Monetary Policy Spillovers under Intermediate Exchange Rate Regimes

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Abstract

I investigate monetary policy transmission under the Trilemma across Advanced and Emerging Market Economies, paying particular attention on the extent of spillovers under intermediate exchange rate regimes (i.e. managed floats). The extent of monetary pass-through: 1) is broadly significant, but more incomplete in Emerging Markets than Advanced Economies, 2) varies *within* intermediate exchange rate regimes, 3) appears to be diversifiable under a basket peg, and 4) is non-linear in exchange rate flexibility. The latter three points suggest that near-corner exchange rate policies can carry starkly different implications from corner policies themselves: Countries can face almost the same monetary autonomy as under a float without resorting to a pure float. Countries under a fixed regime appear to gain disproportionate monetary independence by giving up relatively little exchange rate stability. The use of international reserves as an additional policy instrument appears to play a role in explaining these non-linearities, particularly for Emerging Markets. Such gains in monetary autonomy are allocated towards domestic objectives differently across Advanced Economies and Emerging Markets. Advanced Economies tend to put greater emphasis on output stabilization while Emerging Markets focus on inflation.

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1 Introduction

The international policy Trilemma (Mundell, 1963[51]) states that no country can meet all three objectives: Independent monetary policy, free capital flows, and exchange rate stability. The importance of the theory's implications has grown sharply amid the onset of a rapid financial globalization, remaining an enduring topic of discussion among academics and policymakers alike. However, research on the policy Trilemma almost exclusively focuses on the effects of corner policy choices (e.g., exchange rates are either considered fixed or floating, capital accounts are either open or closed) because of the challenges associated with constructing continuous measures of Trilemma policy variables. Despite the dominating presence of intermediate exchange rate regimes around the world, we know very little about the impact of middle-ground policy choices on monetary autonomy. This study aims to address this gap in the literature.

Despite the deep and active literature on international monetary spillovers under the policy Trilemma, Most empirical studies resort to categorizing exchange rate regimes in a binary fashion (fixed or floating). Klein and Shambaugh (2015)[45] broke this trend by studying monetary autonomy while considering intermediate exchange rate regimes as a class of their own. The authors find that intermediate regimes buy some monetary autonomy relative to fixed exchange rates. While the the study offers a novel insight, the methodology fails to consider heterogeneity *within* intermediate exchange rate regimes. Given the wide spectrum of intermediate peg intensities, this may be an overly constraining restriction. Specifically, whether monetary policy spillovers are linearly, or non-linearly related to exchange rate policy remains an open question requiring greater detail on peg flexibility/intensity within the class of intermediate exchange rate regimes.

A separate literature aims to study the Trilemma configuration using continuous policy measures. Aizenman et al. (2010[2], (2013[4]) and Ito and Kawai (2014)[39] investigate the Trilemma middle-ground under a continuous policy setting, but rather than focusing on monetary policy spillovers, they focus on macroeconomic implications and determinants of such middle-ground policy configurations (Aizenman and Ito, 2014[6], Frankel et al., 2019[24] and Obstfeld et al., 2019[53]).

Studies combining the two approaches - testing monetary policy spillovers under continuous measures of exchange rate flexibility - are few and far apart. One paper, Herwartz and Roestel (2017)[36], studies monetary pass-through in such a fashion, but is limited to a sample of Advanced Economies. I take things a step further by considering a much larger panel of countries across both Advanced Economies and Emerging Markets, while also introducing a different continuous, de facto measure of exchange rate regime by drawing on the literature related to estimating currency zones[1]. This simple yet powerful approach yields several new insights.

I investigate monetary policy transmission under the Trilemma across Advanced and Emerging Market Economies, paying particular attention on the role of middle-ground policies. With that in mind, the literature is extended in several ways. I apply a methodological technique motivated by Haldane and Hall (1991)[32] and Frankel and Wei (1992)[28] to estimate monetary policy spillovers under a continuous measure of de facto exchange rate regime. This enables exchange rate regimes to be classified at a sufficiently fine level to overcome the constraining assumption of treating all intermediate exchange rate regimes identically. Moreover, I explore potential non-linearities in monetary policy spillovers (e.g. Does a some exchange rate flexibility buy a lot of monetary autonomy?). Monetary pass-through from the U.S. and E.U. can be tested jointly under this framework, an important extension for informing basket peg policies.

I document significant evidence of monetary policy pass-through conditional on greater financial openness and greater exchange rate rigidity. The extent of monetary pass-through from the U.S and E.U. 1) is broadly significant, but stronger for Advanced Economies than Emerging Markets, 2) occurs over both the short-run and longer-run, 3) varies *within* intermediate exchange rate regimes, 4) appears to be diversifiable under a basket peg, and 5) is non-linear in exchange rate flexibility. These results are generally robust to using different definitions of exchange rate flexibility, whether monetary spillovers are measured with actual interest rate changes or unanticipated shocks, and when the 2008 Global Financial Crisis period is excluded from the sample.

The latter three points suggest that the intensive margin of exchange rate regimes matter - peg intensity influences monetary pass-through even upon moving away from corner policy choices. Moreover, monetary autonomy is non-linear in exchange rate flexibility. When facing U.S. monetary policy shocks in particular, intermediate exchange rate regimes are not all the same: near-corner policies can carry starkly different implications from corner poli-

[1]Hall (1991)[32] and Frankel and Wei (1992)[28].

cies themselves. In both Advanced Economies and Emerging Markets, the evidence suggests that countries can achieve almost the same monetary autonomy as a float without resorting to a pure float. Countries under a fixed regime can also gain disproportionate monetary independence by sacrificing relatively little exchange rate stability.

Such gains in monetary autonomy are allocated differently across Advanced Economies and Emerging Markets. Advanced Economies tend to put greater emphasis on output stabilization while Emerging Markets focus on inflation. However, Emerging Market monetary policy also becomes increasingly vulnerable global financial shocks as they move towards more flexible exchange rates.

Two possible mechanisms which enable non-linear Trilemma trade offs are explored: The role of international reserves and limits to international arbitrage. The data supports the former, as I find countries tend to significantly expend international reserves in response to U.S. monetary policy shocks, and the reduction is larger under greater exchange rate rigidity, and more pronounced for intermediate pegs. Managing reserves to stabilize the exchange rate without necessarily losing monetary autonomy allows countries to 'lean against' the Trilemma constraint. The effects are particularly pronounced among Emerging Markets- the group of countries exhibiting more non-linearity between the Trilemma trade offs. I also test whether costly arbitrage may weaken monetary spillovers when interest rate differentials are sufficiently small. The evidence supporting this mechanism is relatively weak.

These favorable features of intermediate exchange rate regimes under the context of Trilemma trade-offs may help explain the continuous rejection of the Two Corners hypothesis, the scarcity of true pure floats, and the dominance of middle-ground exchange rate policy.

The rest of the paper is structured as follows. Sections 2 and 3 survey the relevant literature on the international policy Trilemma and intermediate exchange rate regimes, respectively. Section 4 briefly goes over the data. Section 5 discusses measurement and estimation of continuous de facto exchange rate regimes. Section 6 goes on to discuss notable trends and statistics in de facto exchange rate regimes across countries over the last two decades. Section 7 covers the baseline empirical strategy for analyzing monetary policy transmission under the policy Trilemma. Section 8 then goes over baseline results. Section 9 compares short-run versus long-run transmission of monetary policy. Section 10 pays particular focus on potential non-linear monetary policy spillovers under intermediate exchange rate regimes. Sections 11, 12, 13 cover robustness tests: using different measure of exchange rate regime, using exogenous U.S. monetary policy shocks around FOMC events, and omitting the 2008 Global Financial Crisis period, respectively. Section 14 concludes.

2 The International Policy Trilemma

The international policy Trilemma (Mundell, 1963[51]) states that no country can meet all three objectives: Independent monetary policy, free capital flows, and exchange rate stability. The importance of the theory's implications has grown sharply amid the onset of a rapid financial globalization, remaining an enduring topic of discussion among academics and policymakers alike.

A growing body of evidence suggests that the Trilemma generally holds in the short and long-run: Conditional on open capital flows, international transmission of monetary policy from base countries tends to be stronger under fixed exchange rates than under floating (Shambaugh, 2004[57], Obstfeld et al., 2005[54], Miniane and Rogers, 2007[49], Klein and Shambaugh, 2015[45], Herwartz and Roestel, 2017[36], Eichengreen, 2018[16], Han and Wei, 2018[34])[2]. Typical estimates of monetary pass-through suggest that transmission is incomplete (i.e. less than 1-for-1) and even less so for Emerging Markets. However, Bluedorn and Bowdler (2010)[10] document that the *unanticipated* component of base country monetary policy changes tend to fully pass-through.

A related literature argues that the the effects of Trilemma policies go beyond monetary policy, bearing consequences for macroeconomic performance. Jorda et al. (2015)[42], Aizenman et al. (2016)[3], Frankel et al. (2019)[24] and Obstfeld et al. (2019)[53] document that Trilemma policies, and particularly the exchange rate regime, can explain not just the extent of monetary policy spillovers, but also the extent of (or insulation from) international financial shocks to domestic outcomes like the volatility of inflation,

[2]In contrast, a number of studies debate that the Trilemma has broken down to a 'Dilemma', rendering exchange rate policy irrelevant for monetary independence due to several reasons related to financial globalization (Calvo and Reinhart, 2002[12], Frankel et al., 2004[26], Rey, 2015[56], Agrippino and Rey, 2015[50], Giorgiadis and Zhu, 2019[30]). However, Klein and Shambaugh, (2015)[45] and Han and Wei (2018)[34] specifically consider these factors and still find that monetary policy pass-through to foreign interest rates is significantly stronger (weaker) under fixed (floating) exchange rate regimes.

output, credit growth and asset prices.

Despite the extensive and active literature on the policy Trilemma, it largely emphasizes corner policy choices, leaving the implications associated with middle ground policies inconclusive. This is particularly surprising given that the majority of countries chose to administer exchange rate policy somewhere in between fixed and floating.

3 Intermediate Exchange Rate Regimes

The Two-Corners Hypothesis gained popularity after the late 90's early 2000's chain of financial crises experienced across the world. The argument is that middle ground exchange rate regimes are unstable and crisis prone, therefore exchange rate policy should converge to either fixed or floating (Frankel et al., 2000[25]). However, empirically this hypothesis has been continuously rejected, as middle-ground exchange rate policies are alive and well (Fischer, 2001[20], Masson, 2001[47], Williamson (2002)[60], Frankel, 2019[22], Frankel et al. (2019)[24]). Most of the world follows an intermediate exchange rate regime. As of 2018, 46.6% of the 189 IMF member countries report administering intermediate pegs - up from 40% in 2010[3].

In addition, extensive empirical evidence suggests that many of the world's floating exchange rates are actually *managed* floats - i.e., intermediate pegs of varying flexibility. Calvo and Reinhart (2002)[12] and Ilzetzki et al. (2019)[37] both highlight the systematic 'Fear of Floating' exhibited by exchange rates of countries which presumably claim to float, despite pervasive contradicting evidence.

Despite the overwhelming presence of intermediate exchange rate regimes along a wide spectrum of flexibility, little is known about why they persist or more specifically, their role in the international transmission of monetary policy. This paper aims to address this gap in the literature.

4 Data

I consider a panel composed of 46 countries which does not include the U.S. and E.U. countries over the period Q1 2000 to Q4 2018 (quarterly frequency).

[3]Source: IMF Annual Report of Exchange Arrangements and Exchange Restrictions (AREAER) for the year 2018

12 are Advanced Economies and 34 are Emerging Markets. The data was collected from multiple sources.

Quarterly central bank policy interest rates are taken from the BIS and IMF IFS database[4]. Nominal GDP, Inflation and CPI data are primarily drawn from the BIS, IMF IFS, and the World Bank. Growth rates and inflation are year-over-year percentages. The Chinn-Ito index derived from the IMF AREAER database is used as a measure of financial openness[5]. Values are normalized to range between 0 and 1, where 1 indicates completely open capital flow. The index is annual, thus I repeat annual values over each quarter within the year.

Daily exchange rates are from the BIS and are used to estimate de-facto exchange rate peg intensity at the quarterly frequency. Moreover, daily log returns are aggregated to the quarterly frequency, and combined with inflation data to construct quarterly real exchange rate returns. A positive change in the real exchange rate corresponds to local depreciation against the USD.

Data on the CBOE VIX index, a common gauge for global risk appetite, are from FRED. I remove country-quarter observations which are deemed outliers based on: Interest rate changes greater than 5 percentage points in absolute value, interest rate levels greater than 50%, and inflation greater than 40%[6]. Additional data detail can be found in the Data Detail, Section 15.

5 De-Facto Peg Intensities

A key limitation across studies on the policy Trilemma is the course classification of exchange rate regimes. Most studies resort to a binary splitting of observations into either 'floating' or 'fixed' exchange rate regimes. While this is an important consideration when focusing on the corner configurations of the policy trilemma, little can be said about the monetary autonomy trade-off under more complex exchange rate targeting policy, such as an intermediate peg or basket peg. Moreover, intermediate exchange rate regimes are not all

[4] Additional data on interest rates were collected from individual central bank websites and Global Financial Data. When official central bank policy rates could not be used, short-term treasury bills, repos, or discount rates are used.

[5] Chinn and Ito (2006)[13].

[6] Comparable to Ilzetzki et al. (2019)[37].

equal: policymakers choose the degree of flexibility which potentially gives way to a spectrum of exchange rate regimes (peg intensities) which vary both across countries and over time.

As a parsimonious solution for estimating a continuous measure of the de-facto exchange rate regime, I follow the methodology introduced in Haldane and Hall (1991)[32], Frankel and Wei (1992)[28], and later on in Benassy-Quere et al. (2006)[9]. This regression-based technique estimates continuous 'peg intensities' that are directly associated with a base currency[7]. The first-step here is to estimate non-overlapping de-facto peg intensities at the quarterly frequency. Then these estimates characterizing a country's exchange rate regime can be used in the main analysis testing for monetary policy transmission.

Like Haldane and Hall (1991)[32] I use daily exchange rate data which yields a sufficient number of observations for consistent quarterly peg intensity estimates. However at the daily frequency the issue of asynchronous trading hours across international exchange rate markets might pollute the regression analysis. One solution would be to use weekly exchange rates (Frankel and Wei, 1992[28] and McCauley and Chan, 2014[48]), but the number of observations to estimate quarterly peg intensities would drop drastically. To overcome the issue of potential non-overlapping trading hours while preserving the number of observations, I compute 2-day rolling average exchange rate returns as done in Forbes and Rigobon (2002)[21] and Wang et al. (2017)[59]. Then over each quarter, I estimate the following regression:

$$\Delta e_t^i = \alpha_i + W_i^{€}\Delta e_t^{€} + W_i^{¥}\Delta e_t^{¥} + W_i^{\$}\Delta e_t^{\$} + \epsilon_{it}, \quad (1)$$

where Δe_t^i is the change in the log exchange rate of country i vis-a-vis the IMF's Special Drawing Rights currency basket (SDR) and base currencies on the RHS, Δe_t^h, $h \in \{€, ¥, \$\}$, are the Euro, Japanese Yen, and U.S. Dollar vis-a-vis the SDR, respectively. I choose these three currencies as the possible set of base currencies because of their disproportionately large role in international trade and finance. The U.S. Dollar and the Euro together make up the large majority of: base currency pegs, international reserves holdings, external debt currency denomination, and trade invoicing currency

[7] Variants of this methodology have been recently implemented in McCauley and Chan (2014)[48], Ito and Kawai (2016)[40] and Ito and McCauley (2019)[41] to study cross-country patterns in trade invoicing currencies, global imbalances and the composition of central bank foreign reserves. Frankel et al. (2019)[24] consider continuous de facto exchange rate regimes to study their effects on economic growth.

globally[8]. Note that the question of which numeraire to use is discussed extensively in the literature as it affects the interpretation of the error term when the currency does not follow a perfect hard peg[9]. To circumvent this issue, I use SDRs as the numeraire (Frankel and Wei, 1993[29][10]).

Equation 1 implies that the movements of each currency i are decomposed to a weighted average of the base currencies plus an idiosyncratic error term. These weights translate to peg intensities against base currencies. For example, with a currency that pegs perfectly to the U.S. Dollar (e.g. Hong Kong), $W_i^{\$}$ would equal 1 and the other weights would equal zero. In contrast, a purely floating exchange rate would have weights statistically indifferent from zero across all three base currencies, and an exchange rate which targets a basket (e.g. Singapore) would have non-zero weights on multiple base currencies. Therefore, the strength of the peg is given by a value between 0 and 1, where 0 is no weight (float), and a 1 is interpreted as a hard peg to the base currency. This way we arrive at a continuous measure of peg intensity for each country, for each quarter[11].

6 Trends in Exchange Rate Policy

I estimate peg intensities for a sample of 52 currencies against the U.S. Dollar, Euro, and Japanese Yen (Tables 16 and 17). Because of the broadly low peg levels against the Yen, I focus on the cross-country dynamics of USD and EUR peg intensities. Figure 1 shows percentages of countries falling into each exchange rate classification over the 2000-2018 period. Floats, intermediates and pegs are defined as peg intensity estimates $\hat{W}_{it}^b \in \{[0, .1], (.1, .9], (.9, 1]\}$,

[8] See [31] and [11].

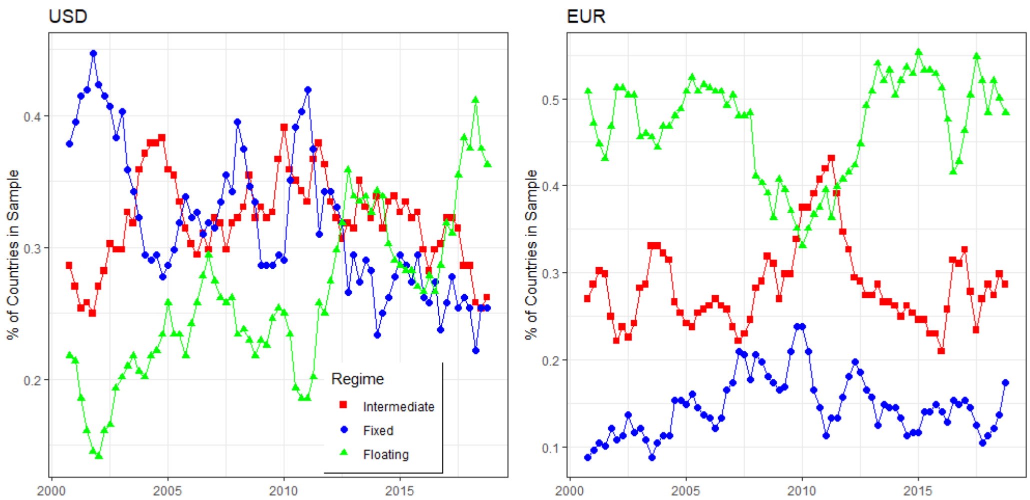
[9] Additionally, if the numeraire moves closely in line with one of the candidate base currencies, then that base currency will have very small variance and may be confused with the constant term (Benassy-Quere et al., 2006[9]).

[10] Other solutions have been proposed: Frankel et al. (2001)[23] use a basket of currencies not unlike the SDR and Frankel (1993)[27] use consumer price indices as the numeraire. Ma and McCauley (2011) demonstrate that the results from Frankel and Wei (1993)[29] do not vary by much under either SDR or the U.S. Dollar as the numeraire.

[11] I follow the algorithm of Ito and McCauley (2019)[41] to clean and remove spurious estimation results: I remove daily exchange rate changes of greater than 5% to prevent crisis-related outliers from influencing peg intensities (Ilzetzki et al., 2019[37] similarly remove inflation greater than 40% in their analysis). Any statistically significant negative coefficient estimate is set to be a missing value. Statistically insignificant negative values are set to zero. Values statistically significantly greater than one are taken to be missing values, and values insignificantly greater than 1 are set to 1.

respectively. 4-quarter averages are plotted for clarity. A striking consistency is how persistent the proportion of intermediate exchange rate regimes have been over the past two decades across both base currencies, particularly the USD. Roughly a third of the sample follows an intermediate peg at any given period. Moreover, the proportion of countries floating against the USD nearly doubled from 20% in 2000 to 40% by 2018. This trend was driven by countries transitioning away from a hard USD peg, rather than intermediate pegs becoming more flexible.

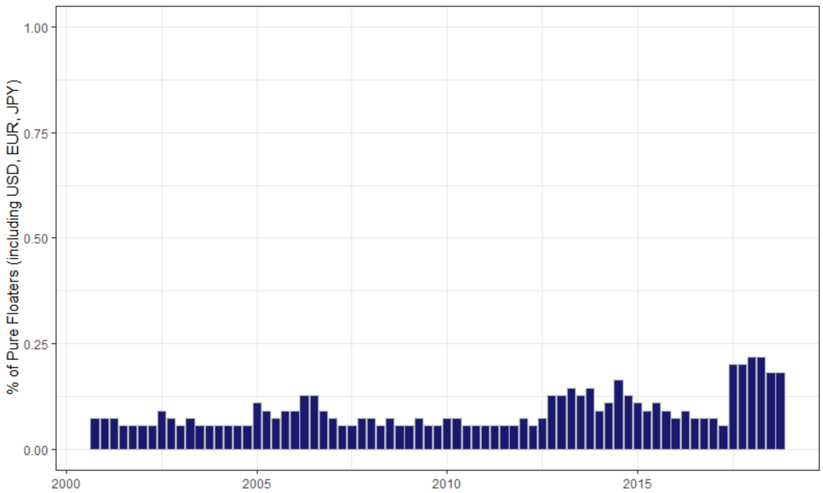
Figure 1: Exchange Rate Regimes Across Countries, vis-a-vis USD (left), EUR (right)



Floats, intermediates and pegs are defined as peg intensity estimates $\hat{W}_{it}^{b} \in \{[0, .1], (.1, .9], (.9, 1]\}$, respectively. Rolling 4-quarter averages.

A striking statistic in the data is the number and proportion of actual pure floats across the sample (Figure 2). In 2000, the only currency which had estimated peg intensities of less than or equal to 0.20 against all three base currencies was the British Pound. Including the three base currencies, that amounts to just four pure floats at the turn of the century. Proportionately, it is clear from the figure that pure floating currencies are historically scarce and continue to be so. In 2018, the number rose to ten, including USD, EUR and JPY. Brunei and Singapore (which are pegged to each other), the Chinese Yuan, Korean Won, Thai Baht, Canadian Dollar and British Pound. The Emerging Market cases are of particular interest: The currencies of Brunei and Singapore are officially pegged to each other. Throughout 2018, the Thai Baht / Singapore Dollar exchange rate was exceptionally stable, suggesting that Thailand was likely de facto targeting vis-a-vis the SGD. Singapore itself has realized steady gains in exchange rate flexibility over the past two decades. The Chinese Yuan saw its peg intensity to the USD weaken dramatically since 2016 amidst rising trade tensions between China and the United States. South Korea has been under an Inflation Targeting monetary regime sine the early 2000's. If Brunei and Thailand are omitted, and the case of China is considered transient, that leaves just 6 currencies under a truly pure float in 2018, with Singapore being a new, notable independent floater.

Figure 2: Sample Proportion of 'Pure' Floaters, 2000-2018



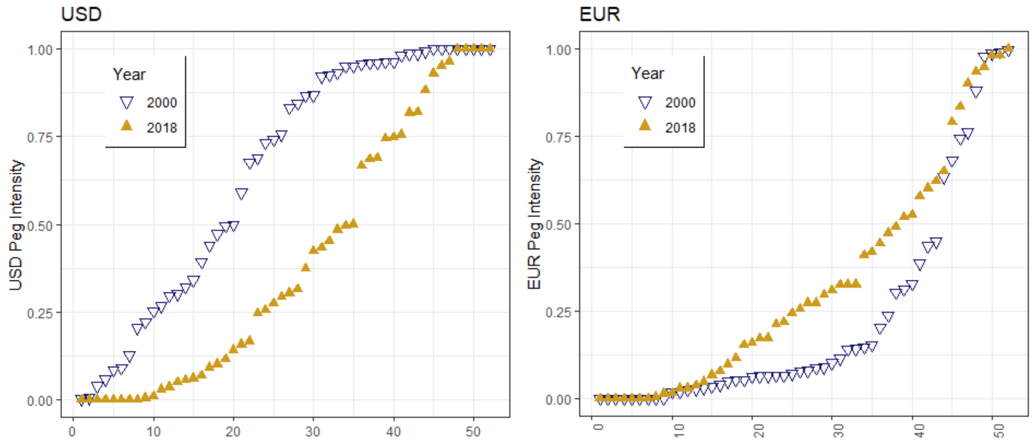
I define a currency as a pure floater in any particular quarter if all three weights, $\hat{W}_{it}^{b}$ where, $b \in \{\text{USD, EUR, JPY}\}$, are estimated to be less than 0.20. Rolling 4-quarter average of $\hat{W}_{it}^{b}$ is used. Total sample contains 55 countries; number is inclusive of USD, EUR, and JPY.

Figure 3 sorts peg intensities from lowest to highest across countries, for the year 2000 and 2018[12]. The number of hard U.S. pegs (intensity greaater than 0.90) have fallen drastically over the past two decades, while the number of floaters rose. In contrast, peg intensities against the EUR have risen over the past 20 years[13]. Moreover, the number of countries under intermediate pegs remains substantial in 2018 (roughly 60% of the sample considering both

[12]The plotted intensities are 4-quarter averages)

[13]Ito and McCauley (2019)[41] attribute this partly to commodity currencies moving away from the pure U.S. Dollar zone to a more intermediate position between the Dollar and Euro.

Figure 3: Peg intensities in 2000 vs 2018, vis-a-vis USD (left), EUR (right)



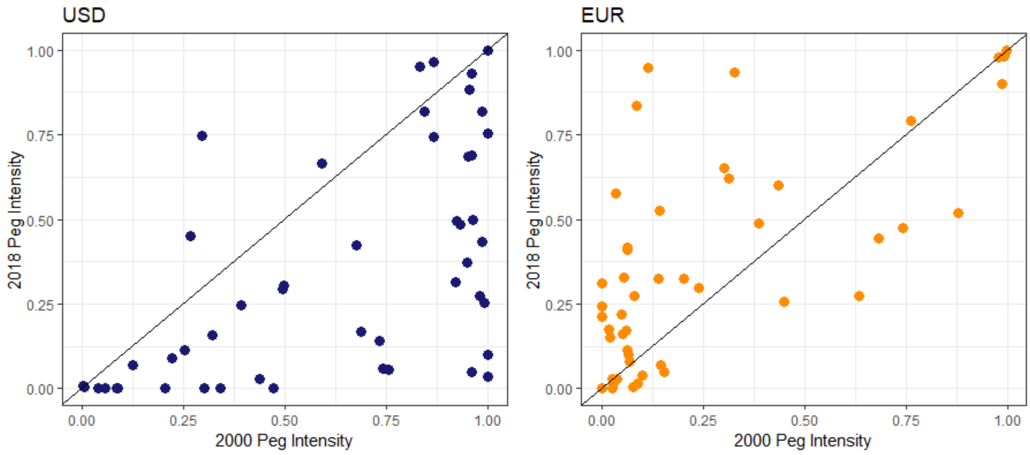
Annual 2000 and 2018 estimates of $\hat{W}_{it}^{b}$ are 4-quarter averages.

USD and EUR), and the 'intensity curves' are relatively smooth - highlighting the importance of considering intermediate pegs across a broad spectrum. Figure 4 in the appendix plots peg intensity transitions currency-by-currency. Against the USD, many countries which were hard pegs in 2000 have relaxed their policy by 2018, most of them following de facto intermediate policies. At the same time, most countries did increase the pegging weight attributed to the EUR.

An important possibility to consider is whether countries which moved away from the USD are switching to EUR as a base currency to peg against. The estimated correlation between 2000-2018 changes in USD peg intensities and 2000-2018 changes in EUR peg intensities is equal to -0.23 (t=-1.64) but not highly significant in the statistical sense. The weak negative correlation implies that changes in USD peg intensity can explain roughly 5% of the variation in changes in EUR peg intensity. The evidence, therefore suggests that base currency substitution was not a major factor driving transitions in exchange rate policy.

Figures 6 in the Appendix shows changes in peg intensity by currency. Focusing on USD pegs, Romania, South Korea, China, Brazil, Mexico, and Thailand round out the countries exhibiting the largest changes. Over this time period, Romania transitioned from a hard peg to the USD to targeting the EUR, explaining the near-maximal drop in USD peg intensity coinciding with a large rise in EUR peg intensity. In 2015, China begun transitioning

Figure 4: Change in Peg Intensity from 2000 to 2018



Annual 2000 and 2018 estimates of $\hat{W}^{b}_{it}$ are 4-quarter averages.

from a hard de facto USD peg amidst the country's push to globalize it's currency, while the other countries are notable Emerging Markets that have adopted Inflation Targeting monetary policy over the period, thereby allowing market forces to increasingly drive their currency movements.

Taking a look at exchange rate intensities over time, I plot 4-quarter rolling average USD and EUR intensities for select countries in Figure 7 and aggregate, cross-country averages in Figure 8. Romania's early-2000's transition from a USD peg to a EUR peg becomes clear. Singapore has steadily reduced it's peg against the USD to nearly zero, through for a large part of the 2000's the country seems to have targeted a basket with partial pegs against both the EUR and USD.

Switzerland had a strong yet imperfect peg against the EUR over most of the sample period, though the EUR peg intensity dropped considerably during the 2011 European Debt Crisis, then returning to high levels until Switzerland surprised the world with their sudden re-valuation in January 2015 where the Franc appreciated roughly 30% against the Euro. Since then, the peg intensity has continued to steadily weaken. China's hard peg to the USD is very apparent in the early 2000's (despite the government claiming to target a basket). The country continued to administer a strong (though not perfect) USD peg up until Q4 2015, and since then - the USD peg intensity has dropped sharply amidst the country's push towards introducing the Yuan as a global currency to less than 0.10, and this drop is not substituted with increased EUR intensity[14].

Overall trends in USD and EUR peg intensities across all countries in the sample are shown in Figure 8. What is clear is that the average USD peg intensity has crept lower steadily over the past 20 years (from over 0.60 to below 0.45), with the exception of 2011 during the European Debt Crisis where a sharp rise in USD peg intensity appears to have been driven by countries substituting away from targeting the EUR, which realized a coinciding sharp drop in intensity. Moreover the persistent rise of intermediate pegs accompanying a persistent scarcity of pure floats are not supportive of the Two Corners hypothesis, and highlight the importance of better understanding middle-ground policies.

The question of what might determine a country's choice of exchange rate policy is a natural (extensively-studied) follow-up. Many potential factors might drive this choice. For example, Edwards (1996)[15] finds that political economy factors play a major role, as the choice of between fixed and floating is related to the country's historical degree of political instability, the probability of abandoning a pegged rate, the policy objectives of the domestic monetary authorities. Devereaux and Engel (1998)[14] argue that what matters is whether prices are set in the currency of the consumer or producer. Recent studies also consider the choice of operating an intermediate exchange rate regime. Ito and Kawai (2014)[39] suggest that countries opt for more flexible exchange rate regimes when the country has: greater international reserves, more trading partners, a lower proportion of commodity exports, and greater domestic savings, while McCauley and Chan (2014)[48] report that the composition of foreign exchange reserves strongly explains cross-country variation in (continuous measures of) exchange rate peg intensities.

Armed with continuous peg intensities against the USD and EUR, the two globally dominant base currencies, one can effectively measure monetary policy spillovers with finer granularity. That is, we can shift our attention from the corners of exchange rate policy to interior choices, i.e. intermediate regimes. The following analysis leverages these estimated peg intensities to study whether and to what degree monetary policy spillovers are consistent with the Trilemma, particularly under intermediate pegs.

[14] It is also possible that this sharp drop in China's targeting the USD was driven by the U.S.-China trade war in an effort to insulate against the effects of tariffs.

7 Testing the Trilemma: Empirical Strategy

There are a number for steps that must be taken before arriving that the final econometric specification to test monetary policy spillovers. For illustrative purposes, consider a modified Uncovered Interest Rate Parity (UIP) condition which allows for both open and closed capital flow regimes:

$$R_{it} = (1 - \tau_{it})(R_{bit} + E_t[\Delta e_{ib,t+1}] + \rho_{it}) + \tau_{it} R^*_{it}, \quad \tau_{it} \in \{0, 1\}, \tag{2}$$

where whether country i administers closed (open) capital flow is given by τ_{it}: a value of 0 for open and 1 if closed. Under free capital flow ($\tau_{it} = 1$), the interest rate of country i, R_{it} should equal the interest rate of the base country, R_{bit} plus the expected percent appreciation of base country b's currency vis-a-vis country i's currency denoted $E_t[\Delta e_{ib,t+1}]$, plus a risk premium ρ_{it}. Under a perfectly credible hard peg, $E_t[\Delta e_{ib,t+1}]$ equals zero. So under a hard peg and assuming a zero risk premium and $\tau = 0$, its easy to see that $R_{it} = R_{bit}$. That is, country i does not have any monetary autonomy as the base country interest rate fully passes through. In contrast, under a flexible exchange rate and/or time-varying risk premia, R_{it} can indeed deviate from the base country interest rate. The Trilemma implies that limiting capital flows by introducing capital controls can reduce this policy pass-through and grant greater monetary autonomy. This is shown in Equation 2 under $\tau_{it} = 1$. Under a closed capital account, UIP no longer applies and country i's interest rate is fully independent, $R_{it} = R^*_{it}$.

A major simplifying assumption of the illustration just presented is that exchange rates can be either fixed or floating, and capital controls can either be open or closed. Despite this unrealistic assumption, most studies on the policy Trilemma are restricted to such cases. By leveraging continuous measures of peg intensity, I aim to relax this assumption. Second, interest rate *levels* tend to be very persistent, thus raising the issue of potential unit roots and spurious regression results. Therefore, following the literature, we test the for monetary pass-through using interest rate *changes*. Third, as in Han and Wei (2018)[34], it is important to condition interest rates on domestic variables which the central bank may target as we wish to capture interest rate changes exclusively driven by the Trilemma and remove bias driven by policy responses to domestic economic conditions. Additionally, it is crucial to condition base country interest rates on domestic variables (Jorda et al., 2019[61]) to identify *unanticipated* base country monetary policy shocks. In addition to the baseline analysis, in Section 12 I test monetary spillovers using unanticipated shocks to U.S. monetary policy around FOMC announcements.

7.1 Identification of Base Country Monetary Shocks

The base interest rates under consideration are the U.S. and E.U. (ECB) policy interest rates, $b \in \{U.S., E.U.\}$[15]. A key identifying assumption here and in the broad majority of related studies is that all other countries take changes in U.S. and E.U. monetary policy as exogenous. That is, country i's economic condition does not factor into monetary policy decisions for the U.S. and E.U., whereas domestic conditions strictly determine the interest rate. Though plausible, this assumption may or may not be reasonably satisfied at all times. Therefore, as a robustness check I also consider a measure of unanticipated U.S. monetary policy shocks later in Section 12.

To remove potential endogeneity arising from policy changes driven by domestic economic conditions, instead of using interest rate changes directly, I first run the following Taylor Rule regression:

$$\Delta R_{bit} = \alpha_b + \beta_1 \Delta y_{bit} + \beta_2 \Delta y_{bit} D_{b,ZLB} + \beta_3 \Delta \pi_{bit} + \beta_4 \Delta \pi_{bit} D_{b,ZLB} + Z_{bit}, \quad (3)$$

where ΔR_{bit} is the quarterly change (now t reflects quarters) in interest rate for base country b, in this case either the U.S. or E.U. Δy_{bit} and $\Delta \pi_{bit}$ are year-over-year GDP growth and inflation, respectively. Because of the drastic change in monetary policy after hitting the Zero Lower Bound (ZLB), I allow for the Taylor Rule coefficients to change conditional on base country interest rates hitting their effective lower bounds. This is captured by a Dummy variable, $D_{b,ZLB}$ which takes a value of 1 if base country b's policy rate is at the effective lower bound, and 0 otherwise. The estimated residual policy rate change $\hat{Z}_{bit} \in \{\hat{Z}_{US,t}, \hat{Z}_{EU,t}\}$ - cleaned of domestic confounders - is then a measure of base country monetary policy changes that are uncorrelated with domestic economic conditions.

The second step required for identification is motivated by Jorda et al. (2015, 2019)[42][61], and more generally consistent with the broader literature on the policy Trilemma. That is, the effect of base country b's monetary policy shock on country i's interest rate depends on: country i's peg intensity with respect to the base currency of country b given by $\hat{W}^b_{it}$, and country i's

[15]These two countries make up the lions share of globally held international reserves, and currency pegs

capital account openness, K_{it}. Both of these variables lie within $[0, 1]$, where 0 indicates fully floating exchange rate/closed capital accounts, and 1 indicates fully pegged exchange rate and full capital openness. Taken together, the variable of interest in the baseline regression specification will be the interaction term $\hat{Z}_{bit} \times \hat{W}_{it}^{b} \times K_{it}$. The key difference between this measure and prevailing studies is that here, the variable measuring exchange rate regime, $\hat{W}_{it}^{b}$ is continuous and lies within $[0, 1]$[16]. Importantly, the identification assumption that must be satisfied is monotonicity:

$$\frac{\partial E[\Delta R_{it}|\mathbf{x}]}{\partial[\hat{Z}_{bit} \times \hat{W}_{it}^{b} \times K_{it}]} \geq 0. \quad (4)$$

What the assumption requires is that the change in country i's interest rate (conditional on controls, $\mathbf{x}$), is increasing in the denominator. Think of peg intensity and capital openness as measures of how exposed country i's interest rate is to the base country's, and we ideally, wish to compare two identical countries in terms of fundamentals and capital controls, but varying in exchange rate flexibility. For zero exposure, either $\hat{W}_{it}^{b}$ or K_{it} must equal zero. That is, the country must administer either a pure float, or close capital controls for complete monetary autonomy - precisely what the Trilemma implies. Conversely, exposure to the base country's monetary policy is conditionally maximized when either $\hat{W}_{it}^{b}$ or K_{it} is equal to 1; when country i administers either a hard peg or free capital flow.

7.2 Econometric Specification

The baseline regression to be tested is:

$$\begin{aligned} \Delta R_{it} = \alpha_i + \phi_1 \Delta R_{i,t-1} + \phi_2 \Delta y_{it} + \phi_3 \Delta \pi_{it} + \phi_4 \Delta RER_{it} \\ + \phi_5 \Delta VIX_t + \phi_6 \Delta \bar{R}_t \\ + \gamma_{US}[\hat{Z}_{US,t} \times \hat{W}_{it}^{\$} \times K_{it}] + \gamma_{EU}[\hat{Z}_{EU,t} \times \hat{W}_{it}^{€} \times K_{it}] + \epsilon_{it}. \quad (5) \end{aligned}$$

The baseline regression assumes that country i follows an open economy Taylor Rule (Aizenman et al., 2011[5] and Engel, 2011[18], Han and Wei (2014, 2018)[33][34]) and conditions on key domestic variables which may influence changes in the policy rate. Changes in country i's policy rate

[16] Jorda et al. (2015)[42] defines exogenous monetary policy shocks in the same way - as the interaction of the base country's monetary policy change, the exchange rate regime and degree of capital openness - but using binary measures of exchange rate regimes.

are regressed on lagged policy rates[17] $\Delta R_{i,t-1}$, nominal GDP growth Δy_{it}, changes in inflation $\Delta\pi_{it}$, and changes in the log real exchange rate ΔRER_{it} vis-a-vis the USD. Positive changes in the real exchange rate indicate country i depreciation. Including the real exchange rate also will capture any possible evidence of Fear of Floating, one phenomena which challenges the sustainability of the Trilemma (Calvo and Reinhart (2002)[12]). Additionally the validity of the Trilemma has been actively debated in light of new evidence of a global financial cycle (Agrippino and Rey, 2015[50], Rey, 2015[56]), hence the specification also controls for global factors: log changes in the VIX index given by ΔVIX_t, and $\Delta\bar{R}_t$ which denotes changes in the global average interest rate.

The final two terms preceding the residual ϵ_{it} of Equation 5 are the focus of this study. Coefficients γ_{US} and γ_{EU} capture the degree of spillover from base interest rates (U.S. monetary policy and ECB monetary policy, respectively) to country i's interest rate. Given a foreign monetary policy shock to the base country, $\hat{Z}_{bt}$, the total spillover to country i is an increasing function of peg intensity and capital account openness, $\gamma_b[\hat{W}_{it}^b \times K_{it}]$[18].

A potential drawback of the regression specification is the imposed homogeneity of coefficients across countries. For example, weights on Taylor Rule coefficients might differ across countries which aim to prioritize different policy objectives: Emerging Markets may prioritize targeting the real exchange rate, while this may not be an objective at all among some Advanced Economies (Aizenman, 2011[5] and Ahmed et al., 2019[1]). Despite this limitation, much of the literature stands by the pooled panel regression specification as it buys considerable statistical power when dealing with cross-country panels[19]. In support of homogeneous coefficients restriction, Han and Wei (2018)[34] find that after estimating country-specific Taylor Rules, weights assigned to inflation for Inflation Targeting countries and non-Inflation Targeting countries are not statistically different. However to account for potential heterogeneity in regression coefficients, I estimate the

[17] The specification taking the form of a dynamic panel model is well known to suffer from Nickell (1981)[52] bias when the time dimension is small. However, our quarterly sample provides T ranging from mid-40 to mid-70 depending on the sub-sample and country. Judson and Owen (1999)[43] show through Monte-Carlo studies that the LSDV estimator performs well in comparison with GMM and other estimators when T=30.

[18] Ito and Kawai (2012, 2014)[38][39] apply a similar method to estimate a country's monetary independence, but they do not pre-condition base country interest rates on domestic variables or account for financial openness.

[19] Obstfeld et al. (2005)[54], Klein and Shambaugh (2015)[45], Han and Wei (2018)[34], Obstfeld et al. (2019)[53] all employ the pooled specification in their baseline analysis.

regression on Developed and Emerging Market sub samples of countries along with the full sample. Moreover in Section 10 I allow the coefficients to be estimated separately for each sub-group, reflecting the possibility that countries with greater monetary autonomy under a flexible exchange rate can put more weight on domestic policy objectives compared to countries administering stronger pegs (Klein and Shambaugh, 2015[45]).

7.3 Tests and Hypotheses

The policy Trilemma assumes that $\gamma_b = 1$ from Equation 5. That is, under a perfect peg *and* open capital flows ($\hat{W}_{it}^b = 1$, $K_{it} = 1$), interest rate pass-through should be one-for-one, while under a pure float ($\hat{W}_{it}^b = 0$) *or* closed capital flows ($K_{it} = 0$), there is no interest rate pass-through (i.e. complete monetary autonomy). However, in practice it is difficult to expect this assumption to hold. First, the policy Trilemma relies on UIP being satisfied, but there is extensive empirical evidence of UIP being violated in the data. Second, as Klein and Shambaugh (2015)[45] show, one cannot expect Trilemma-consistent pass-through if country i's interest rate changes are correlated with other factors that influence their policy rate such as expected exchange rate changes, risk premia or global shocks.

Nonetheless, there are a number of valuable tests that can be conducted. If γ_b is statistically significant and positive, that itself is evidence in favor of the Trilemma despite imperfect pass-through. A positive coefficient implies a statistically significant relationship between base country policy rates and country i's policy rates which strengthens as the exchange rate policy becomes increasingly rigid, or as capital accounts become more open. A continuous measure of exchange rate regime will let us infer whether intermediate exchange rate regimes offer intermediate degrees monetary policy autonomy. Different coefficient estimates of γ_{US} and γ_{EU} suggest that monetary policy spillovers are heterogenous, and may be different depending on the base currency. Finally, a significant coefficient on both γ_{US} and γ_{EU} suggest that basket pegs can offer diversification benefits compared to a hard peg against a single base currency as long as the base country monetary policies are not perfectly correlated with one another. For example, a country targeting a basket of two exchange rates would be imperfectly exposed to both monetary policies, versus being fully exposed to a single country's monetary policy. The latter two tests would bring novel insights to the literature.

A key assumption of the regression specified in Equation 5 is the implicit linearity imposed on monetary pass-through. The effect of monetary pass-through implied by $\gamma_b[\hat{W}_{it}^b \times K_{it}]$ is linear in peg intensity and capital account openness. The Trilemma trade-offs however are not necessarily required to be linear, though have been assumed to be so in some studies (Ito and Kawai, 2014[39]). There is no consensus on the linearity of Trilemma trade-offs. Aizenman et al. (2010)[2] test the linearity assumption and find supportive evidence. In contrast, Obstfeld et al. (2019)[53] find non-linear effects of (non-monetary) spillovers under varying degrees of exchange rate flexibility. Because of the important policy implications of (non) linearity, I explore this issue in more detail in Section 10 by exploiting the continuous nature of peg intensity measures.

8 Baseline Results

The results for the full sample of countries are reported in Table 6. The three columns represent different variants of the peg intensity estimate $\hat{W}_{it}^b$. The second and third columns use a 2-quarter and 4-quarter rolling average of $\hat{W}_{it}^b$, respectively denoted with (RA, 2) and (RA, 4), to replace the unsmoothed measure (column 1). Smoothing out the peg intensity estimate with past observations helps makes a more conservative choice to ensure that pegs, which tend to be persistent, are well-established (Jorda et al., 2015[42], 2019[61]). Moreover, smoothing even over 2 quarters helps ensure that results are not driven by outliers and helps eliminate episodes of opportunistic pegging and sudden short-lived devaluations. Regardless, estimates are consistent and significance is broadly robust across columns.

8.1 All Countries

Significant non-zero estimates on both $\hat{\gamma}_{US}$ and $\hat{\gamma}_{EU}$ indicate Trilemma-consistent monetary spillovers from both base countries to others (Table 6). As peg intensity rises under free capital flows, the pass-through of base country interest rates strengthens (weakens). Note that the effects are statistically different from 1, implying imperfect Trilemma pass-through. That is, under a perfect peg and free capital flows, a 1 percentage point change in the base country (US, EU) interest rate is associated with interest rates roughly (+0.36, +0.50) percentage points higher. Column 4 removes global variables (ΔVIX_t and $\Delta \bar{R}_t$) and introduces time fixed effects as a robustness check - the effects of monetary pass-through broadly hold under this specification.

8.2 Advanced Economies

Table 7 reports estimates for the sub-sample of Advanced Economies. Both base country Trilemma coefficients are highly significant across the varying specifications of peg intensity and remain robust to both country and time fixed effects. Both U.S. and E.U. base country pass-through is roughly 0.70 for Advanced Economies, much higher than it was for the full sample. In fact, in many instances the confidence interval includes 1 - indicative of near-perfect monetary policy pass-through.

8.3 Emerging Markets

Table 8 reports pass-through estimates for the sub-sample of Emerging Markets. Across all four specifications, there is no evidence of significant monetary policy spillovers from EU monetary policy, despite a number of Emerging Market economies pegging, at some point, to the Euro[20]. In contrast, the effect of U.S. monetary policy is statistically significant in most specifications, ranging from 0.24 to 0.39, indicating that under a perfect peg and free capital flows, monetary spillovers from the U.S. are imperfect, with Emerging market interest rates rising on average +0.30 percentage points for every +1 percentage point rise in U.S. interest rates.

8.4 Intermediate Pegs

Column 5 of Tables 6, 7 and 8 consider the sub-sample of country-quarter observations which do not include pure floats or hard pegs (i.e. excluding values of 0 or 1 for $\hat{W}_{it}^{b}$). This is done to verify whether corner policies are driving the results of the regression tests, or whether the range of intermediate pegs actually offer a spectrum of monetary autonomy. Across the full sample, the effects of both U.S. and E.U. peg intensity remain highly significant upon omitting corner policy observations, suggesting that the intensive margin of peg intensity also matters for monetary policy. The Advanced Economy subgroup signals the same message: The effects of monetary policy pass-through hold for both the intensive and extensive margin of exchange rate regimes. This has implications for countries which target a basket of currencies. Basket pegs can be viewed as intermediate pegs against more than one exchange

[20]These countries include but are not limited to: Albania, Bulgaria, Croatia, Czech Republic, Hungary.

rate[21]. This can give rise to monetary policy exposure from multiple base currencies, although each individual pass-through effect is smaller than it would be under a unitary peg against any individual component of the basket (basket weights cannot exceed one).

For the Emerging Market sub-group, the significance of the coefficient estimate on $\hat{\gamma}_{US}$ disappears when removing observations containing corner policies (Column 5, Table 8). This may have several interpretations. One is that across Emerging Markets, intermediate pegs may not offer intermediate monetary autonomy, but rather *disproportionately greater* monetary autonomy than a hard peg, indicating a non-linear relationship between exchange rate flexibility and monetary autonomy: A country which introduces a little bit of exchange rate flexibility can potentially buy a lot of monetary independence. There are other possible interpretations as well: For these countries, increasing flexibility of the exchange rate might disproportionately increase the sensitivity of monetary policy to non-Trilemma factors (domestic objectives, Fear of Floating, financial cycles or commodity cycles, risk premia, etc.). So, while the base country's monetary policy spillovers are less influential, the costly rising importance across other external factors may offset any benefits from monetary autonomy. In the next section, we will investigate these non-linearities further, and allow regression coefficients to vary across peg intensities to possibly reflect changing weights on policy objectives as countries move from pegs to floats. Finally, in an interesting twist when considering only intermediate peg observations, monetary spillovers under the Trilemma with regards to E.U. monetary policy becomes statistically significant ($\hat{\gamma}_{EU}$), implying that under intermediate peg intensities, E.U. monetary policy passes through to countries which partially target the Euro and the pass-through increases as the country approaches a peg. However surprisingly, hard pegs to the Euro do not exhibit Trilemma-consistent monetary spillovers.

8.5 Discussion

To summarize, significant evidence of monetary policy spillovers are present in both Advanced Economies and Emerging Markets, but estimated monetary policy pass-through is considerably stronger among Advanced Economies. Both monetary policy spillovers and overall regression fit (R^2) are lower for

[21] For example, a peg intensity of 0.5 to both the U.S. Dollar and the Euro would qualify as a basket peg.

the Emerging Markets sub-sample compared to Advanced Economies. This could be due to the presence of important factors which are correlated with country i's interest rate. For example, monetary pass-through estimates may be low in Emerging Markets because risk premia tend to be highly volatile (Kalemli-Ozcan, 2019[44]). Fear of Floating and Global Financial Cycles, operating through the real exchange rate and financial conditions respectively, may also impact country i's policy choices (Calvo and Reinhart, 2002[12] and Rey, 2015[56]). Some Emerging Markets are heavily reliant on commodity trade, hence exposing themselves to commodity cycles which in turn can influence policy objectives (Aizenman et al., 2011[5]). Finally, recent evidence suggests that the burgeoning debt positions of Emerging Markets (and Advanced Economies) brought in by unprecedented monetary easing after the 2008 Financial Crisis may be interacting with monetary policy objectives (Ahmed et al., 2019[1]).

For the full sample, particularly Advanced Economies, there is robust evidence consistent with Klein and Shambaugh (2015)[45] that the Trilemma holds under interior policy choices (i.e. peg intensities between 0 and 1), potentially allowing for partial monetary autonomy. Hence a key policy implication is that basket pegs can potentially mitigate monetary policy spillovers from a single country via a unitary peg by taking on monetary spillovers from an additional country, effectively diversifying spillover risk. Interestingly, Emerging Markets do not seem to exhibit Trilemma-consistent monetary policy spillovers under intermediate pegs. However, this may imply that among these countries, moving from a hard peg to an intermediate peg buys a disproportionate amount of monetary independence - either unconditionally or relatively by assigning greater weight on other policy objectives. Potential non-linearities in the exchange rate regime - monetary spillover function are explored in the next section.

9 Long-Run Monetary Policy Adjustment

In the previous section its shown that the link between base country interest rates and country i strengthens in peg intensity, for a given capital openness. The specification focuses on short-run associations, while Shambaugh (2004)[57] highlight the possibility of long-run adjustment in the policy rate which might depend on the Trilemma configuration. That is, even if policy rates across countries respond immediately to one another, it's also possible for country i's interest rate to be increasingly cointegrated with the base country's interest rate as peg intensity rises - so interest rate adjustment occurs over both the short-run and over a longer period of time[22]. To test for this, I extend Equation 5 to include two error-correcting terms: A cointegrating vector between country i's interest rate and the base country (U.S. and E.U. interest rates, respectively), interacted with peg intensity and capital openness:

$$(r_{i,t-1} - C_b r_{b,t-1}) \times \hat{W}^b_{i,t-1} \times K_{i,t-1}. \tag{6}$$

Typically one estimates C_b in a first-stage, but I pre-set $C_b = 1$, effectively defining the cointegrating vector as the interest rate differential between country i and base country b[23]. A negative coefficient on this term implies that when country i's interest rate exceeds the base country's, it will induce adjustment in the policy rate to catch down to the base country's. The interaction with peg intensity allows the rate of reversion to strengthen with peg intensity as expected undre the policy Trilemma. The interaction with capital openness allows for comparison across countries with identical openness yet differing peg intensities.

Table 1 reports long-run spillover effects[24]. Short run estimates are included to verify that they are not sensitive to the inclusion of error-correction terms. Across the sample, there is evidence of longer-run adjustment in country i's interest rate to both base countries - E.U. and U.S. which increases in country i's peg intensity to either base country. The negative coefficient sign is theoretically consistent: When the interest rate differential is positive (negative), country i's policy rate adjusts in the direction of the base country interest rate. When stratifying the sample into Advanced and Emerging Market economies, it's the Emerging Markets which exhibit evidence of statistically significant error-correction in their policy rates under both U.S. and E.U. pegs, while Advanced Economies generally only exhibit evidence of strong short-run monetary spillovers. If the sample is limited to only intermediate pegs ($\hat{W}^b_{it} \in (0, 1)$), the long-run effect against EU peg intensity turns significant at the 1% level while the long-run effect vis-a-vis the

[22]This could be due to various financial market imperfections or practical limits to arbitrage.

[23]Constraining the cointegrating vector to the interest rate differential by setting $C_b = 1$ is theoretically consistent with UIP and also reduces bias that would otherwise arise from the error-in-variables issues with first-stage estimation.

[24]Robust standard errors clustered at the Country level. Regression specification of Equation 5 plus error correction terms (Equation 6). Estimation period: Q2 2000 - Q4 2018. Peg intensity used: $\hat{W}^b_{it}$ (RA, 2).

Table 1: Short vs. Long-run Monetary Spillovers

Dep. Variable Δr_{it}	All Countries	Advanced Economies	Emerging Markets
$\hat{\gamma}_{US}$	0.370***	0.783***	0.248**
	(0.122)	(0.199)	(0.121)
$\hat{\gamma}_{EU}$	0.403***	0.684***	0.165
	(0.144)	(0.120)	(0.241)
$(r_{i,t-1} - r_{US,t-1}) \times \hat{W}^{US}_{i,t-1} \times K_{i,t-1}$	-0.021**	-0.035	-0.023**
	(0.010)	(0.025)	(0.011)
$(r_{i,t-1} - r_{EU,t-1}) \times \hat{W}^{EU}_{i,t-1} \times K_{i,t-1}$	-0.055*	0.001	-0.061*
	(0.031)	(0.031)	(0.034)

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Estimation period: Q2 2000 - Q4 2018. Peg intensity used: $\hat{W}^b_{it}$ (RA, 2).

U.S. turns insignificant[25], precisely matching patterns in short-run effects for EMEs under intermediate pegs, thereby supportive of potentially non-linear policy trade-offs between exchange rate stability and monetary autonomy.

Given the high rate of short-run pass-through among Advanced Economies, it is plausible that base country monetary policy spillovers occur rather quickly and to their full extent among these countries. The significant long-run adjustment among Emerging Markets at least in part, may explain their relatively weak and imperfect short run pass-through, suggesting that across Emerging Markets, the monetary spillover from base countries may take longer. These results are consistent with the fact that Emerging Markets are considerably less financialized and host to generally weaker institutions - both factors potentially inducing greater financial market frictions - compared to their Advanced Economy counterparts.

10 Non-linear Trilemma Trade-offs

In this section we further explore monetary policy pass-through under intermediate peg intensities - an area which has received limited attention in the literature. First I test for any cursory evidence of non-linear monetary

[25]This result is not reported in Table 1.

spillovers based on thresholding the exchange rate peg intensity, $\hat{W}_{it}^{b}$ (Hansen, 2000[35]). I use the 2-quarter rolling average peg intensities, $\hat{W}_{it}^{b}$ (RA, 2), as they offer good compromise in smoothing out outliers without generating excessive persistence. I modify Equation 5 by allowing for a threshold effect for U.S. monetary policy pass-through, thereby allowing γ_{US} to vary in a discrete fashion depending on whether peg intensity is above or below some value.

Figure 9 plots the (robust) t-statistics for the additional monetary pass-through under a peg intensity that is equal to or greater than the value denoted on the x-axis. For Advanced Economies, there is stark evidence of potential non-linear spillovers from the U.S., where weak/moderate de facto pegs (intensities less than approximately 0.40) can enjoy similar monetary independence as pure floats, implied by the statistically insignificant t-statistics. But moderate/stronger pegs (intensities greater than 0.50 and less than 0.80) experience significant interest rate pass-through. Intensities greater than 0.8, strongly managed pegs and fixed exchange rates, have larger stronger t-statistics. Patterns are similar but slightly weaker among Emerging Markets. Past an intensity of 0.50, t-statistics on the threshold effect hover around the 10% significance level, and remain so across greater thresholds. Testing thresholds below 0.50, statistics are unanimously statistically insignificant, suggesting not much difference between monetary independence under a pure float or some stability.

To further investigate any potential non-linearity in monetary policy spillovers under varying peg intensity, we relax the linear-implied specification of the baseline regression (Equation 5) and estimate separate sub-samples, sorting by peg intensity. Again, using the 2-quarter rolling average peg intensities, $\hat{W}_{it}^{b}$ (RA, 2). Country-quarter observations are sorted into the following 6 bins (Table 2).

Table 2: Peg Intensities by Bin

	Pure Float					Hard Peg
	1	**2**	**3**	**4**	**5**	**6**
W_{it}^{b}	[0,0.1]	(0.1,.30]	(0.30,.50]	(0.50,0.70]	(0.70,0.90]	(0.90,1]

The regression specification must be modified due to the more limited number of observations per sub-sample after dividing the data into 6 separate groups. Moreover, I only consider peg intensities to one base country at a time, starting with the U.S (Results for E.U. shocks can be found in Table 12). Constructing bins which condition both on U.S. and E.U. peg intensity would lead to too few observations per group[26]. The regression takes the following form:

$$\Delta R_{it} = \alpha_i + \theta_1 \Delta y_{it} + \theta_2 \Delta \pi_{it} + \theta_3 \Delta RER_{it} + \theta_4 \Delta VIX_t + \theta_5 \Delta \bar{R}_t + \gamma_{US}[\hat{Z}_{US,t} \times K_{it}] + \epsilon_{it}. \quad (7)$$

There are two key differences between Equation 7 and the previous specification, Equation 5. The first is that the lagged dependent variable is removed from the RHS. This is due to data limitations - by constructing sub-groups using more refined exchange rate regime categories, each group will not have sufficient data along the time dimension to reduce the bias that a fixed effects dynamic panel specification generates. Moreover, each observation is now increasingly valuable for statistical power, and therefore lost observations from including a lagged dependent variable becomes costly for inference. On a positive note, since the regression specification is in interest rate *changes* the data is not persistent, thereby excluding a lagged dependent variable will not influence the results in a meaningful way[27].

The second change is related to peg intensity. First, I only consider U.S. monetary policy spillovers, so the variable capturing shocks from the E.U. is removed. Second, peg intensity, $\hat{W}_{it}^{US}$ is removed from the trio of interactions. This is simply because now we condition the entire sample on $\hat{W}_{it}^{US}$ by estimating separate regressions per intensity bin. By conditioning the entire sample, we allow all coefficients to be heterogeneous across peg intensity bins, lending to more realistic and flexible inference, and addressing some of the limitations mentioned previously over the original specification.

[26]One could take Equation 5 and interact $\hat{Z}_b$ with binned peg intensities, which would potentially allow for both U.S. and E.U. to be jointly tested for non-linear pass-through. However, this comes at the cost of constraining all other regression coefficients to be pooled together across the entire sample. Because policy weights can vary across countries which peg or don't peg, It's crucial to allow for coefficient flexibility, something that can be achieved by estimating on sub-samples. Results from this approach are reported in Table 12 and are broadly consistent with other specifications.

[27]If the regression was estimated in *levels*, removing the lagged dependent variable would very likely have a major impact on coefficient estimates.

10.1 All Countries

Table 9 reports spillover estimates from U.S. monetary policy across bins ($\dot{}$US), but also reports coefficients on domestic inflation ($\Delta\pi_{it}$), output growth (Δy_{it}) targets along with effects transmitted through the Global Financial Cycle (ΔVIX_{it}) to capture external drivers of policy interest rates. This way we can infer whether monetary spillovers are non-linear in peg intensity, but also if greater monetary autonomy indeed translates to greater weights on domestic variables. The fourth row reports the spillover coefficients given by $\hat{\gamma}_{US}$, and as the Trilemma implies, the coefficients roughly increase with peg intensity, with hard pegs having the largest spillover coefficients (0.48). However, there is evidence of potential non-linearity in spillovers based on peg intensities. Under weak to moderate peg intensities ranging from 0.1 to 0.5 (bin 2 and 3), evidence of monetary spillovers is statistically indifferent from zero - the same as if under a fully floating policy. Evidence of monetary spillovers begin to manifest under more rigid exchange rate policy (bins 4 to 6, peg intensities from 0.5 to 1). Moreover, moderately strong pegs (bin 4 and 5) exhibit weaker monetary pass-through from the U.S.compared to hard pegs (bin 6), 0.27 and 0.20 versus 0.48, respectively. This evidence has policy implications, as it suggests that a little bit of exchange rate flexibility can potentially buy a considerable degree of monetary autonomy, and that some exchange rate stability can be bought *without* sacrificing monetary autonomy. Hence, the policy Trilemma trade-off appears to be non-linear in the data, which differs from findings of Aizenman et al. (2010)[2] and Ito and Kawai (2014)[39].

Moreover, coefficients on inflation tend to remain highly significant even under weak to moderate peg intensity (bins 2 and 3) and are approximately 7 times larger than under a hard peg (bin 6), suggesting that the gains from monetary autonomy are associated with greater emphasis on targeting domestic policy objectives, particularly inflation, The evidence suggests that pure floating is not necessary to achieve these gains. There is also some evidence that under a both floating and fixed exchange rates, and a particular intermediate pegs (bins 1,2 and 5,6), monetary policy is increasingly influenced by global financial conditions proxied by changes in the VIX index. Under a flexible (fixed) exchange rate, interest rate changes tend to respond positively (negatively) to changes in the VIX. Because U.S. monetary policy tends to ease in the presence of heightened risk, pegged monetary policy also falling when the VIX rises is consistent with the Trilemma. Under floating exchange rates, interest rates tend to rise - this is shown to be driven by the Emerging Markets sub-sample, who tend to exhibit interest rates which rise, instead of fall, during periods of heightened risk aversion in hopes to stem capital outflows.

10.2 Advanced Economies

Table 10 reports results across Advanced Economies. Again, monetary policy pass-through estimates are nearly monotonically increasing in peg intensity. Hard pegs (bin 6) suggest full pass-through with a coefficient of approximately 1. A non-linear trade-off between exchange rate regime and monetary autonomy is present among the Advanced Economy sub-sample. A moderate to strong peg (bins 4 and 5) have spillover estimates of 0.43 and 0.62, respectively, suggesting that giving up a little exchange rate stability can cut monetary spillovers by 50%. Weaker pegs (bins 2 and 3) suggest even greater gains in monetary autonomy which are not statistically different than monetary autonomy under a floating exchange rate. The evidence suggests that a country which floats it's exchange rate can administer stabilization with little cost in monetary independence, while a country running a hard peg can give up a little stability to buy a considerable degree of monetary autonomy.

Across Advanced Economies, there is consistent evidence that intermediate exchange rate regimes offer countries greater weight allocation to domestic objectives, particularly output growth, but not inflation. Under Floating and most intermediate exchange rate regimes, output growth has a significant coefficient (bins 1, 3, 4 and 5) which is not present under a hard peg. Evidence that global financial conditions have strong influence over Advanced Economy interest rates is weak (mostly insignificant coefficient estimates on ΔVIX_{it}). Taking this point together with the results on domestic policy objectives, it appears that for Advanced economies, flexibility allows countries to focus on domestic objectives without surrendering autonomy to global financial forces.

10.3 Emerging Markets

Table 11 reports results for Emerging Markets and I also report estimates on real exchange rates (ΔRER_{it}) for this sub-sample because of its importance as a policy target (Aizenman et al., 2011[5]). Across the Emerging Market sample under hard Pegs there is significant evidence of U.S. monetary pass-through, through imperfect (coefficient of 0.367). Consistent with hard pegs to the U.S. Dollar, changes in the VIX index are associated with interest rate cuts among hard pegging Emerging Markets. In addition, these countries exhibit the strongest evidence of responding to real exchange rate changes with interest rate policy (Fear of Floating, Calvo and Reinhart, 2002[12]).

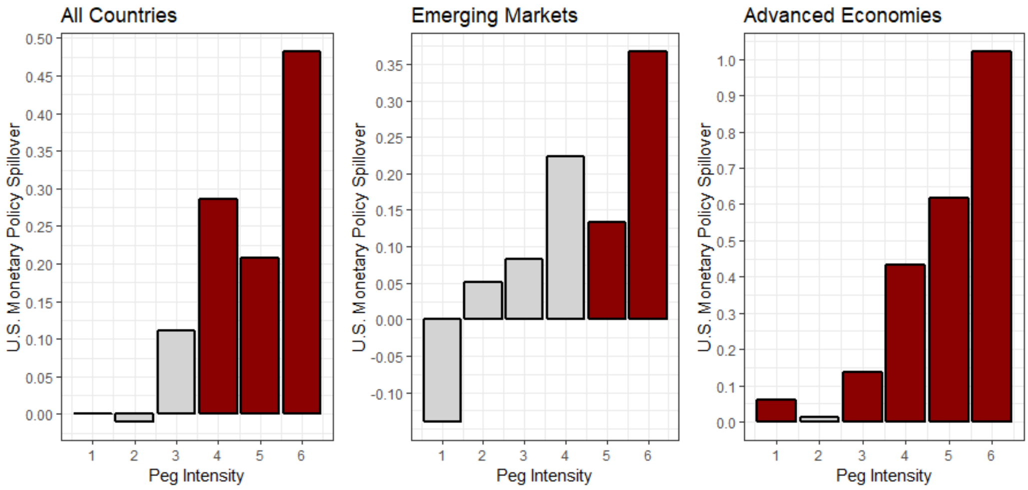
Like their Advanced Economy counterparts, across bins monetary policy pass-through appears non-linear in exchange rate peg intensity. Moving from a hard peg (bin 6) to a moderately strong peg (bin 5) can reduce on average, interest rate pass-through by two-thirds (from 0.37 to 0.13). Even more striking, is that bins 2 through 4 all show no evidence of significant monetary pass-through. That is, light pegs (bin 2) and even moderate pegs (bins 3 and 4), on average, afford as much monetary autonomy as a free floating exchange rate (bin 1). It's important, however to disclose that Emerging Markets are highly heterogeneous in their characteristics - reflected in the large standard errors among some of the effect estimates.

Moderate pegs (bins 2 and 3) appear to put as much weight on targeting inflation as free floating Emerging Markets (bin 1) and about 7 times as much weight compared under a hard peg (bin 6). However, contrasting with Advanced Economies, there is evidence of global financial conditions significantly impacting the monetary policy of Emerging markets under free floats or moderate floats (bins 1 and 2). Therefore, flexible exchange rates in Emerging Markets may be double-edged: while it buys monetary autonomy and greater allocation to domestic objectives, policy choices will also be influenced by global factors (Agrippino and Rey, 2015[50]). The sweet spot seemingly lies in the intermediate range - U.S. peg intensities between 0.30 and 0.5, where policy rates are able to adjust to domestic inflation, while buying a significant degree of monetary policy autonomy and insulation from global financial shocks.

10.4 Discussion

Digging deeper with more refined exchange rate regime classifications, evidence points to non-linear Trilemma trade-off between monetary autonomy and exchange rate stability - in both Advanced and Emerging countries. Weak and Moderate pegs can provide more stability than floating exchange rates with just as much monetary independence. Even moving from a hard peg to one that is strongly managed appears to reduce disproportionately the degree of monetary policy pass-through a country is exposed to. Among Advanced Economies, greater monetary autonomy bought with exchange rate flexibility is associated with stronger weights on domestic policy objectives (output growth), with no evidence of a global financial cycle effect on mon-

Figure 5: U.S. spillover estimates $\hat{\gamma}_{US}$ by Peg Intensity



Peg intensity of 1 corresponds to pure float. Peg intensity of 6 corresponds to hard peg vis-a-vis the USD. Estimates of $\hat{\gamma}_{US}$ from Equation 7. Dark-shaded bars are statistically significant at the 10% level.

etary policy. For Emerging Markets, exchange rate flexibility and greater monetary autonomy translates to heavier emphasis on inflation as a domestic policy target. Global financial cycle effects on monetary policy are present under both floating/near-floating and near-hard/hard peg regimes in Emerging Markets, therefore mid-intensity pegs appear to offer the best trade-off for this group of economies in terms of monetary independence and exchange rate stability.

10.5 The Role of International Reserves

I explore two possible mechanisms which could result in a non-linear trade off between exchange rate stability and monetary independence. The first of these is the role of reserves accumulation as an additional policy tool. The potential for foreign exchange interventions to allow a country to violate the Trilemma constraint has been discussed in the literature. Obstfeld et al. (2010)[55] argue that the demand for reserves is crucially motivated by the objective of financial stability amid increased financial integration. Empirically, they find that countries under soft pegs tend to hold significantly greater levels of reserves[28]. These countries may wish to actively intervene in exchange markets to prevent external financial shocks from causing large exchange rate devaluations. Aizenmen et al. (2010)[2] document the trend of several Emerging Markets choosing to target intermediate levels of exchange rate stability and financial openness while maintaining high levels of exchange rate stability, thereby violating the Trilemma. These countries also tend to hold sizable levels of international reserves. Steiner (2017)[58] and Angrick (2018)[7] also report evidence suggesting that the policy Trilemma constraint can be relaxed with active reserves management.

Using international reserves to relax the policy Trilemma constraints could apply whether in both the case where UIP holds or does not. If UIP holds, a country may choose to intervene in foreign exchange markets as an alternative way to stabilize the exchange rate rather than altering the interest rate directly. Specifically, sterilized interventions would, in theory, achieve exchange rate stability without changing the money supply. On the other hand, unsterilized interventions would alter the money supply, but with a lag, and therefore unsterilized interventions can also grant exchange rate stability with monetary independence - in the short-run. If UIP fails to hold (as it seems to empirically) then that itself causes the Trilemma constraints to break down. In this situation, matching the monetary policy of the base country may simply not be sufficient to maintain the desired level of exchange rate stability, with direct intervention being more effective.

To investigate the role of reserves, I test whether the accumulation and reduction of foreign exchange reserves are associated with base country monetary policy changes. To do this, I simply replace the dependent variable of the baseline equation (Equation 5) with changes in international reserves:

$$\begin{aligned}\Delta IR_{it} = \alpha_i + \phi_1 \Delta IR_{i,t-1} + \phi_2 \Delta y_{it} + \phi_3 \Delta \pi_{it} + \phi_4 \Delta RER_{it} \\ + \phi_5 \Delta VIX_t + \phi_6 \Delta \bar{R}_t \\ + \gamma_{US}[\hat{Z}_{US,t} \times \hat{W}^{\$}_{it} \times K_{it}] + \gamma_{EU}[\hat{Z}_{EU,t} \times \hat{W}^{€}_{it} \times K_{it}] + \epsilon_{it}, \quad (8)\end{aligned}$$

where ΔIR_{it} is the log change in international reserves (excluding gold) of country i in quarter t. Data on international reserves is taken from the IMF International Reserves and Foreign Currency Liquidity database.

[28]the effect of a hard peg was found not to be statistically significant, but economically significant and quantitatively similar to that under a soft peg.

A negative coefficient on $\hat{\gamma}_b$ suggests that a reduction in reserves is associated with a positive shock to the foreign interest rate, and this reduction strengthens in the degree of exchange rate rigidity. Under a rigid exchange rate regime, a higher foreign interest rate, without a reciprocated change in the local country interest rate, would cause capital outflows. However, this could be mitigated without an interest rate change (i.e. preserving monetary independence) if the central bank steps in by selling reserves to maintain exchange rate stability.

Table 3: International Reserves and Monetary Spillovers

Dep. Variable ΔIR_{it}	All Countries	Advanced Economies	Emerging Markets
$\hat{\gamma}_{US}$	-2.00**	-0.787	-3.296***
	(0.815)	(1.445)	(1.033)
$\hat{\gamma}_{EU}$	1.400	0.456	1.923
	(3.630)	(6.723)	(2.102)
$\hat{\gamma}_{US}$, $\hat{W}_{it}^{US} \in (0,1)$	-2.079**	-1.434	-4.117***
	(0.958)	(1.344)	(1.303)
$\hat{\gamma}_{EU}$, $\hat{W}_{it}^{EU} \in (0,1)$	-1.344	-3.001	0.949
	(5.065)	(7.268)	(4.162)

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Estimation period: Q2 2000 - Q4 2018. Peg intensity used: $\hat{W}_{it}^b$ (RA, 2).

Table 3 reports coefficient estimates. The first two rows consider the full spectrum of exchange rate flexibility including pure float and pure pegs (1,926 full sample observations) while the second two rows are considering only intermediate exchange rate regimes ($\hat{W}_{it}^b \in (0,1)$) (1,330 full sample observations) to assure that the results aren't driven by corner policies. Reserves seem to be more sensitive to U.S. shocks than E.U. shocks, with the latter not statistically significant across sub-samples. The significant negative coefficients on U.S. monetary shocks suggest that countries tend to reduce international reserves in response to a U.S. tightening, possibly to stabilize the exchange rate and prevent excessive depreciation. This effect strengthens in peg intensity, and is particularly significant among Emerging Markets, consistent with previous studies. The effects become more pronounced when considering the sub-sample of intermediate exchange rate regimes, with E.U. shocks turning negative and economically significant (but not statistically significant) for Advanced Economies. For Emerging Markets under intermediate pegs to the U.S. Dollar, a coefficient of -4.12 implies that under a strongly managed peg (peg intensity of 0.80), a 1 percentage point U.S. interest rate shock is associated with a reduction of international reserves equal to [+1% x -4.12 x 0.80] = -3.2%.

The significant response of international reserves to monetary shocks in Emerging Markets, which is particularly strong under intermediate exchange rate regimes, provides some evidence supporting their role in mitigating the policy Trilemma, thereby enabling a non-linear trade off between exchange rate stability and monetary autonomy.

10.6 Limits to International Arbitrage

A second mechanism that may produce a non-linear trade off between monetary autonomy and exchange rate stability is if there exists costly frictions which inhibit the free flow of capital (e.g. transaction costs, intermediation fees, illiquidity), thereby violating the UIP condition (Fama, 1984[19], Engel, 1996[17], Bansal and Dahlquist, 2000[8]). In the presence of such frictions, interest rate differentials between two pegged countries can persist, only to be arbitraged when the differential widens enough to compensate the investor for the associated costs. This suggests that monetary policy spillovers should not just be an increasing function in a) financial openness and b) exchange rate rigidity, but also the c) interest rate differential between the base country and country i. in other words, when the interest rate differential is small, country i has more monetary autonomy, therefore the pass-through of a U.S. monetary policy shock should be smaller, than when the interest rate differential is large (all else fixed).

I test for evidence consistent with this hypothesis with a simple extension to the baseline regression (Equation 5):

$$\Delta r_{it} = \alpha_i + \phi_1 \Delta r_{i,t-1} + \phi_2 \Delta y_{it} + \phi_3 \Delta \pi_{it} + \phi_4 \Delta RER_{it} + \phi_5 \Delta VIX_t + \phi_6 \Delta \bar{R}_t + \gamma_{US}[\hat{Z}_{US,t} \times \hat{W}^{\$}_{it} \times K_{it} \times |r_{i,t-1} - r_{US,t-1}|] + \gamma_{EU}[\hat{Z}_{EU,t} \times \hat{W}^{€}_{it} \times K_{it} \times |r_{i,t-1} - r_{EU,t-1}|] + \epsilon_{it}, \quad (9)$$

where the monetary policy shock instrument $[\hat{Z}_{US,t} \times \hat{W}_{it}^{b} \times K_{it}]$ is further interacted with the absolute lagged interest rate differential, $|r_{i,t-1} - r_{b,t-1}|$. Under this specification, a positive estimate on $\hat{\gamma}_b$ implies that for a given degree of exchange rate flexibility and financial openness, monetary policy spillovers will be larger when interest rate differentials are wider.

Table 4: International Arbitrage and Monetary Spillovers

Dep. Variable Δr_{it}	All Countries	Advanced Economies	Emerging Markets
$\hat{\gamma}_{US}$	0.042***	0.182	0.0419***
	(0.006)	(0.161)	(0.007)
$\hat{\gamma}_{EU}$	0.004	0.317**	-0.047
	(0.054)	(0.131)	(0.060)
$\hat{\gamma}_{US}$, $\hat{W}_{it}^{US} \in (0,1)$	0.013	0.208	-0.007
	(0.029)	(0.164)	(0.026)
$\hat{\gamma}_{EU}$, $\hat{W}_{it}^{EU} \in (0,1)$	0.150**	0.291**	0.108
	(0.070)	(0.130)	(0.084)

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Estimation period: Q2 2000 - Q4 2018. Peg intensity used: $\hat{W}_{it}^{b}$ (RA, 2).

Table 4 reports estimates of $\hat{\gamma}_b$, testing whether the interest rate differential influences monetary policy transmission. While broadly, coefficient estimates are positive (consistent with limits to arbitrage), statistical significance varies. The strongest evidence supporting limits to arbitrage is present in Advanced Economies targeting the Euro (estimtae of 0.317), and this effect is robust for the sub-sample of intermediate pegs (estimate of 0.291). A significant effect of interest rate differentials on monetary pass through is also seen in Emerging Markets targeting the USD, however, this effect is driven by corner policies (namely Emerging Markets under floating exchange rate regimes).

The non-linearities in the trade-off between monetary independence and exchange rate flexibility are specifically documented with regards to U.S. monetary policy spillovers. With this in mind, note that this evidence is generally not supporting the limits to arbitrage mechanism playing a role in the non-linear Trilemma trade-off that is observed (for U.S. spillovers).

Comparing the two mechanisms, the data suggests that the use of international reserves, especially in Emerging Markets, may be an import factor enabling countries to 'lean against' the Trilemma constraint (Aizenman et al., 2010[2]), thereby achieving exchange rate stability, but not necessarily at the cost of losing monetary autonomy.

11 Alternative Measures of Exchange Rate Flexibility

To stress test the results on non-linear monetary policy transmission, I take the Ilzetzki, Reinhart, Rogoff (2019)[37] (IRR) de facto *fine* exchange rate regime classifications to validate whether the non-linear results found in the previous sections generally hold under a different data classification. For this exercise, I only consider U.S. shocks rather than both U.S. and E.U. shocks since the construction of the IRR data doesn't consider de facto basket anchors. The IRR exchange rate regime data, which are monthly, are aggregated to quarterly averages. There are five levels: Floating, Weak Managed Float, Moderate Managed Float, Strong Managed Float, and Fixed. Denote them: 1, 2, 3 and 4 and 5, respectively. The original IRR fine classification contains 15 different regimes. I consolidate levels 2 through 13 into the respective bins described below:

Table 5: Consolidating IRR (2019)[37] Fine Classifications

IRR (2019)	To
13	1 (Float)
11, 12	2 (Weak Managed)
9, 10	3 (Moderate Managed)
6, 7, 8	4 (Strong Managed)
2, 3, 4, 5	5 (Peg)

IRR level 1, 14 and 15 are omitted. They correspond to, respectively: 1: no legal tender, 14: collapsing currency, 15: dual market with missing data.

The regression specification used is the same as Equation 5, but with only U.S. shocks, and now the discrete IRR exchange rate regimes:

$$\Delta R_{it} = \alpha_i + \phi_1 \Delta R_{i,t-1} + \phi_2 \Delta y_{it} + \phi_3 \Delta \pi_{it} + \phi_4 \Delta RER_{it} + \phi_5 \Delta VIX_t + \phi_6 \Delta \bar{R}_t + \gamma_{US}(IRR)[\hat{Z}_{US,t} \times D(IRR)^{\$}_{it} \times K_{it}] + \epsilon_{it}. \quad (10)$$

The coefficient $\hat{\gamma}_{US}(IRR)$ represents the spillover coefficients across the five different IRR exchange rate regime classifications. If the estimates are not significantly and/or monotonically increasing in exchange rate rigidity, the story of non-linear monetary spillovers remains consistent with the primary analysis.

Table 13 reports estimates of $\hat{\gamma}_{US}(IRR)$ across all countries, Advanced Economies, and Emerging Markets. The general pattern persists: under more rigid exchange rates (4 and 5), there is disproportionately less monetary independence. The hard peg (bin 5) estimates, interestingly, are statistically insignificant for Emerging Markets, but highly rigid floats (bin 4) are indeed significant. Across all three groups of countries, pass-through under free floating regimes are statistically insignificant, suggesting considerable monetary independence from the U.S.

For Emerging Markets, both bin 2 and bin 4 have significant, positive pass-throughs, suggesting that under both weak and strong managed floats there is some evidence of monetary pass-through. Similar to the focal set of tests, the middle-ground appears to offer both exchange rate stability and greater monetary autonomy (bin 3). Across Advanced Economies, the coefficients across middle ground regimes: Bins 2, 3 and 4, all are statistically significant ranging from 0.153 to 0.483. This itself implies non-linearity, as the estimated pass-through under a managed float is statistically significant despite the absence of a full peg.

To summarize, under a different measure of exchange rate regime, the results of suggestive non-linearity hold in most cases, where different degrees of flexibility *within* intermediate exchange rate regimes indicate disproportionate gains/losses in monetary autonomy. For Advanced Economies, no monetary independence appears to be lost when transitioning from a weakly managed to a strongly managed intermediate exchange rate regime. For Emerging Economies, the results appear to vary, yet evidence of linearly rising monetary pass-through as exchange rate rigidity rises is clearly absent.

12 Exogenous U.S. Monetary Policy Shocks

It's very possible that residual changes in interest rates $\hat{Z}_{US,t}$ and $\hat{Z}_{EU,t}$, used as interest rate 'shocks' are still containing endogenous movements related to omitted or unobservable expectations and macroeconomic forces. As an additional robustness check, I replace $\hat{Z}_{US,t}$ with identified U.S. monetary policy shocks, exploiting the movement in Fed Fund futures contracts around FOMC announcements (Kuttner, 2001[46])[29]. The slight alteration to the baseline regression then yields the following specification:

$$\begin{aligned}\Delta R_{it} = \alpha_i + \phi_1 \Delta R_{i,t-1} + \phi_2 \Delta y_{it} + \phi_3 \Delta \pi_{it} + \phi_4 \Delta RER_{it} \\ + \phi_5 \Delta VIX_t + \phi_6 \Delta \bar{R}_t \\ + \gamma_{US}[\mathbf{FFS}_{US,t} \times \hat{W}^{\$}_{it} \times K_{it}] + \gamma_{EU}[\hat{Z}_{EU,t} \times \hat{W}^{€}_{it} \times K_{it}] + \epsilon_{it}. \quad (11)\end{aligned}$$

Notice that the only alteration is that U.S. interest rate residuals $\hat{Z}_{US,t}$ are replaced with Fed Fund shocks $\mathbf{FFS}_{US,t}$. These shocks are computed by taking the change in the front-month Fed Funds futures contract over the day of a scheduled FOMC meeting. Then, these daily changes are aggregated to the quarterly frequency[30].

14 reports the baseline spillover estimates, but now with Fed Funds shocks replacing the U.S. interest rate residual. Consistent with Bluedorn and Bowdler (2010)[10], estimates across the full sample, Advanced Economies, and Emerging Markets all suggest $\hat{\gamma}_{US} = 1$ within 95% confidence bands, suggesting approximate 1-for-1 U.S. interest rate pass-through under open capital flows and a fixed exchange rate. The full country sample and Advanced Economy sub-sample estimates are statistically significant at the 1% level (estimates of 0.944 and 1.049, respectively), while the Emerging Market estimate of $\hat{\gamma}_{US}$ using $FFS_{US,t}$ is statistically significant at the 11% level (estimate of 0.867). Overall estimates of monetary pass-through under continuous exchange rate regime measures are robust to using either actual or unanticipated changes in U.S. monetary policy.

[29] Bluedorn and Bowdler (2010)[10] replace changes to U.S. interest rates with these 'Fed Funds shocks' to test the Trilemma, reporting highly significant results and near complete monetary pass-through to pegged countries.

[30] There is no severe serial correlation generated through aggregation. Unit root tests on the quarterly FF shock series reject the null of a unite root.

13 Omitting 2008-2010 Global Financial Crisis

I omit Q1 2008 - Q4 2010 and re-estimate the baseline regression (Equation 5) to infer to what degree the Global Financial Crisis may be driving estimates of monetary pass-through. It's the conventional view that over this period, global factors were driving synchronized fluctuations in real activity and financial volatility across countries. Thereby, it may be possible that correlations between monetary policy of different countries were actually responding to domestic conditions which happened to be synchronized.

Table 15 reports the results of the baseline tests (Equation 5) after omitting the crisis period, Q1 2008 - Q4 2010. Across all countries, Advanced Economies, and Emerging markets, the pass-through effects remain robust to omitting the crisis period. In fact, the pass-through effects on both U.S. and E.U. coefficients rise in the All Country sample after omitting the crisis period (to 0.522 and 0.398, respectively). Across Advanced countries, spillover estimates remain stable and highly significant. The pass-through coefficient for Emerging Markets rises considerably (to 0.474) after omitting the crisis period. The evidence of intermediate exchange rate regimes affecting the pass-through of monetary policy remains a highly robust feature of the data, insensitive to the Global Financial Crisis.

14 Conclusion

In this study, I investigate monetary policy spillovers under the Trilemma with a particular focus on intermediate exchange rates. To overcome the challenges typically faced exchange rate related research, I suggest a continuous de facto measure of exchange rate regime which considers the entire spectrum of exchange rate flexibility, thereby loosening the tight assumption that all middle-ground policies are equal.

Over the sample period of 2000-2018 and across Advanced and Emerging Markets alike, I document significant evidence of monetary policy pass-through conditional on greater financial openness and greater exchange rate rigidity. The extent of monetary pass-through from the U.S and E.U. 1) is broadly significant, but stronger for Advanced Economies, 2) occurs over both the short-run and longer-run, 3) varies *within* intermediate exchange rate regimes, 4) appears to be diversifiable under a basket peg, and 5) is non-linear in exchange rate flexibility. These results are generally robust to using different definitions of exchange rate flexibility and whether monetary spillovers are measured with actual interest rate changes or unanticipated shocks. The results are not driven by the Global Financial Crisis period.

The latter three points suggest that the intensive margin of exchange rate regimes matter - peg intensity influences monetary pass-through even upon moving away from corner policy choices. Moreover, monetary autonomy is non-linear in exchange rate flexibility. When facing U.S. monetary policy shocks in particular, intermediate exchange rate regimes are not all the same: near-corner policies can carry starkly different implications from corner policies themselves. In both Advanced Economies and Emerging Markets, the evidence suggests that countries can achieve almost the same monetary autonomy as a float without resorting to a pure float. Countries can also gain disproportionate monetary independence by sacrificing a relatively little exchange rate stability.

Two possible mechanisms which enable non-linear Trilemma trade offs are explored: The role of international reserves and limits to international arbitrage. The data supports the former, as I find countries tend to significantly expend international reserves in response to U.S. monetary policy shocks, and the reduction is larger under greater exchange rate rigidity, and more pronounced for intermediate pegs. Managing reserves to stabilize the exchange rate without necessarily losing monetary autonomy allows countries to 'lean against' the Trilemma constraint. The effects are particularly pronounced among Emerging Markets- the group of countries exhibiting more non-linearity between the Trilemma trade offs. I also test whether costly arbitrage may weaken monetary spillovers when interest rate differentials are sufficiently small. The evidence supporting this mechanism is relatively weak.

Such gains in monetary autonomy are allocated differently across Advanced Economies and Emerging Markets. Advanced Economies tend to put greater emphasis on output stabilization while Emerging Markets focus on inflation. However, Emerging Market monetary policy also becomes increasingly vulnerable global financial shocks as they move towards more flexible exchange rates.

The fact that the Two-Corners hypothesis has been continuously rejected, combined with the scarcity of pure floats, suggests that the de facto dominance of intermediate exchange rate regimes is here to stay. This paper's findings, specifically those suggesting a non-linear Trilemma trade-off concerning monetary independence, may provide one possible explanation as to why the majority of countries consistently choose middle-ground exchange rate policies.

15 Appendix: Data Detail

Quarterly central bank policy interest rates are taken from the BIS and IMF IFS databases. Additional data on interest rates were collected from individual central bank websites and Global Financial Data. When official central bank policy rates could not be used, short-term treasury bills, repos, or discount rates are used.

Inflation and CPI data is primarily drawn from the BIS, IMF IFS, and the World Bank. For country-quarter observations where data was not available, annual inflation rates (divided by four) were used for imputation. Inflation is year-over-year. Nominal GDP data is from the IMF IFS database. Growth rates are computed as year-over-year. Missing observations were filled in using annual frequency growth rates from the World Bank.

Daily exchange rate data is taken from the BIS and are used to estimate de-facto exchange rate peg intensity. Moreover, daily log returns are aggregated to the quarterly frequency, and combined with inflation data to derive quarterly real exchange rate returns. A positive change in the real exchange rate corresponds to local depreciation.

Annual capital controls measures are from the Chinn-Ito index and repeated over each quarter within the year, derived from the IMF AREAER. For Serbia, capital control measurements are taken from the Wang-Jahan index, which is also derived from the IMF AREAR index. Remaining missing values for Serbia are extrapolated (2000-2004, and 2014-2018). Since the index is updated through 2017, I extrapolate 2017 values to 2018. Developed and Emerging/Developing Economy classifications are taken from IMF WEO (2019).

Data on foreign exchange reserves are taken from the IMF International Reserves and Foreign Currency Liquidity database. International reserves are measured as the sum of total foreign currency reserves, IMF reserve positions and SDRs. Gold holdings are excluded from calculation.

For robustness, additional tests are run using alternative definitions of exchange rate regime. Specifically, I use the Ilzetzki, Reinhart, Rogoff (2017) data set on de-facto exchange rate regimes (coarse classification), which has 14 classes of flexibility which I consolidate into a smaller set. IRR exchange rate regime only thorough Q 4 2016. I take quarterly averages of monthly exchange rate regimes.

Fed Fund Futures data are taken from Bloomberg. 1st contract month yield changes are computed over the day of a scheduled FOMC meeting. Daily monetary policy shocks are then aggregated to the quarterly level (simple sum).

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16 Appendix: Main

Figure 6: Change in Peg Intensity from 2000 to 2018 by currency

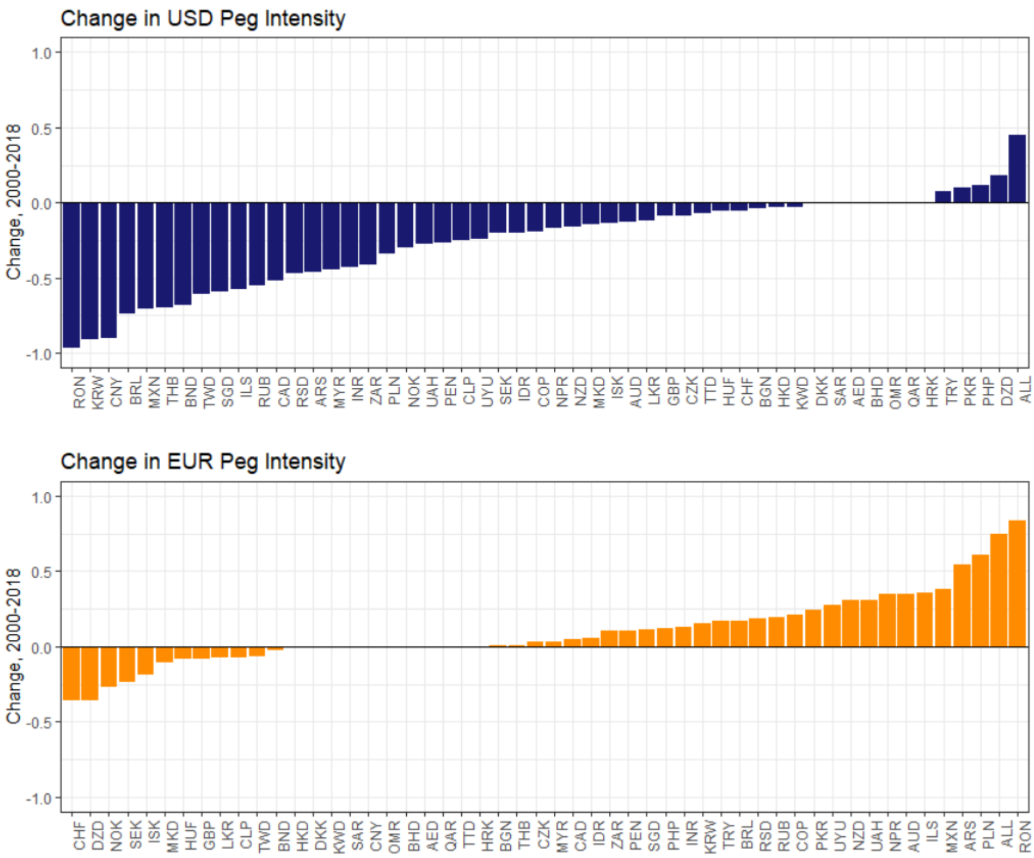


Figure 7: Peg intensities over time, selected countries

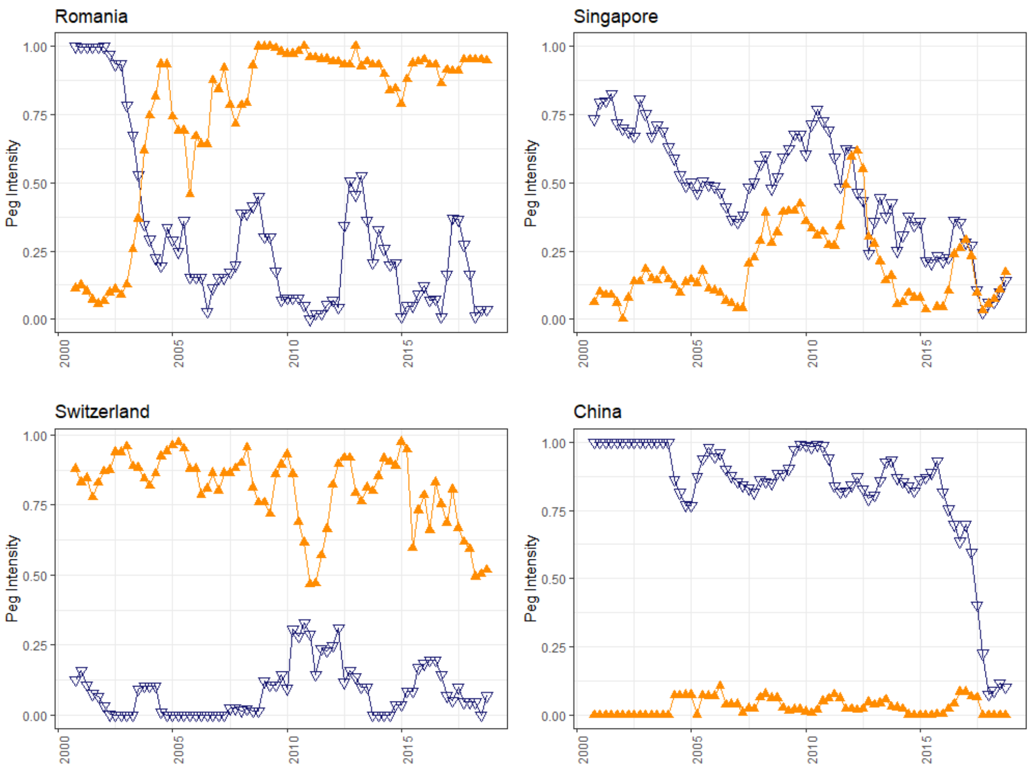


Figure 8: Peg intensities over time, cross-country average

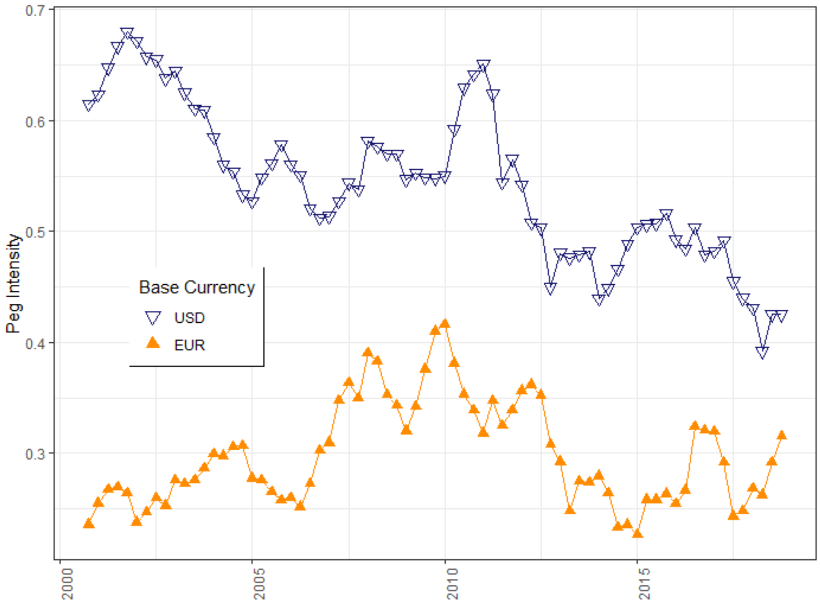
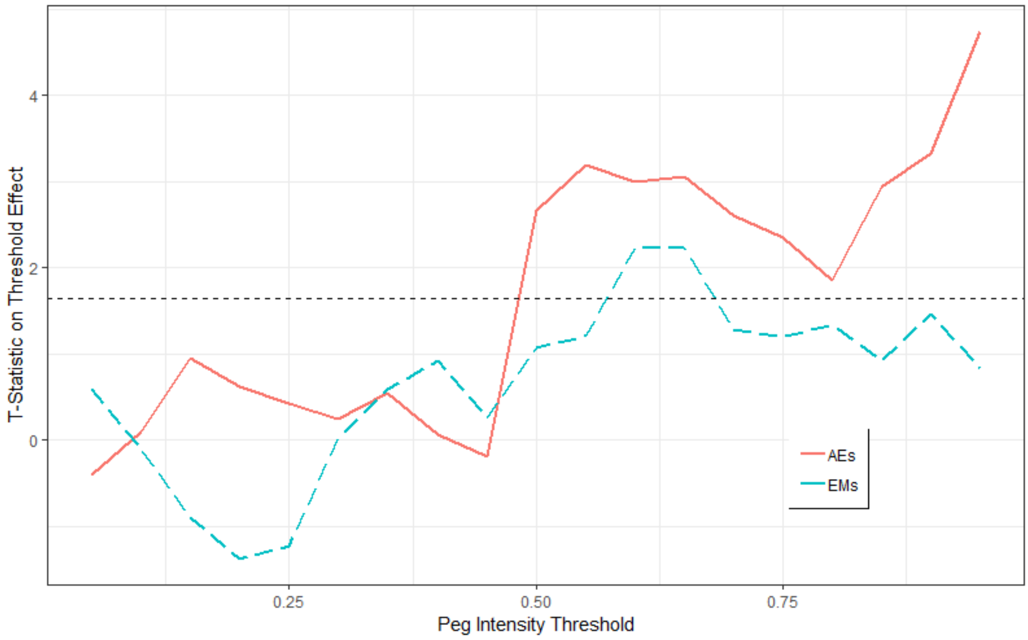


Figure 9: Threshold Testing for Non-Linear Spillover Effects, Advanced and Emerging Markets



Reporting robust t-statistics from regression (Equation 5 with a threshold indicator on de facto peg intensity, $\hat{W}_{it}^{US}$, RA(2)). X-axis denotes the threshold. Dashed horizontal line denotes t-statistic of 1.65 (10% significance).

Table 6: Baseline Regression Results:
All Countries

	(1)	(2)	(3)	(4)	(5)
	$\hat{W}_{it}^{b}$	$\hat{W}_{it}^{b}$ (RA, 2)	$\hat{W}_{it}^{b}$ (RA, 4)	$\hat{W}_{it}^{b}$ (RA, 2)	$\hat{W}_{it}^{b}$ (RA, 2) $\in (0, 1)$
$\hat{\gamma}_{US}$	0.351***				
	(0.108)				
$\hat{\gamma}_{EU}$	0.497***				
	(0.124)				
$\hat{\gamma}_{US}$		0.348***		0.442***	0.378**
		(0.125)		(0.168)	(0.154)
$\hat{\gamma}_{EU}$		0.467***		0.285*	0.667***
		(0.135)		(0.17)	(0.124)
$\hat{\gamma}_{US}$			0.362**		
			(0.148)		
$\hat{\gamma}_{EU}$			0.538***		
			(0.183)		
Adj. R^2	0.15	0.14	0.14	0.06	0.15
F-Statistic	69.38	58.06	46.05	46.86	43.96
N×T	2,882	2,532	1,937	2,532	1,727
Country FE	Y	Y	Y	Y	Y
Time FE	N	N	N	Y	N

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Regression specification of Equation 5. Estimation period: Q2 2000 - Q4 2018. Column 5 estimates on the sub-sample of intermediate pegs (peg intensities between 0 and 1, for both U.S. and E.U.

Table 7: Baseline Regression Results:
Advanced Economies

	(1)	(2)	(3)	(4)	(5)
	$\hat{W}^b_{it}$	$\hat{W}^b_{it}$ (RA, 2)	$\hat{W}^b_{it}$ (RA, 4)	$\hat{W}^b_{it}$ (RA, 2)	$\hat{W}^b_{it}$ (RA, 2) $\in (0,1)$
$\hat{\gamma}_{US}$	0.656***				
	(0.213)				
$\hat{\gamma}_{EU}$	0.799***				
	(0.071)				
$\hat{\gamma}_{US}$		0.742***		0.701***	0.737***
		(0.209)		(0.198)	(0.178)
$\hat{\gamma}_{EU}$		0.759***		0.422***	0.663***
		(0.117)		(0.121)	(0.088)
$\hat{\gamma}_{US}$			0.797***		
			(0.220)		
$\hat{\gamma}_{EU}$			0.700***		
			(0.131)		
Adj. R^2	0.42	0.43	0.42	0.186	0.40
F-Statistic	70.40	62.91	46.60	39.59	40.04
N×T	746	644	486	644	444
Country FE	Y	Y	Y	Y	Y
Time FE	N	N	N	Y	N

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Regression specification of Equation 5. Estimation period Q2 2000 - Q4 2018. Advanced Economies sub-sample only. .

Table 8: Baseline Regression Results:
Emerging Markets

	(1)	(2)	(3)	(4)	(5)
	$\hat{W}_{it}^{b}$	$\hat{W}_{it}^{b}$ (RA, 2)	$\hat{W}_{it}^{b}$ (RA, 4)	$\hat{W}_{it}^{b}$ (RA, 2)	$\hat{W}_{it}^{b}$ (RA, 2) $\in (0,1)$
$\hat{\gamma}_{US}$	0.266**				
	(0.108)				
$\hat{\gamma}_{EU}$	0.176				
	(0.165)				
$\hat{\gamma}_{US}$		0.238*		0.387**	0.119
		(0.127)		(0.181)	(0.154)
$\hat{\gamma}_{EU}$		0.145		-0.001	0.761***
		(0.182)		(0.209)	(0.288)
$\hat{\gamma}_{US}$			0.213		
			(0.153)		
$\hat{\gamma}_{EU}$			0.366		
			(0.327)		
Adj. R^2	0.13	0.13	0.12	0.04	0.13
F-Statistic	46.05	38.85	30.36	32.01	29.49
N×T	2,135	1,887	1,451	1,887	1,282
Country FE	Y	Y	Y	Y	Y
Time FE	N	N	N	Y	N

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Regression specification of Equation 5. Estimation period Q2 2000 - Q4 2018. Emerging Markets sub-sample only. .

Table 9: Spillover Effects across Peg Intensity Bins:
All Countries

Bin	1	2	3	4	5	6
$\hat{W}_{it}^{US}$ (RA, 2)	[0,0.1]	(0.1,.30]	(0.30,.50]	(0.50,0.70]	(0.70,0.90]	(0.90,1]
$\Delta\pi_{it}$	0.094***	0.115***	0.092***	0.056	0.170***	0.014*
	(0.022)	(0.043)	(0.015)	(0.045)	(0.025)	(0.007)
Δy_{it}	0.029**	0.014	0.017	0.022	0.004	0.005
	(0.012)	(0.012)	(0.015)	(0.017)	(0.006)	(0.006)
ΔVIX_{it}	0.163**	0.303**	-0.009	0.157	0.174*	-0.138**
	(0.068)	(0.118)	(0.064)	(0.129)	(0.088)	(0.060)
$\hat{\gamma}_{US}$	-0.047	0.006	-0.061	0.274**	0.204***	0.481***
	(0.103)	(0.095)	(0.271)	(0.134)	(0.066)	(0.132)
F-Statistic	7.19	6.14	10.31	9.23	26.65	9.84
N×T	385	356	409	356	389	684

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Regression specification of Equation 7. Estimation period Q2 2000 - Q4 2018. Country Fixed Effects included. .

Table 10: Spillover Effects across Peg Intensity Bins:
Advanced Economies

Bin	1	2	3	4	5	6
$\hat{W}_{it}^{US}$ (RA, 2)	[0,0.1]	(0.1,.30]	(0.30,.50]	(0.50,0.70]	(0.70,0.90]	(0.90,1]
$\Delta\pi_{it}$	0.009	0.115**	0.101**	0.003	-0.099	0.092***
	(0.024)	(0.047)	(0.049)	(0.031)	(0.068)	(0.012)
Δy_{it}	0.050***	0.049***	0.009	0.016***	0.039***	0.010
	(0.017)	(0.017)	(0.013)	(0.006)	(0.009)	(0.022)
ΔVIX_{it}	-0.093	0.062	-0.042	0.132*	0.043	-0.121
	(0.069)	(0.091)	(0.054)	(0.066)	(0.119)	(0.107)
$\hat{\gamma}_{US}$	0.060*	0.012	0.137**	0.433***	0.616***	1.021***
	(0.035)	(0.065)	(0.057)	(0.030)	(0.106)	(0.115)
F-Statistic	8.71	10.73	2.51	3.05	4.54	19.03
N×T	167	130	100	50	37	84

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Regression specification of Equation 7. Estimation period Q2 2000 - Q4 2018. Country Fixed Effects included. Advanced Economy sub-sample only. .

Table 11: Spillover Effects across Peg Intensity Bins:
Emerging Markets

Bin	1	2	3	4	5	6
$\hat{W}_{it}^{US}$ (RA, 2)	[0,0.1]	(0.1,.30]	(0.30,.50]	(0.50,0.70]	(0.70,0.90]	(0.90,1]
$\Delta\pi_{it}$	0.098***	0.109**	0.093***	0.058	0.172***	0.014**
	(0.023)	(0.050)	(0.016)	(0.046)	(0.026)	(0.007)
Δy_{it}	0.024	0.005	0.018	0.023	0.003	0.005
	(0.015)	(0.015)	(0.019)	(0.018)	(0.007)	(0.006)
ΔRER_{it}	0.026	-0.011	0.005	0.021**	-0.010	0.040**
	(0.018)	(0.009)	(0.010)	(0.008)	(0.007)	(0.018)
ΔVIX_{it}	0.285***	0.441***	0.007	0.168	0.175*	-0.133**
	(0.077)	(0.152)	(0.082)	(0.151)	(0.098)	(0.067)
$\hat{\gamma}_{US}$	-0.264	0.129	-0.255	0.208	0.131***	0.367***
	(0.270)	(0.436)	(0.509)	(0.180)	(0.059)	(0.113)
F-Statistic	5.19	3.05	8.02	9.04	25.63	6.42
N×T	218	226	309	306	352	600

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Regression specification of Equation 7. Estimation period Q2 2000 - Q4 2018. Country Fixed Effects included. Emerging Market sub-sample only. .

Table 12: Spillover Effects across Peg Intensity Bins:
Pooled Model (Equation 5) with Exchange Rate Regime Dummies

Bin	1	2	3	4	5	6
$\hat{W}_{it}^{US}$ (RA, 2)	[0,0.1]	(0.1,.30]	(0.30,.50]	(0.50,0.70]	(0.70,0.90]	(0.90,1]
All Countries						
$\hat{\gamma}_{US}$	-0.049	0.207	-0.206	0.025	0.125*	0.388***
	(0.082)	(0.166)	(0.269)	(0.212)	(0.064)	(0.140)
$\hat{\gamma}_{EU}$	0.296*	0.177	0.631***	0.990**	-0.066	0.439***
	(0.152)	(0.236)	(0.226)	(0.395)	(0.246)	(0.124)
Advanced Economies						
$\hat{\gamma}_{US}$	0.079*	0.098	0.168***	0.305***	0.376***	0.771***
	(0.041)	(0.104)	(0.056)	(0.066)	(0.050)	(0.211)
$\hat{\gamma}_{EU}$	0.444***	0.303***	0.399**	1.039***	0.332***	0.566***
	(0.081)	(0.066)	(0.171)	(0.199)	(0.096)	(0.085)
Emerging Markets						
$\hat{\gamma}_{US}$	-0.307	0.361	-0.491	-0.067	0.075	0.288**
	(0.215)	(0.534)	(0.496)	(0.300)	(0.073)	(0.133)
$\hat{\gamma}_{EU}$	0.221	0.040	0.771**	0.356	-0.764	0.444**
	(0.206)	(0.342)	(0.356)	(1.112)	(0.677)	(0.180)

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Regression specification of Equation 5, using dummy variables for values of $\hat{W}_{it}^{US}$ (RA, 2). Estimation period Q2 2000 - Q4 2018. Country Fixed Effects included. .

Table 13: Spillover Effects across IRR (2019)[37] Exchange Rate Regimes: Pooled Model (Equation 10) with Exchange Rate Regime Dummies

	Floating				Fixed
IRR Classification	**1**	**2**	**3**	**4**	**5**
All Countries					
$\hat{\gamma}_{US}(IRR)$	0.214	0.483***	0.153**	0.220**	0.177
	(0.155)	(0.162)	(0.074)	(0.087)	(1.772)
Advanced Economies					
$\hat{\gamma}_{US}(IRR)$	0.491	0.265***	0.341***	0.219***	2.374***
	(0.304)	(0.074)	(0.050)	(0.076)	(0.197)
Emerging Markets					
$\hat{\gamma}_{US}(IRR)$	0.076	0.868***	0.069	0.358***	-0.513
	(0.155)	(0.274)	(0.104)	(0.129)	(2.309)

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Estimation period Q2 2000 - Q4 2016. Country Fixed Effects included. .

Table 14: FOMC Monetary Policy Shocks

	(1)	(2)	(3)
	All Countries	Advanced Economies	Emerging Markets
$\hat{\gamma}_{US}$	0.944**		
	(0.392)		
$\hat{\gamma}_{EU}$	0.535***		
	(0.128)		
$\hat{\gamma}_{US}$		1.049***	
		(0.281)	
$\hat{\gamma}_{EU}$		0.817***	
		(0.117)	
$\hat{\gamma}_{US}$			0.867
			(0.534)
$\hat{\gamma}_{EU}$			0.239
			(0.168)
Adj. R^2	0.12	0.33	0.13
F-Statistic	42.88	42.61	38.88
N×T	2,120	644	1,887
Country FE	Y	Y	Y
Time FE	N	N	N

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Regression specification of Equation 5. Estimation period: Q2 2000 - Q4 2018. Peg intensity estimate used is $\hat{W}^b_{it}$ RA(2). FOMC monetary policy shocks are implied yield changes from front month Fed Funds Futures contracts over the day of an FOMC announcement. Changes are aggregated to quarterly frequency.

Table 15: Omitting the 2008 Global Financial Crisis

	(1)	(2)	(3)
	All Countries	Advanced Economies	Emerging Markets
$\hat{\gamma}_{US}$	0.522***		
	(0.127)		
$\hat{\gamma}_{EU}$	0.398***		
	(0.152)		
$\hat{\gamma}_{US}$		0.616***	
		(0.121)	
$\hat{\gamma}_{EU}$		0.575***	
		(0.102)	
$\hat{\gamma}_{US}$			0.474***
			(0.166)
$\hat{\gamma}_{EU}$			0.183
			(0.343)
Adj. R^2	0.12	0.39	0.11
F-Statistic	42.88	44.78	28.91
N×T	2,120	539	1,580
Country FE	Y	Y	Y
Time FE	N	N	N

***,**,* refer to significance at the 1%, 5% and 10% level, respectively. Robust standard errors clustered at the Country level. Regression specification of Equation 5. Estimation period: Q2 2000 - Q4 2018 but omitting crisis window of Q1 2008 - Q4 2010. Peg intensity estimate used is $\hat{W}^b_{it}$ RA(2).

Table 16: Peg Intensities to Base Currencies

#	Country/FX	USD (2000)	USD (2018)	EUR (2000)	EUR (2018)	JPY (2000)	JPY (2018)
1	AED	1.00	1.00	0.00	0.00	0.00	0.00
2	ALL	0.30	0.75	0.09	0.84	0.00	0.08
3	ARS	0.96	0.50	0.03	0.58	0.02	0.16
4	AUD	0.22	0.09	0.30	0.65	0.22	0.05
5	BGN	0.04	0.00	1.00	1.00	0.01	0.00
6	BHD	1.00	1.00	0.00	0.00	0.00	0.00
7	BND	0.74	0.06	0.03	0.00	0.03	0.07
8	BRL	0.99	0.25	0.05	0.22	0.02	0.51
9	CAD	0.69	0.17	0.06	0.11	0.12	0.00
10	CHF	0.13	0.07	0.88	0.52	0.03	0.24
11	CLP	0.68	0.42	0.08	0.00	0.02	0.12
12	CNY	1.00	0.10	0.00	0.00	0.00	0.00
13	COP	0.50	0.30	0.00	0.21	0.09	0.18
14	CZK	0.08	0.00	0.76	0.79	0.04	0.00
15	DKK	0.01	0.00	0.99	0.98	0.00	0.00
16	DZD	0.27	0.45	0.63	0.27	0.06	0.00
17	GBP	0.09	0.00	0.15	0.07	0.00	0.01
18	HKD	0.96	0.93	0.03	0.02	0.03	0.00
19	HRK	0.00	0.01	0.98	0.98	0.02	0.00
20	HUF	0.06	0.00	0.99	0.90	0.00	0.01
21	IDR	0.50	0.29	0.24	0.30	0.32	0.00
22	ILS	0.95	0.37	0.06	0.42	0.04	0.08
23	INR	0.92	0.49	0.02	0.15	0.03	0.01
24	ISK	0.25	0.11	0.45	0.26	0.00	0.18
25	KRW	0.96	0.05	0.02	0.17	0.19	0.05

Table 17: Peg Intensities to Base Currencies (cont.)

#	Country/FX	USD (2000)	USD (2018)	EUR (2000)	EUR (2018)	JPY (2000)	JPY (2018)
26	KWD	0.85	0.82	0.04	0.03	0.04	0.02
27	LKR	0.87	0.74	0.09	0.01	0.04	0.06
28	MKD	0.39	0.25	0.15	0.05	0.01	0.08
29	MXN	0.98	0.27	0.14	0.53	0.09	0.23
30	MYR	0.93	0.48	0.07	0.10	0.03	0.01
31	NOK	0.30	0.00	0.74	0.47	0.09	0.01
32	NPR	0.99	0.82	0.06	0.41	0.01	0.18
33	NZD	0.32	0.16	0.31	0.62	0.09	0.10
34	OMR	1.00	1.00	0.00	0.00	0.00	0.00
35	PEN	0.95	0.68	0.05	0.16	0.07	0.02
36	PHP	0.83	0.95	0.20	0.32	0.12	0.05
37	PKR	0.87	0.96	0.00	0.24	0.09	0.11
38	PLN	0.34	0.00	0.33	0.94	0.00	0.03
39	QAR	1.00	1.00	0.00	0.00	0.00	0.00
40	RON	1.00	0.04	0.11	0.95	0.03	0.03
41	RSD	0.47	0.00	0.14	0.33	0.14	0.13
42	RUB	0.99	0.43	0.08	0.27	0.12	0.00
43	SAR	1.00	1.00	0.00	0.00	0.00	0.00
44	SEK	0.20	0.00	0.68	0.44	0.04	0.08
45	SGD	0.73	0.14	0.06	0.17	0.08	0.04
46	THB	0.76	0.06	0.07	0.08	0.16	0.02
47	TRY	0.59	0.67	0.44	0.60	0.07	0.00
48	TTD	0.96	0.88	0.03	0.03	0.04	0.02
49	TWD	0.92	0.32	0.10	0.04	0.06	0.06
50	UAH	0.96	0.69	0.00	0.31	0.00	0.05
51	UYU	1.00	0.76	0.05	0.33	0.04	0.14
52	ZAR	0.44	0.03	0.39	0.49	0.08	0.26