-cyclical, while government consumption has a positive sign.

[18] *It should be noted that in the case of negative net foreign currency assets, depreciation would result in a decrease in the local currency value of financial wealth.*

Figure 3

Number of Observations per Regime in Model 3 of Estimated Equation 3



Note: Regimes 1 and 2 represent fixed and flexible exchange rate regime with high levels of net foreign currency denominated assets (low foreign currency exposure). Regimes 3 and 4 represent flexible and fixed exchange rate regimes with low levels of net foreign currency denominated assets (high foreign currency exposure).

The effect of the interaction term for real global GDP shocks is positive and significant in all six coefficients for the high stability (fixed exchange rates) regime and in all three models, which is consistent with theoretical expectations.

5. Conclusion

This paper proposes the original sin hypothesis as an alternative explanation for the existence of the global financial cycle (GFC). To that end, we simultaneously tested the dilemma (Rey, 2015), original sin and quadrilemma (Aizenman *et al*., 2008) hypotheses, using a dynamic panel threshold model with four regimes.

To test for the dilemma hypothesis, we used the exchange rate stability index and two measures of financial integration as threshold variables. The ratio of the sum of foreign assets and liabilities to GDP and net foreign currency assets were used as measures of financial integration. The quadrilemma hypothesis was tested using international reserves and the exchange rate stability index as threshold variables. Threshold values were endogenously selected for all threshold variables through a grid search methodology.

Results indicate that the stability of the exchange rate has significant effects on the correlation between the volatility of the GDP growth rate and the volatility of independent variables (the volatility of foreign net assets, international reserves and government

expenditures). The difference in the estimated coefficients between two exchange rate regimes is obvious even in the group of financially highly integrated economies.

Bearing in mind that high levels in the ratio of net foreign assets and liabilities to GDP imply free capital flows, and that the estimation results indicate significant differences between exchange rate regimes at high levels of financial integration, it is possible to conclude that the global financial cycle does not dominate over domestic monetary policy in our sample of countries.

In terms of the quadrilemma hypothesis, our results are ambiguous. As expected, compared to fixed exchange regimes with low levels of international reserves, all other regimes (including the fixed exchange regime with a high level of international reserves) had mostly insignificant coefficients for the volatility of economic policy variables. Nevertheless, our expectation was that monetary independence will lead to an active role of monetary policy and a statistical significance of coefficients in regimes with independent monetary policy.

The original sin proposition with foreign currency exposure as a secondary threshold variable resulted in interesting results. Estimates for the countries with high foreign currency exposure (more liabilities than assets in foreign currency) offered an alternative explanation for the high level of correlation between the international business cycle and the volatility of the GDP growth rate in emerging, developing and transition countries.

The alternative explanation basically implies that foreign currency exposure motivates countries to use fixed exchange rates to avoid the negative wealth effects of exchange rate depreciations. Countries with negative foreign currency exposure (more foreign currency liabilities than assets) face a trade-off between counter-cyclical and pro-cyclical monetary policy, and usually choose the latter in order to avoid negative valuation and wealth effects. Consequently, the international business cycle is transmitted to emerging and developing countries due to the choice of exchange rate regimes and not because of the ineffectiveness of monetary policy *per se*.

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