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Monetary trilemma, dilemma, or something in between?

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Abstract

This paper revisits the monetary "trilemma" versus "dilemma" debate by examining empirically interest-rate policy independence for a large sample of both advanced and developing countries over the period 1973–2014. We broadly concur with the growing body of literature that suggests that the trilemma still holds, emphasizing the important insulating effects afforded by exchange-rate flexibility. However, as with Han and Wei (2018), we also document the existence of an asymmetric pattern or 2.5-lemma between the trilemma and dilemma; though, in contrast to them, we find there seems to be evidence of a "fear of capital reversal" rather than a "fear of appreciation." We further find that holding higher levels of foreign reserves may help countries regain a degree of monetary-policy autonomy.

KEYWORDS
asymmetry, capital controls, dilemma, exchange-rate regime, trilemma

1 | INTRODUCTION

For many economies, large-scale cross-border capital flows have been a double-edged sword. Since the 1990s, debates have been centered on whether global capital mobility is welfare-enhancing or whether it has imparted greater instability to the national economy and complicated macroeconomic management (Ostry, Ghosh, Chamon, & Qureshi, 2012). The classical "monetary trilemma" suggests that if a peripheral small open country wishes to use monetary-policy to manage the domestic economy, it will need to forsake a fixed exchange-rate regime (or will eventually be forced to do so via a currency crisis). A number of emerging-market and developing economies (EMDEs hereafter) have, over time, been moving toward greater exchange-rate flexibility (Corbacho & Peiris, 2018; Duttagupta, Fernandez, &

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Karacadag, 2005; Rajan, 2012). This reflects, in part, the belief that more flexible exchange-rates afford a small open country a greater degree of monetary-policy autonomy in responding to foreign shocks such as surges and sudden stops in capital flows (Friedman, 1953).[1]

However, Rey (2015) has challenged the relevance of the trilemma in this era of financial globalization, declaring that a small open country with an open capital account would inevitably be affected by the global financial cycle regardless of the exchange-rate regime. She specifically emphasized the role of the VIX level (the Chicago Board Options Exchange Volatility Index, which is commonly used as an indicator to measure market uncertainty and risk aversion) as being the key driver of large comovements in asset prices, gross flows, and bank leverage. In this sense, the *trilemma* collapses into a *dilemma* due to the existence of the common global factor. Therefore, a small open economy can maintain an independent monetary-policy if and only if it forsakes capital-account openness.

This paper furthers the foregoing debate by investigating interest-rate policy independence for a large sample of 88 countries comprising both advanced economies (AEs hereafter) and EMDEs over the period 1973–2014. While this paper builds on earlier studies of this issue (Klein & Shambaugh, 2015; Obstfeld, Shambaugh, & Taylor, 2005; Shambaugh, 2004), it differs from them in two substantive ways. First, we take into account possible asymmetries in the manner in which peripheral countries respond to changes in the base-country interest-rate (Han & Wei, 2018). Second, we explicitly consider the role of reserves in overcoming the constraints in monetary-policy autonomy imposed by an open capital account.

The remainder of the paper is organized as follows: Section 2 discusses the methodology and data. Section 3 presents the baseline results and confirms the findings of earlier studies that the trilemma seems to still hold and that both the exchange-rate system and capital controls matter. Section 4 extends the earlier findings by considering potential asymmetric responses by small open countries to an increase-versus-a-decrease in the base interest-rates and presents a partial dilemma pattern. In particular, we find that peripheral countries tend to follow suit when base-countries raise interest-rates independent of the exchange-rate regime but not when base-countries loosen their monetary-policy stance. We interpret this so-called 2.5-lemma as being due possibly to a “fear of capital reversal” or “fear of reserve loss”. We then examine this hypothesis further and find that the 2.5-lemma is, in fact, largely driven by the subsample of countries with low levels of foreign reserves. Section 5 extends the analysis to consider the case of intermediate exchange-rate regimes and capital controls. Section 6 concludes the paper.

2 | METHODOLOGY AND DATA

Following the general approaches by Shambaugh (2004), Obstfeld et al. (2005) and Klein and Shambaugh (2015), the methodology starts with the simple interest-rate parity equation:

$$R_{it} = R_{bit} + (E^{e}_{i,t+1} - E_{it}) + \rho_{it}, \tag{1}$$

where R_{it} is the nominal local interest-rate for country i at time t. R_{bit} is the nominal interest-rate of the base-country of country i at time t. E_{it} is the log of the current bilateral exchange-rate (domestic price of foreign currency) at time t, $E^{e}_{i,t+1}$ is the log of the expected exchange-rate next period at time $t+1$. The term in parentheses captures the expected change in the nominal exchange-rate between country i and the base-country from this period to the next. If investors are risk neutral, $\rho_{it} = 0$; however, if we assume investors are risk averse, ρ_{it} is the premium for compensation for risk-taking.

It would be ideal to include the expected change in exchange-rate, as well as the risk premium in the regressions, although both are unobservable. Estimating Equation (1) directly poses some further problems. Usually, nominal interest-rates exhibit strong persistence, and there exists a unit root, so spurious regressions are possible if level regressions are estimated. Because of this, we adopt the first difference estimation of Equation (1). The baseline model specification is as follows:

$$\Delta R_{it} = \alpha + \beta \Delta R_{bit} + u_{it}, \quad (2)$$

where $u_{it} = \Delta[(E^e_{i,t+1} - E_{it}) + \rho_{it} + \varepsilon_{it}]$, ε_{it} is the idiosyncratic error term or time-varying unobserved heterogeneity. We estimate regressions for different subsamples of data to capture the effects of different combinations of exchange-rate and capital account regimes. Specifically, we can divide the data into four subsamples according to whether the exchange-rate system is fixed or non-fixed, and whether the country imposes capital controls. The four subsamples are peg with closed capital account (Quadrant 1), non-peg with closed capital account (Quadrant 2), peg with open capital account (Quadrant 3), and non-peg with open capital account (Quadrant 4).

	Peg	
	Yes	**No**
Capital controls		
Yes	Quadrant 1	Quadrant 2
No	Quadrant 3	Quadrant 4

2.1 | Priors

We compare β and R^2 across all four categories. The larger—or more significant—the β, the less the degree of monetary autonomy enjoyed. Assume in the first instance that u_{it} is uncorrelated with ΔR_{bit}. Theoretically β would be close to 1 for a subsample panel of pegged countries with open capital accounts (Quadrant 3) because a country with a fixed exchange-rate regime and an open capital account would have to change its interest-rate one-for-one with that of the base-country, all else being constant, that is, no monetary autonomy. The β coefficient ought to be equal to 0 for Quadrant 2 where the country has a flexible exchange-rate and has imposed capital controls, that is, complete monetary autonomy.

However, as documented by Klein and Shambaugh (2015), in reality, many situations can cause ΔR_{bit} to be correlated with components in u_{it}. For example, a common shock can cause similar responses in interest-rates across countries. In addition, when the exchange-rate operates within a credible band, $\text{cov}(\Delta R_{bit}, u_{it})$ could also be non-zero. Therefore, in practice, we do not expect the benchmark estimated values of β to necessarily be 1 or 0, as there are possible correlations between ΔR_{bit} and u_{it} (also see Obstfeld et al., 2005). In addition, proxies for capital controls and exchange-rate regimes remain far from perfect. Therefore, more generally we would expect the β in Quadrant 3 to be greater than the rest and the β in Quadrant 2 to be the lowest, while the βs in Quadrants 1 and 4 ought to be somewhere in between if the country retains a degree of monetary-policy autonomy. A priori, one cannot tell whether the β in Quadrant 1 is greater or less than the β in Quadrant 4 as it depends on whether capital controls or peg grants a country relatively greater monetary autonomy. In contrast, if the dilemma holds, one would expect that the βs in Quadrants 3 and 4 to each be closer to 1 than 0, as the exchange-rate regime should not matter.

2.2 | Data

The main interest-rate data we use is the short-term Treasury-bill rate (average monthly values) from *Global Financial Data*.[2] In all, there are 176 countries in the data set, but short-term Treasury-bill rates data are only available for 88 countries. For our baseline model, we use the exchange-rate regime data from the Shambaugh data set, which is based on de facto classification. It emphasizes the bilateral exchange-rate between a given country and its base-country. We use the Chinn-Ito index (KAOPEN) as the base to generate our binary index of capital controls in the baseline. Since the Chinn-Ito index is a financial account openness index, rather than one that directly measures capital controls, we define our index of capital controls as 1-ka_open. We first only consider a binary case, namely, no capital controls when our index takes the value of 0 and with at least some capital controls when our index takes the value other than 0.

Overall, we have an unbalanced panel for the period 1973–2014[3] and our sample consists of 703 peg observations, 1,309 non-peg observations, 1,384 capital control observations and 630 no control observations. There are 25 advanced economies and 63 EMDEs in the sample. AEs constitute around 40% of observations while EMDEs account for the remaining 60%. Among them, 46 EMDEs and 19 AEs in the sample once adopted a fixed exchange-rate regime. In addition, there are eight base-countries in the sample: the United States, Germany, France, South Africa, the United Kingdom, India, Portugal, and Malaysia.[4] The United States is the dominant country as 58 countries (about three-fifths of the observations) are pegged to the U.S. dollar.[5]

3 | BASELINE RESULTS

3.1 | Does the trilemma hold?

We first test the first-difference specification Equation (2) using pooled ordinary least squares (OLS). The specification was run for these four subsamples. To correct for potential heteroskedasticity and serial correlation problems, cluster-robust standard errors are reported, and the data are clustered at the country level. The results are reported in Table 1 (Panel A).

As the trilemma predicts, countries with a fixed exchange-rate regime with no capital controls must surrender monetary autonomy. This subgroup has the highest β coefficient of 0.94, which is statistically significant at the 99% confidence level, while the R^2 is relatively high at 0.42. At the other end of the spectrum, for countries without pegs but with capital controls, the β coefficient is 0.09 and is statistically insignificant with rather low R^2 of close to 0, suggesting multiple factors impacting domestic interest-rate changes. This is consistent with the priors of the trilemma. Even with capital controls, exchange-rate regime choice is still meaningful as the β coefficient for pegged countries with capital controls is 0.31, statistically significant at the 99% level, which is far greater than that for non-pegged countries with capital controls (0.09). The β for the subsample of non-pegged countries with no capital controls is 0.48,

TABLE 1 Two by two classification of exchange-rate and capital control regimes

	PEG			
	Yes		No	
	Coef. (SE)	N [R^2]	Coef. (SE)	N [R^2]
Capital controls	(A) First-difference			
Yes	0.31***	426	0.09	956
	(0.09)	[0.05]	(0.07)	[0.00]
No	0.94***	277	0.48***	353
	(0.08)	[0.42]	(0.11)	[0.10]
Capital controls	(B) Time-fixed effects			
Yes	0.30*	426	−0.05	956
	(0.15)	[0.19]	(0.11)	[0.13]
No	0.80***	277	0.13	353
	(0.19)	[0.54]	(0.14)	[0.31]
Capital controls	(C) Adding $\Delta\mathrm{VIX}_t$			
Yes	0.31***	332	0.01	758
	(0.12)	[0.04]	(0.09)	[0.01]
No	0.87***	266	0.34***	303
	(0.08)	[0.39]	(0.12)	[0.06]

Note: Cluster-robust standard errors are reported.
***Significantly different from 0 at the 99% level.
**At 95% level.
*At 90% level

significant at the 99% level, with a modest R^2 of 0.10. These results reaffirm the existence of the monetary trilemma rather than the dilemma. Since the coefficient for the subsample of non-pegged countries with no capital controls (0.48) is greater than the coefficient for the subsample of pegged countries with capital controls (0.31), this suggests that exchange-rate flexibility offers somewhat less monetary-policy autonomy than capital controls. Broadly, these results are comparable to other studies using similar methodologies but different samples.[6]

It is plausible that the results are driven in part by common shocks. If the economic shocks facing every country are almost identical, we would expect the β coefficients to be biased upward. To this end, we re-estimate Equation (2) but include year-fixed effects. From Table 1, we see that there is hardly any change in the coefficients in the two peg subsamples with and without capital controls when time dummies are added (Panel B). This suggests that global common shocks do not spuriously drive the significant results for the pegged samples. It shows that the value of β for the subsample of pegged countries with no capital controls, is slightly lower but still relatively high at 0.80, and the R^2 indicates that the base interest-rate changes explain over half of local country interest-rate changes.[7] In comparison to the previous results, the β coefficient for the subsample of non-pegged countries with a closed capital account is even smaller, reaffirming the earlier findings. Thus, our priors still hold after accounting for common shocks. The β coefficient for countries with pegged regimes with capital controls is 0.30, very similar to the previous result, though the confidence level is slightly reduced. The one notable change is the subsample of non-pegged countries without capital controls. The β is now neither economically nor statistically significant, indicating that the β for the non-pegged samples may be driven by common shocks.[8]

Instead of time-fixed effects, we use the VIX index as a proxy to control for global common factors. We introduce ΔVIX_t in Equation (2) as an additional control variable and re-estimate the subsample results. As can be seen in Table 1 (Panel C), the subsample of countries with a fixed exchange-rate regime and no capital controls still has the highest β coefficient of 0.87, significant at the 99% level, and the β coefficient for non-pegged countries with capital controls is still the lowest at 0.01 among all quadrants and insignificant. The trilemma pattern holds when we account for the global financial cycle effect.

3.2 | Full sample with controls

To explicitly examine the differences in the $\hat{\beta}$ across different regimes, we can also pool the data and run a regression that includes the interaction terms of the change in the base interest-rate with the exchange-rate regime dummy, and with a capital control indicator, and test for the statistical significance of the coefficients on the regime interactions (Shambaugh, 2004). The equation to be estimated is as follows:

$$\Delta R_{it} = \alpha + \beta \Delta R_{bit} + \beta_2 (peg)_{it} {}^* \Delta R_{bit} + \beta_3 (\text{no capital controls})_{it} {}^* \Delta R_{bit} + \beta_4 (peg)_{it} + \beta_5 (\text{no capital controls})_{it} + \varepsilon_{it}. \tag{3}$$

The variable $(peg)_{it}$ is a dummy indicating the exchange-rate system for the country i at time t. It equals 1 if it is a pegged regime and equals 0, otherwise. Similarly, the variable $(\text{no capital controls})_{it}$ is another dummy specifying the country i's capital account regime at year t. It equals 1 if there is no capital control and 0 otherwise. β captures the impact of a change in the base-country interest-rate on the change in the domestic interest-rate for a country that does not peg its exchange-rate and closes its capital account in year t. If β is statistically significantly different from 0, this is evidence of the existence of common shocks, or "fear of floating". β_2 is the marginal impact of pegged regimes. If β_2 is positive, it indicates that local interest-rates follow more closely the base-country interest-rate when countries have a fixed exchange-rate, everything else being equal. A t test of the significance of the coefficient β_2 directly and explicitly demonstrates the difference between pegged and non-pegged observations. The expected positive value of β_3 indicates that the local interest-rate follows more closely the base-country interest-rate when countries do not impose capital controls, all else being equal.

Results are reported in Table 2.[9] It appears that the exchange-rate regime and capital controls matter as the coefficients for the interaction terms are both significant at the 99% confidence level. In general, the results with interaction terms are consistent with the subsample results shown in Table 1, and the regime effects of different combinations still follow the same pattern. β_2 and β_3 are both positive, indicating that pegging and maintaining open capital accounts cause local interest-rates to more closely follow their base interest-rates. The magnitude of β_2 is 0.28 (the degree of monetary-policy autonomy a flexible exchange-rate regime has imparted), smaller than that of β_3 which is 0.47 (the degree of monetary autonomy capital controls has conferred), suggesting that capital controls appear to matter somewhat more for preserving monetary autonomy than the role of exchange-rate flexibility. In addition, we include ΔVIX_t in Equation (3) to control for global common factors in the interaction regression. β_2 and β_3 are both positive, indicating that both exchange-rate regime and capital controls still matter. The trilemma is verified once again when the global financial cycle effect is captured in the model.

TABLE 2 Interaction terms with regime types

Variables	(1) Pool	(2) Pool (Adding ΔVIX_t)
β	0.07	−0.02
β SE	(0.07)	(0.08)
β_2	0.28***	0.36***
β_2 SE	(0.08)	(0.10)
β_3	0.47***	0.41***
β_3 SE	(0.10)	(0.10)
β_6		0.02***
β_6 SE		(0.01)
Observations	2,012	1,659
R^2	0.05	0.04

Note: Cluster-robust standard errors are reported.

Abbreviations: β, coefficient on ΔR_b; β_2, coefficient on (peg) $\times \Delta R_b$; β_3, coefficient on (no capital controls) $\times \Delta R_b$; β_6, coefficient on ΔVIX_t.

***Significantly different from 0 at the 99% level.

**At 95% level.

*At 90% level.

4 | BEYOND THE TRILEMMA AND DILEMMA DEBATE

Overall, we can conclude that the monetary trilemma still holds in the modern era. Contrary to Rey's (2015) thesis, we find that exchange-rate regimes do matter in terms of ensuring monetary independence. The combination of a floating regime with capital controls offers the greatest degree of monetary autonomy, while countries with fixed exchange-rate regimes and an open capital account almost completely lose control over their domestic monetary-policy. This is consistent with the monetary trilemma, although we partially concur with Rey that there is evidence that capital controls are somewhat more effective in helping a country regain a degree of monetary autonomy compared to exchange-rate flexibility.

However, countries might not feel equally compelled to follow the base-country's policy changes depending on whether the base-country raises or cuts its interest-rate. In particular, Han and Wei (2018) suggest that there may exist a 2.5-lemma between trilemma and dilemma:

> *a flexible exchange-rate regime appears to convey monetary-policy autonomy to peripheral countries when the center country raises its interest-rate but does not do so when the center lowers its interest-rate … Capital controls provide insulation to peripheral countries from foreign monetary-policy shocks even when the center lowers its interest-rate (p. 206).*[10]

4.1 | Asymmetric responses

We examine potential asymmetric responses of the peripheral country's monetary-policy to a change in the base-country's monetary-policy. As noted, we have four subsamples of different regime type combinations; within each subsample, we further divide the sample into two more subgroups: one in which the base-country raises its interest-rate and the other where the base-country lowers its interest-rate. The specification Equation (2) was run for these eight subsamples. The results are reported in Table 3.

Generally speaking, for each of the four policy regime combinations, the β coefficient for the subsample in which base-countries raise interest-rates is always higher than the β coefficient for the subsample where base-countries lower interest-rates. To be sure, for the set of pegged countries without capital controls, the β coefficient remains very high for the full sample as well as for the two subsamples in this case. This seems to imply that no matter whether the base-country raises or lowers its interest-rate, a peripheral country follows suit if it has a pegged exchange-rate regime and capital controls are not imposed. For non-pegged countries with capital controls, this group theoretically has complete monetary-policy autonomy. For the subsample where base-countries lower interest-rates, the β coefficient is not significantly different from 0. However, when there is a rise in base interest-rates, the β coefficient for this subsample rises to 0.30 and is statistically significant at the 95% level. This indicates that peripheral countries lose some degree of monetary-policy independence and to some extent follow the changes in base interest-rate. These results suggest two things. First, capital controls tend to be more effective in moderating inflows than in preventing outflows (Bird & Rajan, 2001; IMF, 2012; Mathieson & Rojas-Suarez, 1992; Montiel, 2013; Reinert, Rajan, Glass, & Davis, 2010). Second, there may be a "fear of capital reversal"[11] or possibly a "fear of reserve loss" (also see Aizenman & Hutchison, 2012; Aizenman & Sun, 2012).

When base-countries raise their interest-rates, since capital controls have generally been proven to be rather ineffective at preventing outflows, countries may respond by raising interest-rates to prevent capital outflows or the loss of reserves. However, when base-country interest-rates decline, while peripheral countries may experience massive surges in capital inflows if they stand pat on interest-rates, they can maintain monetary-policy autonomy via a combination of sterilized foreign exchange intervention (leading to sustained reserve accumulation) as well as tightening of capital controls and/or macroprudential policies (MaPs). To emphasize this point, note that if base-countries raise their interest-rates, the coefficients for pegs and non-pegs are fairly close no matter whether capital controls are present or not.[12] This indicates that the exchange-rate regime does not appear to matter when the base-country tightens its monetary-policy but does matter when the base loosens its monetary-policy stance.

We also re-estimate Equation (3) to cross check whether the asymmetric responses hold by estimating the equation with interaction terms. As we can see, the results with interaction terms from Table 4 show that β_2 and β_3 are statistically significant and positive for the full sample and the subsample in which base-countries lower interest-rates. This is evidence broadly in support of the predictions of the trilemma. However, for the subsample in which base-countries raise their interest-rates, β_2 is neither statistically nor economically significant, indicating that the exchange-rate regime does not matter. Note that β_3 for this subsample is still significantly positive, suggesting capital controls still matter. These results are consistent with the subsample results above. Regardless of whether capital controls are imposed, the coefficients do not differ very much between the pegged and non-pegged groups in the case of a rise in the base interest-rate. This suggests that the trilemma does not hold perfectly when we account for the asymmetry in the movement of base interest-rate. When there is a rise in the base interest-rate, a flexible exchange-rate regime is no longer able to generate greater monetary-policy independence. Once again, this is evidence of a partial dilemma or a 2.5-lemma.

TABLE 3 Asymmetric responses—subsample results

		Peg											
		Yes						No					
		Baseline		Raise IR		Lower IR		Baseline		Raise IR		Lower IR	
		Coef. (SE)	N [R^2]	Coef. (SE)	N [R^2]	Coef. (SE)	N [R^2]	Coef. (SE)	N [R^2]	Coef. (SE)	N [R^2]	Coef. (SE)	N [R^2]
Capital controls	Yes	0.31*** (0.09)	426 [0.05]	0.32** (0.15)	198 [0.03]	0.00 (0.15)	228 [0.00]	0.09 (0.07)	956 [0.00]	0.30** (0.12)	362 [0.01]	−0.19 (0.12)	594 [0.00]
	No	0.94*** (0.08)	277 [0.42]	1.00*** (0.21)	129 [0.27]	0.87*** (0.12)	148 [0.25]	0.48*** (0.11)	353 [0.10]	0.88*** (0.22)	143 [0.11]	0.35** (0.14)	210 [0.03]

Note: Cluster-robust standard errors are reported.
***Significantly different from 0 at the 99% level.
**At 95% level.
*At 90% level.

TABLE 4 Interaction terms with regime types

Variables	Full sample	Base countries raise interest-rate	Base countries lower interest-rate
β	0.07	0.31***	−0.22*
β SE	(0.07)	(0.11)	(0.11)
β_2	0.28***	−0.01	0.30**
β_2 SE	(0.08)	(0.17)	(0.14)
β_3	0.47***	0.57***	0.65***
β_3 SE	(0.10)	(0.19)	(0.15)
Observations	2,012	832	1,180
R^2	0.05	0.04	0.04

Note: Cluster-robust standard errors are reported.

Abbreviations: β, coefficient on ΔR_b; β_2, coefficient on (peg) × ΔR_b; β_3, coefficient on (no capital controls) × ΔR_b.

***Significantly different from 0 at the 99% level.

**At 95% level.

*At 90% level.

4.2 | Is there a "fear of reserve loss"?

On the basis of the foregoing discussion we hypothesize that countries with high levels of reserves may have more ability to maintain monetary autonomy, while countries with relatively low levels of reserves lack this policy option and hence are more likely to follow base-countries' suit. We, therefore, further split the sample into two subgroups, country/year observations with high reserves and country/year observations with low reserves. Our foreign reserve (minus gold) data is scaled by country's GDP.[13] Based on the distribution of foreign reserves in the sample, the top 50% of the observations country/year observations with foreign reserves that are greater than around 10% of total GDP are coded as high foreign reserves, while the bottom 50% of the observations are coded as low foreign reserves. Now for each quadrant (or regime combination) we have four more subgroups: observations with high foreign reserves when base-countries raise interest-rate; observations with high foreign reserves when base-countries reduce interest-rate; observations with low foreign reserves when base-countries raise interest-rate; and observations with low foreign reserves when base-countries lower interest-rate. The specification Equation (2) was run for these subsamples. The consolidated results are reported in Table 5.

We first focus on the non-peg regime subsamples. For country observations that have a non-peg regime and capital controls, we find that the coefficient on the base-country interest-rate is 0.30 and statistically significant at the 95% level of confidence when base countries raise interest-rate for the full sample, higher than that in the baseline and that in the subsample where base-countries lower interest-rate, whose coefficients are both insignificant. When we further divide the sample into high reserves and low reserves subsamples, what is interesting is that the significant effect for the subsample where there is a rise in the base interest-rate mainly arises from the country observations with low level of foreign reserves and the coefficient for this subgroup is 0.38 and significant at the 95% level. In contrast, the coefficient for the subsample of country observations with high foreign reserves is not significantly different from 0. This is evidence in support of the "fear of reserve loss" argument.

TABLE 5 Is there a "fear of reserve loss"?

	Peg						Non-Peg					
	Baseline		Raise IR		Lower IR		Baseline		Raise IR		Lower IR	
	Coef.(SE)	$N[R^2]$	Coef.(SE)	$N[R^2]$	Coef.(SE)	$N[R^2]$	Coef.(SE)	$N[R^2]$	Coef.(SE)	$N[R^2]$	Coef.(SE)	$N[R^2]$
Capital controls												
Full sample	0.31*** (0.09)	426 [0.05]	0.32** (0.15)	198 [0.03]	0.00 (0.15)	228 [0.00]	0.09 (0.07)	956 [0.00]	0.30** (0.12)	362 [0.01]	−0.19 (0.12)	594 [0.00]
High reserves	0.22 (0.16)	250 [0.02]	0.29 (0.36)	112 [0.01]	−0.14 (0.18)	138 [0.00]	0.07 (0.07)	476 [0.00]	0.16 (0.10)	156 [0.01]	−0.02 (0.12)	320 [0.00]
Low reserves	0.38*** (0.10)	176 [0.11]	0.22 (0.15)	86 [0.02]	0.18 (0.20)	90 [0.01]	0.08 (0.11)	480 [0.00]	0.38** (0.18)	206 [0.01]	−0.34 (0.22)	274 [0.01]
No capital controls												
Full sample	0.94*** (0.08)	277 [0.42]	1.00*** (0.21)	129 [0.27]	0.87*** (0.12)	148 [0.25]	0.48*** (0.11)	353 [0.10]	0.88*** (0.22)	143 [0.11]	0.35** (0.14)	210 [0.03]
High reserves	0.71*** (0.13)	115 [0.24]	0.68** (0.23)	49 [0.09]	0.57*** (0.18)	66 [0.11]	0.23** (0.11)	182 [0.02]	0.42 (0.33)	70 [0.02]	0.18 (0.17)	112 [0.01]
Low reserves	1.11*** (0.10)	162 [0.59]	1.16*** (0.29)	80 [0.46]	1.19*** (0.12)	82 [0.43]	0.74*** (0.14)	171 [0.28]	1.28*** (0.25)	73 [0.27]	0.57** (0.20)	98 [0.10]

Note: Cluster-robust standard errors are reported.

***Significantly different from 0 at the 99% level.

**At 95% level.

*At 90% level.

In particular, it suggests that when the base tightens monetary-policy, countries with low reserve levels are more likely to follow suit, as they fear depleting their reserves too quickly if they attempt to undertake sterilized foreign exchange intervention. In contrast, countries with high reserve levels have a larger war chest to deal with capital outflows/reversals, and thus they can opt to not follow the base rate and have more capability to preserve monetary autonomy if they are willing to. In contrast, when the base interest-rates fall, peripheral countries with a flexible exchange-rate regime can either allow their currency to appreciate or their central banks can intervene in the foreign exchange market to build up international reserves. Since reserves are accumulating in this case, there is no fear of reserve loss, so the size of the reserves does not matter. Consistent with this, we see that in the case of the base interest-rate declining, there appears to be complete monetary autonomy regardless of the size for reserve holdings.

Broadly similar evidence can be found for country observations that have non-peg regime without capital controls. We see that for country observations with high reserve levels, the coefficients on the base interest-rate are not significant regardless of whether there is a rise or a fall in the base-country interest-rate. However, for the subsample of low reserves, the coefficient on the base interest-rate is over 1 and statistically significant at the 99% level for the subgroup where base-countries raise interest-rates; this signifies that peripheral countries perfectly follow the base rate and no monetary-policy autonomy is retained.[14]

In addition to estimating the subsample results, based on the reserve levels, we run interaction regressions based on Equation (3). The results indicate that for countries with low levels of reserves, the 2.5-lemma pattern still holds.[15] Specifically, when base-countries raise interest-rates, exchange-rate regime does not matter. A flexible exchange-rate regime cannot afford the peripheral countries a degree of monetary autonomy, so pegs and non-pegs both follow suit. When base-countries lower interest-rates, in contrast, the exchange-rate flexibility induces a greater degree of insulation from foreign monetary-policy transmission. For countries with a high level of reserves, however, peripheral countries tend not to comove with base-country interest-rates, regardless of whether base-countries raise or lower interest-rates. For a fixed exchange-rate regime, when base-countries raise interest-rates, capital tends to flow out of peripheral countries to base-countries and local currency will depreciate. To maintain the peg, conceptually peripheral countries may have to raise domestic interest-rate to follow suit. However, with sufficient foreign reserves, these countries can undertake sterilized foreign exchange intervention to defend the currency and maintain monetary-policy autonomy. In this sense, a fixed exchange-rate regime does not necessarily have to follow the base-country's interest-rate, as reserves provide an additional policy tool to cushion the external impact. Similarly, if a peripheral country does not have capital controls, it can still manage to maintain monetary autonomy by using reserves to deal with external shocks if it has sufficient reserves. This may explain why the coefficients in the regime interaction terms become insignificant for high reserve samples when base-countries raise interest-rates.

4.3 | Subperiod

It is generally believed that 1990 onward marked the start of an "inflation targeting" era during which the "fear of appreciation" was a major concern for these regimes. This era ended when the Fed, and major central banks, entered the "zero-bound" era from 2009. Accordingly, we rerun the regression for this subperiod (1990–2009).[16] In the interest of space, we only show the interaction regression results based on Equation (3), as reported in Table 6.[17] The results validate the findings of the asymmetric responses. Consistently, β_2 and β_3 are significant and

TABLE 6 Interaction terms with regime types 1990–2009

Variables	(1) Full sample	(2) Base countries raise interest-rate	(3) Base countries lower interest-rate
β	−0.11	0.23**	−0.29*
β SE	(0.09)	(0.12)	(0.16)
β_2	0.45***	0.09	0.49**
β_2 SE	(0.11)	(0.23)	(0.19)
β_3	0.45***	0.22	0.62***
β_3 SE	(0.10)	(0.20)	(0.17)
Observations	1,177	478	699
R^2	0.04	0.03	0.04

Note: Cluster-robust standard errors are reported.
Abbreviations: β, coefficient on ΔR_b; β_2, coefficient on (peg) × ΔR_b; β_3, coefficient on (no capital controls) × ΔR_b.
***Significantly different from 0 at the 99% level.
**At 95% level.
*At 90% level.

positive for the full sample in this subperiod as well as the subsample in which base-countries lower interest-rate, which supports predictions of the trilemma. However, for the subsample in which base-countries raise interest-rate, β_2 is 0.09. While this is slightly greater than that in Table 4, it is still not statistically significant, indicating that the role of exchange-rate regime does not matter in impacting monetary-policy autonomy, validating the dilemma story noted earlier.[18] Based on these results, the asymmetric finding is reaffirmed by the 1990–2009 subsample. The evidence that non-pegs follow suit when base-countries raise interest-rates but not when base-countries lower interest-rates, indicates that there is indeed a “fear of capital reversal” or “fear of reserve loss” rather than a “fear of appreciation”.

4.4 | Modified Taylor rules

Thus far, we have not incorporated the role of domestic factors and their impact on domestic interest-rates. This omission could lead to concerns about misspecification, especially in the case of countries with non-pegged regimes. Accordingly, we re-estimate an augmented Equation (2) which now incorporates domestic variables, specifically inflation and output. Following Klein and Shambaugh (2015) the model is specified as follows:

$$\Delta R_{it} = \alpha + \beta \Delta R_{bit} + \gamma \Delta Y_{it-1} + \delta \Delta \pi_{it-1} + u_{it}, \tag{4}$$

where ΔY_{it-1} is the lagged GDP growth and $\Delta \pi_{it-1}$ is the lagged change in inflation. As indicated by the Taylor monetary-policy rule, the change in the policy interest-rate is a function of the change in the domestic economic conditions that is, the change in growth rate of the economy and the change in the inflation rate. Conventional countercyclical monetary-policy suggests that the coefficients γ and δ should be positive. However, given the rather complex and often unpredictable impact of exchange-rate changes on the domestic economy, many EMDEs have included the exchange-rate explicitly in the monetary-policy rule (Cavoli & Rajan, 2006;

Hutchison, Singh, & Sengupta, 2010; Taylor, 2001). Thus, we include the role of exchange-rate and extend Equation (4) to estimate a modified Taylor rule. In addition, we are interested in investigating whether the asymmetric responses hold by estimating the equation with interaction terms and Taylor rule variables. The specification is as follows:

$$\Delta R_{it} = \alpha + \beta \Delta R_{bit} + \beta_2 (peg)_{it} {}^* \Delta R_{bit} + \beta_3 (\text{no capital controls})_{it} {}^* \Delta R_{bit} + \beta_4 (peg)_{it} + \beta_5 (\text{no capital controls})_{it} + \gamma \Delta Y_{it-1} + \delta \Delta \pi_{it-1} + \zeta \Delta e_{it-1} + \varepsilon_{it}, \quad (5)$$

where Δe_{it-1} is the lagged change in bilateral nominal exchange-rate (log) relative to the U.S. dollar. Since e is the domestic price of foreign currency, an increase in e indicates a domestic currency depreciation. ζ is expected to be positive, implying a higher domestic policy interest-rate if the local currency depreciates. When the domestic currency depreciates, there is an expansionary effect on aggregate demand; the depreciation makes domestic goods cheaper and stimulates net exports. The depreciation may also induce inflation because the price of the imported goods will also rise.

Since we are not adopting high-frequency data, and we do not account for the forward-looking monetary-policy, we do not focus on estimates of γ, δ, and ζ in the monetary-policy reaction function. Instead, we estimate Equation (5) to see if ΔR_{it} responds to these three variables or if it is simply constrained by the trilemma predictions. In the first instance, to account for potential reverse causality that policy rate changes affect current output, inflation and exchange-rate, we include lagged rather than contemporaneous GDP growth, inflation change and exchange-rate change. We also focus on the F test of the joint significance of coefficients on the three Taylor rule variables.

Estimation results are reported in Table 7. When incorporating domestic factors, including the change in the inflation rate, the change in the bilateral exchange-rate, and the GDP growth, we see from the results that for the full sample and the subsample where there is a fall in the base interest-rate, β_2 and β_3 are still statistically significant, reaffirming the trilemma pattern. However, for the subsample in which base-countries raise interest-rate, β_2 is still statistically and economically insignificant, indicating that the role of exchange-rate regime does not matter. These results are broadly comparable to the results from Table 4. F statistic of the joint significance of inflation, exchange-rate, and growth is 6.86 for the full sample and 5.69 for the subsample where base-countries lower interest-rate, implying the significance at the 99% confidence level. However, the F statistic is only 1.54 for the subsample where base countries increase interest-rate, indicating no joint significance of local condition variables in this case.

5 | INTERMEDIATE REGIMES AND CAPITAL CONTROLS

Thus far the focus has been on the binary classification of peg versus non-peg. As emphasized by Aizenman, Chinn, and Ito (2010) and others, many EMDEs in particular have chosen the middle ground of managed floats and partial capital controls. Accordingly, we reconsider a slightly more nuanced classification of peg, managed float and float and full, partial, and no capital controls in our estimation.

Our emphasis in this section is to measure the degree of monetary autonomy in the midrange of the policy regime between a fixed exchange-rate and a pure float, and when capital accounts are partially open. With regard to the exchange-rate regime, we use a dummy variable

TABLE 7 Interaction terms with regime types in modified taylor rules

Variables	(1) Full sample	(2) Base countries raise interest-rate	(3) Base countries lower interest-rate
β	0.08	0.24**	−0.07
β SE	(0.07)	(0.11)	(0.13)
β_2	0.26***	−0.03	0.28**
β_2 SE	(0.08)	(0.17)	(0.12)
β_3	0.46***	0.60***	0.61***
β_3 SE	(0.10)	(0.22)	(0.16)
β_4	−0.28***	0.07	−0.31**
β_4 SE	(0.10)	(0.20)	(0.15)
β_5	0.16	-0.18	0.45***
β_5 SE	(0.10)	(0.19)	(0.17)
γ	2.79***	0.97	3.45***
γ SE	(0.91)	(1.31)	(1.02)
δ	−0.09***	−0.09*	−0.08***
δ SE	(0.02)	(0.05)	(0.03)
ζ	1.80**	0.52	2.50**
ζ SE	(0.83)	(1.09)	(1.07)
F stat	6.86***	1.54	5.69***
Observations	1,848	737	1,111
R^2	0.07	0.06	0.06

Note: Cluster-robust standard errors are reported.

Abbreviations: β, coefficient on ΔR_b; β_2, coefficient on (peg) $\times \Delta R_b$; β_3, coefficient on (no capital controls) $\times \Delta R_b$.

***Significantly different from 0 at the 99% level.

**At 95% level.

*At 90% level.

"soft peg",[19] compiled from the Shambaugh data set, to indicate the middle-ground of the exchange-rate regime policy. For the capital account regime, we use a continuous Chinn-Into index (KAOPEN) as the base to construct three dummy variables: open capital accounts, closed accounts, and middle level of openness. Based on the empirical distribution function of KAOPEN in the sample, the classification puts 681 observations in the open category, 669 observations in the closed category, and 664 observations in the mid-range of capital controls category.

Since we have three exchange-rate regime categories and three capital account openness categories, we have nine subsamples/regime combinations. The baseline specification Equation (2) is re-estimated for these nine subsamples of different regime combinations. The estimates are reported in Table 8. The subsample results are shown in the 3×3 matrix in bold. We can compare coefficients across rows so as to check the differences across exchange-rate systems and down columns to see the differences across capital account openness arrangements. The marginal columns and rows show the results estimated from an interaction regression. The estimates of the differences among open, closed, and mid-open capital accounts are presented in

TABLE 8 Three by three classification of exchange rate and capital control regimes

	Peg		Soft peg		Float			
	Coef.(SE)	$N[R^2]$	Coef.(SE)	$N[R^2]$	Coef.(SE)	$N[R^2]$	Versusmid-open	Versusclosed
Open	**0.94*** (0.07)**	**295 [0.39]**	**0.52** (0.22)**	**189 [0.11]**	**0.45*** (0.12)**	**197 [0.09]**	0.39*** (0.10)	0.55*** (0.11)
Mid-open	**0.41*** (0.10)**	**198 [0.10]**	**0.34*** (0.10)**	**242 [0.03]**	**0.04 (0.13)**	**224 [0.00]**		
Closed	**0.21 (0.15)**	**210 [0.02]**	**0.25* (0.15)**	**167 [0.02]**	**−0.08 (0.14)**	**290 [0.00]**	0.16 (0.11)	
Versus soft peg	0.13 (0.11)				0.24** (0.11)			
Versus float	0.37*** (0.10)							

Note: Entries in shaded areas in marginal columns and rows based on an interaction regression. Cluster-robust standard errors are reported.

***Significantly different from 0 at the 99% level.

**At 95% level.

*At 90% level.

the marginal columns of the right pane, and the estimates of the differences among peg, soft peg, and float are reported in the marginal rows of the bottom.[20]

As we can see, the first row shows that the coefficient on the base-country interest-rate for the open peg subsample (0.94) is greater than the coefficient for the open soft peg subsample (0.52), which is also greater than the coefficient for the open float subsample (0.45). This supports the implications of the monetary trilemma concerning the three broad types of exchange-rate regimes. The same pattern holds for mid-open capital account subsamples, as documented in the second row. However, this pattern no longer holds for closed capital account subsamples, as shown in the third row.[21] For pegged subsamples, we find that the coefficients are statistically significant at the 99% confidence level with the exception of closed pegs. However, we cannot reject the null hypothesis that the coefficients are equal to 0 for each of the floating subsamples except for the open float subsample. The marginal rows at the bottom indicate that there is a statistically significant difference between the coefficients on pegs and floats, and between soft-pegs and floats; we cannot reject the hypothesis that pegged observations have the same β coefficient as soft pegged ones, with a difference of only 0.13 that is not significant. These estimation results from an interaction regression suggest that monetary autonomy is only conferred by the most flexible exchange-rate regime and soft pegs, or a managed floating regime has no role to play in gaining a degree of monetary-policy autonomy.

Now we turn to the columns that allow for comparisons across capital account openness arrangements. For the first and the second columns, we see that the open capital account subsamples (in the top row) always have higher coefficients than the mid-open subsamples (in the middle); mid-open subsamples have greater coefficients than the closed subsamples (in the bottom). In addition, the coefficients for the open capital account subsamples are all statistically different from 0 at greater than 95% confidence level. However, the coefficients for some mid-open and closed capital account subsamples become insignificant. The estimates in the marginal columns on the right suggest the difference of coefficients is 0.39 when comparing open and mid-open capital accounts, which is significantly different from 0 at the 99% confidence level. The difference between the coefficients in both open and closed capital accounts is also significant and greater (0.55). Nevertheless, we fail to reject the null hypothesis that mid-open observations have the same β coefficient as closed ones. The difference is 0.16, but not statistically significant. These estimates imply that mid-open financial accounts can afford a country more monetary-policy autonomy compared to instances of complete open capital accounts and the effects are comparable to those provided by the closed capital accounts. In addition, based on our sample results, there is little evidence that the mid-range exchange-rate regime, that is, soft pegs or intermediate degrees of flexibility, can confer monetary-policy independence.

6 | CONCLUSION

In this paper, we have reinvestigated the monetary "trilemma" versus "dilemma" debate for a large sample of 88 countries over the period 1973–2014. Broadly, we find evidence that the trilemma still holds and that a flexible exchange-rate affords insulating effects from international monetary-policy transmission. As with Han and Wei (2018), we have documented the existence of "2.5-lemma" pattern; however, unlike their results, we find that for peripheral countries without capital controls, a flexible nominal exchange-rate allows them to maintain some degree of monetary-policy autonomy when the base-countries loosen their monetary-policy (likely via a combination of sterilized foreign-exchange intervention and tightening of MaPs to manage possible credit growth). Alternatively, when the center countries tighten their respective interest-rates, peripheral countries may fear sharp capital reversals which lead them to pursue similarly tighter monetary-policy domestically.

There are two important caveats to the foregoing findings. First, whereas completely flexible exchange-rates allow a country to maintain a degree of monetary-policy autonomy (albeit in an asymmetric manner), intermediate degrees of flexibility do not seem to do so. Second, it appears that interest-rates of countries with high level of reserves tend not necessarily to comove with the base-country interest-rate even when the center countries tighten their monetary-policy stances, while countries with low reserve levels closely follow the base-country rate and tighten their monetary-policy as well. This suggests that the asymmetric reaction to base-country monetary-policy may be due to a "fear of capital reversal/reserve loss" as opposed to "fear of appreciation".

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author.

ENDNOTES

[1] Using a sample of 40 EMDEs covering the period 1986–2013, Obstfeld, Ostry, and Qureshi (2019) find that the exchange-rate regime does matter and the transmission of global financial shocks is intensified under pegged regimes compared to more flexible exchange-rate regimes.

[2] The weblink for the databank: https://www.globalfinancialdata.com/

[3] The time period is limited to 2014 as the Shambaugh data set is only updated till then.

[4] The United States, Germany, and France are clear bases. However, for some years, India was also the base for Bhutan, Nepal, and Sri Lanka; Malaysia was the base for Singapore; Portugal was once the base for Cape Verde, Guinea-Bissau, Sao Tome and Principe, Angola, and Mozambique; and South Africa was the base for Botswana, Lesotho, Namibia, and Swaziland. Details can be found in the Shambaugh data set https://www2.gwu.edu/~iiep/about/faculty/jshambaugh/data.cfm. According to Shambaugh (2004), the choice of the base-country is determined by countries' previous pegging histories, which is relevant in almost all cases, but otherwise determined by the dominant currency in the region, that is, the one to which neighboring countries peg.

[5] Table S1 summarizes the means, standard deviations, minimum values, and maximum values of interest-rate differential for different subsamples.

[6] See Table S2.

[7] The coefficient in the open peg sample is reduced from 0.94 to 0.80. Some effects are soaked up by the year effects. However, the value of the β is still the highest among all subsamples which supports the trilemma proposition.

[8] However, since the vast majority of pegs are to the U.S. dollar and therefore the same (U.S.) base-country, there is likely to be a high degree of collinearity between the year dummies and the base interest-rate series. Thus, it can be problematic to use time-fixed effects when the number of base countries is limited.

[9] We omit reporting β_4 and β_5 for peg and capital control variables to conserve space.

[10] There is a related literature that suggests that EMDEs especially in Asia undertake asymmetric foreign exchange interventions, that is, they more likely/more frequently prevent sharp appreciations than depreciations due to a so-called "fear of appreciation" (see Levy-Yeyati, Sturzenegger, & Gluzmann, 2013; Pontines & Rajan, 2011; Ramachandran & Srinivasan, 2007).

[11] Steiner (2013) also finds empirical evidence that central banks demand foreign reserves as a buffer against possible capital flight and refers to the rise in central banks' foreign exchange holdings in line with greater capital account liberalization as being due to a "fear of capital mobility" and therefore, acts as a substitute for capital controls.

[12] If there are capital controls, the coefficient for pegs is 0.32, while it is 0.30 for non-pegs. If the capital account is open, the coefficient for pegs is 1 while it is 0.88 for non-pegs.

[13] Reserves as a share of lagged monetary base offer similar results.

[14] To confirm the results, we rerun the specification on all non-pegged regimes regardless of capital controls. The results are shown in Table S3. We find that the "fear of reserve loss" hypothesis is largely verified for all non-pegged regimes regardless of capital controls.

[15] See Table S4.

[16] We are indebted to an anonymous referee for suggesting this.

[17] We omit reporting β_4 and β_5 for peg and capital control variables to conserve space.

[18] However, in this subperiod β_3 also turns insignificant, suggesting the role of capital controls does not matter either. This may be due to the more proactive use of macroprudential policies from the 1990s, especially in EMDEs.

[19] A soft peg is defined as occurring when a country-year observation is not classified as a peg, but the bilateral exchange-rate with the base-country fluctuates by less than $\pm 5\%$ in a given year, or when there is no month where the exchange-rate changed by more than 2% up or down (Klein & Shambaugh, 2015, p.41). Hence, *peg*

refers to a ±2% band and *soft peg* refers to a ±5% band and *float* refers to all other observations. In our previous binary coding, pegs versus non-pegs, the latter include both floats and soft pegs.

[20] The numbers reported in these columns represent more open capital account minus less open capital account, and those in the rows represent less exchange-rate flexibility minus more exchange-rate flexibility, so the expected values of these estimates are always positive.

[21] Other than the fact that the coefficient for the closed soft-peg subsample is 0.25 and marginally significant at the 90% confidence level, the coefficients for closed peg and closed float are both insignificant, which may indicate that the most stringent capital controls make the role of the exchange-rate regime irrelevant and insulate countries from foreign monetary shocks.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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