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Monetary Policy Effectiveness, Net Foreign Currency Exposure and Financial Globalisation

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Abstract

In this paper we use an innovative methodological approach to investigate how the classic Mundell-Flemming trilemma monetary policy mix is affected by global financial integration ("dilemma" hypothesis), accumulation of international reserves ("quadrilemma" hypothesis) and foreign exchange rate exposure of developing, emerging and transition countries. In order to compare competing policy mix hypotheses within the single methodological framework we use two threshold variables simultaneously in a dynamic panel threshold model. Thresholds values are endogenously estimated using a grid search. Exchange rate stability index is used as a primary threshold variable and international reserves, financial openness and foreign currency exposure are rotated as secondary threshold variables. Results imply that there are significant differences between fixed and flexible exchange rate regimes even at the high levels of financial integration and that transmission of international business cycle might be a consequence of an exchange rate regime choice (due to foreign currency exposure) of developing and emerging countries and not a consequence of inability to implement counter-cyclical monetary policy.

Key words

Mundell-Fleming, Dillemma vs. trilemma, Foreign currency exposure, Qaudrilemma, Panel threshold model

JEL classification

F15, F31, F41, E42

Monetary Policy Effectiveness, Net Foreign Currency Exposure and Financial Globalisation

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Abstract

In this paper we use an innovative methodological approach to investigate how the classic Mundell-Flemming trilemma monetary policy mix is affected by global financial integration ("dilemma" hypothesis), accumulation of international reserves ("quadrilemma" hypothesis) and foreign exchange rate exposure of developing, emerging and transition countries. In order to compare competing policy mix hypotheses within the single methodological framework we use two threshold variables simultaneously in a dynamic panel threshold model. Thresholds values are endogenously estimated using grid search. Exchange rate stability index is used as primary threshold variable and international reserves, financial openness and foreign currency exposure are rotated as secondary threshold variables. Results imply that there are significant differences between fixed and flexible exchange rate regimes even at the high levels of financial integration and that transmission of international business cycle might be a consequence of a exchange rate regime choice (due to foreign currency exposure) of developing and emerging countries and not a consequence of inability to implement counter-cyclical monetary policy.

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JEL Codes: F15 F31 F41 E42

1. Introduction

The goal of this paper is to estimate effects of financial integration and net foreign currency exposure (currency mismatch) on the monetary policy in the transition, emerging and developing countries. We use new methodological approach that can test for the "dilemma vs. trilemma vs. qudrilemma" hypothesis within the single econometric framework and provide alternative expla-

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nation for the effect of the level of financial internationalisation on international business cycle transmission.

Our motivation stems from the "dilemma vs. trilemma" debate (Rey, 2015; Aizenman et al., 2015) about the effects of financial integration on the policy choices and the "currency mismatch" (Hausmann and Panizza, 2011) and/or "original sin" literature (Eichengreen et al., 2007) that analysed effects of net and gross foreign currency exposure on the policy choices faced by monetary authorities.

The "trilemma" hypothesis is a fundamental implication of the Mundell-Fleming model that a country simultaneously may choose any two of the following three goals: monetary independence, exchange rate stability and financial integration.

Recently, effects of financial integration on traditional Mundell-Fleming monetary "trilemma" setting have been subject of considerable debate. Dramatic buildup of net foreign assets as well as changes in foreign currency exposure in developing and emerging economies (see Figures 1 and 2) provoked a wide discussion on the repercussions of the financial integration on the traditional view of Mundell-Fleming monetary "trilemma" options.

Rey (2015) posted a "dilemma" hypothesis claiming that international business cycles dominates domestic monetary policy if capital flows are free. As a consequence, according to "dilemma" hypothesis, the choice of exchange rate regime does not affect the business cycle in a financially integrated economies.

Furthermore, Eichengreen et al. (2007) and Hausmann and Panizza (2011) noticed that incapability of countries to issue debt in domestic currency (Original sin) and/or foreign exchange exposure (currency mismatch) can interfere with capability of conducting anti-cyclical monetary policy.[1]

According to them, governments avoid expansionary monetary policy in such economic setup in order to avoid negative wealth effects (valuation effects) of depreciation on the domestic currency value of their debt. As a consequence, according to the original sin/currency mismatch hypothesis, countries indebted in foreign currency face the choice between lowering the net foreign currency exposure (debt abstention and/or accumulation of foreign exchange reserves) and/or running procyclical monetary policies (stabilizing exchange rates).

Original sin and currency mismatch hypothesis (Eichengreen et al., 2007; Hausmann and Panizza, 2011) basically offers theoretical framework that can explain the stylised facts that majority of de-

[1]Currency mismatches is defined as differences in the values of the foreign currencydenominated assets and liabilities on the balance sheets of households, firms, the government, and the economy as a whole.

veloping and emerging countries run pro-cyclical monetary policies (Vegh and Vuletin, 2012) and the fact that a group of emerging countries managed to use exchange reserves accumulation in order to attain higher level of monetary independence, the "quadrilema" hypothesis (Aizenman et al., 2008).

It should be highlighted that original sin (currency mismatch) hypothesis is not incompatible with "dilemma" hypothesis. According to the mismatch approach, developing and emerging countries are not able to choose floating exchange rates due to adverse effects of exchange rate fluctuations on the domestic currency value of net foreign assets.

According to "dilemma" (Rey, 2015) point of view, regardless of the exchange rate regime chosen, emerging and developing countries will not be able to stabilise output without capital controls. Implying that even if an emerging country achieves positive level of net foreign currency assets (for example by accumulation of international reserves), a switch to floating exchange rate regime will not stabilise economy unless capital controls are imposed.

Besides being of interest for the analysis of implications of Mundell-Fleming model within the short-run macroeconomic framework, "dilemma" and currency mismatch hypothesis' are interesting from a perspective of Feldstein-Horioka puzzle (Feldstein and Horioka, 1980) as well.

Theoretically, the choice that is faced by policy makers in the emerging countries that are exposed to "dilemma" and or currency mismatch creates incentive to prevent deviation of net foreign and/or net foreign currency assets from zero and results with a high level of correlation between investments and savings over sustained period of time.[2]

In this paper we use panel threshold methodology in order to estimate effects of capital flows, fiscal and monetary policy in several regimes. We use exchange rate stability, level of financial integration (measured with net foreign assets and financial openness[3]) and international reserves as threshold variables. In order to test for "dilemma vs. trilemma" hypothesis within the single econometric framework we employ two threshold variables simultaneously in a dynamic threshold model with 4 regimes: (i) fixed exchange rate and high financial integration, (ii) fixed exchange rate and low financial integration, (iii) floating regime and high financial integration, and (iv) floating regime and low financial integration. We re-estimate the same dynamic panel threshold model with the international reserves instead of financial integration in order to test "trilemma vs. qudrilemma" hypothesis.

[2] Blanchard (2007) analysed buildup of current account deficits in the Euro area within the framework of private saving and investment decisions and potential optimal policy response. Introduction of monetary union in Europe had a positive effect on net foreign currency assets and on the divergence of savings and investments across EMU members.

[3] Financial openness is defined as ratio of sum of foreign assets and liabilities to GDP.

Our new methodological approach is interesting due to the fact that Rey (2015) and Aizenman et al. (2015) tests of "dilemma vs. trilemma" hypothesis were based on on completely incompatible methodology and reached opposite results. Rey (2015) used VAR methodology in order to estimate impact of US interest rate and VIX index on credit in emerging and developing countries, while Aizenman et al. (2015) used two stage panel regression in order to investigate effect of exchange rate stability, *de jure* capital openness (and a vector of control variables) on the divergence between domestic and US interest rates. Our methodological approach offers unique analytical framework in order to address "dilemma vs. trilemma vs. quadrilemma" hypothesis.

Furthermore, we built on the "original sin" literature and introduce net foreign currency exposure together with financial openness as an alternative measure of financial integration of developing countries (or negative side effects of it).

Similar approach was recently used by Georgiadis and Mehl (2015) who used two stage regression in order to estimate effects of net foreign currency exposure and net foreign assets on through of impulse response functions to positive EMU interest rate shock. Compared to our study, focus of their analysis was group of EMU countries who have positive foreign exchange exposure (more foreign denominated assets than liabilities), while we use developing, transition and emerging countries that usually face opposite problems (more likely to have more liabilities then assets in foreign currency). Also, our threshold approach will improve methodology in order endogenously and simultaneously estimate all 4 regimes and test all hypothesis within the single econometric framework.

Our results imply that major differences exist between fixed and flexible exchange rate regime even at the high levels of financial integration. On the other hand, foreign exchange exposure affects the choice of exchange rate regime at low levels of FX exposure (more FX liabilities than assets). Our results imply that transmission of international business cycle might be a consequence of a exchange rate regime choice of developing and emerging countries and not a consequence of inability to implement counter-cyclical monetary policy.

The remainder of the paper is organized as follows: Section 2 summarizes the theory; Section 3 provides an overview of the methodology and discusses the data; Section 4 presents the results of the various empirical models; and Section 5 summarizes the results.

2. FX exposure, International reserves, financial integration and Mainstream Macro model

The central idea of "dilemma" hypothesis is based on financial integration of global commercial banks. According to the proposition, fluctuations in asset prices are cause and consequence of the pro-cyclicality of financial leverage of global banks. Prolong periods of loose monetary policy may reduce market uncertainty and funding costs, with a boost to asset prices. Rising asset prices might mask fragile foundations of expanding global banks balance sheet, since VaR constrained investors will build up leverage during expansion periods.

On top of that, global commercial banks are able to transmit monetary conditions form the center countries through cross-border capital flows, and influence provision of global credit. Finally, receiving emerging and developing countries, especially if they are small open economies, might not be able to protect domestic output cycle from global financial cycle. Having all that in mind, in our research we focus on the volatility of the growth rate of the net foreign assets (foreign assets minus foreign liabilities of countries).

Meier (2013) is one of the rare papers that have attempted to incorporate global financial integration into the standard New-Keynesian theoretical framework. They have assumed that domestic and foreign consumers have domestic B and foreign bonds F in the consumer budget constraint and that domestic currency value of their portfolio is function of the nominal exchange rate that is determined by the uncovered interest parity condition.

In such a setting the slope of the dynamic IS curve will be affected by the effect of interest rate change on the value of consumers portfolio in the next period. The interest rate change will create intertemporal substitution of consumption in the same way as in basic NK model (rotation of a budget constraint), but the effect of interest rate on the value of foreign currency denominated bonds owned by domestic households will also induce shift in the budget constraint.

In the model, Meier (2013) assumes, due to technical reason, that net foreign assets are 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 intent do develop theoretical model, but we highlight the fact that assumption of zero net foreign assets is not realistic and that 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 efficiency of monetary policy (Figures 1 and 2).

Furthermore, even is we ignore empirical stylized facts about the long term movement of net foreign assets, in the long run growth model of open economies unbalanced growth is mainstream model (Turnovsky, 2009), which brings us back to Feldstein-Horioka puzzle (Feldstein and Horioka, 1980) and (i)llogical behaviour of investment and savings across countries.

Having that in mind we try to highlight importance of unbalanced growth on the global financial integration and with it we focus on the foreign exchange exposures of small open economies in the unbalanced growth position. In order to understand interference between conventional understanding of macroeconomic mechanism and foreign exchange rate exposure, it is most intuitive to use standard undergraduate macroeconomic model. We can start with basic demand relation of GDP $Y = C + I + G + NX$ 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 link between foreign exchange exposure and GDP it is neccesary to incorporate wealth W in consumption function $C = f(W, Y, T)$, where $C_W > 0$, $C_Y > 0$, $C_T < 0$. W is total net foreign financial assets of economy (foreign assets minus foreign liabilities) and T represents taxes.

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

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

The next important assumption in order to understand effect of foreign currency exposure to monetary policy is interest parity condition. We define nominal exchange rate as a function of expected nominal exchange rate E^e_{t+1} and domestic i and foreign i^* interest rate $E = e(E^e_{t+1}, i^*, i)$, where $E_{E^e_{t+1}} > 0$, $E_{i^*} > 0$ and $E_i < 0$.

Final assumption is that wealth $W \equiv EF/P + B/P$ is invested in a portfolio with domestic currency denominated net assets B and foreign currency denominated net assets F. Having in mind that wealth, as all other macroeconomic aggregates is expressed in local currency, wealth is a function of nominal exchange rate $W = w(E)$. Increase in nominal exchange rate (depreciation) will increase the absolute value of assets and liabilities. If net assets are positive depreciation will have positive valuation effects on the wealth and consumption. Otherwise, if country has much more foreign currency liabilities than assets, depreciation will contract wealth and consumption in that case.[4]

In order to formally prove this, we need to derive typical IS function with wealth effects

$$Y = f(e(E^e_{t+1}, i^*, i)F/P + B/P, Y, T) + g(i - \pi^e, Y) + G + n(Y, Y^*, e(E^e_{t+1}, i^*, i)P^*/P) \tag{1}$$

[4]Households liabilities on CHF mortgage loans in eastern Europe during the appreciation of CHF vs. EUR are most vivid, although quite simplified example of such a scenario.

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

Novelty is that new monetary transition channel that affects consumption demand through wealth effect. Sign of the partial derivation will depend on the foreign currency exposure within the portfolio. If foreign currency exposure is equal to zero, depreciation will not have any effects on the wealth and consumption.

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

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

If foreign currency assets are negative $F < 0$ and low in absolute terms, changes in investment and net exports will dominate, and effectiveness of monetary policy will be standard. In the opposite extreme, if the absolute value of foreign currency assets $|F|$ is above certain threshold, wealth valuation effect can dominate over investment and net export changes.

Besides investigating the effect of financial integration (openness) and foreign currency exposure with the "dilemma" hypothesis, our empirical attention is also focused toward the role of international reserves in monetary policy effectiveness. "Quadrilemma" hypothesis is closely related to the "original sin" premise that is defined as "inability of a country to borrow in its own currency". One consequence of original sin is the tendency for countries afflicted by the problem to accumulate international reserves as a way of protecting themselves from foreign exchange rate exposure (Eichengreen et al., 2007).

Furthermore, as Aizenman et al. (2008) pointed out, accumulation of international reserves might provide emerging economies with more monetary independence even in the fixed exchange regime. Higher level of international reserves reduces currency mismatch in countries afflicted with original sin, but also provides a short run tool to boost economy during the recession while keeping the exchange rate fixed.

3. Methodology and Data

In this paper, we attempt to employ two dynamic threshold panel models. First, we start with the threshold dynamic panel data model in order to endogenously estimate threshold parameter using the exchange rate stability index $ERS_{i,t}$ as the threshold variable. The basic idea is to split the sample endogenously into the regime with low and the regime with high exchange rate stability and to determine potential differences in the estimated coefficients with respect to the level of exchange rate volatility.

In the second step we want to investigate how did the level od international integration affected the differences between low and high volatility exchange rate regime. In order to do that, we use additional threshold variable together with exchange rate stability. We pair exchange rate stability with each of the following three threshold variables: (i) financial openness, (ii) international reserves, and (iii) net foreign exchange exposure.

We first start with the following general form of the threshold dynamic panel data model

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

where $\sigma_{\Delta y_{i,t}}$ is five year rolling 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 rolling standard deviation of the growth rate of private net foreign assets[5], which is the key variable of interest. $X_{i,t}$ is a vector of control variables. α_i is a cross-sectional fixed effect, $ERS_{i,t}$ is the exchange rate stability index (threshold variable), and θ is the value of the estimated threshold.

Vector of of control variables $X_{i,t}$, contains between five and seven variables: five year rolling standard deviation of the growth rate of the international reserves $\sigma\Delta ir_{i,t}$, five year rolling standard deviation of the growth rate of the general government final consumption expenditure $\sigma_{\Delta g_{i,t}}$, PPP GDP per capita level $Y^{PPP}_{i,t}$, interaction term of US GDP as a proxy for global business cycle and trade openness[6] Y^*, index of monetary independence $MI_{i,t}$ and index of exchange rate stability $ERS_{i,t}$.[7]

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

Second model is similar dynamic panel threshold model

[5] We define net private foreign assets as net foreign assets minus international reserves

[6] We define trade openness as the ratio of export and import to GDP.

[7] In the estimation of equation 3 we do not use $MI_{i,t}$ and $ERS_{i,t}$ in the vector of the control variables.

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

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

New approach with simultaneous estimation of two threshold parameters, one for each threshold variable, enables us to investigate possibility of dilemma, trilemma and qaudrilemma hypothesis within the single empirical approach. Output of our estimating methodology will result with four regimes. Within each of this regimes it will be 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.

We use fixed-effect panel estimator and both threshold parameters are endogenously chosen to minimize RMSE statistics. Data set includes, depending on the estimate, between 96 and 141 countries and spans between 1950(80) to 2011(14) depending on variable used in vector of control variables. We minimised root mean square error statistics (RMSE) in order to endogenously find threshold value(s). In order to avoid problems with autocorrelation within the five year rolling standard deviations, we use five year non-overlapping time frequency ($t = 1, 5, 10, ..., T$). Also we have excluded 22 advanced countries from the sample.[8]

We use The World Bank (2016) as a source for GDP in constant local currency units (LCU), general government final consumption expenditure also in LCU and share of exports and imports in GDP. Local currency units are used whenever possible in order to address issues related with Gerschenkron effect (Nuxoll, 1994).[9] 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 are from Lane and Milesi-Ferretti (2007) and net foreign currency exposure data are from Bénétrix

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

[9] According to Nuxoll (1994), there are is not any systematic relationship between PPP and LCU growth rates across countries. Therefore, he suggest to use local currency units for growth rates and PPP GDP in order to comapre levels in international comparison.

et al. (2015).

In order to construct proxy for the financial internationalisation, we use ratio of the sum of foreign assets and liabilities to GDP (Lane and Milesi-Ferretti, 2007) as a proxy for financial openness. We express international reserves as ratio to GDP (Lane and Milesi-Ferretti, 2007) and we use net foreign currency exposure as the ratio of the difference between foreign currency assets and liabilities to GDP (Bénétrix et al., 2015).

4. Results

Table 1 shows the results of the estimated equation 2. We have estimated five different models with different combinations of independent variables. Exchange rate stability index $ERS_{i,t}$ was used as a threshold variable in order to split the sample in two regimes. Endogenous grid search was performed in order to minimise root mean square error and depending on the model, threshold value θ between 0.42 and 0.61 was selected.[10]

If we compare estimated coefficients between to regimes, it is possible to find several differences between high and low exchange rate stability. In the low exchange rate stability regime, volatility of international reserves $\sigma_{\Delta ir_{i,t}}$ has 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, volatility of government expenditure $\sigma\Delta g_{i,t}$ is positive and highly significant in low stability regime, while it is sporadically significant and with much smaller effect in the high stability regime.

Persistency of volatility of the GDP growth rate is between two to three times higher in low exchange rate stability regime and interaction term between openness and global GDP positively affects volatility of dependent variable in both regimes, but almost twice as strong in the high stability regime. When it comes to the interaction terms of level of trade openness and world GDP, estimated coefficient in the high stability model is much higher and more significant.

Such a finding is consistent with theoretical expectation that countries with fixed exchange rate regimes (high stability regime) will be much more exposed to a global business cycle. Having in mind "dilemma" hypothesis, it is obvious that there are significant differences between fixed (high stability regime) and flexible (low stability regime) exchange rate regimes.

Nevertheless, this empirical proof should be taken with caution. The "dilemma" hypothesis is using financial integration as a variable that creates macroeconomic framework in which the choice of the exchange rate regime does not "protect" countries from a international business cycle.

[10] Higher value of the index imply lower standard deviation of nominal exchange of the respective country vis á vis numeraire country (Aizenman et al., 2008).

Results in the table 2 estimate the difference between low and high exchange rate stability regime on the average during the 1970-2011 period. Unfortunately, it is not obvious in the results how did the effects of the choice of exchange rate regime changed with the 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 results for the model with two threshold variables. In a model 1, we use financial openness (measured as a ratio 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 gird search in order to endogenously select the threshold values for both threshold variables. In the model 1 grid search has selected threshold value $\theta_1 = 0.382$ for the exchange rate stability and threshold value $\theta_2 = 0.956$ for financial openness. Above θ_1, exchange rate is more stabile and below it is more flexible ($ERS = 1$ imply fixed exchange rate regime).

When it comes to financial openness, below the θ_2 there is a regime with financially less opened country/years, and above are country/years in which there was a high level of financial integration.[11] Having in mind the fact that foreign assets and liabilities are measured in terms of GDP, $\theta_2 = 0.956$ implies that threshold is in the vicinity of the 100% of GDP.

Table 3 represents results for four regimes: (1) high stability and high integration, (2) low stability and high integration, (3) high stability and low integration, (4) low stability and low integration. In the terms of "dilemma" hypothesis, it is extremely interesting to compare regime 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 country/years that were financially integrated (sum of foreign assets and liabilities over 95% of GDP).

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

On the other hand, regime 2 that represents flexible exchange rate regime has drastically different set of estimated coefficients. Basically, only the lag dependent variable is highly significant and volatility of net foreign assets is marginally significant. Such a starking difference between regime 1

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

and 2 obviously indicate that the choice of the level of exchange rate stability (volatility) strongly affects relationship between the volatility of macroeconomic policy tools and volatility of GDP growth rate even in a highly integrated economies.

Model 2 in the table 3 uses the ratio of international reserves to GDP in order to test for "quadrilemma" hypothesis. Estimated threshold value for model 2 is 0.60 for international reserves and 0.369 for the exchange rate stability regime. In order to analyse "quadrilemma" hypothesis, regimes 1 and 4 are of interest. Regime 1 is estimated for observations with high stability of exchange rate and high level of international reserves, while regime 4 has low level of international reserves and exactly the same exchange rate regime (fixed).

Results for model 2 indicate that there is a significant effect of government consumption (although procyclical) and international reserves on the volatility of GDP growth rate in the countries/years with low level of international reserves. Furthermore, lag dependent variable and interaction term for real international shock is also significant in regime 4. On the other hand, in the regime 1, only level of GDP per capita is statistically significant variable.

Obviously, the result is counterintuitive and exactly opposite to the theoretical expectations. According to economic theory, higher level of international reserves should enable countries to use monetary policy even in the fixed exchange rate regimes. The "quadrilemma" hypothesis highlighted this issue based on the empirical results that many emerging countries managed to accumulate high levels of international reserves. On the contraire, our results indicate the opposite.

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

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 difference between foreign currency denominated assets and liabilities in terms of GDP. Therefore, at the threshold, a 10% depreciation will increase local currency net assets for 3.82% if net foreign currency exposure is 0.382. Regimes 3 and 4 are in the focus of our analysis. Both regimes are below 0.382 level of net foreign currency exposure and also include countries with negative foreign currency exposure (foreign currency assets minus liabilities).[12]

[12]It should be noted that in case of negative foreign currency net assets, depreciation will results in a decrease of local currency value of financial wealth.

Regime 3 does not have any significant variables, which is closely connected with small number of observations in this regime (Figure 3), which confirms theoretical expectation that exposed countries will avoid exchange rate fluctuations and predominantly choose fixed and/or high stability exchange rate regimes in order to minimise valuation effects. In the regime 4, volatility of net foreign assets, international reserves and government consumption are significant variables together with 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.

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

5. Conclusion

The goal of this paper is to test mainstream Mundell-Fleming's "trilemma" hypothesis *via á vis* two alternative hypothesis: "dilemma" and "quadrilemma" hypothesis. We use new methodological framework that enables us to test all three hypothesis' within the single dynamic panel threshold model.

In order to test for "dilemma" hypothesis we use the exchange rate stability index and two measures of financial integration as threshold variables. Ratio of the sum of foreign assets and liabilities to GDP and net foreign currency exposures are used as measures of financial integration. "Quadrilemma" hypothesis is tested with international reserves and exchange rate stability index as threshold variables. Threshold values are endogenously selected for all threshold variables through the grid search methodology.

Results indicate that stability of exchange rate have significant effects on the correlation between the volatility of GDP growth rate and volatility of independent variables (the volatility of foreign net assets, international reserves and government expenditure). Difference in the estimated coefficients between two exchange rate regimes is quite big even in the group of financially highly integrated economies.

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

In terms of "quadrilemma" hypothesis, our results have indicated significance levels which are different from theoretical expectations. Countries with a high level of international reserves had mostly insignificant coefficients for the volatility of economic policy variables. The result is not expected and might imply problems with the feedback effects in our dynamic panel threshold models.

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

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

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Tables

Table 1: Estimation of equation 2 using Exchange Rate Stability as a threshold variable Variable

	(1)	(2)	(3)	(4)	(5)
Regime1 ($ERS_{i,t} \leq \theta$):					
$\sigma_{\Delta y_{i,t-1}}$	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)
MI_t	0.007	-0.008			
	(0.54)	(-1.12)			
ERS_t	-0.040*		-0.011	-0.036***	
	(-1.95)		(-0.96)	(-2.90)	
$Y_{i,t}^{PPP}$	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)
Regime2 ($ERS_{i,t} > \theta$):					
$\sigma_{\Delta y_{i,t-1}}$	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)
MI_t	-0.000	0.004			
	(-0.02)	(0.62)			
ERS_t	-0.000		0.007	-0.003	
	(-0.01)		(0.77)	(-0.41)	
$Y_{i,t}^{PPP}$	0.000	0.000*	0.000	0.000	0.000**
	(1.57)	(1.81)	(0.77)	(1.51)	(2.36)
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_a^2	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. Standard deviation of GDP growth rate is dependent variable, $\sigma_{\Delta y_{i,t-1}}$ is lag dependent variable, $\sigma_{\Delta nfa_{i,t}}$ is rolling standard deviation for net foreign assets minus international reserves, $\sigma_{\Delta ir_{i,t}}$ is rolling stand. dev. of international reserves, $\sigma_{\Delta g_{i,t}}$ is stad. dev. of growth rate of government expenditure (all stand. dev. are 5 year rolling windows), MI_t is monetary independence index, ERS_T is exchange rate stability index, $Y_{i,t}^{PPP}$ is GDP per capita and Y_t^* is interaction term of global GDP and trade openness.

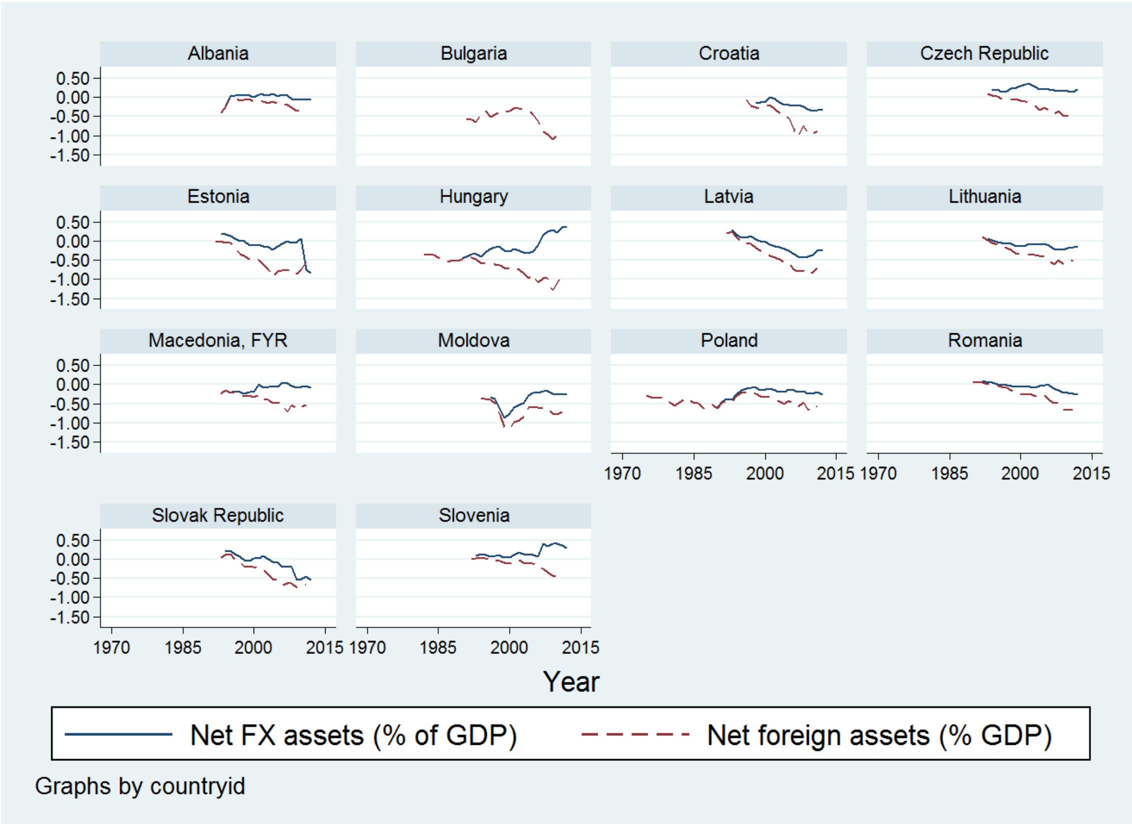
Table 2: Estimation of the equation 3 using two threshold variables

	(1)		(2)		(3)	
Regime1 ($ERS_{i,t} > \theta_1$ 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)
$Y_{i,t}^{PPP}$	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)
Regime2 ($ERS_{i,t} \leq \theta_1$ 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)
$Y_{i,t}^{PPP}$	-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)
Regime3 ($ERS_{i,t} \leq \theta_1$ 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)
$Y_{i,t}^{PPP}$	-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)
Regime4 ($ERS_{i,t} > \theta_1$ 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)
$Y_{i,t}^{PPP}$	-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)
_cons	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	
r2	0.304		0.271		0.300	
r2_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 the model 1, $q_{i,t}$ is financial openness, in the model 2 international reserves and in the model 3 foreign currency exposure. Standard deviation of GDP growth rate is dependent variable, $\sigma_{\Delta y_{i,t-1}}$ is lag dependent variable, $\sigma_{\Delta nfa_{i,t}}$ is rolling standard deviation for net foreign assets minus international reserves, $\sigma_{\Delta ir_{i,t}}$ is rolling stand. dev. of international reserves, $\sigma_{\Delta g_{i,t}}$ is stad. dev. of growth rate of government expenditure (all stand. dev. are 5 year rolling windows), $Y_{i,t}^{PPP}$ is GDP per capita and Y_t^* is interaction term of global GDP and trade openness.

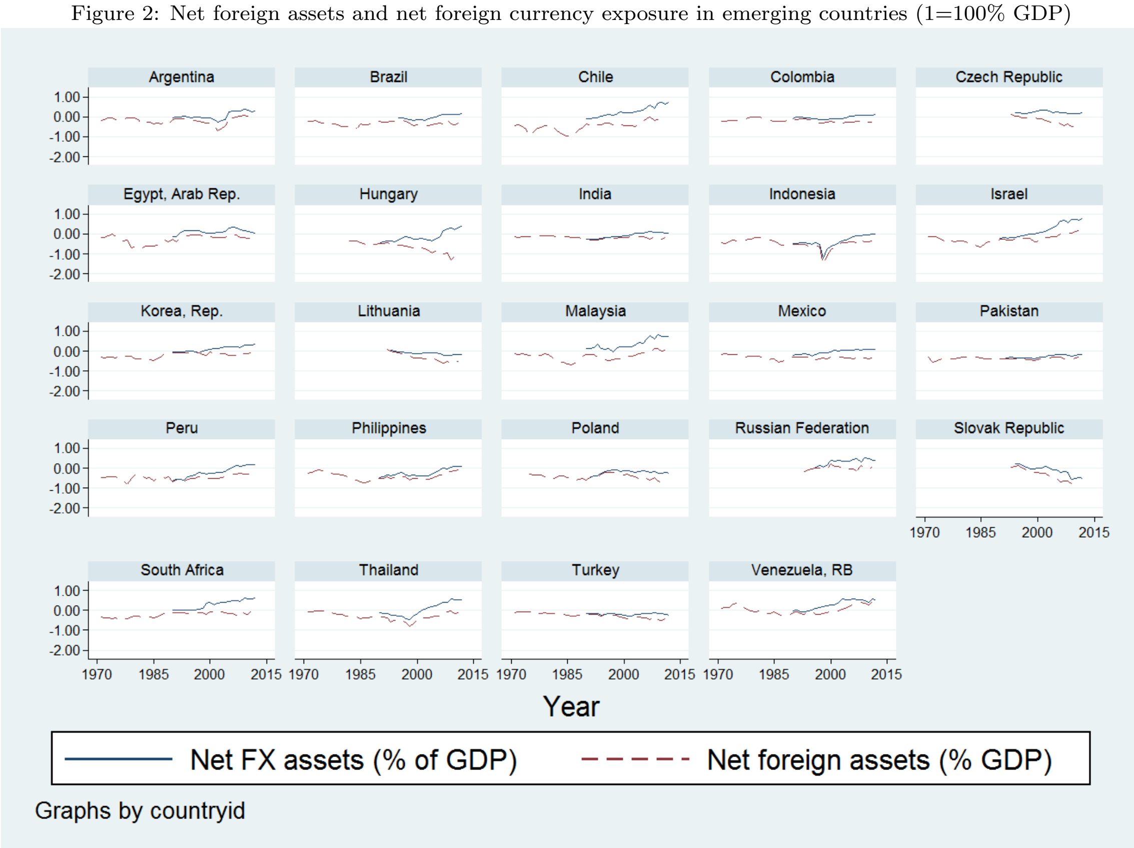
Figures

Figure 1: Net foreign assets and net foreign currency exposure in transition countries (1=100% GDP)



Izvor: Bénétrix et al. (2015); Lane and Milesi-Ferretti (2007)

Figure 2: Net foreign assets and net foreign currency exposure in emerging countries (1=100% GDP)



Izvor: Bénétrix et al. (2015); Lane and Milesi-Ferretti (2007)

Figure 3: Number of observations per regime in the model 3 of the estimated equation 3