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Global Financial Conditions and Monetary Policy Autonomy

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Abstract

Is the Mundell-Fleming trilemma alive and well? International co-movement of asset prices takes place alongside synchronized business cycles, complicating the identification of financial spillovers and assessments of monetary policy autonomy. A benchmark for interest rate co-movement is to impose the null hypothesis that central banks respond only to the outlook for domestic inflation and output. We show that common approaches used to estimate interest rate spillovers tend to understate the degree of monetary autonomy enjoyed by small open economies with flexible exchange rates. We propose an empirical strategy that partials out those spillovers that are associated with impaired monetary autonomy. Using this approach, we revisit the predictions of the trilemma and find more compelling evidence that flexible exchange rates deliver monetary autonomy than prior work has suggested.

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I. Introduction

Domestic financial conditions in small open economies tend to move in tandem with those prevailing abroad, as evidenced by the strong co-movement in interest rates across countries. The international interdependence of interest rates—particularly at short maturities— has been widely interpreted in the literature as evidence that small open economies lack monetary autonomy. It has been claimed that this calls into question the prediction of the classical trilemma that floating exchange rates enable open economies to implement an independent monetary policy (Rey, 2014; Hofman and Takáts, 2015; and Passari and Rey, 2015).

While the observed co-movement of interest rates across countries could be due to limited monetary autonomy, it could alternatively reflect the behavior of fully independent central banks that react to synchronized and interdependent economic cycles. Indeed, the correlation of interest rates is higher among countries whose macro conditions are more aligned with the rest of the world. As Bernanke (2015) has argued, the challenge is to establish a benchmark degree of co-movement beyond which we would suspect that a small open economy lacks monetary autonomy.

The concept of monetary autonomy is intimately related to the notion that interest rates "spill over" from large to small open economies. This paper argues that inference about monetary autonomy based on spillover estimates —a common approach in the international finance literature— tends to overstate the limits of monetary autonomy when business cycles are synchronized across countries. The reason is that not all monetary spillovers necessarily signal a lack of monetary autonomy. This paper proposes a strategy to identify limits to monetary autonomy in small open economies by isolating a subset of spillovers from foreign to domestic interest rates, allowing us to revisit the applicability of the classical trilemma.

We start by distinguishing between the correlation of interest rates in a small open economy and foreign interest rates that are due to common shocks leading to business cycle synchronization—often referred to as interest rate interdependence or *pass-through* in the literature— and movements in domestic interest rates that have been triggered by foreign monetary policy—typically denoted as monetary policy *spillovers*. While pass-through is relatively straight-forward to estimate, two familiar empirical challenges stand in the way of assessing monetary autonomy using estimates of spillovers. The first is the simultaneity of international asset prices that are affected by common drivers, which complicates the identification of foreign interest rate shocks. The second is the endogenous response of the domestic macroeconomic outlook following a change in foreign interest rates, which in turn calls for a response from domestic monetary policy.

The intuition behind the second challenge is as follows. Suppose that a central bank in a small open economy adjusts its policy rate in response to a change in its domestic macroeconomic outlook that was, in turn, triggered by a monetary policy decision made abroad. Whether these spillovers constitute evidence of impaired monetary autonomy will depend crucially on whether the policy decision was consistent with domestic developments. Rather, autonomy-impairing spillovers are the subset of responses of domestic rates to foreign shocks that are above and beyond what can be explained by the pursuit of these domestic objectives.

We propose addressing these challenges by reversing the problem, starting by the domestic monetary policy reaction function. More precisely, we estimate autonomy-impairing spillovers using a two-stage estimation of vector autoregressive (VAR) models. In the first stage, our estimation imposes the benchmark null hypothesis that the central bank exclusively pursues the objectives of stabilizing domestic output and prices. In the second stage, we estimate the impact of foreign interest rate movements on the deviations of domestic interest rates from their fitted values. We then compare our approach to alternatives that have been employed in the literature, using both simulated and actual data.

To illustrate how inference about autonomy is affected by alternative estimation methods, we generate artificial time series of macroeconomic conditions and interest rates in 'base' and 'small' stylized economies using stochastic simulations. We assume shocks to macroeconomic conditions in the large economy can affect those in the small economy, but that central banks in both economies follow inward-looking policy rules that react exclusively to domestic macroeconomic conditions. By construction, there are no autonomy-impairing spillovers in this artificial setting. We estimate a set of models used in the literature to assess the monetary autonomy of the small economy using the artificial data. Although the data generating process is characterized by full autonomy, ours is the only method that does not lead us to reject the null of full autonomy across a wide set of parameterizations.

A vast empirical literature has sought to quantify monetary policy spillovers under alternative exchange rate regimes to test the validity of the trilemma hypothesis. The impossible trinity or monetary trilemma in open economies (Mundell, 1963; Obstfeld and Taylor, 1998) states that if the monetary authority fixes the exchange rate, monetary policy cannot be tailored to achieve domestic objectives, such as ensuring output and price stability. Many studies have found that even if floaters enjoy more autonomy than peggers, the pass-through of international to domestic interest rates remains significant in both groups (some examples include Frankel, Schmukler, and Servén, 2004; Shambaugh, 2004; and Edwards, 2015). Some have even questioned the validity of the trilemma based on the large co-movement of interest rates and other asset prices across integrated economies (Rey, 2014; Hofman and Takáts, 2015; and Passari and Rey, 2015).

We revisit this question by employing our empirical approach to infer limits to monetary autonomy in a large set of countries. In a first exercise, we focus on a group of advanced small open economies with highly flexible exchange rates, including Australia, Canada, New Zealand, South Korea, Sweden and the United Kingdom. In country-by-country estimates, we find large and significant spillovers in all of these economies, confirming a result that has lead some authors to question the predictions of the trilemma. However, we find that autonomy-impairing spillovers are much smaller, and do not allow us to reject the null hypothesis of monetary autonomy for several of these highly integrated economies.

To generalize this result across a range of policy frameworks, we use a panel VAR setting to assess whether a more flexible exchange rate has led to greater monetary autonomy in a group of 40 advanced and emerging economies. By focusing on the relative size of autonomy-impairing spillovers, we find strong support for the trilemma hypothesis: monetary autonomy is greater in countries with floating exchange rates than in those with fixed exchange rates. In fact, autonomy-impairing spillovers are indistinguishable from zero in countries that implement floating exchange rate regimes.

We focus our discussion on the autonomy of the central bank to set short-term interest rates because it is precisely on the short-end of the yield curve that monetary authorities can hope to have the strongest influence. Certainly, other factors in the monetary transmission mechanism raise important questions.[2] For instance, it could well be the case that a central bank has strong influence on short-term rates, but that it has little influence on rates at longer maturities.[3] It could also be the case that risk-free rates are largely driven by monetary policy, but that they have little influence on the behavior of credit. Finally, monetary and credit conditions may have little impact on overall economic activity and inflation, which are the ultimate objectives of the central bank. These relevant and interesting questions go beyond the scope of this paper.

The outline of the paper is as follows. Section II presents a definition of monetary autonomy grounded in optimal monetary policy and reviews the estimation strategies that have been used in the empirical literature. Section III presents our empirical strategy for estimating the degree of autonomy, and uses a Monte Carlo exercise to test alternative estimation methods in the context of an artificial economy. Section IV revisits the trilemma question by estimating spillovers in a group of open economies with flexible exchange rates that are highly integrated with international capital markets. Section V extends this analysis to a large panel of countries, testing the predictions of the trilemma by evaluating whether monetary autonomy differs according to the exchange rate framework.

II. The Elusive Concepts of Monetary Spillovers and Autonomy

One strategy used to estimate the pass-through of foreign interest rates to domestic interest rates is to fit the following linear model:

$$\Delta i_t = \alpha + \beta \Delta i_t^* + e_t, \qquad \text{(Method I)}$$

where i_t^* is the monetary policy rate in a large base country and i_t is the corresponding domestic rate in a smaller economy.[4] An estimated $\hat{\beta}$ coefficient that is significantly different

[2] Many studies have indeed argued that there is a global financial cycle that does not coincide with movements in monetary policy (Obstfeld, 2015; Borio, 2014; Bruno and Shin, 2015; Rey, 2015). However, disentangling the effect of global financial conditions from domestic economic conditions on, say, credit growth relies on convincingly identifying their separate effects on credit demand and supply, something that is not always feasible.

[3] For example, if a significant fraction of domestic firms have access to foreign bond markets, or if cross-border bank lending is pervasive, overall credit growth may be less sensitive to changes in domestic interest rates.

[4] Some studies estimate country by country regressions, while others use a panel setting. Based on considerations about the integration order of interest rate data, some studies relied on estimations in levels while

(continued…)

from zero has been interpreted as evidence of lack of monetary policy autonomy in the small economy. For instance, Frankel, Schmukler, and Servén (2004), Shambaugh (2004), and Obstfeld, Shambaugh, and Taylor (2005) use panel regressions with specifications similar to Method I to assess whether the choice of exchange rate regime affects the sensitivity of local to foreign interest rates.

Yet there are many reasons why domestic financial conditions would be synchronized with those prevailing in international financial markets. For instance, when economic cycles are highly synchronized across countries —for instance, reflecting common shocks to oil prices, climate, and global demand— one would expect monetary policies and financial conditions to be broadly aligned as well. A high degree of correlation between the interest rates of these countries would thus not necessarily reflect a lack of monetary autonomy, complicating inference based on estimates of the pass-through coefficient $\hat{\beta}$.

One possible benchmark degree of interest rate co-movement between countries is that which would prevail if the central bank acted with full monetary autonomy in the sense of the trilemma. That is, domestic interest rates are set exclusively according to domestic objectives, without explicit regard for external variables such as the exchange rate. Under this benchmark, interest rate decisions that reflect autonomous reactions to domestic developments —regardless of where these might originate— are consistent with monetary autonomy.

Autonomy-impairing spillovers correspond to those movements in domestic interest rates that are triggered by foreign shocks but are unaligned with domestic monetary objectives. In this spirit, other studies have included a vector of controls $\boldsymbol{X}_t$ in order to isolate monetary policy spillovers, estimating a model such as:

$$\Delta i_t = \alpha + \delta \Delta \boldsymbol{X}_t + \beta \Delta i_t^* + e_t. \qquad \text{(Method II)}$$

The interpretation of the parameter β as a proxy for (lack of) monetary autonomy depends crucially on what is included in $\boldsymbol{X}_t$, because $\hat{\delta}\boldsymbol{X}_t$ will act as a benchmark. As all movements in the short-term domestic policy rate are chosen by the central bank, it will be possible to choose a sufficiently large vector $\boldsymbol{X}_t$ that fully characterizes movements in i_t, implying complete autonomy. Our definition of autonomy-impairing spillovers suggests that a key conceptual guide for the choice of $\boldsymbol{X}_t$ is the central bank's stated policy objectives.

The choice of $\boldsymbol{X}_t = \{\pi_t, y_t\}$, where π_t is a measure of inflation and y_t a measure of economic activity, is grounded in the literature on optimal monetary policy in open economies, in the tradition of Svensson (1997, 1999) and Clarida, Galí, and Gertler (2001, CGG). The latter show that the key monetary policy trade-offs in a canonical new-Keynesian open economy model are the same as in a closed economy: optimal monetary policy should target a linear combination of inflation and the output gap.

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others set up the estimations in first differences, or used error-correction specifications. The use of first-differences avoids the problem of spurious regression in a context where the levels are non-stationary.

Should $\boldsymbol{X}_t$ also include external variables? In most settings, the theoretical literature has argued that global financial conditions —including but not limited to the foreign monetary policy rate i_t^*— should not be included as additional arguments in the central bank's policy function. Indeed, Woodford (2007) considers several deviations from CGG's framework and concludes that globalization of goods markets, factor markets, and financial markets does not affect the ability of a Taylor rule on inflation and the output gap to effectively control the dynamics of domestic inflation, without any need for international policy coordination.

In contrast, de Paoli (2009) shows that in the presence of terms of trade externalities, the central bank's loss function in a small open economy may also include the real exchange rate. Engel (2011) also finds that addressing exchange rate misalignment is welfare-enhancing when local-currency pricing by firms is introduced in CGG's model, but the instrument rule that implements optimal policy in his model can take the form of a simple policy rules based on domestic prices. A similar conclusion is reached by Fujiwara et al. (2013) in the context of a global liquidity trap. And even under circumstances that raise theoretical reasons why the central bank might care about additional policy objectives, the weight that should be placed on them is typically found to be small.[5] In general, optimal monetary policy would react to i_t^* to the extent that it impacts (π_t, y_t), but additional reactions tend to impose large costs.[6]

The empirical literature has tended to share this view in terms of the variables to include in $\boldsymbol{X}_t$. In an early contribution, Clarida, Galí, and Gertler (1998) include expected inflation and industrial production in $\boldsymbol{X}_t$ in the estimation of monetary policy reaction functions for six advanced economies that allow for the possibility of spillovers from foreign interest rates. In recent studies within the trilemma literature, Klein and Shambaugh (2015) and Obstfeld (2015) control for actual domestic inflation and output growth when assessing the degree of monetary independence under different exchange rate regimes. A similar approach is adopted by Hofmann and Takáts (2015) to explore whether the high correlation found between interest rates in small emerging and advanced economies and those in the United States arise from synchronized business cycles—or other common factors—or, alternatively, reflects responses to U.S. rates above and beyond what may be explained by economic linkages. Aizenman, Chinn, and Ito (2015) assess the sensitivity of short-term interest rates in a large

[5] For instance, Obstfeld and Rogoff (2002) assess the potential gains from cross-country monetary policy cooperation in the presence of international economic interdependencies and find that they are at best very small. Benigno and Benigno (2006) also find that inward-looking policy rules can replicate cooperation allocations in standard settings. Coenen *et al.* (2010) confirm this result using a richer model calibrated to the U.S. and euro area economies. Walsh (2014) argues that the weight that should be placed on currency misalignment in Engel's model in a standard setting would be only 1/8th of that placed on the price stability objective. Batini, Levine, and Pearlman (2007) use welfare analysis in a model extended to include distortions such as financial frictions and liability dollarization and conclude that policymakers should not aim at achieving exchange rate objectives.

[6] For instance, consider the case of a shock to foreign interest rates that causes a depreciation of the local currency and increases the price of imported goods, raising domestic inflation. While such a shock may increase the tradeoff of meeting both π_t and y_t objectives, CGG show that reacting to the increase in π_t is consistent with optimal monetary policy so long as e_t remains orthogonal to global financial factors with $e_t \sim i.i.d.(0, \sigma^i)$.

set of countries to those of four large economies, including domestic industrial production in $\boldsymbol{X}_t$, and then explore what factors explain the cross-country heterogeneity found in the degree of sensitivity. Edwards (2015) explores whether policy changes by the Federal Reserve affect monetary policy rates in three Latin American countries with flexible exchange rates while controlling for domestic inflation in these economies.

To summarize these arguments, consider the central bank reaction function given by:

$$i_t = \alpha + h[\pi_t(i_t^*; \dots), y_t(i_t^*; \dots)] + g(i_t^*) + e_t, \quad \text{with } e_t \sim i.i.d.(0, \sigma^i).$$

Spillovers s_t from global financial conditions are those movements in domestic rates that can be attributed to changes in global financial conditions:

$$s_t = \frac{\partial i_t}{\partial i_t^*}.$$

However, we propose that those spillovers that signal impaired monetary autonomy are the subset of s_t that are not associated with domestic objectives, or in our notation, are driven by shifts in $g(i_t^*)$ but not through its impact on π or y:

$$\bar{s}_t = \frac{\partial \{i_t | \pi_t, y_t\}}{\partial i_t^*} = \frac{\partial i_t}{\partial g} \cdot \frac{\partial g}{\partial i_t^*}.$$

By forcing the central bank to deviate from domestic objectives, autonomy-impairing spillovers $\bar{s}_t \neq 0$ likely impose costly trade-offs on monetary policy. Their presence can thus be interpreted as evidence that monetary policy in the small country is constrained to some extent by foreign developments, and monetary autonomy limited.

III. Measuring Autonomy-Impairing Spillovers

While the coefficient $\hat{\beta}$ from method II captures our concept of autonomy-impairing monetary policy spillovers $\bar{s}_t$, it may be difficult to estimate in practice. First, there is likely to be endogeneity between the dependent variable i_t and the regressors $\boldsymbol{X}_t$ and i_t^*. This could be driven, for instance, by an unobserved common shock that drives all three variables. Second, the relationship between the variables is likely to be dynamic, with lag structures playing an important role. Taken together, these issues make it difficult to partial out the systemic response of domestic rates i_t to changes in domestic macro conditions included in $\boldsymbol{X}_t$.

In order to explore what these issues imply for assessing limits to monetary autonomy in practice, we generate artificial data and explore whether using the methods presented in the previous section could lead to misleading conclusions about monetary autonomy. We start by generating artificial stochastic series for policy rates using Monte Carlo simulations in a setting where a small open economy has complete monetary autonomy. Using a large number of simulations with the same data generating process, we evaluate whether alternative empirical approaches capture the absence of autonomy-impairing spillovers correctly.

Table 1. Baseline parameterization

	Base country	Small open economy
ρ	0.5	0.5
τ	0.5	0.5
σ	1	1
θ	0	0
α	1.25	1.75
δ	0.5	0.5
γ	-	1
β	-	0

We consider a 'base' economy and a 'small' open economy, where shocks to macroeconomic conditions in the base economy can affect macro conditions in the small economy, but not the other way round.[7] Macro conditions in the base (X_t^*) and small economy (X_t) follow autoregressive processes:

$$X_t^* = \alpha^* + \rho^* X_{t-1}^* + e_t^*, \qquad \text{and } e_t^* \sim N(0, \sigma^*) \tag{1}$$
$$X_t = \alpha + \rho X_{t-1} + \gamma e_t^* + e_t\ , \qquad \text{and } e_t \sim N(0, \sigma). \tag{2}$$

When $\gamma \neq 0$, shocks to macro conditions in the base economy propagate to macro conditions in the small economy; our baseline calibration will use $\gamma = 1$.

Central banks in both economies follow inward-looking policy rules, reacting exclusively to their respective domestic macro conditions. Monetary policy rates in these economies are given by:

$$i_t^* = \bar{\imath}^* + \tau^* i_{t-1}^* + \delta^*(X_t^* - \bar{X}^*) + u_t^*, \qquad \text{and } u_t^* \sim N(0, \theta^*) \tag{3}$$
$$i_t = \bar{\imath} + \tau i_{t-1} + \delta(X_t - \bar{X}) + \beta i_t^* + u_t, \qquad \text{and } u_t \sim N(0, \theta), \tag{4}$$

where $\bar{X}^*$and $\bar{X}$ denote the unconditional mean of X_t^* and X_t, respectively, and $\bar{\imath}^*$and $\bar{\imath}$ are the natural nominal interest rates. The central bank in the small economy reacts exclusively to deviations of macro conditions from their time-invariant target levels, so long as $\beta = 0$.[8]

[7] Macroeconomic conditions can include activity, price inflation, and other variables of interest. For simplicity and without loss of generality, we summarize them in a single variable labeled 'macro conditions'.

[8] Note also that there is no feedback from policy rates to macro conditions in either of the two economies. That is, monetary policy does not affect real activity or inflation. This simplification is not required for answering the question at hand, but simplifies the exposition.

Table 2. Average correlations between simulated time series using baseline parameter values

	i_t	i_t^*	X_t	X_t^*
i_t	1.00			
i_t^*	0.46	1.00		
X_t	0.98	0.50	1.00	
X_t^*	0.47	0.97	0.51	1.00

Using equations (1) through (4) and the parameter values shown in Table 1, we simulate 5,000 replications of X_t^*, X_t, i_t^* and i_t, each containing 200 observations. Table 2 displays the cross-correlations in these artificial economies under our baseline parameterization. Interest rates in each economy display a correlation close to unity with domestic macroeconomic conditions. Given the link through γ in equation (2), macroeconomic conditions and interest rates are also highly correlated across the two economies. Even though $\beta = 0$, interest rates display a correlation of 0.46 across countries—almost as high as the correlation between X_t^* and X_t.

We then estimate the response of interest rates in the small open economy to changes in base-country interest rates using alternative approaches, with results reported in Table 3. When we employ method I, the estimated pass-through coefficient $\hat{\beta}$ is large and statistically significant, reflecting the fact that interest rates in the two economies are highly correlated.[9] Of course, in our setting this result is exclusively driven by the correlation between economic cycles and does not reflect a lack of monetary autonomy in the small economy.

This method was widely used in the early literature to infer limits to monetary autonomy. For instance, Shambaugh (2004) uses panel regressions for groups of pegged and non-pegged countries under a specification comparable to method I. He finds that the coefficient $\hat{\beta}$ and the fit (R^2) of the regression are larger for pegs, leading to the conclusion that these countries follow base country interest rates more closely than non-pegs. While relatively smaller, the coefficient $\hat{\beta}$ for non-pegs is also statistically and economically significant: about 0.3, and rising above 0.5 when the sample is restricted to countries with no capital controls. Obstfeld, Shambaugh, and Taylor (2005) come to similar findings.

[9] The result is essentially driven by the parameter γ governing the degree of linkages in macro conditions: in the baseline parameterization with $\gamma = 1$, $\hat{\beta}$ is about 1 and the lower bound of its 95 percent confidence interval is above 0.85. If γ is reduced to 0.5, then $\hat{\beta}$ is roughly 0.50 and still strongly significant.

Table 3. Spillover estimation results

Scenario	Parameter values								Spillover estimate by method					
									Single equation			Structural VAR		
	ρ	ρ^*	γ	σ	τ^*	α^*	θ^*	τ	I	II	III	IV	V	VI
Baseline	0.5	0.5	1	1	0.5	0.5	0	0.5	100.0*	36.6*	22.4*	100.1*	93.8*	0.2
1	0.5	0.5	1	1	0.5	0.5	1	0.5	18.1*	4.3*	4.0*	25.7*	23.2*	0.0
2	0.5	0.5	1	1	0	0.5	0	0.5	83.4*	1.4	0.7	156.7*	155.5*	0.1
3	0.5	0.5	1	1	0.5	0.5	0	0	93.5*	0.5	0.3	56.2*	56.6*	0.2
4	0.5	0.5	1	0.1	0.5	0.5	0	0.5	100.0*	76.2*	22.3*	100.3*	98.8*	0.2
5	0.5	0.5	1	0.1	0.5	0.5	1	0.5	18.1*	4.7*	4.1*	26.1*	23.7*	0.0
6	0.5	0.5	1	0.1	0	0.5	0	0.5	83.3*	6.1	0.6	179.6*	189.2*	0.1
7	0.5	0.5	1	0.1	0.5	0.5	0	0	93.6*	1.2	0.3	52.5*	52.6*	0.2
8	0.5	0.5	0.5	1	0.5	0.5	0	0.5	50.2*	13.4*	11.3*	50.6*	44.9*	0.1
9	0.5	0.5	0.5	1	0.5	0.5	1	0.5	9.2*	2.2	2.1	12.3	11.5	0.0
10	0.5	0.5	0.5	1	0	0.5	0	0.5	41.5*	0.4	0.3	76.7*	66.9*	0.0
11	0.5	0.5	0.5	1	0.5	0.5	0	0	46.8*	0.1	0.1	28.4*	28.9*	0.1
12	0.9	0.5	1	1	0.5	0.5	0	0.5	87.2*	2.0	1.1	182.9*	199.0*	0.0
13	0.5	0.9	1	1	0.5	0.5	0	0.5	80.5*	36.3*	29.5*	37.3*	37.6*	0.2

Note: The table shows the cumulative spillover response from i^* to i after 12 periods following an increase of 100-basis points in i^*. "*" denotes that the response is significantly different from zero at a 5% confidence level.

We then turn to method II, including domestic macroeconomic conditions as an additional regressor, such that the estimate $\hat{\beta}$ can be interpreted as an indicator of limited autonomy. This methodology is similar to that employed by Aizenman, Chinn, and Ito (2015), Clarida, Galí, and Gertler (1998), and Klein and Shambaugh (2015), among others.

Under our baseline parameterization, we find that the estimated coefficient remains large and statistically significant: $\hat{\beta}$ is estimated at 0.36, and the lower bound of its 95% confidence interval is as large as 0.25. That is to say, the estimation method leads us to reject the null hypothesis of no autonomy-impairing spillovers despite the DGP being designed to exclude them.

The extent to which we find false evidence of limited autonomy by looking at $\hat{\beta}$ is determined by the correlation structures we impose on our artificially simulated economies. Indeed, under some alternative parameterizations, estimation using method II does not lead us to reject the null hypothesis. For instance, if there is no inertia in the Taylor rules (scenarios 2 and 3), $\hat{\beta}$ is indistinguishable from zero at a 5% confidence level.[10] Other features, such as larger noise in the base country policy rule (i.e. larger θ^*, scenario 1), also

[10] In the empirical literature, Taylor rules are generally found to be highly persistent, suggesting that these scenarios are unlikely to apply in practice.

reduce the bias in our assessment, but estimates of $\hat{\beta}$ remain significantly different from zero, and we would still conclude that there is significant evidence of limited autonomy. The extent of the error in assessing monetary autonomy increases under other parameterizations: for instance, if foreign macro shocks are large relative to domestic shocks, $\hat{\beta}$ can exceed 0.75 and becomes highly significant.

These and other characteristics of the data generating process (e.g., time-varying volatility of the shocks) are likely to affect estimates of $\hat{\beta}$ and assessments of monetary autonomy in empirical work. We suspect that this helps explain the wide range of results reported in the literature, even under very similar estimation techniques. For instance, Klein and Shambaugh (2015) find an insignificant response of domestic rates to changes in base country rates for countries with floating exchange rates and fully open capital accounts, but find a significant and large coefficient (about 0.5) for a subsample of advanced countries—which have highly synchronized business cycles.

Obstfeld (2015) extends the analysis in Obstfeld, Shambaugh, and Taylor (2005) by including domestic price inflation and output growth as additional controls, with only small differences to spillover estimates. Hofmann and Takáts (2015) follow the same approach and find significant monetary spillovers from U.S. to domestic short-term rates in other countries, even when controlling for U.S. and domestic factors. In apparent contradiction to the trilemma framework, they find that the exchange rate regime does not make a significant difference to spillover size. Similarly, Edwards (2015) finds evidence that central banks in three Latin American countries tend to follow the Federal Reserve to a large extent, despite their use of a floating exchange rate regime.

An alternative approach: modelling the domestic policy ruleexplicitly

Some of the aforementioned studies flagged caveats to their conclusions related to the presence of common shocks or to the familiar problem of identifying the response of monetary policy rates to domestic fundamentals. Certain robustness exercises, like adding time fixed effects to cope with common shocks, have been deemed problematic since most small economies are linked to a handful of base countries with correlated interest rates. Some of these studies, such as Shambaugh (2004) and Obstfeld, Shambaugh and Taylor (2005), suggest modeling the domestic policy interest rate more formally as a way to overcome these limitations. We take up this suggestion and explore its influence on assessments of monetary autonomy in the simulated data.

Since the seminal contribution of Bernanke and Blinder (1992), the literature on monetary policy transmission has employed VAR models that accommodate rich dynamics. We therefore take a VAR modeling approach and discuss alternative specifications that can help overcome the endogeneity issues inherent in assessing monetary autonomy in a small open economy. For expositional purposes, we start with the simplest model, writing method I in a reduced-form VAR(p) representation:[11]

[11] Given the data generating process, we use a parsimonious lag structure with $p = 2$.

$$\begin{bmatrix} \Delta i^* \\ \Delta i \end{bmatrix}_t = \boldsymbol{B}_0 + \sum_{j=1}^{p} \boldsymbol{B}_j \begin{bmatrix} \Delta i^* \\ \Delta i \end{bmatrix}_{t-j} + \begin{bmatrix} e^{i^*} \\ e^{i} \end{bmatrix}_t, \quad \text{with} \quad \begin{bmatrix} e^{i^*} \\ e^{i} \end{bmatrix} \sim N(\boldsymbol{0}, \Omega), \qquad \text{(Method IV)}$$

If the domestic economy is sufficiently small, the reduced-form coefficient matrices $\boldsymbol{B}_j$ can be restricted to ensure the block exogeneity of Δi^*, such that interest rates in the base economy are not affected by interest rates in the small economy. Identification of monetary policy shocks will be obtained by imposing timing restrictions on the innovations, under the assumption that policy affects the real economy with a lag. Spillovers can then be measured by examining the impulse-response of Δi following an orthogonalized shock to Δi^*.

In turn, method II can be written in reduced-form VAR representation as follows:

$$\begin{bmatrix} \Delta i^* \\ \Delta \boldsymbol{X} \\ \Delta i \end{bmatrix}_t = \boldsymbol{B}_0 + \sum_{j=1}^{p} \boldsymbol{B}_j \begin{bmatrix} \Delta i^* \\ \Delta \boldsymbol{X} \\ \Delta i \end{bmatrix}_{t-j} + \begin{bmatrix} e^{i^*} \\ \boldsymbol{e}^{\boldsymbol{X}} \\ e^{i} \end{bmatrix}_t, \quad \text{with} \quad \begin{bmatrix} e^{i^*} \\ \boldsymbol{e}^{\boldsymbol{X}} \\ e^{i} \end{bmatrix} \sim N(\boldsymbol{0}, \Omega), \qquad \text{(Method V)}$$

where $\boldsymbol{X} = \{\pi, y\}$ are domestic macroeconomic conditions in the small economy. In a small open economy context, the matrices $\boldsymbol{B}_j$ have again been restricted to ensure the block exogeneity of Δi^*.

However, identifying spillovers—and autonomy-impairing spillovers in particular—in a VAR setting remains subject to serious challenges. First, the timing assumption needed to identify structural shocks to Δi^* is not credible in the presence of endogenous financial variables such as interest rates, since these are likely to respond simultaneously to information that is excluded from the model. For instance, a shock to global demand might affect monetary policy in both the large and the small economy within the period it occurs. Second, it does not allow us to estimate the partial effect of a shock from i_t^* on i_t that excludes the endogenous response of $\boldsymbol{X}$.

Some studies have proposed using high frequency data on market prices of financial contracts to overcome identification restrictions when estimating monetary policy shocks in the United States (e.g., Hanson and Stein, 2015, Gertler and Karadi, 2015, and Gilchrist, López-Salido, and Zakrajsek, 2015). Shocks identified in this fashion have in turn been used to estimate spillovers to interest rates in small open economies (some examples include Dedola, Rivolta, and Stracca, 2015, Passari and Rey, 2015, and Rey 2014). While this approach is likely to succeed in capturing monetary decisions that have not been anticipated by markets, it does not fully address the two issues raised above. First, even if these identified shocks are unanticipated by markets, they may not be fully orthogonal to global economic conditions, in which case simultaneity will remain. For instance, Georgiadis and Jancoková (2016) document how alternative series of identified monetary policy shocks found in the literature tend to be highly correlated across countries, suggesting that they are capturing real and financial interlinkages along with the policy decisions they are meant to isolate.

Second, monetary policy shocks in the base country are likely to affect expected economic conditions in the small economy. To assess monetary autonomy based on interest rate spillovers, we would still need to exclude the endogenous response of i_t to $\boldsymbol{X}$. We come back to these issues in Section IV, where we report estimated responses of domestic rates using both realized and unanticipated changes in U.S. policy rates.

We propose addressing these challenges by reversing the problem, starting by modeling the domestic monetary policy reaction function. The aim is to partial out the systematic policy response to changes in domestic macroeconomic conditions. Our method for estimating autonomy-imparing spillovers involves a two-stage VAR procedure. We begin by estimating those changes in interest rates in the small economy that are not endogenous reactions to changes in domestic macroeconomic conditions, and then estimate whether these have been driven by foreign interest rates.

One way to implement the proposed strategy for the first stage is to estimate a Taylor-type rule for the dynamic relationship between domestic interest rates and domestic macroeconomic conditions:[12]

$$\begin{bmatrix} \Delta \boldsymbol{X} \\ \Delta i \end{bmatrix}_t = \boldsymbol{A}_0 + \sum_{j=1}^{p} \boldsymbol{A}_j \begin{bmatrix} \Delta \boldsymbol{X} \\ \Delta i \end{bmatrix}_{t-j} + \begin{bmatrix} \boldsymbol{e}^{\boldsymbol{X}} \\ e^i \end{bmatrix}_t . \qquad \text{(Method VI, step 1)}$$

Estimation by ordinary least squares ensures that the reduced-form innovations $\hat{\boldsymbol{e}}^{\boldsymbol{X}}$ and $\hat{e}^i$ are orthogonal to lagged values of $\Delta \boldsymbol{X}$ and Δi, but they are likely to display substantial contemporaneous correlation. We then regress the innovations $\hat{e}^i$ on the residuals from the other equation, $\hat{\boldsymbol{e}}^{\boldsymbol{X}}$:

$$\hat{e}^i = \alpha + \boldsymbol{\beta}' \hat{\boldsymbol{e}}^{\boldsymbol{X}} + u_t^i. \qquad \text{(Method VI, step 2)}$$

The residuals $\hat{u}_t^i$ are orthogonal to the reduced-form innovations to domestic economic conditions $\hat{\boldsymbol{e}}^{\boldsymbol{X}}$, corresponding to a timing restriction whereby expectations about the domestic outlook are predetermined with respect to monetary policy.[13] As such, these residuals can be interpreted as deviations from the central bank's historical policy reaction function characterizing its pursuit of price and output stabilization.

Finally, we quantify to what extent these residual movements in domestic interest rates can be explained by movements in Δi^*. To do so, we estimate the following VAR(p) model:

$$\begin{bmatrix} \Delta i^* \\ \hat{u}_t^i \end{bmatrix}_t = \boldsymbol{B}_0 + \sum_{j=1}^{p} \boldsymbol{B}_j \begin{bmatrix} \Delta i^* \\ \hat{u}_t^i \end{bmatrix}_{t-j} + \begin{bmatrix} v^{i^*} \\ v^i \end{bmatrix}_t, \qquad \text{(Method VI, step 3)}$$

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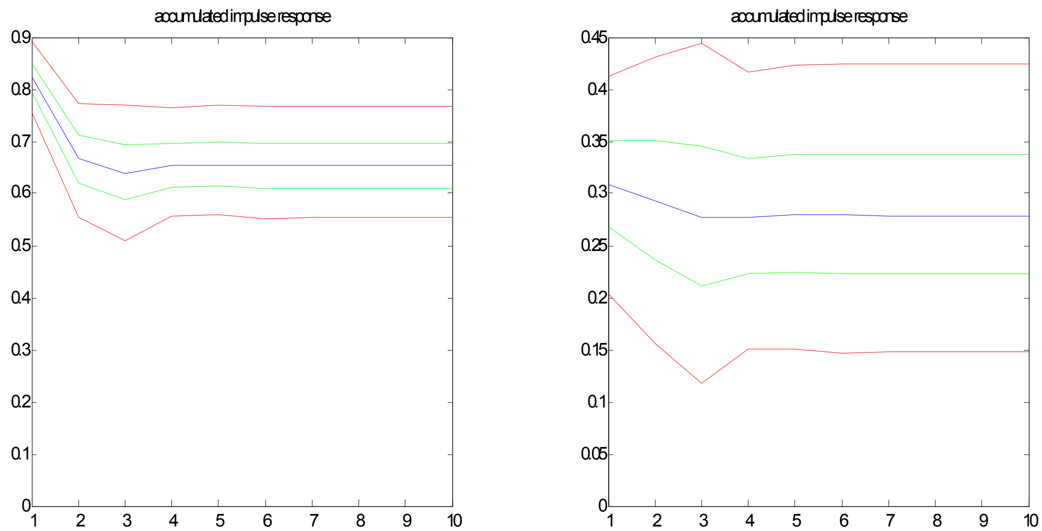
[12] It should be noted that the Taylor-type rule used in the first stage is only one way of implementing this approach. Refinements to better partial out the systematic policy response to domestic macroeconomic conditions in applications with actual data are naturally possible.

[13] The timing restriction is the same that would be imposed through a Cholesky decomposition to obtain structural impulse response functions from monetary policy shocks.

Figure 1. Cumulative impulse response functions following orthogonalized shock to Δi^* under alternative estimation methods (Monte Carlo simulations)

A. Cumulative response of Δi^*

B. Method IV: Cumulative response of Δi



Note: The blue line denotes the median response estimate across simulated samples. The green and red lines denote 75 and 95 percent confidence bands, respectively.

where the matrices $\boldsymbol{B}_j$ are restricted to impose the block exogeneity of Δi^*. Autonomy-imparing spillovers are defined as the response of $\hat{u}_t^i$ from a shock to Δi^*, with identification coming from a timing restriction imposed through Cholesky decomposition.

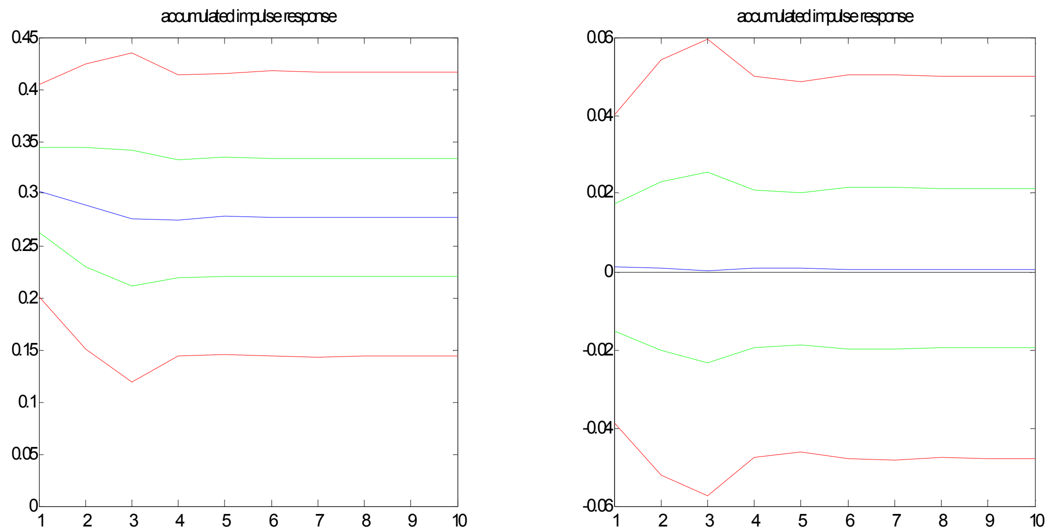
We now turn to the estimates generated by the VAR models corresponding to methods IV through VI. Figure 1 displays the cumulative responses of model variables following an orthogonalized shock to base country interest rates. Panel A shows the response of Δi^*, which rises approximately 65 basis points after one year. The results under alternative parameter values of the Monte Carlo simulation are reported in Table 3, and have been rescaled by the cumulative change in Δi^* to facilitate the comparison across methods and simulation scenarios.

Panel B displays the cumulative impulse response of Δi_t that is estimated using method IV. This response corresponds to the spillover from base country interest rates to domestic interest rates, but does not condition on domestic macroeconomic conditions. Not surprisingly, the results are very similar to the single-equation estimates generated by method I: estimated spillovers are large, significant, and driven by the degree of correlation in macro conditions. Under the baseline parameterization, the 95 percent confidence interval for the spillover estimate lays above 15 basis points, or about ¼ of the increase in interest rates in the base country.

Figure 1 (continued). Cumulative impulse response functions following orthogonalized shock to Δi^{*} under alternative estimation methods (Monte Carlo simulations)

C. Method V: Cumulative response of Δi

D. Method VI: Cumulative response of Δi



Note: The blue line denotes the median response estimate across simulated samples. The green and red lines denote 75 and 95 percent confidence bands, respectively.

The estimates from method V are reported in Panel C. The inclusion of X as an additional endogenous variable in the VAR does not reduce the magnitude of the response of domestic to foreign interest rates, since the estimated impact of Δi^{*} on Δi allows for an endogenous response through X.[14] Taking the spillover estimates at face value, this approach would still lead us to erroneously conclude that monetary autonomy is limited in the artificial small economy.

Finally, spillover estimates using the two-stage VAR approach (method VI) are shown in Panel D. The estimated response of domestic interest rates to changes in interest rates in the base economy is statistically indistinguishable from zero. That is, the estimation results indicate no evidence of autonomy-impairing spillovers, in line with the assumptions underlying the data generating process. Importantly, this result holds for all the alternative parameterizations considered in Table 3.

For completeness, we also implement method II—a single-equation approach—in two stages. That is, in method III we begin by regressing domestic interest rates on domestic macro conditions:

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[14] The ordering of the shocks also imposes that Δi^{*} is predetermined with respect to both X and Δi, so identified shocks are identical to those from method II.

$$\Delta i_t = \alpha + \rho \Delta X_t + u_t. \qquad \text{(Method III, stage 1)}$$

Then, we regress the estimated residuals from the first stage ($\hat{u}_t$) on foreign interest rates Δi_t^*:

$$\hat{u}_t = \alpha + \beta \Delta i_t^* + v_t. \qquad \text{(Method III, stage 2)}$$

In certain environments, method III can lead to a smaller bias in the assessment of monetary autonomy. The two-stage estimate for $\hat{\beta}$ is always closer to zero (the true value of β), and is about 40% smaller than under method II.[15] However, the proxy for lack of monetary autonomy remains positive and statistically significant. This highlights the relevance of allowing for richer dynamics when modeling the domestic monetary policy problem.

IV. Assessing monetary autonomy in Selected Small Open Economies

Largely based on empirical evidence of financial spillovers, Rey (2014, 2015) argues that financial integration constrains monetary autonomy regardless of the exchange rate regime. In the previous sections we have argued that the presence of spillovers does not necessarily imply limits to monetary autonomy.

We now apply alternative empirical approaches to assess monetary autonomy in six economies that are fully integrated with international capital markets and exhibit highly flexible exchange rates: Australia, Canada, New Zealand, South Korea, Sweden, and the United Kingdom. We use monthly data from January 1998 to June 2009 in order to avoid the period during which U.S. policy rates were at the zero lower bound. During the estimation period, these small open economies implemented inflation targeting regimes characterized by flexible exchange rates, and all were well integrated into global financial markets.

We estimate spillovers from changes in the U.S. federal funds rate to domestic short-term interest rates, focusing particularly on Treasury bills with maturity between 3 and 6 months.[16] While this is not the monetary policy instrument, it is closely linked to changes in the monetary policy stance. Indeed, to the extent that the central bank can affect domestic monetary conditions at all, this type of instrument is where we would expect to see it. We focus on spillovers from U.S. monetary policy rates because they are a key driver of global financial conditions measured across a wide range of asset classes. In a robustness exercise, we will consider spillovers from the monetary policy set by the European Central Bank for those countries with closer ties to the euro area.

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[15] Intuitively, methods II and III are quite similar: Method II is equivalent to performing the estimation $(\Delta i_t|\Delta X_t) = \alpha + \beta_2(\Delta i_t^*|\Delta X_t) + u_t$, where $(\Delta i_t|\Delta X_t)$ and $(\Delta i_t^*|\Delta X_t)$ are the residuals from estimating Δi_t and Δi_t^* on ΔX_t, respectively; whereas method III is equivalent to estimating the model $(\Delta i_t|\Delta X_t) = \alpha + \beta_3\, \Delta i_t^* + u_t$. Algebraically, it can be shown that the difference between β_2 and β_3 is always positive, and this difference increases with the correlation between Δi_t^* and ΔX_t.

[16] For more details on the sources and construction of the interest rate series, see Data Appendix.

An important practical decision is the choice of variables to include in the vector $\boldsymbol{X}$ that controls for domestic macroeconomic conditions. As argued previously, theory suggests that a measure of inflation and output are sufficient to characterize the optimal policy reaction function for a central bank in a small open economy. At monthly frequency, consumer price inflation is readily available for most countries and industrial production can be used as a proxy for output. However, monetary authorities operating under inflation targeting usually justify their monetary policy decisions based on changes in the economic outlook, rather than on observed data.[17,18] Ideally, we would employ the forecasts used internally by the central bank to inform the policy decision, as in Romer and Romer (2004), but these are only available for a handful of countries and with a significant delay. As such, we use changes in the expectations of private forecasters about output growth and consumer price inflation, as reported monthly by Consensus Economics. This source delivers fixed-point forecasts, whereby each forecaster reports their expectation for GDP growth and inflation during the current and following calendar year. Following Dovern, Fritsche and Slacalek (2012), we use a linear combination of these fixed-point forecasts to construct a fixed horizon forecast, corresponding to the expected evolution of each variable over the following 12 months.

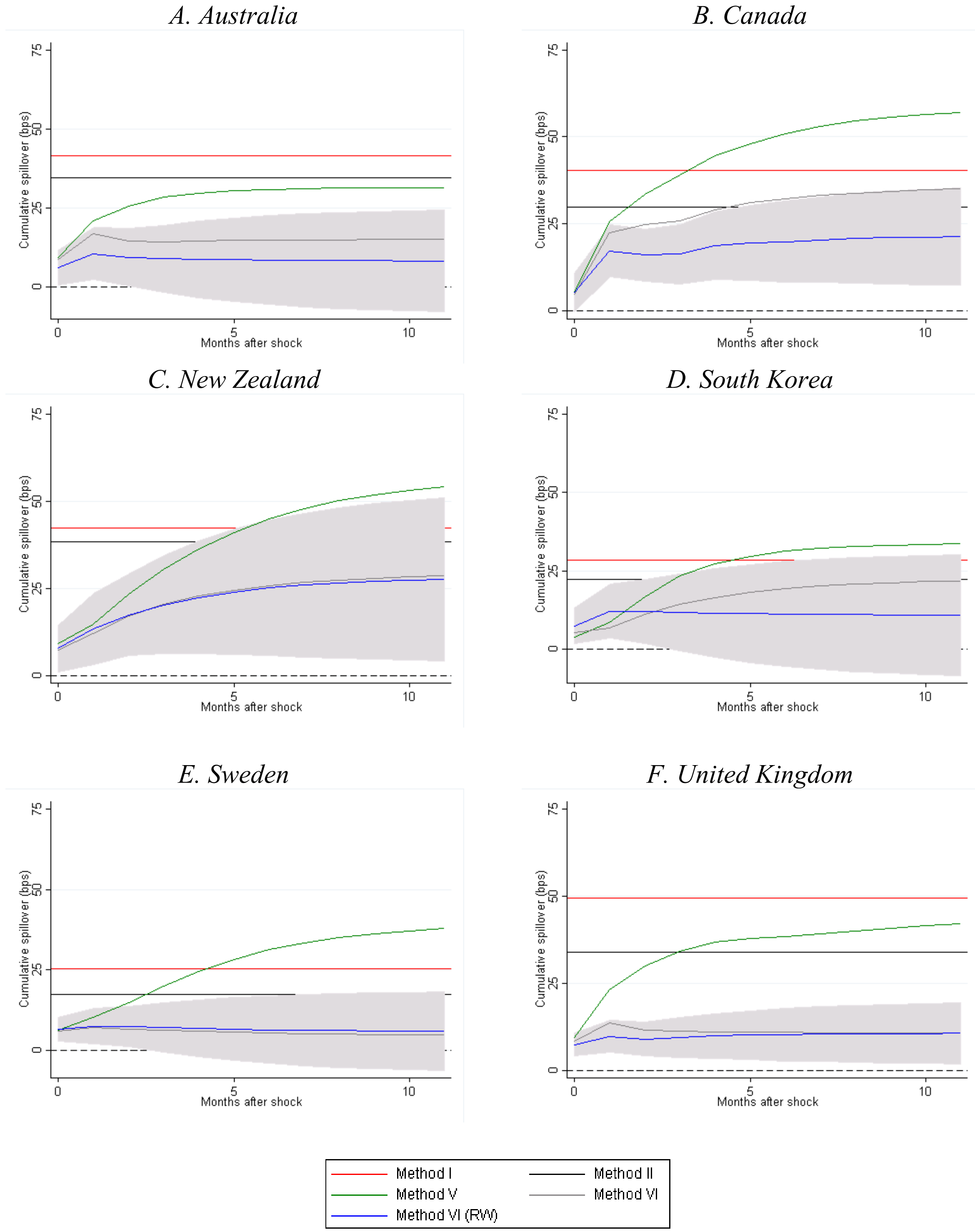
Figure 2 reports estimated monetary policy spillovers using the alternative empirical approaches described in the previous sections for our group of six economies. The responses follow a shock that generates a 100-basis-point increase in the U.S. federal funds rate over 12 months.[19] Green lines correspond to impulse response functions generated using method V, where $\boldsymbol{X} = \{E_{t-1}[\pi_t^e]; E_{t-1}[\Delta y_t^e]\}$, and again imposing a small open economy block exogeneity constraint on Δi^*. Cholesky orthogonalization amounts to a standard timing restriction, whereby monetary policy responds contemporaneously to foreign interest rates and revisions to expectations of domestic output and inflation, while domestic monetary policy affects expectations of output and inflation with a lag.

[17] Svensson (1997, 1999) argues that inflation targeting implies inflation *forecast* targeting, where the central bank's inflation forecast is an ideal intermediate target, even in the presence of output and/or interest rate stabilization concerns, and model uncertainty. There is also empirical evidence that central banks do react to changes in expected macro conditions rather than actual or lagged changes. For instance, Clarida, Galí, and Gertler (1998) show that the central banks of Germany, Japan and the United States adjust monetary policy rates in response to anticipated inflation, as opposed lagged inflation.

[18] It could also be argued that using actual or lagged variables can introduce additional biases in spillover estimates. For example, suppose a given external development is expected to affect aggregate demand both in the United States and in a small open economy sometime in the near future, but has not affected measured activity yet. Both economies adjust their monetary policy stance accordingly in order to achieve their domestic policy objectives. In this context, using actual macro variables would lead to wrongly consider the change in interest rate in the small open economy as a monetary spillover from the United States when, in fact, the domestic authority is acting fully consistently with its domestic objective.

[19] For comparability purposes, all impulse responses have been rescaled such that the response of the interest rate in the base country after 12 months is 100 basis points.

Figure 2. Estimated monetary policy spillovers using alternative methodologies



Note: Bands correspond to 95 percent confidence intervals.

Using method V, the estimated spillover is significantly larger than zero after 12 months for all six countries, with the magnitude of the spillover ranging from 30 to 60 basis points. This suggests that, in a group of inflation targeting countries with highly flexible exchange rates, central banks respond about one-for-two to U.S. monetary policy shocks. This would seem to suggest that exchange rate flexibility is not delivering monetary autonomy, contrary to the predictions of the trilemma.

The red and black lines correspond to the pass-through and spillover estimates generated using methods I and II, respectively.[20] In the cases of Australia, South Korea, and the United Kingdom, the cumulative impulse responses from our structural VAR are similar after 12 months to the estimated spillovers from the single equation specifications. For Canada, New Zealand, and Sweden, the structural VAR generates considerably larger spillover estimates than the single equation methods.

But do these spillovers necessarily indicate a lack of monetary autonomy? Since the inclusion of $\boldsymbol{X}$ has not precluded the endogenous response of Δi to $\boldsymbol{X}$, the estimate generated by method V is nearly identical to the pass-through response. Grey lines display the corresponding impulse-response functions generated using our proposed method VI, where the endogenous variable Δi has been replaced with the residuals from an inward-looking policy rule, as described in the previous section.[21]

Of course, the parameters in the central bank's policy rule may change over time. Blue lines are generated using method VI, but parameters in the policy rule have been allowed to vary using rolling window estimations (denoted as method VI (RW)).[22] In the cases of New Zealand, Sweden, and the United Kingdom, the grey and blue lines are indistinguishable. However, in the case of Canada and South Korea the two lines are quite different, suggesting that the parameters in the central bank reaction function have varied substantially over the estimation period.

Autonomy-impairing spillovers estimated using the multi-stage VAR from method VI tend to be substantially smaller than overall spillovers, especially when we allow the parameters of the policy rule to vary over time. With the exceptions of Canada and New Zealand, the response after 12 months is about 10 basis points—and is indistinguishable from zero at a 5% confidence level in the cases of Australia, South Korea, and Sweden. In Canada and New Zealand, autonomy-impairing spillovers are somewhat larger at around 25 basis points, but are still roughly half the size of the overall spillovers estimated using method V.

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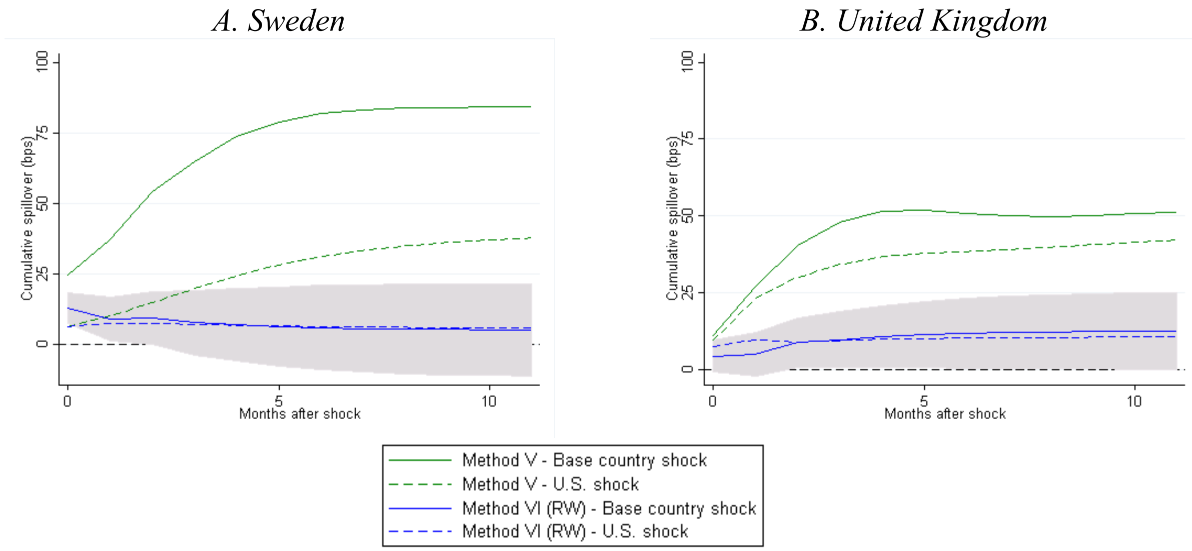
[20] The lines indicate the value of the estimated coefficient $\hat{\beta}$ from the equations $\Delta i = \delta + \beta \Delta i^{*} + \varepsilon$ and $\Delta i = \delta + \beta \Delta i^{*} + \gamma \Delta \boldsymbol{X} + \varepsilon$, respectively.

[21] Shaded regions indicate the 95 percent confidence interval for the IRFs generated by method VI, with standard errors computed analytically. Since one of the endogenous variables is itself estimated in a previous step, it will be necessary to estimate standard errors using a bootstrap procedure, and this is likely to widen the confidence intervals further.

[22] We estimate the first and second stages of method VI in a rolling window of 60 months.

Figure 3. Estimated monetary policy spillovers using alternative methodologies; shocks from euro area monetary policy



Note: Bands correspond to 95 percent confidence intervals.

In contrast to estimates from method V, these results suggest that monetary policy in these open economies is not substantially influenced by U.S. monetary policy, besides what can be attributed to a standard inward-looking policy function. This is not to say that U.S. monetary conditions are irrelevant to domestic monetary policy. Rather, the estimations do not allow us to reject the null hypothesis that these central banks are following an autonomous policy rule that ignores global financial conditions Δi^*.

As a robustness check, we estimate the responses of local policy rates to changes in the monetary policy rate of their closest base country as classified by Shambaugh (2004), which corresponds to the euro area for Sweden and the United Kingdom and to the United States for the others.[23,24] For Sweden and the United Kingdom, we re-estimate monetary policy spillovers from the euro area and report the corresponding cumulative impulse response functions in Figure 3. For the United Kingdom, the estimates are broadly in line with the responses reported earlier, as we detect no significant autonomy-impairing spillovers. For Sweden, the results from method V suggest much larger spillover responses. This is consistent with the high degree of business cycle synchronization between Sweden and the euro area. However, our estimates indicate that Swedish monetary policy does not display any additional response to ECB monetary policy, besides what can be accounted for by a

[23] Shambaugh (2004) classifies Australia as the core financial center for New Zealand, but we do not consider spillovers from Australian monetary policy in this exercise.

[24] The Deutsche Bundesbank monetary policy rate is used before January 1999.

time-varying inward-looking policy function. This suggests that Sweden's monetary policy displays a high degree of autonomy, in line with the flexibility of its exchange rate.

Identification of monetary policy shocks

We have focused our analysis on the effects of realized changes in U.S. monetary policy rates. As Bluedorn and Bowdler (2010) point out, these changes may be anticipated by markets, and thus lead to changes in asset prices ahead of the actual change in U.S. rates. For instance, consider a situation where the U.S. economy strengthens gradually, such that markets suspect that the Federal Reserve will soon increase the federal funds rate. While the rate itself would only move once the decision took place, forward-looking exchange rates would likely adjust ahead of the announcement. This would leave central banks in small open economies left to deal with the impacts of depreciating pressures well ahead of the Federal Reserve's announcement. In such a case, the timing assumption used to identify monetary policy shocks will be invalid, leading us to underestimate the magnitude of monetary policy spillovers.

Many studies have proposed strategies to measure monetary policy surprises that permit credible identification based on timing restrictions. Following Kuttner (2001), Hanson and Stein (2015), Gertler and Karadi (2015) and Gilchrist, López-Salido and Zakrajsek (2015) measure U.S. monetary policy surprises using the change in asset prices in tight windows surrounding FOMC announcements. Since these surprises are by construction orthogonal to market expectations at the time of the policy announcement, the conjecture is that shock identification can be made under the assumption that they are pre-determined with respect to other financial variables.

Others have found that employing these monetary policy surprises affects the assessment of monetary policy spillovers across countries. For instance, Bluedorn and Bowdler (2010) estimate monetary spillovers from realized as well as unanticipated changes in U.S. interest rates and find that spillovers from identified shocks are closer to the theoretical predictions of the monetary trilemma. Similarly, Hausman and Wongswan (2011) find that U.S. monetary surprises transmit significantly to emerging market financial markets. Passari and Rey (2015) use these shocks to quantify monetary spillovers to the United Kingdom, and Rey (2014) extends the analysis to Australia, Canada, New Zealand, Sweden, and the U.K. She finds significant monetary policy spillovers to mortgage spreads in all cases and to policy rates in Canada and New Zealand. Gilchrist, Yue and Zakrajsek (2015) and Albagli *et al.* (2015) estimate the impact of these shocks on asset prices in emerging economies.

These forms of identified monetary shocks are useful for estimating spillovers in a context of high global synchronization, since they capture monetary decisions that have not been anticipated by markets. However, they remain subject to two potential limitations for drawing conclusions in terms of monetary autonomy. First, monetary policy shocks have strong effects on economic conditions in the core economy which, in turn, impact domestic economic conditions in the small open economy. If the central bank follows an autonomous policy rule, it would adjust domestic rates to the extent that the outlook for domestic inflation and output are affected by foreign conditions. Such a response would not constitute an autonomy-impairing spillover as we have defined it, so using identified shocks instead of realized i_t^* could still lead to biased autonomy assessments if domestic conditions are not properly taken into account.

Second, these identified shocks may not be fully orthogonal to global economic conditions, to the extent that Federal Reserve decisions—including those that surprise financial markets—likely reflect some characteristic of the U.S. or global economic cycle. If these also affect monetary policy in other countries, then simultaneity will remain. This effect is likely to be substantially exacerbated to the extent that the Federal Reserve acts on private information about the state of the economy.[25] As such, while the identification ensures that the shocks are unanticipated by markets and thus alleviates the timing problem described above, they may not fully account for the simultaneity between economic cycles across countries. Hausman and Wongswan (2011) report estimation results that are suggestive of this problem, wherein economies with tighter trade linkages to the United States suffer larger estimated spillovers to short-term interest rates than those that are less integrated. As they point out, it may be that these results reflect the fact that central banks in these economies implement policies that are correlated with the Federal Reserve due to the synchronization of their real economies.

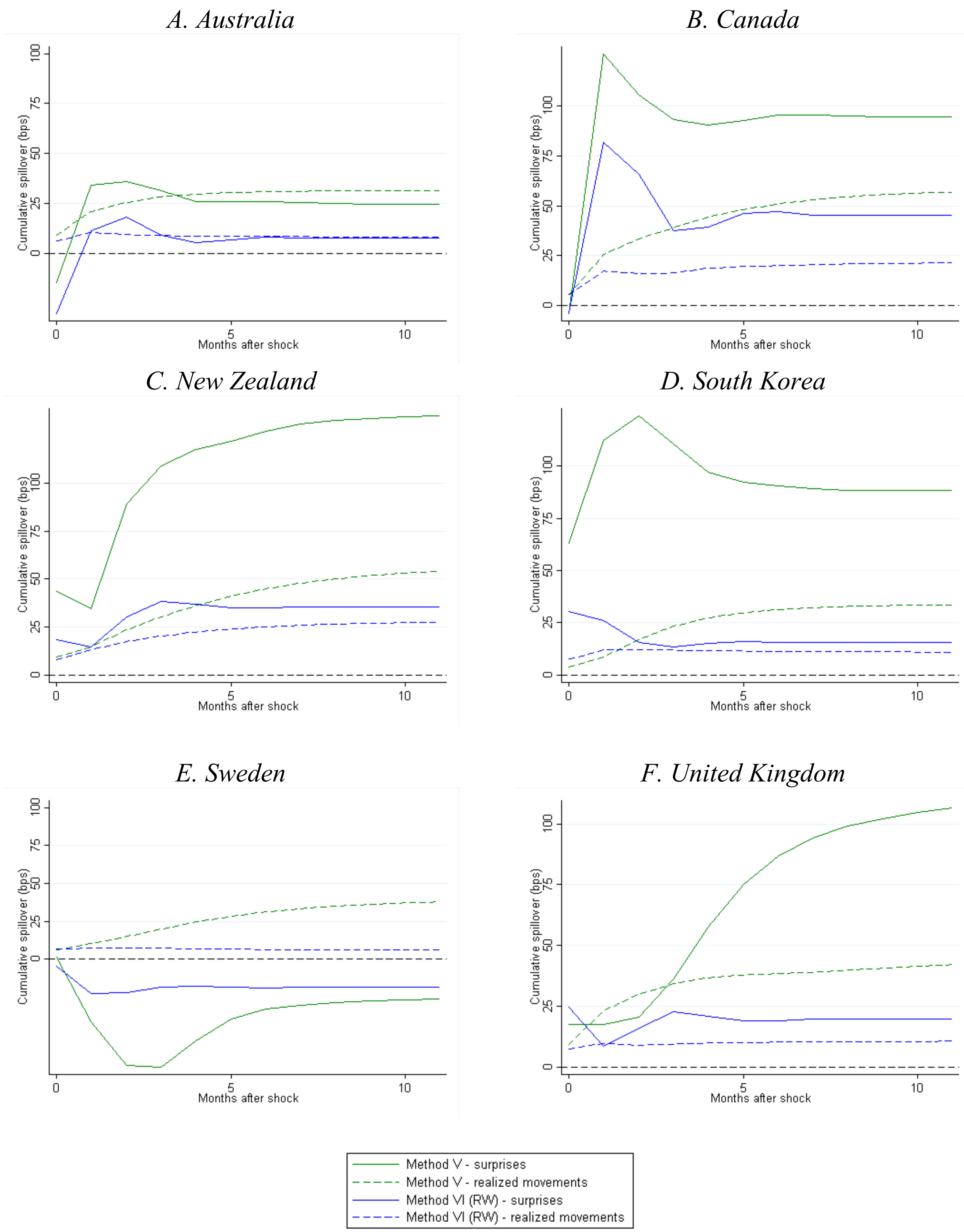
We generate estimates of spillovers to infer the degree of monetary autonomy for the same group of countries using the surprises in futures contracts for short-term interest rates surrounding FOMC announcements, as constructed by Gertler and Karadi (2015). Figure 4 reports the corresponding impulse response functions, where the line colors correspond to the same methodologies employed previously.

In most cases, method V generates spillover estimates that are much larger than those produced when using all realized movements in the Federal Funds rate. That is to say, there are substantially larger spillovers from U.S. monetary policy to foreign short-term rates when those rate movements were unanticipated by financial markets. In the case of New Zealand, South Korea, and the United Kingdom, the magnitude of the estimated spillovers more than doubles.

But do these spillovers signal impaired monetary autonomy? Our results from method VI suggest that they do not. When we employ our multi-stage VAR to remove the endogenous response to domestic macro conditions, the impact of U.S. monetary surprises is substantially smaller, and in all cases is indistinguishable from zero at a 5% confidence level. For instance, the spillover estimate to Canada is about one-to-one, which is very similar to what Rey (2014) estimates using the same identified shocks. But Canada and the United States are highly integrated economies with synchronized business cycles. Once we remove the endogenous response of Canadian interest rates to domestic macro conditions, the spillover estimate is only half as large. Again, we are unable to reject the null hypothesis of full monetary autonomy at a 5% confidence level.

[25] Gertler and Karadi (2015) find that deviations between the forecasts included in the Greenbook of the Federal Reserve Board of Governors and those produced by private forecasters at the time of FOMC meetings are significantly correlated with the identified shocks, although they explain a small share of their variation.

Figure 4. Estimated monetary policy spillovers using alternative methodologies and U.S. monetary policy surprises from Gertler and Karadi (2015)



V. REVISITING THE DILEMMA ABOUT THE TRILEMMA

The trilemma framework points to the degree of exchange rate flexibility and capital account openness as the main determinants of monetary policy autonomy. If monetary policy is geared toward domestic considerations, the trilemma suggests that either the exchange rate must be allowed to float or the capital account must be restricted. Analogously, the cost of implementing a managed exchange rate policy with an open capital account is that monetary policy cannot be tailored to achieve other domestic goals, such as stabilizing output and inflation.

The empirical literature testing the predictions of the trilemma has shed mixed results. Early contributions, such as Haussmann *et al.* (1999) and Frankel, Schmuckler, and Serven (2004) found evidence that even countries with floating exchange rates followed the interest rates of base countries. Other contributions, notably Shambaugh (2004) and Obstfeld, Shambaugh, and Taylor (2005), argued that the differences in estimated coefficients and model fit for pegged versus non-pegged countries suggest that the former follow base country interest rates more closely. However, the null hypothesis of full autonomy from base country interest rates has been rejected in many cases, including among countries with non-pegged currencies. For instance, Shambaugh (2004) found a significant response of more than 50 basis points for a sample of non-pegged countries with no capital controls.

Using a finer classification scheme for exchange rate regimes and capital account openness, Klein and Shambaugh (2015) find results that are closer to the theoretical predictions of the trilemma. In particular, they cannot reject the null hypothesis of no response to changes in base country rates for samples with floating exchange rates and fully open capital accounts. However, they find a significant coefficient on the base country interest rates of about 50 basis points for a sample of advanced countries with relatively open capital accounts—a result that holds even when controlling for local macro conditions.

Hoffman and Takáts (2015) also find a significant response of policy rates to U.S. rates when they focus on a narrower sample of advanced and emerging economies that are well integrated to global financial markets. Moreover, they do not find a significant difference across exchange rate regimes. Edwards (2015) focuses on a handful of Latin American countries with flexible exchange rates and estimates a significant response of domestic policy rates to changes in the federal funds rate—with a 100-basis point increase in the federal funds rate leading to a rise of 74 basis points in Colombia and more than 50 basis points in Chile.[26]

Our results from the previous sections suggest that the way we model the domestic interest rate and its relationship with domestic macro conditions affects our assessment of monetary autonomy based on spillover estimates. We found limited evidence of impaired autonomy for

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[26] Rey (2015) has also questioned the dimensions of the trilemma's trade-off, arguing that autonomy can only be achieved by restricting the capital account. The arguments and evidence Rey presents refer to the effect of global financial conditions on longer-term interest rates or credit aggregates, rather than on the central bank's ability to affect short-term rates.

a small group of economies with highly flexible exchange rates. To generalize this result across a range of policy frameworks, we use panel data from 40 emerging and advanced economies to estimate autonomy-impairing spillovers from base country interest rates. We then pool estimates within subsamples of country-time observations, according to the degree of exchange rate flexibility.

In a first stage, we estimate inward-looking policy rules for each country as a function of private forecasts for domestic inflation and output.[27] In the second stage, we use a panel vector autoregressive (PVAR) model to assess how much of the deviations of domestic rates from historical policy rules can be attributed to changes in base country interest rates. More precisely, we estimate the following first-order process:

$$\boldsymbol{y}_{c,t} = \boldsymbol{B}_0 + \boldsymbol{B}_1{}'\boldsymbol{y}_{c,t-1} + \boldsymbol{\gamma}_c + \boldsymbol{\varepsilon}_{c,t}, \tag{5}$$

where c denotes countries (c=1,…,N); $\boldsymbol{y}_c$ is a vector of variables for country c, which includes the residuals from the first stage ($\widehat{\boldsymbol{u}}_c$) and the change in the base country interest rate ($\Delta\boldsymbol{i}_c^*$); and $\boldsymbol{\varepsilon}_{c,t}$ is a vector of reduced-form innovations. The model includes country fixed effects ($\boldsymbol{\gamma}_c$) that capture unobserved time-invariant idiosyncratic characteristics. Since the fixed effects are correlated with the regressors due to the inclusion of lagged dependent variables—potentially biasing coefficient estimates—we use forward-mean differencing, also referred to as the 'Helmert procedure' (Love and Zicchino, 2006; Arellano and Bover, 1995).[28]

We construct monthly data on domestic short term interest rates and base-country policy rates from January 2000 through October 2015 for the sample of 40 emerging and advanced economies listed in Table 4.[29] The selection of base countries, and the classification of country-time observations according to the exchange rate regime (float, soft peg, and hard peg) and degree of financial openness (open, mid-open, and closed) largely follows Klein and Shambaugh (2015), which in turn is based on Shambaugh (2004) and Chinn and Ito (2006).[30]

[27] While for some countries at some point during the sample period the policy instrument was not an interest rate (i.e., some countries used money growth targets), short-term market interest rates should still capture changes in the stance of monetary policy.

[28] This procedure removes only the forward mean, that is, the mean of the forward observations for each country-month observation, and each observation is weighted so that the variance is standardized. The transformation preserves the orthogonality between transformed variables and lagged regressors, so these can be used as instruments and the coefficients can be estimated by system generalized method of moments (GMM).

[29] We have excluded euro-area countries. The remaining sample of countries is largely determined by the availability of Consensus Forecasts data on expected output growth and price inflation. See Data Appendix for further details on interest rate data sources.

[30] Following Reinhart and Rogoff (2004), the base country used for New Zealand and Singapore is the United States—rather than Australia and Malaysia as in Shambaugh (2004).

Table 4. Country sample for the panel VAR estimation

Advanced economies			
Australia	Hong Kong	Norway	Switzerland
Canada	Japan	Singapore	United Kingdom
Czech Republic	Latvia	South Korea	
Denmark	New Zealand	Sweden	
Emerging and developing economies			
Argentina	Croatia	Peru	Turkey
BoliviaBrazil	EgyptHungary	Philippines	Vietnam
Bulgaria	India	Poland	
Chile	IndonesiaIsrael	Romania	
China	Mexico	Russia	
Colombia	Malaysia	Saudi Arabia	
Costa Rica		South Africa	
		Thailand	

We restrict the sample to observations with open and mid-open capital accounts. We then split the restricted sample, estimating the response to base country interest rates separately for floating exchange rates and pegged or soft-pegged exchange rates. The subsamples include 2,178 and 3,616 observations, respectively. Once the models are estimated, we compute cumulative Cholesky-orthogonalized impulse response functions for each subsample, with variables ordered such that the base-country interest rates are most exogenous.

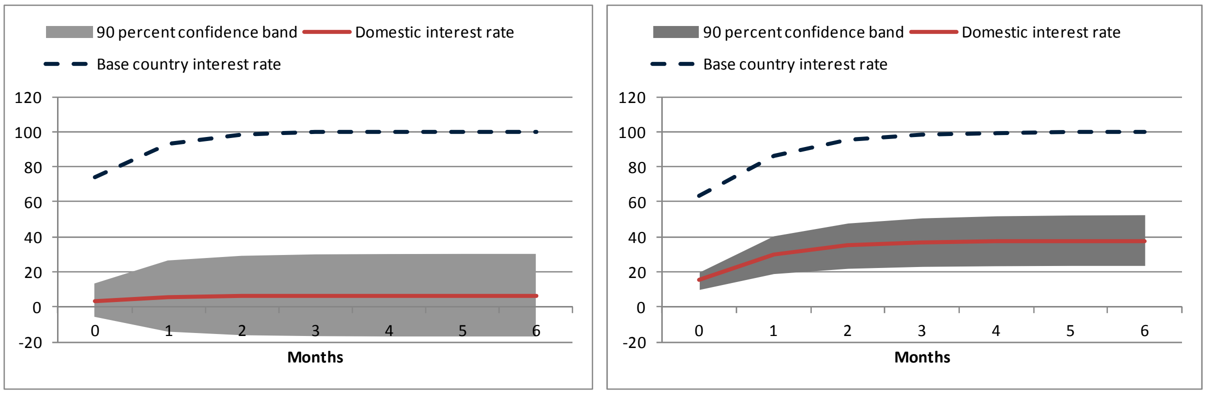
Figure 5 reports the cumulative monetary policy spillovers for each subsample following a 100-basis-point increase in the base country interest rate after one year. Under floating exchange rates, the autonomy-impairing spillover response of domestic rates—i.e. that which cannot be accounted for by an inward-looking policy function—is only 6 basis points after six months, and is indistinguishable from zero at a 10% confidence level.[31] The corresponding response under a soft or hard peg is significantly larger: the cumulative response after six months is about 38 basis points, with the 90% confidence band ranging from 24 to 53 basis points.

These findings are consistent with the predictions of the trilemma. First, the estimated autonomy-impairing spillovers from base country to domestic interest rate are significantly larger for countries with pegged exchange rates. Moreover, we cannot reject the null hypothesis of full monetary autonomy among countries with floating exchange rates.

[31] Confidence intervals around the impulse responses are calculated with Monte Carlo simulations. In practice, a draw of coefficient matrices $\boldsymbol{B}_0$ and $\boldsymbol{B}_1$ in equation (5) is randomly generated using the estimated coefficients and their variance-covariance matrix and used to re-calculate impulse-responses. The process is repeated 2,000 times to generate 5th and 95th percentiles of this distribution, which are used as confidence bands for the impulse-responses.

Figure 5. Estimated monetary policy spillovers under alternative exchange rate regimes

A. Floating exchange rate *B. Hard and soft pegs*



Sources: IMF staff calculations
Note: Cumulative spillover response of domestic short-term interest rates to a 100-basis-points increase in the base country policy rate.

While the first result has been documented in the empirical literature—and has been broadly interpreted as proof of validity of the trilemma—the second result has been more difficult to confirm. The results in this paper suggest this is partly due to an underestimation of the degree of monetary autonomy based on spillover estimates.

VI. Conclusion

International asset prices are highly correlated across countries and asset classes. In particular, an extensive empirical literature has documented the pass-through of U.S. monetary policy to domestic interest rates in other countries. This has been cited as evidence of a lack of monetary policy autonomy among small open economies, despite their use of flexible exchange rate regimes.

But is this co-movement excessive? A benchmark for assessing the degree of monetary autonomy is that policy rates are set exclusively as a function of the outlook for domestic inflation and outlook. Spillovers that do reflect impaired monetary autonomy would then correspond to responses to global financial conditions that cannot be accounted for by this endogenous domestic relationship.

In a context of business cycle synchronization, identifying the subset of spillovers that reflect a lack of monetary autonomy is challenging. Using a Monte Carlo simulation on artificial data, we show that empirical approaches commonly employed in the literature tend to understate the extent of monetary autonomy under common parameterizations. The reason is that the endogenous relationship between foreign interest rates, foreign macroeconomic conditions, and local macroeconomic conditions, makes it difficult to identify the monetary spillover channel.

We propose a more conservative approach to assess monetary autonomy that is implemented in multiple stages. The first stage consists of modelling monetary policy in the small open economy in order to identify movements in domestic interest rates that are orthogonal to the outlook for domestic output and inflation. In this paper, we implement this by estimating a domestic system where monetary policy rates are dynamically determined by local macroeconomic conditions according to an inward-looking policy rule, but refinements to this first stage are naturally possible. Spillovers are then estimated in a separate model, where we allow foreign financial variables to explain these residuals from our domestic policy rule. We interpret significant spillover estimates from this second stage as evidence that monetary autonomy is limited.

In a sample of six small open economies—Australia, Canada, New Zealand, South Korea, Sweden, and the United Kingdom—, we compare the spillovers estimated using our approach to those from methods employed in the literature. We find that spillovers are substantially smaller using our methodology. As a matter of fact, in several cases we cannot reject the null hypothesis that monetary policy is fully autonomous. The difference remains important when we consider U.S. monetary policy surprises measured using high-frequency event windows.

Finally, we use our two-stage approach to estimate autonomy-impairing spillovers in a panel setting including a broad sample of advanced and emerging economies. We test whether responses of domestic interest rates to base country monetary policy shocks differ according to the exchange rate regime. In line with recent papers in the literature (Klein and Shambaugh, 2015; Obstfeld, 2015), we find that the response of domestic rates is much larger in countries with fixed exchange rate regimes. Additionally, we find no evidence of autonomy-impairing spillovers among countries with floating exchange rates, providing strong evidence for the predictions of the trilemma.

REFERENCES

Aizenman, J., M.D. Chinn and H. Ito, 2015. "Monetary Policy Spillovers and the Trilemma in the New Normal: Periphery Country Sensitivity to Core Country Conditions," Working paper 21128. National Bureau of Economic Research: Cambridge, MA.

Albagli, E., L. Ceballos, S. Claro and D. Romero, 2015. "Channels of U.S. Monetary Policy Spillovers to International Bond Markets: Advanced versus Emerging Market Economies," Working paper 771. Central Bank of Chile: Santiago.

Arellano, M. and O. Bover, 1995. "Another Look at the Instrumental Variable Estimation of Error-Components Models," *Journal of Econometrics* 68: 29-51.

Batini, N., P. Levine and J. Pearlman, 2007. "Monetary Rules in Emerging Economies with Financial Market Imperfections," in *International Dimensions of Monetary Policy*, pp. 251-311. National Bureau of Economic Research: Cambridge, MA.

Benigno, G. and P. Benigno. 2006. "Designing Targeting Rules For International Monetary Policy Cooperation," *Journal of Monetary Economics* 53: 473-506.

Bernanke, B.S., 2015. "Federal Reserve Policy in an International Context," Mundell–Fleming Lecture at the 16th Jacques Polak Annual Research Conference, International Monetary Fund, Washington, D.C.

Bernanke, B.S. and A.S. Blinder, 1992. "The Federal Funds Rate and the Channels of Monetary Transmission," *American Economic Review* 82(4): 901-21.

Bluedorn, J.C. and C. Bowdler, 2010. "The Empirics of International Monetary Transmission: Identification and the Impossible Trinity," *Journal of Money, Credit and Banking* 42(4): 679-713.

Borio, C., 2014. "The Financial Cycle and Macroeconomics: What Have We Learned?" *Journal of Banking and Finance* 45: 182-198.

Bruno, V. and H.S. Shin, 2015. "Cross-Border Banking and Global Liquidity," *Review of Economic Studies* 82: 535-564.

Chinn, M.D. and H. Ito, 2006. "What Matters for Financial Development? Capital Controls, Institutions, and Interactions," *Journal of Development Economics* 81(1): 163-92.

Clarida, R., J. Galí and M. Gertler, 1998. "Monetary Policy Rules in Practice: Some International Evidence," *European Economic Review* 42(6): 1033-1067.

_____. 2001. "Optimal Monetary Policy in Open versus Closed Economies: An Integrated Approach," *American Economic Review* 91(2): 248-252.

Coenen, G., G. Lombardo, F. Smets and R. Straub, 2010. "International Transmission and Monetary Policy Cooperation," in *International Dimensions of Monetary Policy*, eds. Jordi Galí & Mark J. Gertler, pp. 157-192. National Bureau of Economic Research: Cambridge, MA.

De Paoli, B., 2009. "Monetary Policy and Welfare in a Small Open Economy," *Journal of International Economics* 77(1): 11-22.

Dedola, L, G. Rivolta and L. Stracca, 2015. "If the Fed Sneezes, Who Catches a Cold?" Mimeo.

Dovern, J., U. Fritsche and J. Slacalek, 2012. "Disagreement Among Forecasters in G7 Countries," *Review of Economics and Statistics* 94(4): 1081-96.

Edwards, S., 2015. "Monetary Policy Independence under Flexible Exchange Rates: An Illusion?" *World Economy* 38: 773–787.

Engel, C., 2011. "Currency Misalignments and Optimal Monetary Policy: A Reexamination," *American Economic Review* 101(6): 2796-2822.

Frankel, J., S.L. Schmukler and L. Servén, 2004. "Global Transmission of Interest Rates: Monetary Independence and Currency Regime," *Journal of International Money and Finance* 23(5): 701-733.

Fujiwara, I., T. Nakajima, N. Sudo, and Y. Teranishi, 2013. "Global Liquidity Trap," *Journal of Monetary Economics* 60: 936-949.

Georgiadis, G. and M. Jancoková. 2016. "Financial Globalisation, Monetary Policy Spillovers and Macro-Modelling: Tales from One Hundred and One Shocks," Mimeo. European Central Bank.

Gertler, M. and P. Karadi, 2015. "Monetary Policy Surprises, Credit Costs and Economic Activity," *American Economic Journal: Macroeconomics* 7(1): 44-76.

Gilchrist, S., D. López-Salido and E. Zakrajsek, 2015. "Monetary Policy and Real Borrowing Costs at the Zero Lower Bound," *American Economic Journal: Macroeconomics* 7(1): 77-109.

Gilchrist, S., E. Zakrajsek and V.Z. Yue, 2015. "The Response of Sovereign Bond Yields to U.S. Monetary Policy," Mimeo.

Hanson, S.G. and J.C. Stein, 2015. "Monetary Policy and Long-term Real Rates," *Journal of Financial Economics* 115(3): 429-48.

Hausman, J. and J. Wongswan, 2011. "Global Asset Prices and FOMC Announcements," *Journal of International Money and Finance* 30: 547-71.

Hausmann, R., M. Gavin, C. Pagés and E. Stein, 1999. "Financial Turmoil and the Choice of Exchange Rate Regime," Working paper 4128, Inter-American Development Bank: Washington, DC.

Hofmann, B. and E. Takáts, 2015. "International Monetary Spillovers," *BIS Quarterly Review*, Bank for International Settlements: Basel.

Klein, M.W. and J.C. Shambaugh, 2015. "Rounding the Corners of the Policy Trilemma: Sources of Monetary Policy Autonomy," *American Economic Journal: Macroeconomics* 7(4): 33-66.

Kuttner, K. N., 2011. "Monetary policy surprises and interest rates: Evidence from the Fed funds futures market," *Journal of Monetary Economics* 47(3): 523-544.

Love, I. and L. Zicchino, 2006. "Financial Development and Dynamic Investment Behavior: Evidence from Panel VAR," *Quarterly Review of Economics and Finance* 46(2): 190-210.

Mundell, R., 1963. "Capital Mobility and Stabilization Policy Under Fixed and Flexible Exchange Rates," *Canadian Journal of Economics and Political Science* 29(4): 475-485.

Obstfeld, M., 2015. "Trilemmas and Tradeoffs: Living with Financial Globalization," in *Global Liquidity, Spillovers to Emerging Markets and Policy Responses*, eds. Claudio Raddatz, Diego Saravia & Jaume Ventura, pp. 13-78. Central Bank of Chile: Santiago.

Obstfeld, M., J.C. Shambaugh & A.M. Taylor, 2005. "The Trilemma in History: Tradeoffs among Exchange Rates, Monetary Policies, and Capital Mobility," *Review of Economics and Statistics* 87(3): 423-38.

Obstfeld, M. and A.M. Taylor, 1998. "The Great Depression as a Watershed: International Capital Mobility over the Long Run," in *The Defining Moment: The Great Depression and the American Economy in the Twentieth Century*, pp. 353-402. National Bureau of Economic Research: Cambridge, MA.

Obstfeld, M. and K. Rogoff, 2002. "Global Implications of Self-Oriented National Monetary Rules," *Quarterly Journal of Economics* 117(2): 503-535.

Passari, E. and H. Rey, 2015. "Financial Flows and the International Monetary System," *Economic Journal* 125(584): 675-698.

Reinhart, C. and K. Rogoff, 2004. “The Modern History of Exchange Rate Arrangements: A Reinterpretation,” *Quarterly Journal of Economics* 119: 1-48.

Rey, H., 2014. “The International Credit Channel and Monetary Policy Autonomy,” Mundell Fleming Lecture. International Monetary Fund: Washington, DC.

_____ , 2015. “Dilemma Not Trilemma: The Global Financial Crisis and Monetary Policy Independence,” Working paper 21162. National Bureau of Economic Research: Cambridge, MA.

Romer, C. and D. Romer, 2004. “A New Measure of Monetary Shocks: Derivation and Implications,” *American Economic Review* 94(4): 1055-84.

Shambaugh, J.C., 2004. “The Effect of Fixed Exchange Rates on Monetary Policy,” *Quarterly Journal of Economics* 119(1): 301-352.

Svensson, L.E.O., 1997. “Inflation Forecast Targeting: Implementing and Monitoring Inflation Targets,” *European Economic Review* 41(6): 1111-1146.

_____, 1999. “Inflation Targeting as a Monetary Policy Rule,” *Journal of Monetary Economics* 43(3): 607-654.

Walsh, C., 2014. “Multiple Objectives and Central Bank Tradeoffs under Flexible Inflation Targeting,” Working paper 5097. CESifo Group: Munich.

Woodford, M., 2007. “Globalization and Monetary Control,” in *International Dimensions of Monetary Policy*, pp. 13-77. National Bureau of Economic Research: Cambridge, MA.

DATA APPENDIX

1. Short-term government bond yield in local currency

Argentina: March 2002 – June 2015: BCRA 6-month Treasury auction yields in new pesos (GFD). Interpolated using BCRA 1-year treasury auction yields in new pesos (GFD) and 2-year treasury auction yields in new pesos (GFD).

Australia: January 1998 – October 2015: 13-week treasury bills (IFS line 19360C..ZF…). Interpolated and spliced using 3-month generic government bond yield (Bloomberg ticker GACGB3M) and 1-year generic government bond yield (Bloomberg ticker GACGB1).

Bolivia: January 2000 – November 2015: Treasury bill rate (IFS line 21860C..ZF…).

Brazil: January 2000 – November 2015: Treasury bill rate (IFS line 22360C..ZF…). Interpolated using Anbima 6-month government bond fixed (Bloomberg ticker BZAD6M) and 6-month generic government bond yield (Bloomberg ticker GEBR06M). Spliced using Anbima 3-month government bond fixed (Bloomberg ticker BZAF3M).

Bulgaria: January 2000 – November 2015: 3-month treasury bill yield (GFD). Spliced using base interest rate (Bulgarian National Bank via Haver Analytics).

Canada: January 1998 – October 2015: Treasury bill rate (IFS line 15660C..ZF…). Interpolated using 6-month government bond yield (Bloomberg GCAN6M). Spliced using 3-month government bond yield (Bloomberg GCAN3M).

Chile: January 2000 – November 2015: 3-month interest rate (OECD MEI series 228.IR3TIB01.ST). Interpolated using 1-year government bond yield in pesos (GFD) and 1-year generic government bond yield (Bloomberg ticker CLGB1Y).

China: January 2000 – October 2015: 3-month treasury bond trading rate proxy (OECD MEI series 924.IR3TIB01.ST). Spliced using 3-month repo on treasury bills in renminbi (GFD) and prime lending rate (People's Bank of China via Haver Analytics).

Colombia: January 2000 – November 2015: 1-year treasury notes (IMF MBRF2 23360C..ZB…). Interpolated using 3-month treasury bill yield in pesos (GFD). Spliced using 1-year generic government bond yield (Bloomberg ticker COGR1Y).

Costa Rica: January 2000 – October 2015: 6-month treasury bill yield in colones (GFD). Interpolated using 12-month treasury bill yield in colones (GFD). Spliced using 1-3 year government bond yields in colones (GFD).

Croatia: January 2000 – October 2015: 3-month treasury bill yield in kuna (GFD). Interpolated using information from 6-month treasury bill yield in kuna (GFD) and from 1-year government bond yield in kuna (GFD). Spliced using central bank discount rate and Lombard rate (Croatian National Bank via Haver Analytics).

Czech Republic: January 2000 – November 2015: Treasury bill rate (IFS line 93560C..ZF…). Interpolated using 1-year government bond yield (Bloomberg CZGB1YR), 1-year government bond yield in koruna (GFD), and 3-year government bond yield (CZGB3YR).

Denmark: January 2000 – November 2015: 3-month treasury bill yield (Bloomberg ticker GDGT3M). Interpolated using 6-month treasury bill yield (Bloomberg ticker GDGT6M) and 2 year government bond yields (Bloomberg ticker GDGB2YR).

Egypt: January 2000 – October 2015: Treasury bill rate (IMF MBRF2 line 46960C..ZI…). Interpolated using 3-month treasury bill yield in pounds (GFD).

Hong Kong: January 2000 – November 2015: Treasury bill rate (IFS MBTS line 53260C..ZI…). Interpolated using 6-month generic bond yield (Bloomberg ticker HKGG6M).

Hungary: January 2000 – October 2015: 3-month treasury bill yield in forint (GFD). Interpolated using 1-year government bond yield in forint (GFD). Spliced using the base interest rate (National Bank of Hungary via Haver Analytics).

India: January 2000 – November 2015: 3-month treasury bill yield (Bloomberg ticker IYTB3M). Spliced using 3-month treasury bill yield in rupee (GFD).

Indonesia: January 2000 – November 2011: 6-month sovereign zero-coupon bond yield (Bloomberg ticker I26606M). Spliced using treasury bill yield in rupiah (GFD).

Israel: January 2000 – November 2015: Treasury bill yield (IFS line 43660C..ZF…). Spliced using 2-year generic government bond yield (Bloomberg ticker GISR2YR).

Japan: January 2000 – November 2015: 6-month treasury discount bill yield (Bloomberg ticker GJTB6MO). Interpolated using 3-month treasury discount bill yield (Bloomberg ticker GJTB3MO). Spliced using Financing bill rate (IFS line 15860C..ZF…).

Latvia: January 2000 – October 2015: Treasury bill rate (IFS line 94160C..ZF…). Spliced using 6-month treasury bill yield in euro (GFD) and central bank policy rate (IFS).

Malaysia: January 2000 – November 2015: 3-month treasury bill yield (IFS line 54860C..ZF…). Spliced using 1-year Bank Negara Malaysia Treasury bill yield (Bloomberg ticker MGIYBD10).

Mexico: January 2000 – November 2015: CETES 90-day yield (MBRF2 line 27360C..ZI…). Interpolated using 3-month treasury bill yield (Bloomberg ticker MPTBC).

New Zealand: January 1998 – October 2015: 3-month treasury bill new issue rate (IFS line 19660C..ZF…). Interpolated using 6-month treasury bill yield (Bloomberg ticker NDTB6M).

Norway: January 2000 – November 2015: 6-month government treasury bill yield (Bloomberg ticker GNGT6M).

Peru: January 2000 – November 2015: 6-month generic government bond yield (Bloomberg ticker GRPE6M). Interpolated using 3-month zero coupon bond yield (Bloomberg ticker I36103M). Spliced using central bank discount rate in new sol (GFD).

Philippines: January 2000 – October 2015: 91-day treasury bill rate (IFS line 56660C..ZF…). Interpolated using PDEX PDST-F Fixing 3-months (Bloomberg ticker PDSF3MO).

Poland: January 2000 – November 2015: Treasury bill rate (IFS line 96460C..ZF…). Interpolated using 1-year government note yield in new zloty (GFD) and 1-year government note yield (Bloomberg ticker POGB1YR).

Romania: January 2000 – September 2015: 91-day treasury bill rate (IFS line 96860C..ZF…). Spliced using 3-month treasury bill yield in new leu (GFD).

Russia: January 2000 – October 2015: 3-month treasury bill yield in ruble (GFD). Interpolated using 1-year government bond yield in ruble (GFD) and 6-month government bond yield in ruble (GFD). Spliced using 1-week repo OMO auction rate (Haver Analytics).

Saudi Arabia: January 2000 – October 2015: 13-week treasury bill rate (Saudi Arabian Monetary Authority via Haver Analytics). Spliced using 12-month treasury bill yield in riyal (GFD), 26-week treasury bill rate (IMF MBTS line 45660CC.ZN…), and reverse repo rate (IMF MBTS).

Singapore: January 2000 – November 2015: 3-month treasury bill yield (IFS line 57660C..ZF…). Interpolated using Monetary Authority of Singapore paper 3-month yield (Bloomberg ticker MASB3M) and 6-month yield (Bloomberg ticker MASB6M).

South Africa: January 2000 – November 2015: 91-day treasury bill tender rate (South African Reserve Bank via Haver Analytics). Interpolated using same concept from alternative sources (MBRF2 line 19960C..ZI… and OECD MEI series 199.IR3TIB01.ST). Spliced using 2-year government bond yield (Bloomberg ticker GSAB2YR).

South Korea: January 1998 – October 2015: KCMP treasury bond yield (Bloomberg ticker GVSK3MON). Spliced using 3-year government bond yield in won (GFD).

Sweden: January 1998 – October 2015: 3-month treasury bill yield (Sveriges Riksbank via Haver Analytics). Interpolated using 6-month treasury bill yield (Bloomberg ticker GSGT6M) and 3-month treasury bill yield (Bloomberg ticker GSGT3M).

Switzerland: January 2000 – November 2015: Treasury bill rate (IFS line 14660C..ZF…). Interpolated using 1-year government bond yield (Bloomberg ticker GSWISS03) and 1-year government bond yield (Bloomberg ticker GSWISS01).

Thailand: January 2000 – November 2015: Government bill yields (IFS line 57860C..ZF…). Interpolated using Thai bond dealing center 1-month rate (Bloomberg ticker TBDC1M) 6-month rate (Bloomberg ticker TBDC6M).

Turkey: January 2000 – November 2015: 3-month treasury bill rate (MBRF2 line 18660C..YI…). Interpolated using 6-month government bond yield (Bloomberg tickers IESM6M and IECM6M).

United Kingdom: January 1998 – October 2015: Treasury bill rate (IFS line 11260C..ZF…).

2. Domestic macroeconomic conditions

All countries: January 1998 – October 2015: Mean forecast for consumer price inflation and real GDP growth provided by Consensus Economics at monthly frequency. Fixed-point forecasts for current and following year linearly interpolated to form a fixed horizon forecast at a horizon of 12 months.