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MONETARY POLICY TRILEMMA, INFLATION TARGETING AND GLOBAL FINANCIAL CRISIS

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ABSTRACT

We empirically investigate the validity of the monetary policy trilemma postulation for emerging market (EME) and advanced (AE) economies under different exchange rate and monetary policy regimes before and after the recent global financial crisis (GFC). Consistent with the dilemma proposition, domestic interest rates are determined by global financial conditions and the FED rate even under floating exchange rate regimes (ERR) in the long-run. The impact of the FED rates is higher in EME than AE and EME are much more sensitive to global financial cycle under managed than floating ERR. The spillover from the FED rate substantially increases after the GFC in EME with floating ERR and AE. The results from the monetary policy reaction functions based on equilibrium correction mechanism specifications suggest that domestic interest rates respond to inflation and output gaps especially under inflation targeting (IT) in the short-run. The response to inflation gap tends to be smaller in IT AE after the GFC.

Key words: Exchange rate regimes, Global financial crisis, Inflation targeting, Monetary policy, Policy trilemma

JEL Classification: E50, E52, F30, F33, F42, F65

I. INTRODUCTION

According to the Mundell–Fleming impossible trinity (trilemma), countries cannot implement an independent monetary policy towards domestic goals in the presence of a fixed exchange rate regime (ERR) under free capital mobility. The recent studies, on the other hand, often find that an independent monetary policy is not feasible for a financially integrated economy even under a flexible ERR. Rey (2015, p.3), for instance, argues that, for small open economies, under the emergence of a global financial cycle, "independent monetary policies are possible if and only if the capital account is managed, directly or indirectly via macroprudential policies". Consequently, instead of trilemma, these countries face with a dilemma between independent monetary policy and free capital mobility. Rey (2016) finds that the dilemma is the case also for inflation targeting (IT) countries with large financial markets and flexible ERR. The main findings of Rey (2015, 2016) are supported by Edwards (2015), Hofmann and Takáts (2015), Taylor (2013, 2016) and Caputo and Herrera (2017). In contrast, Aizenman *et al*., 2016; Bekaert and Mehl, 2017; Klein and Shambaugh, 2015 are among the recent studies reporting evidence supporting the trilemma postulation.

Global financial and monetary conditions are amongst the important determinants of borrowing costs (Gonzales-Rozada and Levy-Yeyati, 2008; Özatay *et al*., 2009) and thus growth (Kose *et al.*, 2012; Erdem and Özmen, 2015) in emerging and developing (EME) economies;). Thus, it may not be surprising to observe that monetary policies of such economies are not invariant to changes in global financial conditions and interest rates. The seminal paper by Clarida, et al., (1998), indeed, provides a New Keynesian theoretical model and an empirical support for three advanced economies (UK, France and Italy) for the role of foreign interest rates in forward looking Taylor rules.

The literature often uses the degree of a link between domestic and advanced country (mostly the USA) interest rates (e.g. Frankel *et al*., 2004; Obstfeld *et al*., 2005; Aizenman *et al*., 2016) or a link between domestic interest rates and global financial conditions (Rey, 2015) to assess the validity of the trilemma proposition.

The empirical literature, however, often ignores monetary policy reactions to domestic inflation and output gaps. This may be seriously misleading as the estimated equations may be contaminated and biased due to such omitted relevant variables especially under an IT policy regime. In this context, Edwards (2015), Klein and Shambaugh (2015), Obstfeld (2015), Hofmann and Takáts (2015) and Caputo and Herrera (2017) are amongst the growing number of recent studies considering also some domestic variables including inflation and output in assessing the validity of the trilemma hypothesis. The literature often implicitly maintains that the international interest rate linkages are invariant to the recent global financial crisis (GFC) and the consequent unconventional monetary policies. In this paper, we consider also the cases that the magnitude of the interest rate spillovers from the base country (US) may depend not only on prevailing *de facto* ERR, monetary policy framework (IT) and country groupings (AE and EME) but also on the widespread implementation of unconventional monetary policies during and after the GFC.

The plan for the rest of the paper is as follows. Section II presents a brief literature review. Section III is presents our empirical results by using quarterly data for a panel of relatively large number of EME and AE. Differing from a considerable number of recent studies, our sample does not contain data for Eurozone countries (EZ) after they adopt Euro. Although our results are robust to this sample selection, we prefer to do this as the inclusion of EZ with fixed ERR may be "problematic" (Ilzetzki, *et al*., 2017) because their joint currency float internationally and policy interest rates are determined by the European Central Bank. In Section III.1, we estimate the long-run external determinants of domestic interest rates for different ERR both for EME and AE. Section III.2 considers the impact of the GFC on the international interest rate linkages. Section III.3 investigates the trilemma postulation for countries implementing an IT policy regime. To this end, we first estimate monetary policy reaction equations. This section also presents equilibrium correction mechanism equations for the evolution of domestic interest rates which takes into account output and inflation gaps along with deviations from the long-run

relationships between domestic and base country interest rates and global financial conditions. Finally, Section IV concludes.

II. TRILLEMMA OR DILEMMA? A BRIEF LITERATURE REVIEW

Under the Mundell–Fleming's classic "trilemma" or "impossible trinity", international financial integration (IFI) precludes an effective independent monetary policy under a managed or fixed ERR. Consequently, an economy can have at most two out of IFI, managed ERR and independent monetary policy. The recent literature, on the other hand, often suggests that this trilemma morphed into a "dilemma" as, under IFI, the ability of countries to determine domestic interest rates independently towards domestic goals even under a flexible ERR. Specifically, Rey (2015, 2016) suggests that the global financial cycle has turned the trilemma into a dilemma.

In accord with the financial cycle postulation, global financial and monetary conditions are often found to be amongst the important determinants of borrowing costs (Gonzales-Rozada and Levy Yeyati, 2008; Özatay *et al*., 2009; Miranda-Agrippino and Rey, 2015; Özmen and Doğanay-Yaşar, 2016) and thus growth Kose *et al.,* 2012; Erdem and Özmen, 2015) in emerging and developing economies (EME). Consequently, a finding suggesting that global financial conditions often dominate domestic macroeconomic conditions under IFI may not be surprising. The recent results by Erdem and Özmen (2015) and Obstfeld *et al*., (2017) suggest that the impacts of external real and financial shocks on domestic variables are significantly greater under fixed ERR relative to more flexible ERR. According to Dedola *et al*., (2017), on the other hand, neither the ERR nor financial openness appear to matter much for the response of a number of macroeconomic and financial variables to US monetary policy shocks in advanced (AE) and EME.

The literature often uses the degree of a link between domestic and global (mostly the USA) interest rates (Frankel *et al*., 2004; Obstfeld *et al*., 2005; Aizenman *et al*., 2016) or a link between domestic interest rates and global financial conditions (Rey, 2015) to assess the validity of the trilemma proposition. The results by Obstfeld *et al*., (2005), based on data for a relatively large number of countries over

130 years, support a modified view of the trilemma proposition such that the scope for monetary policy independence increases with ERR flexibility and capital controls. Bekaert and Mehl (2017) considers annual data from 1855 to 2014 for 17 AE and finds that, consistent with the trilemma hypothesis, under high IFI, interest rate pass-through from the US is much higher under fixed ERR than flexible ERR. In the same vein, Aizenman, *et al*., (2016) provides evidence supporting that ERR affect the extent of sensitivity to changes in financial conditions or policies in AE. Aizenman, *et al*., (2010) proposes an empirical time-varying measure for the configuration of the dilemma for a large number of EME and AE and finds that the trilemma variables in EME have converged towards intermediate levels especially by the use of international reserves as a buffer. Wu (2015) estimates a *de facto* monetary policy activism index for 18 OECD economies and finds that inefficient trilemma configurations are more likely for economies with higher financial stress. According to the results by Klein and Shambaugh (2015), extensive capital controls or floating ERR enable a country to have monetary autonomy. Edwards (2015) uses weekly data for the 2000-2008 period from three Latin American countries with flexible ERR – Chile, Colombia and Mexico – and finds that policy changes by the FED are substantially transmitted into domestic policy interest rates.

The empirical literature often does not explicitly take into account monetary policy reactions to domestic inflation and output gaps under inflation targeting (IT). This may be seriously misleading as the estimated equations may be contaminated and biased due to such omitted relevant variables especially under an IT policy regime. Clarida, *et al*., (1998), indeed, provides a pioneering theoretical and empirical study stressing the relevance of Taylor rules along with foreign interest rates in monetary policies of three AE (UK, France and Italy). Taylor (2013) argues that many central banks include other central banks' policy rates in their rules during the recent period especially after the global financial crisis (GFC) of 2008-2009. Obstfeld (2015) augments interest rate equation with some country specific factors including domestic output growth and inflation and finds that there are significant interest rate spillovers in long-term rates, but not in short-term rates. Hofmann and

Takáts (2015), on the other hand, finds significant interest rate (short-term, long term and policy) spillovers from the U.S. to EME and smaller AE under both fixed and floating ERR. Hofmann and Takáts (2015), also finds that domestic macroeconomic variables including domestic output gap and inflation are important in determining domestic interest rates. Caputo and Herrera (2017) is amongst the limited number of studies considering both output and inflation gaps in IT countries in investigating the dilemma postulation. The results by Caputo and Herrera (2017) suggest that inflation targeting AE and EME respond to movements in the FED rates along with domestic output and inflation gaps. In the same vein, Rey (2016) finds that the dilemma is the case also for IT countries (Canada, New Zealand, Sweden and UK) with large financial markets and flexible ERR.

III. THE DETERMINANTS OF INTEREST RATES: EMPIRICAL RESULTS

III.1. Exchange Rate Regimes and External Determinants of Interest Rates

A useful starting point to investigate the trilemma proposition is the following benchmark equation (Obstfeld *et al*., 2005; Obstfeld, 2015):

$$R^d_{it} = a_0 + a_1 R^b_t + u_{it} \quad (1)$$

where R^d is the domestic interest rate, R^b is the interest rate of the base country (the US).

According to (1), R^d is solely determined by R^b in the long-run and thus there cannot be an independent monetary policy. Under international financial integration (IFI) and a fixed ERR $a_1 = 1$. In the other extreme, according to the trilemma proposition, $a_1 = 0$ implies full independence from monetary policy which is the case under floating ERR or financial autarky. A significantly positive a_1 under a flexible ERR supports the dilemma hypothesis.

In accord with the financial cycle postulation (Rey, 2015), global financial conditions are often found to be amongst the important determinants of borrowing costs and thus interest rates in EME and DE. The Chicago Board Options Exchange's equity option volatility index (VIX) is often used as a proxy for global

liquidity conditions (Gonzales-Rozada and Levy Yeyati, 2008; Özatay *et al*., 2009) and the state of the financial cycle (Rey, 2015; Miranda-Agrippino and Rey, 2015; Obstefeld, 2015). Consequently, we augment (1) with log of VIX (vix):

$$R^d_{it} = a_0 + a_1 R^b_t + a_2 vix_t + u_{it} \quad (2)$$

A decrease in VIX is associated with a greater risk-appetite or better global financial conditions. As convincingly argued by Obstfeld (2015), changes in global financial conditions may lead to a change in both the domestic and the base country interest rates in the same direction. Therefore, the omission of VIX may lead to R^b coefficient estimate to be biased[1].

Table 1 presents the results from the estimation of equation (2) for the whole sample, AE and EME by employing panel fixed effects procedure. In all the estimated equations, the natural log. of interest rates (INT) are used such that R^d = log(1+INT/100). In (2), R^d is the domestic policy or short-term interest rate and R^b is the effective FED funds rate[2]. Our unbalanced quarterly panel data sample contains 22 advanced (AE) other than the US and 39 emerging/developing (EME) economies spanning the period between 1990:1 and 2016:2. The choice of countries and the sample are basically determined by data availability[3]. Our sample does not contain the observations belonging to the Eurozone (EZ) countries after their adoption of the Euro. This is because, as noted also by Ilzetzki, *et al*., (2017), the (policy) interest rates for these countries are indeed the same as they are determined by the European Central Bank. As argued by Obstfeld (2017), the inclusion of EZ countries with fixed

[1] However, the direction and the magnitude of the bias might be different for AE. This is because, an increase in VIX, for instance, may lead to capital outflows from EME to AE due to a flight to safety concern. In such a case, the bias may be negative of insignificant.

[2] Domestic interest rates are policy rates for most of the IT countries. For the rest of the countries domestic interest rates are short-term (three-month) or money market rates. The data for domestic interest rates are from the IMF International Financial Statistics (IFS) data base and national central bank web sites. The data for the effective FED rate are from Board of Governors of the Federal Reserve System (US). The VIX data are quarterly averages of daily data.

[3] Table A1 of the Appendix presents the country list and estimation period. The VIX data are available only after 1990. Therefore, the effective estimation sample for the equations containing VIX is 1990-2016. This choice of the sample is consistent is Obstfeld (2015, p. 15) arguing that the post-1990 sample "captures the regularities that apply during the recent period of high and growing financial globalisation".

ERR may be "problematic" also because of the fact that these countries' joint currency float internationally.

Table 1. The External Determinants of Domestic Interest Rates			
Country Grouping	All	EME	AE
Equation	1.1	1.2	1.3
R^b_t	1.205 (0.033)**	1.228 (0.047)**	0.671 (0.031)**
vix_t	0.0065 (0.0021)**	0.020 (0.003)**	-0.017 (0.002)**
constant	0.020 (0.007)**	-0.012 (0.009)	0.076 (0.006)**
Statistics	R^2 = 0.45 F = 61.2 N=60 NT=4647 Pedr= -8.24^{+++} IPS = -5.98^{+++} LLC = -3.67^{+++}	R^2 = 0.41 F = 51.8 N=38 NT=2986 Pedr=-7.01^{+++} IPS = -7.47^{+++} LLC = -5.34^{+++}	R^2 = 0.58 F = 99.8 N=22 NT=1661 Pedr=-1.55^{++} IPS = -4.07^{+++} LLC = -4.24^{+++}
Notes: The values in parentheses are robust standard errors. N and NT are, correspondingly, the numbers of countries and observations for the sample. ** denotes significance at 5% level. Pedr represents the panel ADF test statistics by Pedroni (2004) to test the null hypothesis of "no panel co-integration". IPS and LLC are the Im, Pesaran and Shin (2003) and Levin, Lin and Chu (2002) are, respectively, the panel unit root tests for the stationarity of the residuals from the related equations. The optimum lag lengths for these tests are determined by Schwarz Information Criteria (SIC). $^{+++}$ and $^{++}$, respectively, indicate that null of "no panel co-integration" is rejected at the 1% and 5 % levels.			

Table 2. *Unit Root Tests*		
Variables	*LLC*	
	Levels	*First Differences*
r^d_{it}	-0.71[2]	-6.92[2]**
π^g_{it}	26.7[1]**	-53.9[0]**
y^g_{it}	-10.3[1]**	-46.3[1]**
Variables	*ADF*	
vix_t	*-2.25[4]*	*-4.37[4]***
r^b_t	*-1.72[4]*	*-4.41[4]***
LLC and ADF are the Levin, Lin and Chu (2002) panel unit root and augmented Dickey-Fuller tests, respectively. ** denotes the rejection of the unit root null at the 5% level. The values in brackets [.] are the lag lengths determined by SIC.		

Table 2 reports the results of Levin, *et al.*, (2002) panel unit root test for R^d_{it} along with augmented Dickey-Fuller tests for vix_t and R^b_t. The results[4] suggest that all these variables are integrated of order 1 (I(1)). The results from the Pedroni (2004), Im, *et al*., (2003) and Levin, *et al*., (2002) tests presented by Table 1 suggest that all the equation residuals are stationary. Given that R^d_{it}, R^b_t and vix_t are I(1), the stationary of the residuals implies cointegration between these variables.

The results by Table 1 strongly suggest that domestic interest rates of both EME and AE significantly respond to the base country interest rate and global financial conditions. In particular, the long-run response of domestic interest rate to the Fed rate is around unity for EME. The impact of the foreign rate is about the twice in EME compared to AE. An increase in VIX (a decrease in the risk appetite in international financial markets leading to worsening global liquidity conditions) leads to an increase in domestic interest rates in EME. The negative and significant VIX coefficient for the AE sample, on the other hand, suggests that the opposite is the case for AE. This may be explained by the capital outflows from EME to AE due to flight to quality/safety concerns during turmoil phases of the international financial cycle.

Table 3 presents the estimation results for managed and floating exchange rate regimes (ERR) based on the coarse-grid *de facto* classification by Ilzetzki, *et al*., (2017) (IRR). IRR classifies ERR on a 1–4 scale with higher values denoting more flexible ERR. In this specification, 1, 2, 3 and 4, respectively, corresponds to hard pegs (full dollarization, currency boards and *de facto* pegs), limited flexibility (crawling peg or crawling band that is narrower than or equal to +/− 2 %), managed floating and freely floating ERR[5]. Following IRR, we classify categories 1 and 2 as managed ERR and categories 3 and 4 as floating ERR.

The results from Table 3 suggest that the sign and magnitude of the US policy rate into domestic rates are almost invariant to the prevailing ERR in both EME and

[4] The unit root tests for the subsamples of countries yielded essentially the same results and not reported to save the space.

[5] The IRR notes that classifying episodes of severe macroeconomic instability with very high inflation and exchange rate change as floating, intermediate or pegged may be misleading as they could be incorrectly attributed to the ERR. IRR classifies these episodes as "freely falling" (FF). We exclude FF and dual market episodes.

AE. Consequently, consistent with the dilemma postulation, ERR flexibility appears to be ineffective in insulating central bank policy actions of countries from the US monetary policy. The impact of the US rates tends to be substantially higher on the domestic rates of EME than AE. ERR matters for the impact of global financial conditions represented by VIX. EME appear to be substantially more sensitive to the global financial cycle under managed than floating ERR. Under global financial stress, capital outflows from EME seem to prefer AE with more exchange rate stability as suggested by the negative VIX coefficient under managed ERR (Eq. 3.3).

Table 3. Exchange Rate Regimes and the External Determinants of Domestic Interest Rates

Country Grouping	EME		AE	
Exchange Rate Regime	Managed	Floating	Managed	Floating
Equation	3.1	3.2	3.3	3.4
R^b_t	1.002 (0.045)**	1.112 (0.073)**	0.631 (0.075)**	0.760 (0.029)**
vix_t	0.010 (0.003)**	0.023 (0.004)**	-0.043 (0.004)**	0.002 (0.002)
constant	0.018 (0.008)**	-0.019 (0.013)**	0.161 (0.011)**	0.015 (0.006)**
Statistics	R^2 = 0.60 F = 81.0 N=30 NT=1718 Pedr= -4.59^{+++} IPS = -4.35^{+++} LLC = -2.62^{+++}	R^2 = 0.42 F = 36.5 N=22 NT=1162 Pedr= -4.38^{+++} IPS = -5.51^{+++} LLC = -6.50^{+++}	R^2 = 0.52 F = 44.5 N=16 NT=714 Pedr= -0.50 IPS = -0.43 LLC = -2.11^{+++}	R^2 = 0.67 F = 161.4 N=10 NT=871 Pedr= -0.84 IPS = -3.95^{+++} LLC = -1.85^{++}

Notes: The values in parentheses are robust standard errors. N and NT are, correspondingly, the numbers of countries and observations for the sample. ** denotes significance at 5% level The optimum lag lengths for the unit root tests are determined by SIC. $^{+++}$ indicates that null of no co-integration is rejected at the 1% level.

III.2. Global Financial Crisis and External Determinants of Interest Rates

The literature empirically investigating the trilemma proposition often maintains that the impact of the US interest rate on the domestic rates is invariant to the shift to unconventional monetary policies in many countries including the US in the aftermath of the recent global financial crisis (GFC) of 2008-2009. The sharp decline of policy interest rates in the USA in response to very high (negative) output and inflation gaps with the GFC may be transmitted to EME and other AE leading to

higher interest rate interdependence. To investigate this important issue, we estimate eq. 2 separately for the periods before and after (2008q1) the GFC. The results[6] for AE under floating ERR suggest that the and impact of the FED rates substantially increases (from around 0.6 to 1.4) after the GFC. A similar result, albeit not much substantial as for the AE, is found for EME with floating ERR. The pass-through tends to be smaller for EME under managed ERR.

Inflation targeting central banks following a rule towards domestic ends may be expected to be enable to conduct an independent monetary policy as suggested by the trilemma proposition. Taylor (2013), in this vein, argues that the main source of monetary policy spillovers is the discretionary deviations of central banks from their own reaction functions or monetary policy rules during the recent period especially after the GFC.

Table 4. Global Financial Crisis and Domestic Interest Rates

Country Grouping	AE		EME			
ERR	Floating		Managed		Floating	
Sample	Before GFC	After GFC	Before GFC	After GFC	Before GFC	After GFC
Equation	4.1	4.2	4.3	4.4	4.5	4.6
R^b_t	0.580 (0.047)**	1.370 (0.114)**	0.834 (0.072)**	0.474 (0.119)**	0.588 (0.133)**	0.975 (0.106)**
vix_t	-0.0036 (0.0026)	0.011 (0.002)**	0.012 (0.004)**	0.009 (0.002)**	0.056 (0.007)**	0.014 (0.002)**
constant	0.037 (0.007)**	-0.014 (0.007)**	0.023 (0.011)**	0.016 (0.007)**	-0.085 (0.022)**	-0.001 (0.006)**
Statistics	R^2 = 0.62 F = 85.5 N=10 NT=583 Pedr=-1.95^{++} IPS = -2.05^{+++} LLC = -2.85^{+++}	R^2 = 0.79 F = 107.2 N=9 NT=288 Pd=-2.96^{+++} IPS= -7.16^{+++} LLC=-5.29^{+++}	R^2 = 0.61 F = 57.2 N=30 NT=1164 Pedr=-3.82^{+++} IPS= -2.53^{+++} LLC=-.40^{+++}	R^2 = 0.70 F = 59.3 N=20 NT=554 Pedr=-1.56^{++} IPS= -6.60^{+++} LLC=-6.02^{+++}	R^2 = 0.54 F = 29.4 N=21 NT=567 Pedr=-1.68^{++} IPS= -3.82^{+++} LLC=-4.30^{+++}	R^2 = 0.73 F = 69.6 N=21 NT=595 Pedr=-1.73^{++} IPS= -2.89^{+++} LLC=-3.35^{+++}

Notes: Robust standard errors in parentheses. N and NT are, correspondingly, the numbers of countries and observations for the sample. ** denotes significance at 5% level. The lag lengths for the unit root tests are determined by SIC. $^{+++}$ and $^{++}$ indicate that null of "no panel co-integration" is rejected, respectively, at the 1% and 5% levels.

[6] For the AE sample, most of the countries continued to implement a managed ERR by joining the Eurozone (EZ). With Canada, Iceland and the UK implementing a floating ERR, we are left only with Denmark with a managed ERR both before and after the GFC. Therefore, the impact of the GFC is not investigated for AE with a managed ERR for a sample excluding EZ.

We estimate eq. 2 separately for inflation targeting (IT) and non-IT episodes[7] for AE and EME both for the pre and post-GFC periods. Table 5 reports the results for AE. As the bulk of the non-IT countries implements a managed ERR such as the EZ members, we consider the data only for IT AE. Before the GFC, global financial conditions appear to be insignificant for the IT AE. Consistent with the earlier result for AE with floating ERR, this may be interpreted as neither flight to safety nor the risk appetite impact dominates the other before the GFC. After the GFC, on the other hand, improvements in global financial conditions (a decrease in VIX) often combined with quantitative easing allow central banks in AE to pursue lower interest rates. The pass through from the US interest rates, however, substantially jumps to a very high level (from around 0.5 to 1.7) after the GFC.

Table 5. Inflation Targeting, GFC and Interest Rates: Advanced Economies			
Sample	Before GFC		After GFC
Equation	5.1	5.2	5.3
R^b_t	0.530 (0.044)**	0.528 (0.044)**	1.691 (0.134)**
vix_t	0.002 (0.002)		0.013 (0.003)**
constant	0.028 (0.007)**	0.035 (0.002)**	-0.017 (0.008)**
Statistics	R^2 = 0.64 F = 77.4 N=7 NT=356 Pedr=-1.80^{++} IPS = -2.57^{+++} LLC = -3.34^{+}	R^2 = 0.64 F = 88.3 N=7 NT=356 Pedr=-2.16^{+++} IPS = -2.36^{+++} LLC = -3.24^{+++}	R^2 = 0.79 F = 107.3 N=7 NT=231 Pedr=-1.81^{++} IPS = -3.74^{+++} LLC = -3.16^{+++}
Notes: Robust standard errors in parentheses. N and NT are, correspondingly, the numbers of countries and observations. ** denotes significance at 5% level. The lag lengths for the unit root tests are determined by SIC. $^{+++}$ indicates that null of "no panel co-integration" is rejected at the 1% level.			

The results for EME are presented by Table 6. As for the IT AE the impact of the US rate substantially increases in IT EME after the GFC. The estimated interest rate spillover coefficient is only 0.25 before the GFC. For non-IT EME economies, on the other hand, the impact of the US rate remains almost the same after the GFC.

[7] The list and dates of IT episodes are from Ilzetzki, et al., (2017) and Caputo and Herrera (2017). Table A2 presents the list and dates.

A similar case tends to apply also for the response to the global liquidity conditions both for IT and non-IT EME.

The analyses so far does not take into account the impact of domestic conditions on the evolution of interest rates. Whilst such an approach is consistent with one strand of the literature including Frankel *et al*., 2004; Obstfeld *et al*., 2005; Aizenman *et al*., 2016, it may be misleading depending on the degree and sign of the correlations between the external and domestic variables. In the following section, we thus proceed with the estimation of models explicitly taking into account monetary policy rules towards domestic ends under IT.

Table 6. Inflation Targeting, GFC and Interest Rates: Emerging Economies

Monetary Policy	IT		Non IT	
Sample	Before GFC	After GFC	Before GFC	After GFC
Equation	6.1	6.2	6.3	6.4
R^b_t	0.247 (0.066)**	1.222 (0.105)**	0.687 (0.091)**	0.417 (0.130)**
vix_t	0.030 (0.004)**	0.015 (0.002)**	0.022 (0.005)**	0.007 (0.002)**
constant	-0.020 (0.011)**	-0.014 (0.006)**	0.016 (0.014)	0.027 (0.008)**
Statistics	R^2 = 0.80 F = 93.2 N=17 NT=435 Pedr=-2.65^{+++} IPS = -2.56^{+++} LLC = -5.82^{+++}	R^2 = 0.75 F = 87.6 N=17 NT=552 Pedr=-1.85^{++} IPS = -4.28^{+++} LLC = -3.00^{+++}	R^2 = 0.55 F = 46.1 N=36 NT=435 Pedr=-5.13^{+++} IPS = -4.28^{+++} LLC = -2.32^{+++}	R^2 = 0.65 F = 51.4 N=20 NT=602 Pedr=1.58 IPS = -3.89^{+++} LLC = -7.56^{+++}

Notes: Robust standard errors in parentheses. N and NT are, correspondingly, the numbers of countries and observations. ** denotes significance at 5% level. The lag lengths for the unit root tests are determined by SIC. $^{+++}$ indicates that null of no co-integration is rejected at the 1% level.

III.3. Inflation Targeting and the Trilemma

Global financial and monetary conditions are often found to be amongst the important determinants of growth in EME (Kose *et al.*, 2012; Erdem and Özmen, 2015). Consequently, it may not be surprising to observe that monetary policies of EME are not invariant to changes in global financial conditions and interest rates. Such a policy may be consistent with the trilemma proposition as the interest rates, indeed, respond to domestic conditions. In the same vein, according to Taylor (2016, p.241), "the empirical correlations" supporting the dilemma hypothesis "are likely

spurious, stemming from a substantial deviation from rule-based monetary policy in many countries". To investigate this issue along with the trilemma postulation, we first consider a Taylor-type monetary reaction function for a flexible inflation targeting economy:

$$\Delta R^{d}_{it} = \beta_0 + c_1\pi^{g}_{it} + c_2 y^{g}_{it} + v_{it} \quad (3)$$

where π^g and y^g are, respectively, inflation and output gaps.

Table 7 presents the panel fixed effects estimation results for AE and EME explicitly implementing an IT policy regime. In the estimations, output gap (y^g) and inflation gap (π^g) are, respectively, defined as deviations of seasonally adjusted real GDP (log.) and annualised inflation rates[8] from their Hodrick-Prescott cycles. By construction y^g and π^g are both stationary (see also Table 2), therefore we consider ΔR^d which is also stationary. In this context, the coefficients in (3) can be interpreted as short-run policy responses. This is consistent with the New Keynesian framework which maintains that monetary policy can be effective on real variables only in the short-run.

Table 7. Inflation Targeting and GFC

Sample	IT AE		IT EME	
	Before GFC	After GFC	Before GFC	After GFC
Equation	7.1	7.2	7.3	7.4
π^g_{it}	0.047 (0.026)**	-0.0020 (0.037)	0.106 (0.018)**	0.007 (0.018)
y^g_{it}	0.109 (0.019)**	0.093 (0.032)**	0.105 (0.019)**	0.099 (0.012)**
constant	-0.0005 (0.0003)**	-0.0013 (0.0005)**	-0.002 (0.0005)**	-0.001 (0.0003)**
Statistics	R^2 = 0.10 F = 4.8 N=7 NT=355	R^2 = 0.05 F = 1.33 N=7 NT=228	R^2 = 0.16 F = 4.8 N=17 NT=463	R^2 = 0.13 F = 4.3 N=17 NT=536

Notes: Robust standard errors in parentheses. N and NT are, correspondingly, the numbers of countries and observations. ** denotes significance at 5% level. The lag lengths for the unit root tests are determined by SIC. $^{+++}$ indicates that null of no co-integration is rejected at the 1% level.

For both the AE and EME, domestic interest rates respond positively to output and inflation gaps under IT before the GFC. EME appear to put almost the same

[8] The inflation data are from IMF-IFS. The quarterly real GDP data are from IMF-IFS and OECD. All the GDP series are seasonally adjusted using X12 ARIMA method.

weight on inflation and output gaps whilst the weight of the latter tends to be higher for IT AE. After the GFC, on the other hand, both AE and EME take into account only the output gap in determining interest rates which is, indeed, consistent with the severe output contraction especially in the earlier phase of the crisis.

The recent literature often augments (1) or (2) with some country specific factors:

$$R^{d}_{it} = a_0 + a_1 R^{b}_{t} + a_2 vix_t + bX'_{it} + u_{it} \quad (4)$$

where X′ is the transpose of the vector of domestic variables. When the set of domestic variables in (3) is defined to contain inflation and output gaps, we obtain the following model:

$$R^{d}_{it} = a_0 + a_1 R^{b}_{t} + a_2 vix_t + b_1 \pi^{g}_{it} + b_2 y^{g}_{it} + v_{it} \quad (5)$$

An important problem with the estimation of (5), as already presented by Table 2, is the different integration levels of the variables such that R^{d}_{it}, R^{b}_{t} and vix_t are I(1), whilst π^{g}_{it} and y^{g}_{it} are stationary (I(0)). The results from Table 1, however, suggest that R^{d}_{it}, R^{b}_{t} and vix_t are co-integrated. For these reasons, we proceed with an equilibrium correction specification[9].

To estimate a panel equilibrium correction mechanism (ECM) representation which allows us to assess the adjustment mechanism to deviations from the long-run equilibrium relationship along with the short-run dynamics, we consider the following specification:

$$\Delta R^{d}_{it} = c_0 + d_1 EC_{it-1} + d_1 \Delta vix_t + d_2 \Delta R^{b}_{it} + d_3 \pi^{g}_{it} + d_4 y^{g}_{it} + v_{it} \quad (6)$$

where Δ is the first difference operator and EC (equilibrium correction term) are the stationary residuals from the corresponding cointegrating equations in Tables 5 and 6.

Equations (8.1) and (8.2) in Table 8 presents the estimation results for the IT AE with EC are, correspondingly, defined as the residuals from Eqs. (5.2) and (5.3). The specifications maintain that domestic interest rates are determined by the US rates and global financial conditions (after the GFC for IT AE) in the long-run.

[9] Edwards (2015, p. 777) notes that, equilibrium correction mechanism specifications are "standard in the literature on interest rate dynamics". Frankel (2004), Obstfeld and Shambaugh (2005), Edwards (2015), Obstfeld (2015) are among the studies favouring to use differences of interest rates often "to avoid spurious regression problems" (Obstfeld, 2015, p.14).

Consequently, we maintain that the trilemma proposition does not hold in the long-run for both AE and EME. The significant and negative EC coefficients suggest that domestic interest rates adjust to deviations from the long-run equilibrium relationships. According to the results, domestic interest rates respond to the FED rate also in the short-run. As in the long-run, the short-run impact of the US rate substantially increases with the GFC in IT AE. The short-run spillovers from the FED rate and global financial cycle, however, tends not to change significantly after the GFC in the IT EME.

Compared to the results from the equations in Table 7, the inflation gap coefficients considerably increase with the inclusion of the external variables especially for the IT AE. The inflation gap coefficient, indeed, becomes statistically significant for both AE and IT for the post-GFC sample. This may suggest that, the estimated inflation gap coefficients in the equation excluding the foreign variables are downward biased. The possible negative correlation between the foreign interest rate and domestic inflation gap leading to the downward bias may not be surprising as an increase in the former spillovers to the domestic rate causing a decline in the inflation gap. The short-run impact of the omission of the external variables on the output gap coefficient, however, tends to be negligible.

Table 8. Inflation Targeting, GFC and the Trilemma: ECM Results				
	IT AE		IT EME	
Sample	Before GFC	After GFC	Before GFC	After GFC
Equation	8.1	8.2	8.3	8.4
EC_{t-1}	-0.123 (0.019)**	-0.268 (0.033)**	-0.203 (0.019)**	-0.147 (0.021)**
π^{g}_{it}	0.111 (0.024)**	0.211 (0.037)**	0.137 (0.020)**	0.067 (0.020)**
y^{g}_{it}	0.094 (0.016)**	0.073 (0.029)**	0.045 (0.016)**	0.089 (0.013)**
ΔR^{b}_{t}	0.435 (0.056)**	1.213 (0.131)**	0.322 (0.085)**	0.417 (0.107)**
Δvix_t	0.0001 (0.0014)	-0.0005 (0.0015)	0.005 (0.002)**	0.005 (0.001)**
constant	-0.0003 (0.0002)	-0.0003 (0.0004)	-0.0011 (0.0004)	-0.0004 (0.0003)
Statistics	R^2 = 0.34 F = 15.7 N=7 NT=356	R^2 = 0.43 F = 14.3 N=7 NT=221	R^2 = 0.36 F = 10.9 N=17 NT=434	R^2 = 0.24 F = 7.46 N=17 NT=515
Notes: Robust standard errors in parentheses. N and NT are, correspondingly, the numbers of countries and observations. ** denotes significance at 5% level. The lag lengths for the unit root tests are determined by SIC. $^{+++}$ indicates that null of no co-integration is rejected at the 1% level.				

IV. CONCLUDING NOTES

Floating ERR are often advocated as shock-absorber since they enable economies to insulate them from external shocks including interest rates and global financial conditions even under international capital mobility. This insulation allows countries to implement independent monetary policies towards domestic ends under floating ERR. The recent literature, on the other hand, often finds that, instead of this monetary policy trilemma, economies face with a dilemma between an independent monetary policy and international capital mobility. The findings of this study provide support to the dilemma proposition under different monetary policy regimes both before and after the recent GFC.

For the whole sample, the choice of the ERR appears does not matter significantly for the magnitude of the spillovers from the external conditions for the long-run evolution of interest rates both in EME and AE. These impacts, however, considerably change after the recent GFC. Under floating ERR, the impact of the FED rates substantially increases in both AE and EME after the GFC. For the EME with managed ERR just the reverse tends to be the case. The evidence for the

floating ERR countries may not be surprising given the fact that major AE economies implemented unconventional monetary policies including the zero lower bound interest rates and quantitative easing in the aftermath of the GFC. EME and AE, experiencing negative output and inflation gaps with the GFC tend to follow a similar path for the determination of their interest rates.

The impact of the global financial cycle proxied by VIX (Rey, 2015), on the other hand, differs across country groupings and ERR. A decrease in the risk appetite in international financial markets and thus worsening global financial conditions leads to an increase in domestic interest rates in EME. EME appear to be substantially more sensitive to global changes in risk sentiment under managed than floating ERR. A worsening of global financial conditions leads to a decrease in domestic interest rates of AE with managed ERR. AE with floating ERR or implementing an IT regime, on the other hand, tend to respond positively to an increase in VIX after the GFC.

Global financial and monetary conditions are amongst the important determinants of growth and thus inflation and output gaps especially in EME. Consequently, it may plausibly be argued that, the response to the global financial cycle and the FED rate, indeed, represents independent monetary policies towards domestic ends. The significance of output and inflation gaps in the short-run monetary reaction equations for IT AE and EME lends a support for this trilemma interpretation. However, the results from the equilibrium correction specifications for these countries strongly suggest that domestic interest rates are also determined by deviations from the long-run relationship between interest rates and VIX along with output and inflation gaps. Therefore, the dilemma postulation appears to be the case not only in the long-run but also in the short-run. Inflation targeting, *per se*, provides some flexibility but not fully insulate economies from the spillovers from external financial and monetary conditions.

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Table A1. Country List and Estimation Sample Periods			
Emerging or Developing (EME)		Advanced (AE)	
Argentina	1991:2-2016:1	Australia	1990:3-2016:1
Bolivia	1995:1-2016:1	Austria	1990:1-2001:4
Brazil	1999:1-2016:1	Belgium	1990:1-2001:4
Bulgaria	1997:2-2016:1	Canada	1992:4-2016:1
Chile	1995:1-2016:1	Denmark	1990:1-2016:1
China	1990:1-2016:1	Finland	1990:1-2001:4
Colombia	1995:2-2016:1	France	1990:1-2001:4
Costa Rica	1990:1-2016:1	Germany	1990:1-2001:4
Croatia	1994:1-2016:1	Greece	1990:1-2001:4
Czech R.	1993:1-2016:1	Iceland	1990:1-2016:1
Dominican R.	2000:1-2016:1	Ireland	1990:1-2001:4
Ecuador	2001:3-2016:1	Italy	1990:1-2001:4
El Salvador	1995:1-2016:1	Japan	1990:1-2016:1
Estonia	1996:1-2016:1	Netherlands	1990:1-2001:4
Guatemala	1997:1-2016:1	New Zealand	1990:1-2016:1
Honduras	2001:1-2016:1	Norway	1990:1-2016:1
Hungary	1991:1-2016:1	Portugal	1990:1-2001:4
India	1990:1-2016:1	Singapore	1990:1-2013:4
Indonesia	1991:1-2016:1	Spain	1990:1-2001:4
Israel	1992:1-2016:1	Sweden	1990:1-2016:1
Jamaica	1998:1-2016:1	Switzerland	1990:1-2016:1
Latvia	1998:1-2016:1	UK	1990:1-2016:1
Malaysia	1997:1-2016:1		
Mexico	1990:1-2016:1		
Morocco	1994:1-2016:1		
Paraguay	1991:1-2016:1		
Peru	1996:1-2016:1		
Philippines	2001:4-2016:1		
Poland	1996:2-2016:1		
Romania	2002:1-2016:1		
Russian F.	1997:4-2016:1		
S. Africa	1990:1-2016:1		
Slovak R.	1995:3-2016:1		
Slovenia	2002:1-2016:1		
S. Korea	1991:1-2016:1		
Thailand	2000:2-2016:1		
Turkey	2002:1-2016:1		
Uruguay	2000:1-2016:1		

Table A2. Inflation Targeting Countries			
Emerging or Developing (EME)		Advanced (AE)	
Country	Date of Implementation	Country	Date of Implementation
Brazil	1999:3	Australia	1993:3
Chile	1999:3	Canada	1991:1
Colombia	1999:4	Iceland	2001:1
Czech R.	1998:1	Norway	2001:2
Guatemala	2005:3	New Zealand	1989:3
Hungary	2001:3	Sweden	1995:3
Indonesia	2005:2	UK	1992:2
Israel	1997:3		
Mexico	2001:3		
Peru	2002:2		
Philippines	2002:1		
Poland	1999:1		
Romania	2005:3		
S. Africa	2000:1		
S. Korea	1998:3		
Thailand	2000:2		
Turkey	2002:1		