

# The Puzzling Change in the International Transmission of U.S. Macroeconomic Policy Shocks\*

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## **Abstract**

We present two empirical conundrums on the nature of international policy transmission. First, there has been a qualitative shift in the impact of U.S. monetary and fiscal policy shocks on other economies after 1990. Second, the reactions to monetary shocks are particularly difficult to reconcile with standard new open-economy theories, even with several significant modifications to the benchmark model. This raises the question as to whether the theoretical reference point on which welfare analysis and policy prescriptions are based is still the appropriate one for the recent decades.

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\*We thank participants in the CFE conference for their useful comments and suggestions.

# 1 Introduction

The international transmission of macroeconomic policies is one of the central topics in international macroeconomics, forming the basis for policy design and potential policy coordination. As globalization intensifies, the spillover of macroeconomic policies can be large. And with many developing countries joining the global economy, the issue of whether the nature of transmission to these countries accords with conventional perception merits a rigorous investigation. Indeed, the impact of U.S. monetary and fiscal policies during the recent crisis seemed to have been felt in many places outside of the U.S., with reactions of various sorts that quickly ensued. The spillover of policy is undeniably relevant and forms part of the broader debate on the ramifications of international linkages. But this paper raises two challenges to existing knowledge on spillovers. First, we document a dramatic shift in how U.S. monetary and fiscal policy shocks are transmitted to other economies. In an earlier period prior to 1984, a contractionary monetary shock in the U.S. lowers output of the 8 largest high-income economies in the world (ex-US), and appreciates the US dollar in both nominal and real terms against these currencies. This accords with conventional views. In the sample post-1984, in which among the largest developing countries are also included, a contractionary monetary shock now *raises* output overseas and *depreciates* the U.S. dollar in real and nominal terms. Fiscal policy shocks have witnessed a similar metamorphosis: while unexpected fiscal expansions appreciated the dollar in both nominal and real terms in the earlier period, it depreciated the dollar in the later period. A natural question to ask is whether this qualitative shift in the nature of spillovers owes to changes in the foreign monetary policy reaction, and the answer is decidedly no: policy responses overseas are broadly similar across these two sample periods.

The second challenge is that the responses to U.S. monetary policy shocks in the latter period have become somewhat of an empirical conundrum. Exchange rate and output effects in foreign economies are opposite of predictions from standard theories. While aptly capturing many aspects of reality in earlier periods, these theories have a hard time describing recent patterns. There is reason to believe that an altogether different channel of transmission from the ones emanating from existing models is required to understand even the basic effects on output and exchange rates. With a radical shift in the nature of transmission comes along a need for rethinking of the theoretical reference point on which policy prescriptions and

welfare analysis are invariable based.

Empirical evidence on the international propagation of U.S. monetary and fiscal policy shocks is first of all, limited, despite its central importance. The focus has been, second of all, primarily centered on developed economies, although more recent attention has been drawn to the emerging periphery as their economies are gradually more subjugated to shocks originating from the industrialized core. Comparing to the existing empirical studies with a similar undertaking, our findings for monetary shocks in the earlier period are in line with those in Eichenbaum and Evans (1995), Cushman and Zha (1997) and Kim and Roubini (2000), whose sample period is roughly from the 1970s to about 1990. The empirical results for the later period where a qualitative shift occurs is new, and robust to alternative identification schemes standard in the literature. Interestingly, we find that developing countries respond in a similar manner to U.S. policy shocks as advanced economies, in the later sample. These findings resonate with Canova (2005)'s study on Latin American economies.

Theoretical frameworks of international policy transmission with explicit micro-foundations presaged by Svensson and van Winjeerger (1989), and later developed and popularized by Obstfeld and Rogoff (1995) have now become the main analytical machinery for positive and normative analysis. The ability to conduct formal welfare evaluation of macroeconomic policies significantly advanced the Mundell-Flemming-Dornbusch tradition in being able to incorporate international wealth distributions and current account dynamics that can induce additional dimensions of propagation. Yet the sensibilities of the classic channels of propagation and attendant exchange rate and output behaviour are essentially inherited from the traditional view, by design. But the analytical rigor of the new open-economy models turned what was a mere empirical plausibility into theoretically justified conventional wisdom.

One of the central transmission channels emphasized in the classic tradition, and explicitly demonstrated in the micro-founded intertemporal approach is the expenditure-switching effect. Contractionary monetary shocks in the domestic economy and the associated appreciation of its nominal exchange rate leads to a terms of trade improvement. This fall in the relative price of foreign-produced goods occasions a substitution away from domestic goods towards foreign goods and thereby puts upward pressure on overseas output. A second channel of transmission embodied in this model is a demand effect, whereby reduced world consumption falls on both domestic and foreign goods, thus exerting downward pressure on output in both countries. Underlying the micro-founded intertemporal approach is a dis-

tinctive third effect coming from international distributions of wealth. The shift in wealth from the U.S. to abroad via a current account deficit induces greater labor supply in the U.S. and reduction in labor supply in Foreign. Depending on the strength of the expenditure switching effect, Foreign output could rise or fall.

Our empirical results are easy to comprehend in light of these theoretical predictions for the pre-1984 period, but outright puzzling for the later period. In order to generate an output increase overseas following a U.S. contractionary monetary shock as seen by recent data, one would need the expenditure switching effect to dominate the demand and wealth effect channels. The prerequisite for this expenditures switching effect to operate in the ‘right’ way, however, is a domestic terms of trade improvement—brought about an exchange rate appreciation. Yet this prerequisite is strongly rejected by the data for the post-1990 sample—associated with a rise in foreign output is an appreciation of the foreign currency rather than a depreciation. Under these circumstances, it appears implausible that any of these channels underpinning the basic theory is the primary conduit of transmission. However, for the earlier sample period, the depreciation of the dollar satisfies this criterion and there is nothing inconsistent with the common perception that expenditure switching can be a guiding principle.

The puzzle is not resolved once we can account for the exchange rate aspect of it. In fact, the puzzle is actually worsened. Even if existing theories successful at explaining the UIP puzzle can generate a depreciating US dollar where the US nominal interest rate is high, the concomitant terms of trade deterioration kills every chance for the expenditures switching effect to exert even a qualitatively helpful impact. This terms of trade effect actually leads to a further fall in Foreign output. The puzzle is therefore *especially* acute when the exchange rate behaves according to the data.

A natural question to ask is whether foreign interest rates respond endogenously to US policy rates in a way that occasion these exchange rate and output behaviour—making the main channel of spillover effectuated through foreign policy reactions rather than through outcome variables. Of course, this still begs the question as to why the set of responses it elicits in one period is the opposite of that of another period —when the policies themselves, as we document, have largely remained the same. Still, looking at the data, the answer for the later period does not come from policy responses. First, foreign economies roughly mimicked the U.S. policy rates, with a small lag—hence unable to explain the immediate

and significant depreciation of the US dollar. Also, the rise in foreign interest rate does not create a channel that raises foreign output, and rather, does quite the reverse.

It is well known that the nature of price setting can be of critical importance for certain theoretical objectives. The above discussion is based on the conventions of the Mundell-Flemming-Dornbusch tradition and of the Obstfeld-Rogoff school in adopting producer currency pricing (PCP). The pricing-to-market and local currency pricing approach (LCP), receiving equal fervour in the works of Devereux and Engel (1997) and Betts and Devereux (2000), among others, leads to markedly different implications on how exchange rate fluctuations feed into domestic and foreign prices, and the real exchange rate. In this context, however, alternating between the different structures of price setting changes little the perplexing nature of international transmission during the later period. In a framework with LCP the expenditure switching effect would be muted, since a dollar appreciation is not associated with a U.S. terms of trade improvement that would subsequently shift world demand towards foreign goods. If anything, it would lead to a shift away from foreign goods if a terms of trade deterioration is associated with a dollar appreciation—a theoretical possibility with this type of approach. One must look beyond the nature of price setting.

The ways in which the basic open-economy model with nominal rigidities can be modified and extended are inherently numerous, filling the literature with many notable contributions and insights at various levels. But criss-crossing between different assumptions most commonly made in the literature is unlikely going to change the key results by much. Whether it is the nature of asset markets—complete or incomplete, the former embodied in works such as Chari et al (2002), Devereux and Engel (2003) and others, and the latter in Obstfeld Rogoff (1995, 1998), Corsetti and Pesenti (1997), and Tille (1997)—or preferences that are biased towards domestically produced tradable goods (Warnock (1998)) or nontradable goods (Hau (2000)), or the ability to accumulate capital that makes investment contribute to output determination (Chari et al (1998) and Betts and Devereux (1997, 1999)) would most likely fall short of producing a plausible explanation. The main issue lies in the fact that the extant channels of transmission work on affecting foreign output in the same way, and the aforementioned variations to the benchmark model either make one channel or the other more or less prominent, without creating a new conduit to make Foreign output react in the opposite direction. These variations, while often crucial for welfare analysis and policy prescriptions, is unlikely going to significantly alter the positive implications arising from the

basic theoretical structure.

Section 2 provides a comprehensive empirical investigation on the impact of U.S. monetary and fiscal policy shocks on developing and developed economies. Section 3 presents the workhorse two country open-economy model with price rigidity. Section 4 and 5 discusses its parameterization and quantitative results, focusing on the discrepancy between theory and data. Section 6 concludes.

## 2 Empirical Evidence

We now provide evidence that the nature of spillovers from US fiscal and monetary policy to the rest of the world has changed. We track the effects of shocks to US policy on a number of macroeconomic variables for a panel of the 8 largest economies outside the US.<sup>1</sup> We show that the effects of US monetary and fiscal policy on output and the real and nominal exchange rate have changed qualitatively and that this change is statistically significant.

Spillovers from both monetary and fiscal policy in the early part (up to 1990) of the sample are broadly consistent with standard theory. A contractionary monetary shock in the US decreases output overseas and appreciates the US dollar in real and nominal terms.<sup>2</sup> Expansionary fiscal shocks increase output overseas and cause a dollar appreciation. The effects of fiscal and monetary policy in the later part (post-1990) of the sample are more difficult to reconcile with standard theory, as we discuss in more detail in the following section. Contractionary monetary policy in the US now stimulates output overseas while depreciating the US dollar. Expansionary fiscal policy now causes the US dollar to depreciate.

The first challenge in ascertaining the effects of US policy on international macroeconomic variables is the identification of shocks to policy instruments in the US. While US policy may affect macroeconomic outcomes, policy also responds to macroeconomic circumstances, posing a difficulty for an econometrician attempting to determine the effects of policy. There is no broad consensus on the best way to disentangle the direction of causation in the relationship between monetary and fiscal policy and other macroeconomic variables. In this paper, we do not take a position on identification. Instead we use a variety of identification

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<sup>1</sup>Results are robust to the inclusion of 9 of the 14 largest developing countries, for which high-frequency data are available. But as time series for developing countries are relatively short and typically unavailable for the earlier period studied, we exclude developing countries from our benchmark regressions.

<sup>2</sup>This has been shown to be the case before, for example in Eichenbaum and Evans (1995).

schemes to show that the spillovers from US policy have changed circa 1990. Our main results are robust across identification methods. We are further reassured that our results are not driven by a specific identifying assumption from the fact that the effects of US monetary, tax and expenditure policy—all identified in very different ways—show significant changes across time.

## **2.1 Identification**

We begin by reviewing the instruments used to identify shocks to monetary and fiscal policy in the US. For monetary policy, use an extension of the monetary policy shock series created by Romer and Romer (RR, 2004). We also use Structural Vector Autoregression methods (SVAR) following Eichenbaum and Evans (1995) and Christiano, Eichenbaum and Evans (CEE, 1999). We then turn to fiscal policy shocks, using historical-narrative approaches of Ramey (2011) for government spending policy and Romer and Romer (2010) for tax policy.

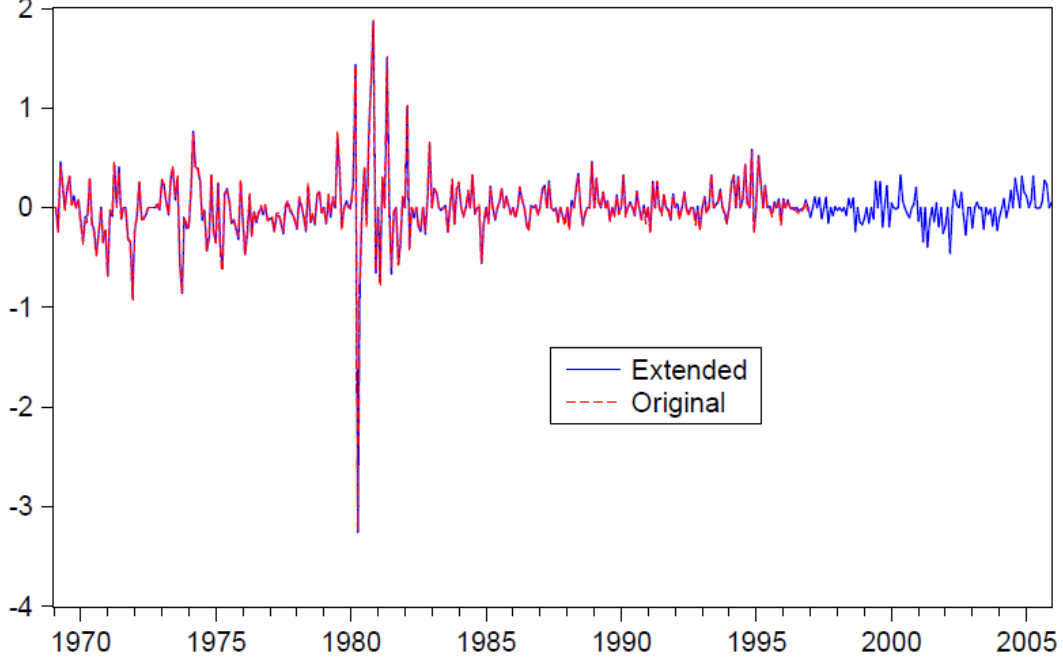
### **2.1.1 Monetary shocks**

We follow RR’s historical identification of monetary shocks. RR create a series of shocks to the Federal Funds Rate (FFR) as deviations from the Federal Reserve’s historical response function to its information set. The information set is compiled from the Federal Reserve’s Greenbook forecasts. Specifically, RR regress the change in the FFR—or the intended change, before the FFR was publicly announced as the Federal Reserve’s policy instrument—on its previous level; forecasts of the current, last quarters, and following two quarters of inflation and GDP; the change in these forecasts since the previous meeting of the Federal Open Market Committee; and its projections of current unemployment. Residuals from this regression are treated as monetary policy shocks, on which outcome variables—in our case foreign variables—can be regressed.

The RR series end in 1996, resulting in a significant loss in observations for our later sample. We therefore updated their series to 2005, using the same methodology. Figure 1 compares shocks as identified in Romer and Romer (2004) to our “RR” shocks. As can be seen, for the period 1969-1996, the difference between the two is barely discernible.

To retain consistency with Romer and Romer’s (2004) approach, we regress the outcome variable of interest on 24 own lags and 24 lags of the RR shock in a single-equation regression

Figure 1: Extending Romer and Romer (2004)



and plot the implied impulse responses. Results are similar when incorporating the RR shock in a VAR.

Structural Vector Autoregression methods, pioneered by Sims (1980), have by now become common practice for the identification of monetary policy shocks.  $Y_t$  is a vector of  $K$  macroeconomic observables following an autoregressive process

$$AY_t = \sum_{q=1}^Q C_q Y_{t-q} + u_t, \quad (1)$$

where  $Q$  is the order of the VAR, the vector  $u_t$  is a vector of orthogonal, i.i.d. shocks to government consumption and output such that  $E u_{n,t} = 0$  and  $E [u_{n,t} u'_{n,t}]$  is the identity matrix. The matrix  $A$  is a  $K \times K$  matrix allows for the possibility of simultaneous effects among the endogenous variables  $Y_t$ . After multiplying both sides of (1) by  $A^{-1}$ , the system can be estimated using a reduced form VAR. The matrix  $A^{-1}$  is unidentified in this estimation. The variance-covariance matrix of the system provides an estimate of  $A^{-1}A$ , however, giving a system of  $\frac{K(K+1)}{2}$  equations (due to the symmetry of the matrix) for the  $K^2$  unknowns in  $A$ . This leaves  $A$  under-identified and an additional  $\frac{K(K-1)}{2}$  are needed to identify  $A$  fully.



A variety of assumptions have been employed to provide these additional identifying assumption. We first follow CEE’s recursive identification, a variant of which has also been used for the purpose of analyzing spillovers from US monetary policy in Eichenbaum and Evans (EE, 1995). As in EE, the VAR includes the following variables: output, CPI, the Federal Funds Rate (FFR), and non-borrowed reserves (NBR). Inclusion of an index of commodity prices and of M2 as in CEE does not alter identification significantly. In addition, the foreign variable of interest is included. Identification is via a Cholesky decomposition of  $A$  with the variables ordered as listed. We use monthly data. Our measure for output, both US and foreign, is therefore industrial production, rather than GDP.<sup>3</sup>

The first three variables comprise a block that is assumed to respond to monetary shocks only with a one-period lag, but which is assumed to be known to the monetary policy maker contemporaneously. As has become common, we assume that the Federal Reserve uses the FFR as its policy instrument.<sup>4</sup> The remaining monetary variables comprise a monetary block that is allowed to respond to shocks to the FFR or NBR.

The ordering of variables within the two blocks is of little consequence for the identification of monetary shocks. The foreign variable is included as a final block, assumed to have no contemporaneous impact on the remaining variables in the system. This corresponds to the notion that macroeconomic variables in a given foreign country have no contemporaneous impact on macroeconomic outcomes or the conduct of monetary policy in the US. Other variable orderings, which allowed US macroeconomic variables to respond to foreign shocks confirmed that this choice is without loss of generality. We include each foreign variable in a separate VAR to preserve degrees of freedom, but including several of the foreign variables in a single VAR yielded similar outcomes.

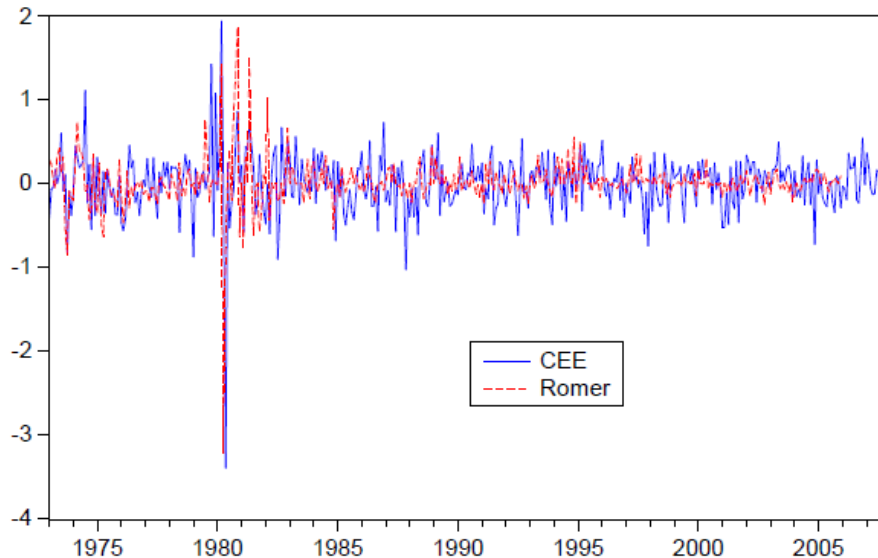
Figure 2 plots the two shock measures. The correlation between the two is not surprising. It is noteworthy, however, the correlation between the shock measures is far from perfect at .30. Thus results we present using these two measures are true tests to the robustness of our results, rather than redundant.

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<sup>3</sup>Using a monthly interpolation of quarterly GDP data yields similar results.

<sup>4</sup>In both cases we identify a shift in monetary policy as a shock to the Federal Funds Rate. This is consistent with the view that this has been the primary instrument used by the Federal Reserve. Studying shocks to non-borrowed reserves or their ratio to total reserves, as in Strongin (1995) is complicated by the fact that this ratio has been essentially 1 since 1992.

Figure 2: Comparing Monetary Shocks



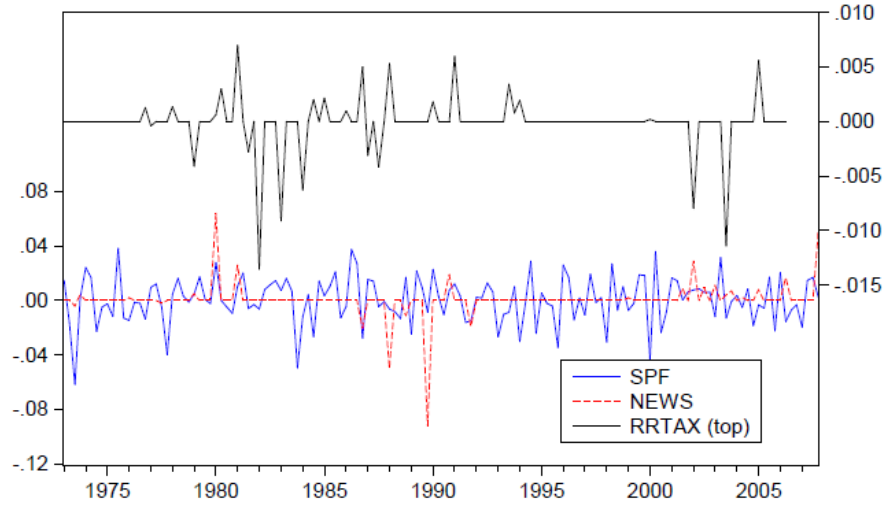
### 2.1.2 Fiscal shocks

Ramey (2011) employs a narrative approach to the identification of shocks to government spending, which also accounts for the possibility that public spending shocks may have been anticipated. She takes follows two approaches. First, she constructs a time series of the forecast errors of professional forecasters, to measure surprises to public spending (SPF). Second, using Business Week reporting of large military buildups, she constructs a variable of expected public spending induced by these buildups (NEWS). Identification relies on the notion that military spending was driven by geopolitical factors, rather than business cycle conditions.

On the tax side, Romer and Romer (2010) follow a historical approach and provide a narrative of tax policy in the United States. This narrative is then used to separate tax changes that were due to cyclical conditions and those that were exogenous to business cycle conditions. We use only the exogenous components (RRTAX) to identify shocks to tax policy.

Figure 3 compares the measures of public spending shocks and tax shocks. The measures are correlated, but weakly so. The correlation between the two public spending measures is only .13 and the correlation between the tax shock measure and the two measures of public spending shocks is essentially zero. Regressions using these various shock measures therefore

Figure 3: Comparing Fiscal Shocks



each provides independent evidence of the change in spillovers of US policy to the rest of the world.

## 2.2 Estimation and Results

In this section we report our main results, first on spillovers from monetary policy and then on spillovers from fiscal policy.

### 2.2.1 Monetary policy

We begin with regressions using the Romer and Romer (2004) identification. For each outcome variable of interest  $X_t^i$ , with  $t$  a monthly time index and  $i$  a country index, we estimate the following panel regression:

$$X_t^i = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \alpha_3 d_i + \sum_{q=1}^Q [\beta_q RR_{t-q} + \gamma_q X_{t-q}^i]. \quad (2)$$

$d_i$  is a country dummy, allowing for country fixed effects. An intercept  $\alpha_0$  and quadratic trend are also included.<sup>5</sup> Each outcome variable is regressed on  $Q = 24$  (2 years of) of own lags and lags of the RR shock  $RR_t$ . Outcome variables  $X_t^i$  are in natural logarithms with the

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<sup>5</sup>Results are similar when the regression is in first differences, rather than levels.

exception of the foreign policy interest rate and deviations from UIP, which are in percentage points.

We estimate (2) using GLS, controlling for cross-sectional heteroskedasticity.<sup>6</sup> We split our sample into two roughly equal sub-periods. (2) is first estimated for 1973-1990. We begin our sample in 1973, as we expect that the international effects of US monetary policy (particularly on exchange rates) was qualitatively different under the Bretton Woods system of fixed exchange rates. The equation is then estimated for 1991-2005. 2005 is the last year for which Greenbook data is available. Splitting the sample circa 1990 allows us to show the shift in spillovers from monetary policy, while preserving sufficient empirical power in both sub-samples.

Alteration of the cutoff by  $\pm 6$  years did not affect our results. For the purpose of robustness, regressions where the cutoff was circa 1984 were of particular interest. Sims and Zha (2006) have suggested that heteroskedasticity in the time dimension is important in characterizing monetary policy in the United States. Splitting our sample around 1984 dates our first regression prior to the “great moderation”, and our second regression during the “great moderation” and as such has the additional advantage of controlling for the largest source of monetary policy heteroskedasticity in the sample. These regressions yielded similar results to the ones reported here.

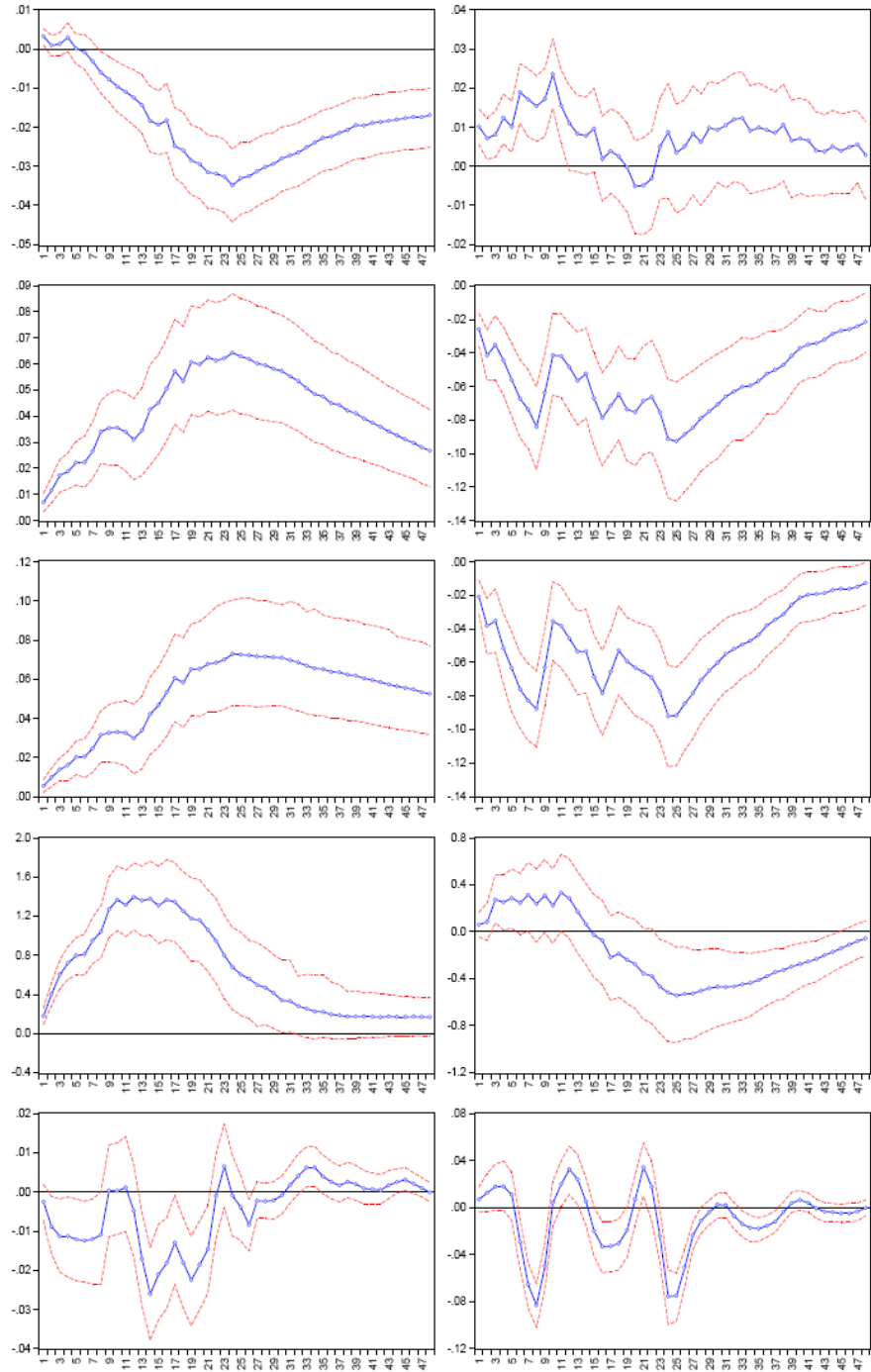
Figure 4 displays the response of a number of variables to a Romer and Romer shock for horizons of up to 4 years (48 months). The left-hand column present responses in the period 1973-1990 and the right-hand column in the period 1991-2005. Dotted lines in this and the following figures present 90% confidence intervals based on Monte Carlo simulations with 1000 repetitions. The first row shows the response of foreign industrial production. In the early period, an unanticipated increase of one percentage point in the Federal Funds rate led to a statistically significant decline in foreign production. The effect is economically significant, peaking at 3% after 2 years. The magnitude—in fact the entire impulse response—is similar to (but slightly smaller than) the decline in output Romer and Romer (2004) found in the United States (see Figure 2 in their paper). In contrast, post-1990 output *increased* by a similar magnitude. The increase is statistically significant in the first year following the monetary tightening.

The response of bilateral real and nominal exchange rates, presented in the second and

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<sup>6</sup>Results are robust to using an OLS regression.

Figure 4: International Responses to a Romer and Romer Shock



Responses to a 1 percentage point increase in the FFR as identified by RR. Left-hand column: 1973-1990. Right-hand column: 1991-2005. Impulses from top to bottom: (1) Foreign industrial production; (2) the real bilateral exchange rate (up reflecting a US dollar appreciation); (3) the nominal bilateral exchange rate; (4) the foreign policy interest rate; and (5) excess returns on foreign 3-month bonds (UIP deviation).

third columns, respectively, are even more striking. The US dollar shows a statistically significant appreciation—in both nominal and real terms—against other major currencies of approximately 6% within two year of the shock, in the early period. But the dollar *depreciated* by an similar magnitude in the later period. Results are similar in regressions where the panel of foreign currencies was replaced by the US real or nominal effective exchange rate. The difference in responses between the two periods is statistically significant at all horizons.<sup>7</sup>

It is natural to ask how foreign central banks responded to a US monetary tightening in the two sub-samples, and whether a change in their response might help explain the differences between the two periods. The fourth row of the figure explores this question by plotting the response of foreign central banks' policy interest rate. Prior to 1990, foreign central banks mimicked the US increase in the policy rate with a slight lag, peaking at a tightening of 1400 basis points—almost identical to response of the FFR to a RR shock. The response in the later period is smaller and reverts to a monetary loosening after approximately two years. We note, however, that the response of the FFR to a RR shock was itself smaller in this later period. In both sub-periods foreign central banks roughly mimic the behavior of the Fed (with a lag) following a monetary policy shock.

In regressions encompassing the earlier sample, Eichenbaum and Evans (1995) obtain similar results to those in our earlier sample. They point out that there is no sign of overshooting in the nominal exchange rate and that this is inconsistent with Uncovered Interest Parity. With US the interest rate having increased (on impact) relative to foreign interest rates, agents must expect a dollar depreciation rather than the appreciation actually observed. This deviation from UIP is evident in the last row of Figure 4 which plots deviations from UIP at three month horizons, using short-term public debt and the actual ex-post exchange rate movements as a rational-expectations proxy for private expectations of these movements. Indeed, US short-term debt instruments show an excess return of approximately 10 basis points during the first half-year following the tightening of US monetary policy.

Exchange rate responses could, however, be consistent with UIP in the post-1984 period, with an increase in US short-term interest rates presaging a US dollar depreciation. But as the last chart in Figure 4 shows, the exchange rate response is large enough in the first few months that UIP is violated here as well, but with US assets now showing a negative excess

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<sup>7</sup>We exclude Eurozone countries—Germany, Italy, and France—after 1999 from the panel of nominal exchange rates, but retain them in the panel of real exchange rates.

return.

As a robustness check we show the results of a VAR with the Eichenbaum and Evans (1995) identification. We include 24 lags of the international variable of interest. To preserve degrees of freedom, we include only 12 lags of US variables. In addition, we treat US variables as block-exogenous, i.e. we do not allow the foreign variable to affect US monetary policy even with a lag. Results are similar, however, if US variables are allowed to respond to foreign macroeconomic variables. We estimate the US-economy block in a separate regression with the full sample from 1973 to 2007, to ensure that results are driven by responses of foreign variables to monetary shocks rather than changes in the identification of monetary policy shocks in the two sub-samples. Results are similar, however, when the US-economy block is estimated separately in the two sub-samples. As before, a quadratic trend is included.

A shock to US monetary policy is an innovation to the FFR that is orthogonal to US production and prices. It has become common practice to include world commodity prices in monetary VARs, and the inclusion of such a variable in the US monetary policy block does not affect our results.

Results are reported in Figure 5. All the results hold up to this different identification methodology. Particularly, the striking change in the response of the real and nominal exchange rate to a shock in US monetary policy holds up. UIP deviations also follow a similar pattern. The reversal of the industrial production response is weakened, however, and disappears in the long run. However, this result is largely driven by the response of foreign industrial production to the decline in US industrial production spurred by the monetary contraction. As an illustration of this fact, Figure 6 shows the response of foreign industrial production to CEE shocks—those presented in Figure 2—in a bivariate regression as in (2). In other words, we trace the response of foreign industrial production to an orthogonalized shock to the FFR to lags of that shock, and own lags. The results are qualitatively similar to those in Figure 4.

In summary, a change appears to have emerged in the late-1980s or early 1990s in the way monetary policy shocks in the US are transmitted to other OECD countries. In the early period, a monetary tightening in the US caused a decline in output in the rest of the world and an appreciation in the US dollar. In the later period, a monetary tightening in the US expanded foreign output and depreciated the dollar.

Figure 5: Responses to an Orthogonalized Shock to the Federal Funds Rate in a SVAR

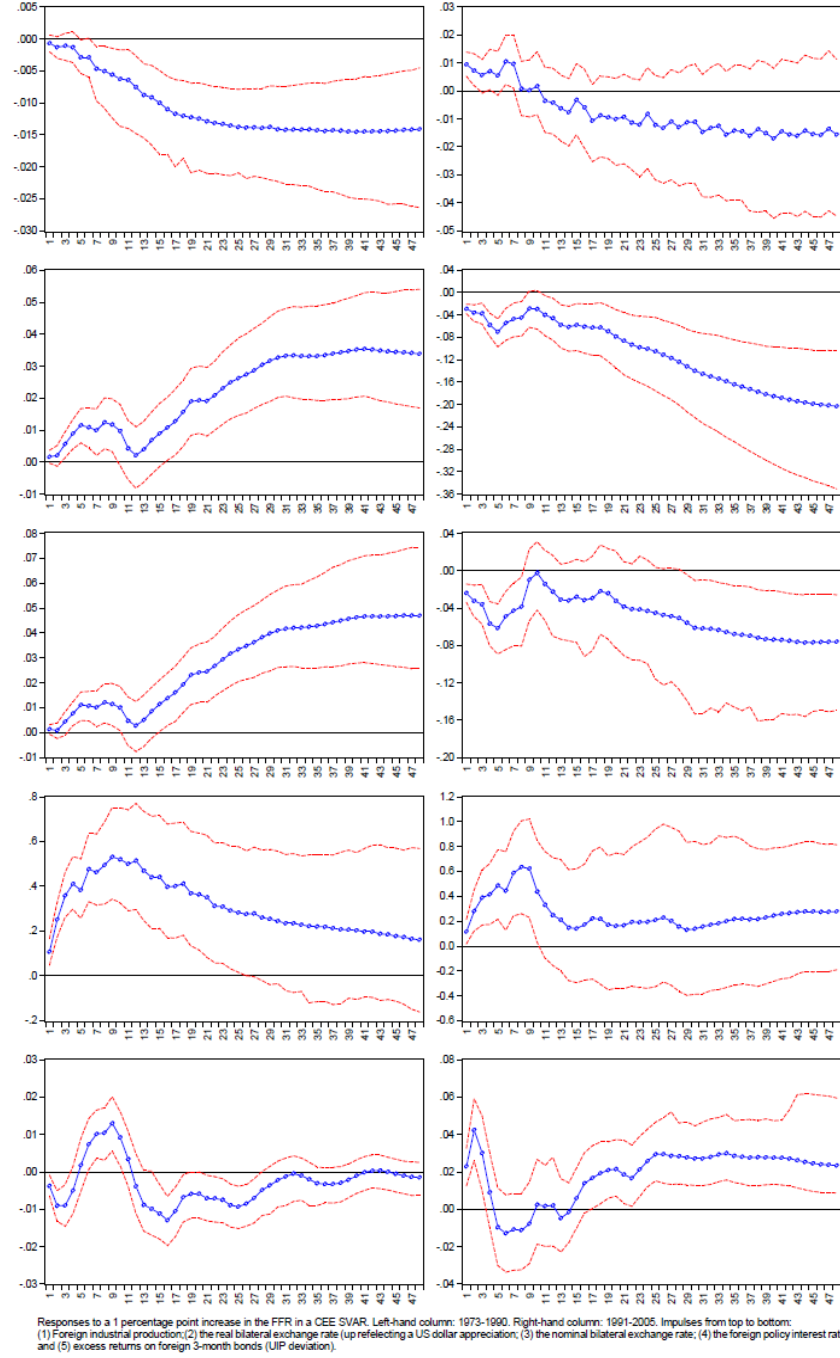
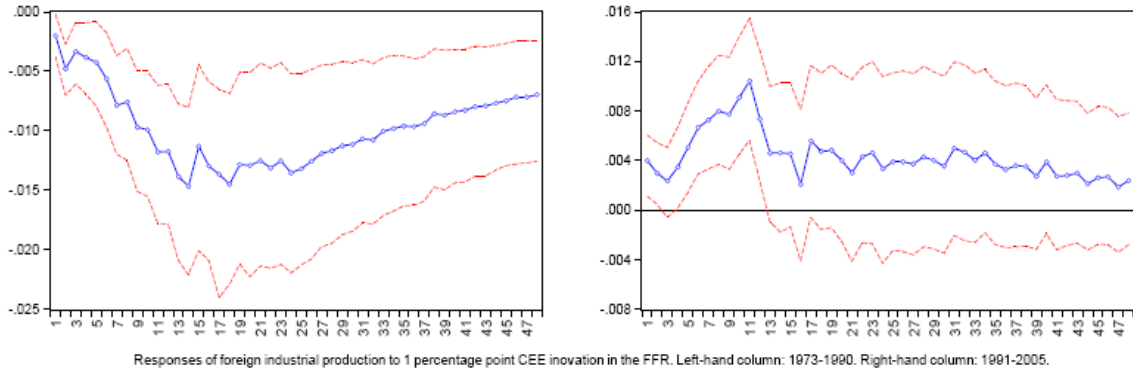




Figure 6: Response of Foreign Industrial Production to CEE shocks.



### 2.2.2 Fiscal policy

Turning to spillovers from fiscal policy, we now study spillovers from shocks to government spending and tax revenues. We begin from government spending and the two identification methods proposed by Ramey (2011). Consistent with Ramey's (2011) approach, we estimate a panel VAR with the government spending measure and a panel of the international variable of interest. We assume that US fiscal policy is block-exogenous with respect to foreign macroeconomic variables, i.e. surprises in US public spending were not affected by macroeconomic variables in the rest of the world. Allowing the US fiscal variable to respond to foreign variables had no effect on our results. As in the previous section, we estimate the coefficients of US fiscal variables for the entire sample, but its effects on foreign variables separately for each sub-sample. This is to assure the reader that it is the transmission, rather than the conduct or identification, of fiscal policy that has changed over time. Results are robust to estimating the autoregressive process of the SPF and NEWS variables separately in each sub-sample. Results are also robust to treating these variables as exogenous, as in the Romer and Romer specification (2).

As before, the panel VAR is estimated using GLS, controlling for cross-sectional heteroskedasticity, with country fixed effects, and with a quadratic trend term. All regressions of fiscal policy reported here use quarterly data and 8 lags. For the sake of consistency with our estimates of monetary policy, the regressions begin at 1973, although the rationale for starting the sample at the breakup of the Bretton Woods system of fixed exchange rates is perhaps weakened in the case of fiscal policy spillovers. All results are robust, however, to

starting the sample at the earliest date of data availability.

Figure 7 shows the responses of foreign macroeconomic variables to 1-year-ahead forecast errors in the Survey of Professional Forecasters. The left-hand column is the earlier period of 1973-1990 and the right-hand column is for 1991-2007. Displayed responses show a horizon of 6 years (24 quarters). The first row shows the response of foreign industrial production. In the early period, we see clear and statistically significant negative spillovers from US fiscal policy. A surprise in US public spending of 1-percent-of-GDP causes a half a percentage point decline in industrial production overseas.<sup>8</sup> In the later period, however, the response of foreign output to government spending shocks is small and statistically insignificant, and reverses in sign.

The second and third rows in the figure show the response of real and nominal exchange rates, respectively, to a SPF shock. As with monetary policy, a reversal in the effects of fiscal policy on exchange rates is evident. In the early period, unanticipated public spending in the US causes a small, but statistically significant, appreciation of the US dollar, both in real and nominal terms, after approximately a year. This follows a brief period of US dollar depreciation. In the later period, the effect is exactly reversed, with a depreciation of the dollar of a similar magnitude in the longer-term, followed by a brief appreciation, lasting approximately one year.<sup>9</sup>

These results are robust to using the NEWS shock variable instead of the SPF shock. As can be seen in the second and third rows of Figure 8, the dollar appreciated in response to news of a US military buildup in the earlier period, but depreciated in the later period. The effects are statistically significant and of a magnitude that is larger than those of the SPF errors, but still small in magnitude. In the case of foreign industrial production, however, a clearer reversal is evident in this case. While production declines by approximately 1% in the early period, following news of a 1% of GDP increase in military spending in the US, it *increases* by a similar amount in the later period.

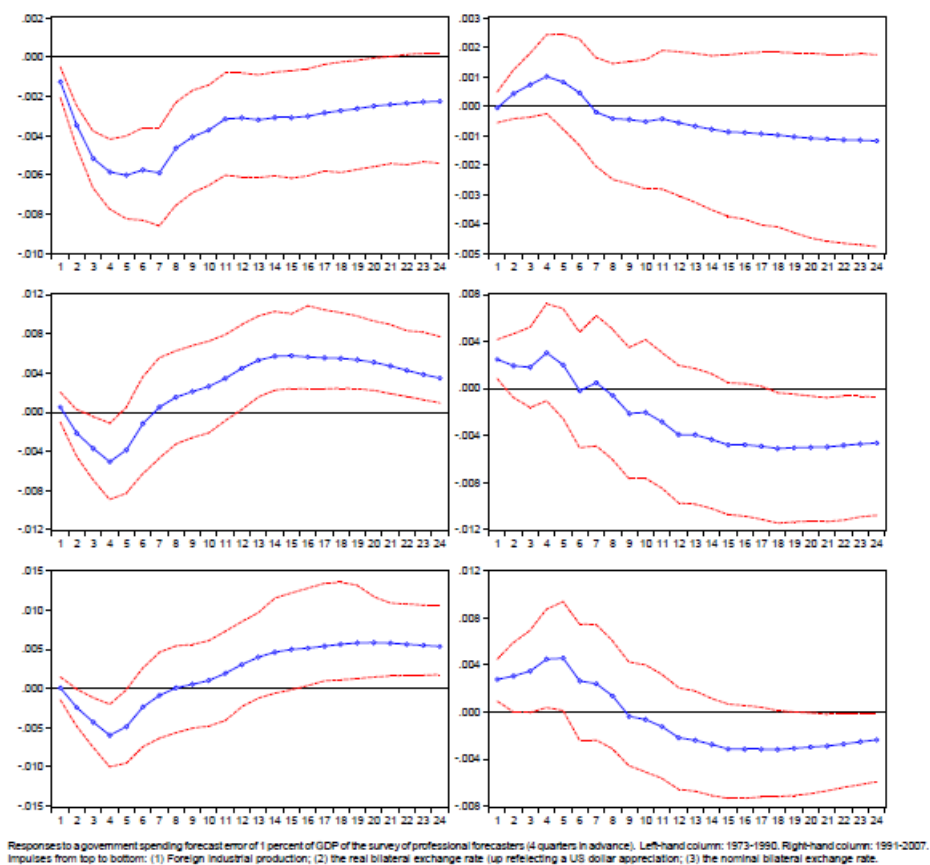
Turning to tax policy, we use the narrative of Romer and Romer (2010) to identify

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<sup>8</sup>This is in stark contrast to the large and positive “spillover multipliers” found by Auerbach and Gorodnichenko (2012), for example. They, however, look at spillovers between any pair of OECD countries, while we look at spillovers from the US alone.

<sup>9</sup>This reversal does not occur when using the one-quarter ahead forecast error instead of the four-quarter error. When using the one-quarter SPF error, impulse responses in the later period are very similar to those observed in the earlier period.

Figure 7: Responses of Foreign Variables to Forecast Errors in the Survey of Professional Forecasters



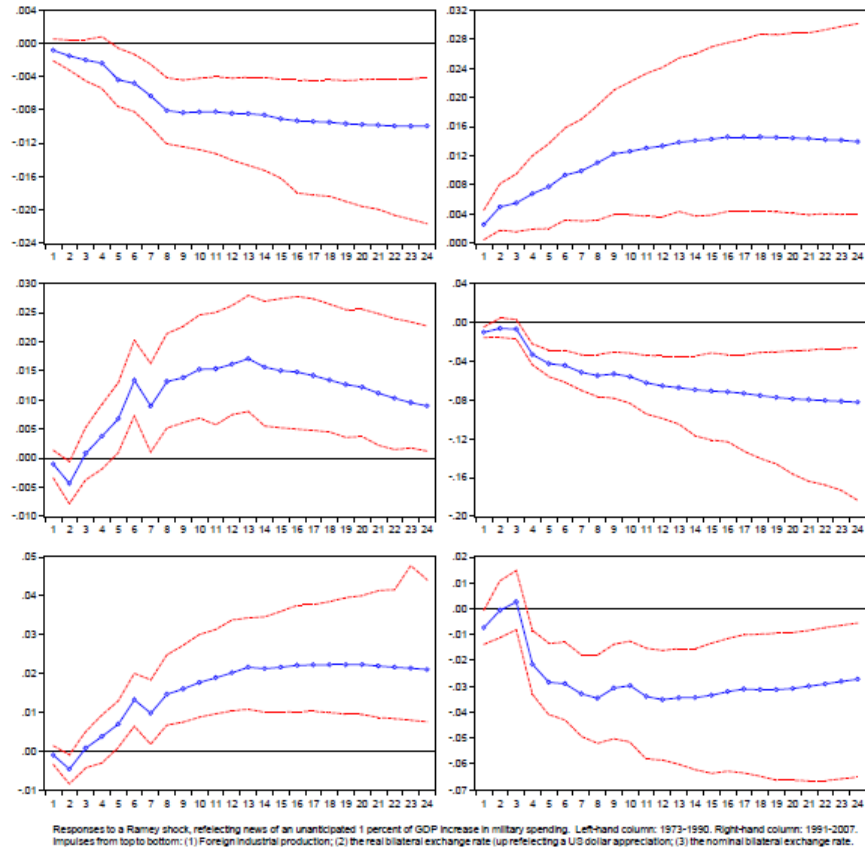


Figure 8: Responses of Foreign Variables to News of a US Military Buildup, as identified by Ramey (2011).

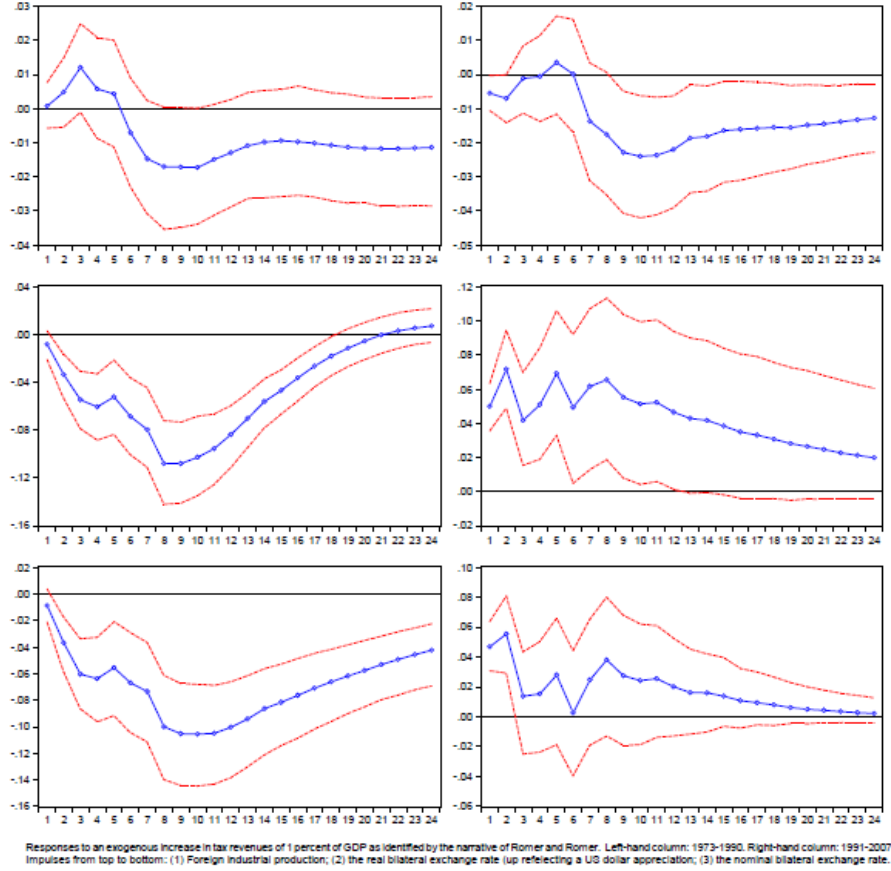


Figure 9: Responses of Foreign Variables to a Romer and Romer (2010) tax shock.

exogenous legislative changes to US government revenues. We regress the foreign variable of interest on 8 lags of the Romer and Romer (2010) tax shock and 8 own lags as in (2). Responses are presented in Figure 9. A tax increase in the US leading to an increase in revenues of 1% of GDP leads to a decline in foreign industrial production of about 1% in both the early and the later period. However, the exchange rate response is different in the two sub-periods. A tax increase leads to a large depreciation (approximately 12% within 2 years) in the US dollar in the early period, but to a (slightly smaller) and statistically significant depreciation in the later period. Thus, in the early period, the US dollar appreciates in response to any fiscal measure that increases the budget deficit, while it depreciates in response to similar fiscal tightening in the recent period.

Similarly to monetary policy, we see a significant shift in the international transmission of US fiscal shocks. The exchange rate response has reversed in sign. We do not see a consistent

reversal of the spillovers of fiscal policy to foreign production. The response of foreign output to US tax increases is almost identical in the two sub-periods, and using the SPF shock to identify shocks to government spending gives inconclusive results in this regard. Using the NEWS variable to identify fiscal shocks, however, does demonstrate a reversal in spillovers from (news of) US public spending. The spillovers were negative in the early period, but positive in the more recent period.

### 3 Theory

We proceed to lay out a two-country model with infinitely lived agents to confront the observations we have just established, zeroing in on the reactions of exchange rates and output of both economies to monetary disturbances originating from one country.

**Households** There are two countries, Home and Foreign, which each produce a range of goods,  $[0, n]$  and  $(n, 1]$ , respectively. In each economy there is a continuum of agents, with population size set equal the range of goods that is produced in each economy. Denote Home by  $h$  and Foreign variables by  $f$ . A representative household in Home has preferences

$$U_t^h = E_t \left[ \sum_{s=t}^{\infty} \beta^{s-t} U(C_{t+s}^h) + N \left( \frac{M_{t+s}^h}{P_{t+s}} \right) - V(L_{t+s}^h) \right]$$

where  $C_t^h$  denotes a home's individual level of consumption in period  $t$ ,  $M_t^h/P_t$  the individual's real balance holdings, and  $L_t^h$  his labor supply. Home and Foreign have symmetric preferences so that the consumption index in both countries is given by

$$C = \left[ n^{1/\zeta} C_H^{(\zeta-1)/\zeta} + (1-n)^{1/\zeta} C_F^{(\zeta-1)/\zeta} \right]^{\zeta/(\zeta-1)}$$

where  $C_H$  and  $C_F$  are two sub-consumption indices of the consumption of home-produced and foreign-produced goods, which are respectively,

$$\begin{aligned} C_H &= \left[ \left( \frac{1}{n} \right)^{1/\sigma} \int_0^n c(z)^{(\sigma-1)/\sigma} dz \right]^{\sigma/(\sigma-1)} \\ C_F &= \left[ \left( \frac{1}{1-n} \right)^{1/\sigma} \int_n^1 c(z)^{(\sigma-1)/\sigma} di \right]^{\sigma/(\sigma-1)} \end{aligned}$$

$\sigma > 1$  denotes the elasticity of substitution for varieties produced within a country, and  $\zeta$  denotes the elasticity of substitution between domestic and foreign goods.

In each period  $t$  the economy faces one of finitely many events  $s_t$ . We denote  $s^t = (s_0, s_1, \dots, s_t)$  the history of events up through period  $t$ . The probability, as of period 0, of any particular history  $s^t$  is  $\pi(s^t)$ . The initial realization  $s_0$  is given. Households seek to maximize their utility subject to the sequence of budget constraints.

With complete markets, agents in both economies have access to a complete set of state contingent bonds with price  $Q(s^{t+1}|s^t)$ , and that pays one unit of the home currency if state  $s_{t+1}$  occurs and 0 otherwise. The home individual's budget constraint satisfies

$$P_t c_t^h + M_t^h + \sum_{s_{t+1}} Q(s^{t+1}|s^t) B^h(s^{t+1}) = W_t^h l_t^h + M_{t-1}^h + B^h(s^t) + \Pi_t^h + T_t^h$$

where  $s^{t+1} = (s^t, s_{t+1})$ ,  $\Pi_t^h$  is nominal profits,  $W_t^h$  nominal wages, and  $T_t$  is transfers of home currency. A state contingent bond. The initial conditions  $M_0$  and  $B(s^0)$  are given.

With incomplete markets, home consumers have access to one-period nominal bonds  $B_{j,t+1}^h$  in period  $t$  that pay a nominal rate of return of  $i_t^j$  between  $t$  and  $t+1$  in units of  $j$ 's currency, where  $j = H, F$ . A Home consumer's budget constraint is thus:

$$P_t c_t^h + M_t^h + B_{t+1}^h + B_{f,t+1}^h = W_t^h l_t^h + M_{t-1}^h + (1 + i_t) B_t^h + (1 + i_t^*) B_{f,t}^h + \Pi_t^h + T_t^h$$

A similar set of equations hold for the Foreign consumer. The standard Euler equation and the first order conditions with respect to labor and real money holds are given by:

$$\begin{aligned} \frac{U_c(C_t^h)}{P_t} &= (1 + i_t) \beta E_t \left\{ \frac{U_c(C_{t+1}^h)}{P_{t+1}^h} \right\} \\ -\frac{V_L(L_t^h)}{U_c(C_t^h)} &= \frac{W_t^h}{P_t^h} \\ \frac{N_m(M_t^h/P_t)}{U_c(C_t^h)} &= \frac{i_t^h}{1 + i_t} \end{aligned}$$

where  $i_t^h$  denotes the nominal interest rate in Home between period  $t$  and  $t+1$ .

Firms

**Technology.** A typical firm in the home economy produces a differentiated good with a linear technology given by

$$y_t(h) = A_{H,t}L_t(h),$$

where  $A_{H,t}$  is aggregate productivity in the home country.

**Price Setting.** We consider Calvo price setting, where in every period, a randomly selected fraction  $1 - \delta$  of firms can reset their prices. With PCP, firms that reset prices solve

$$\max E_t \sum_{k=0}^{\infty} \delta^k M_{t+k|t} (\tilde{p}_t(h) y_{t+k|t}(h) - MC_{t+k} y_{t+k|t}(h))$$

which yields optimal prices

$$\tilde{p}_t(h) = \frac{\sigma}{1 - \sigma} \frac{E_t \sum_{k=0}^{\infty} \delta^k M_{t+k|t} MC_{t+k} \tilde{y}_{t+k|t}(h)}{E_t \sum_{k=0}^{\infty} M_{t+k|t} \tilde{y}_{t+k|t}(h)},$$

where  $MC_t$  denotes the nominal marginal cost,  $M_{t+k|t}$  denotes the firm's discount factor, and  $\tilde{y}_{t+k|t}(h)$  denotes the total demand for the home good under the condition that  $\tilde{p}_t(h)$  is still the price charged at  $t + k$ :

$$y_{t+k|t}(h) = \left( \frac{\tilde{p}_t(h)}{P_{H,t+k}} \right)^{-\sigma} \left( \frac{P_{H,t+k}}{P_{t+k}} \right)^{-\zeta} n(C_{t+k}^w + G_{t+k}^w),$$

where  $C_t^w = nC_t + (1 - n)C_t^*$  denotes aggregate (weighted) world consumption, and  $G^w = nG_t + (1 - n)G_t^*$ .

With LCP, the firms that reset prices choose a domestic reset price  $\tilde{p}_t(h)$  and a foreign reset price  $\tilde{p}_t^*(h)$  to solve

$$\max E_t \sum_{k=0}^{\infty} \delta^k M_{t+k|t}^k \left( \tilde{p}_t(h) y_{t+k|t}^h(h) + S_{t+k} \tilde{p}_t^*(h) y_{t+k|t}^f(h) - MC_t y_{t+k|t}(h) \right) \quad (3)$$

where  $MC_t$  is the firm's nominal marginal costs. where  $y_t(h) = y_t^h(h) + y_t^f(h)$  denote world demand for good  $h$ . The optimal price charged for the home and foreign market therefore



satisfy

$$\begin{aligned}\tilde{p}_t(h) &= \frac{\sigma}{1-\sigma} \frac{E_t \sum_{k=0}^{\infty} \delta^k M_{t+k|t} M C_{t+k} \tilde{y}_{t+k|t}^h(h)}{E_t \sum_{k=0}^{\infty} M_{t+k|t} \tilde{y}_{t+k|t}^h(h)} \\ \tilde{p}_t^*(h) &= \frac{\sigma}{1-\sigma} \frac{E_t \sum_{k=0}^{\infty} \delta^k M_{t+k|t} M C_{t+k} \tilde{y}_{t+k|t}^h(h)}{E_t \sum_{k=0}^{\infty} M_{t+k|t} S_{t+k} \tilde{y}_{t+k|t}^f(h)},\end{aligned}$$

with the demand of for good  $h$  given by:

$$y_{t+k|t}^h(h) = \left( \frac{\tilde{p}_t(h)}{P_{H,t+k}} \right)^{-\sigma} \left( \frac{P_{H,t+k}}{P_{t+k}} \right)^{-\zeta} n(C_{t+k} + G_{t+k}) \quad (4)$$

$$y_{t+k|t}^f(h) = \left( \frac{\tilde{p}_t^*(h)}{P_{H,t+k}^*} \right)^{-\sigma} \left( \frac{P_{H,t+k}^*}{P_{t+k}^*} \right)^{-\zeta} (1-n)(C_{t+k}^* + G_{t+k}^*) \quad (5)$$

With pricing to market, market segmentation implies that at least some firms have the ability to charge different prices for the same good in home and foreign markets. The LCP assumption means that the prices are sticky in each country in terms of the local currency. With identical CES preferences across countries, even these firms will optimally select home and foreign currency prices that are a constant markup over marginal cost and hence the law of one price will be satisfied ex ante. That is, in a perfectly deterministic environment,  $\tilde{p}_t(h) = \tilde{p}_t^*(h)S_t$  and the law of one price would hold. In the event of a shock, however, prices that are sticky in each local currency implies exchange rate movements that cause ex-post deviations from the law of one price.

**Asset Market Structure.** In the case of complete markets, the discount factor  $M_{t+k|t}$  is determined by the marginal rate of substitution

$$M_{t+k|t} = \frac{\beta^k U_c(C_{t+k})}{P_{t+k}} \frac{P_t}{U_c(C_t)}.$$

In the case of incomplete markets, firms are assumed to use the market nominal discount factor

$$M_{t+k} = \prod_{z=0}^k \frac{1}{1+i_{t+z}}$$

which replaces  $M_{t+k|t}$ , to maximize expected profits given in (3).

**Risk Sharing Condition.**

Let the real exchange rate be denoted as  $RER \equiv SP^*/P$ . In the complete markets case, the risk sharing condition between Home and Foreign amounts to

$$RER_t = k \frac{U_c(C_t)}{U_c(C_t^*)} \quad (6)$$

where  $k = S_0 U_c(C_0) P_0^* / (U_c(C_0^*) P_0)$  denotes initial consumption ratios and is equal to 1 when these two economies are ex-ante symmetric. In this case, if PPP holds, as is in the case of PCP, then consumption levels are equated across countries. Movements in the real exchange rate or departures from PPP will be reflected in different consumption levels. Despite the presence of complete insurance markets, it is not efficient to fully equalize consumption across countries unless PPP holds. In the presence of pricing to market, LCP, there will be persistent deviations to PPP.

In the incomplete markets case, the risk sharing condition amounts to

$$E_{t+1} \left[ \frac{u_c(C_{t+1})}{u_c(C_t)} \frac{P_t}{P_{t+1}} \right] = E_{t+1} \left[ \frac{u_c(C_{t+1}^*)}{u_c(C_t^*)} \frac{P_t^*}{P_{t+1}^*} \frac{S_t}{S_{t+1}} \right]$$

Real exchange rate fluctuations therefore drive a wedge between foreign and consumption growth rates, rather than levels—in the complete markets case.

**Terms of Trade, Exchange Rates** Given the structure of preferences, the home consumer's demand functions for varieties  $h$  and  $f$  are given by

$$c^h(h) = \left[ \frac{p(h)}{P_H} \right]^{-\sigma} \left[ \frac{P_H}{P} \right]^{-\zeta} nC, \quad c^h(f) = \left[ \frac{p(f)}{P_F} \right]^{-\sigma} \left[ \frac{P_F}{P} \right]^{-\zeta} nC,$$

$$c^f(h) = \left[ \frac{p(h)}{P_H} \right]^{-\sigma} \left[ \frac{P_H}{P} \right]^{-\zeta} (1-n)C, \quad c^f(f) = \left[ \frac{p(f)}{P_F} \right]^{-\sigma} \left[ \frac{P_F}{P} \right]^{-\zeta} (1-n)C,$$

where  $C = nC_h$  is aggregate consumption in Home and  $C^* = (1-n)c^f$  is aggregate consumption in Foreign. The corresponding domestic and foreign CPI are respectively

$$P = \left[ nP_H^{1-\zeta} + (1-n)P_F^{1-\zeta} \right]^{1/(1-\zeta)} \quad (7)$$

$$P^* = \left[ (1-n)P_H^{*1-\zeta} + nP_F^{*1-\zeta} \right]^{1/(1-\zeta)} \quad (8)$$

where  $P_H$  and  $P_F$  are the sub-price indices faced by a Home individual for domestic produced varieties and foreign produced import goods, both expressed in the domestic currency, and  $P_H^*$  and  $P_F^*$  are the sub-price indices faced by a foreign individual of the its imported goods and domestic goods. These sub-indices take the form of

$$P_H = \left[ \left( \frac{1}{n} \right) \int_0^n p(z)^{1-\zeta} dz \right]^{1/(1-\zeta)} \quad P_F = \left[ \left( \frac{1}{1-n} \right) \int_n^1 p(z)^{1-\zeta} dz \right]^{1/(1-\zeta)}$$

$$P_H^* = \left[ \left( \frac{1}{n} \right) \int_0^n p^*(z)^{1-\zeta} dz \right]^{1/(1-\zeta)} \quad P_F^* = \left[ \left( \frac{1}{1-n} \right) \int_n^1 p^*(z)^{1-\zeta} dz \right]^{1/(1-\zeta)}$$

With PCP, the law of one price holds,  $p(h) = Sp^*(h)$ . In the case of LCP, a domestic firm may find it optimal to charge different prices in the home and foreign market, and deviation from law of one price ensues.

The terms of trade is defined to be the relative price of the imported goods in terms of the domestic goods, expressed in local currency:

$$TOT \equiv \frac{P_F}{P_H}$$

which with PCP yields  $TOT = \frac{SP_F^*}{P_H}$ , and with LCP yields  $TOT = \frac{P_F}{(SP_H^*)}$ . Let the real exchange rate be

$$RER \equiv \frac{S_t P^*}{P}.$$

PCP implies that the real exchange rate is 1. PTM-LCP allows real exchange rates to fluctuate and delinks the home and foreign price levels.

**Monetary Policy** There is a debate over whether monetary growth rules or interest rates is a more appropriate way to model monetary policy. Interest rate rules have been more popular recently, but it is clear that either rule can be interpreted as one or the other. A simple interest rate rule may be a better approximation to the policy reflected in the data, and for this reason we follow the rules according to Taylor (1993).

Domestic and foreign nominal interest rates are both designed to react to deviations of their respective inflation and output from target levels, following

$$\hat{c}_t^j = \phi_\pi \pi_t^j + \phi_y y_t^j + \epsilon_t^j$$

where  $\epsilon_t^j = \gamma \epsilon_{t-1}^j + \nu_t$ ,  $\phi_\pi$  and  $\phi_y$  are weights placed on deviations of consumption-based inflation rates and domestic output gap in each country  $j$ .

## 4 Parameterization

In this section, we describe the parameterization of the model that is most common in the literature. We report the benchmark parameter values in Table 1. The utility functional form is taken to be

$$\begin{aligned} U(c) &= \frac{c^{1-\rho}}{1-\rho} \\ v(L) &= -\frac{L^\mu}{\mu}. \end{aligned}$$

We set  $n = 0.5$  so that the economies are of equal size. For a quarterly frequency, the discount factor  $\beta$  is set to 0.99 so that the steady-state annual real interest rate is 4 percent. The intertemporal elasticity of substitution  $\rho$  is set to 2, and  $\mu$  is set to 0.5.

The elasticity of substitution between home and foreign goods is  $\zeta$  is set to 1.5, following Backus, Kehoe and Kydland (1994) and subsequent papers. and the elasticity of substitution between domestically produced goods,  $\sigma$  is set to 6.

The fraction of firms that can adjust prices is set to be  $1 - \delta = 0.3$  in both Home and Foreign in the case of PCP. We also allow for the possibility that the degree of nominal rigidity can differ across and within countries, manifested by the different values of  $\delta^H, \delta^{H*}, \delta^F$ , and  $\delta^{F*}$ .

We do not need to specify the functional form of money demand as it is determined residually. Following Chari et al (2002), we set  $\gamma = 0.79$ ,  $\phi_\pi = 2.15$  and  $\phi_y = 0.23$ .

## 5 Results

In what follows, we focus on the impact of monetary and fiscal shocks on the exchange rate and output in Home and Foreign. We examine the complete and incomplete markets

Table 1: Parameters

Benchmark Parameter Values		
Preferences	$\beta = 0.99, \rho = 2, \mu = 0.47 \quad \zeta = 1.5, \sigma = 4$	
Firms	PCP: $\delta = 0.7$	LCP: $\delta^H = 0.7, \delta^{H*} = 0.75, \delta^F = 0.6, \delta^{F*} = 0.67$
Taylor Rule	$\gamma = 0.5$	$\phi_\pi = 1.5, \phi_y = 0.5$

case in two alternative price setting structures, PCP and LCP. We then discuss a variety of extensions most commonly adopted in the literature.

**Contractionary Monetary Shocks** The international transmission of monetary shocks can occur through three channels: the “demand effect” whereby lower consumption in Home lowers demand for world output, and thus negatively impacts foreign output. The second effect is a “expenditure switching effect” whereby an exchange rate appreciation leads to a terms of trade improvement and shifts demand towards foreign exports—thus positively affecting foreign exports. In the presence of PCP pricing, the expenditure switching effect is strong, causing an immediate and perfect pass-through from exchange rate to domestic import prices, and can quantitatively dominate the positive demand spillovers. In the presence of PTM-LCP, the expenditure switching effect is weak, causing demand effects to dominate.

*PCP under complete and incomplete markets*

The effects on the nominal exchange rate are shown in Figure 10. The rise in Home interest rate causes an immediate appreciation in the nominal exchange rate. Since uncovered interest parity holds in this economy, it follows from the interest rate differential that the exchange rate then proceeds to depreciate. With PCP, monetary disturbances have no effect on the real exchange rate. Since prices take some time to adjust to the interest rate shock, the nominal exchange rate appreciation causes a change in the terms of trade. In the case of PCP, export prices are invoiced in home currency and import prices in foreign currency, and an exchange rate appreciation is synonymous with an improvement in the terms of trade. Thus, inflation falls in Home as foreign goods have become cheaper and the opposite is true for Foreign.

Three factors determine foreign output. First, the expenditure switching effect causes a

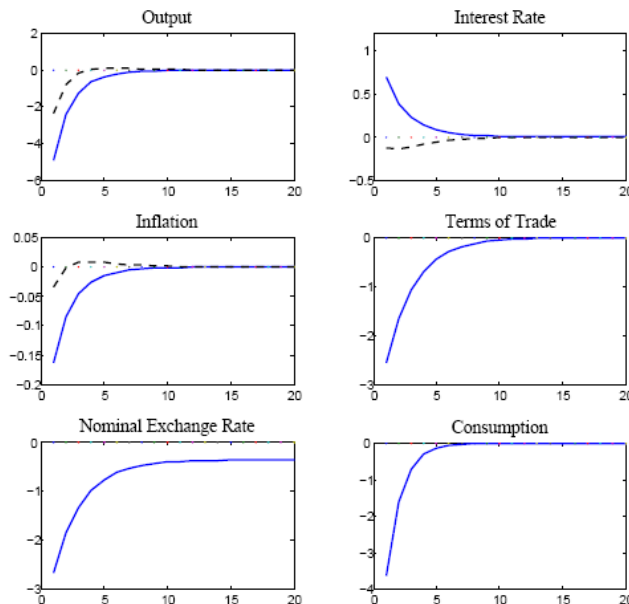


Figure 10: Responses to a Contractionary Monetary Shock under PCP and Complete Markets

shift of world demand towards Foreign, exerting upward pressure on Foreign output. Second, the fall in world demand due to the contractionary monetary shocks adversely affects Foreign output. Third, the foreign interest rate reacts according to the Taylor rule. In this case, as a result of the fall in output, the foreign interest rate falls, and puts upward pressure on Foreign output. The overall impact on foreign output depends on which effect dominates. Here the demand effect is the strongest, causing Foreign output to fall, but by substantially less than Home output.

It has been shown by Betts and Devereux (2000) that financial market completeness has minimal impact on the main results at hand. Figure 11 displays the results in the case where only trade in noncontingent bonds is possible. As before, there is no impact on the real exchange rate. The nominal exchange rate appreciates, leading to a terms of trade improvement, which reduces Home income relative to Foreign's so that the home country runs a current account deficit. Consumption falls by more in Home than in Foreign, and is permanently lower at Home. The current account deficit reduces home's net foreign assets and causes a permanent reduction of home wealth. Another difference is that the foreign interest rate now does not fall as much as before, since inflation is much higher than in

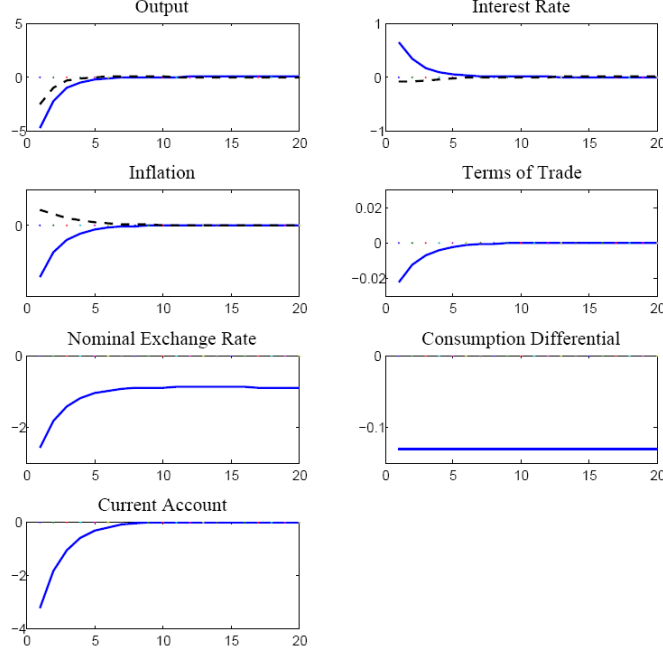


Figure 11: Responses to a Contractionary Monetary Shock under PCP and Incomplete Markets

the case of complete markets. Also, home interest rate now falls as a reaction to the large drop in inflation. Apart from differences in the consumption differential and current account dynamics, the central properties of the international monetary transmission mechanism are basically identical to the ones under complete markets.

#### *LCP under complete and incomplete markets*

Figures 12 illustrate the case of monetary policy under pricing-to-market under complete markets. We omit the case under incomplete markets as the difference is minimal. Since PPP does not hold in the short run, the real exchange rate responds to interest rate shocks. Both real and nominal exchange rate appreciate at Home, with the appreciation of the former causing a consumption divergence across countries. Even in the case of complete markets, it is not optimal to equate consumption levels, according to Eq.6.

All exports are invoiced in foreign currency and imports in domestic currency. The pricing-to-market implies that there is no immediate pass-through from exchange rates to prices. Home and Foreign price levels are now delinked and exchange rate movements are not synonymous with movements in the terms of trade. The response of the terms of trade is now the opposite of that in the PCP case. The expenditure switching effect is thus weak

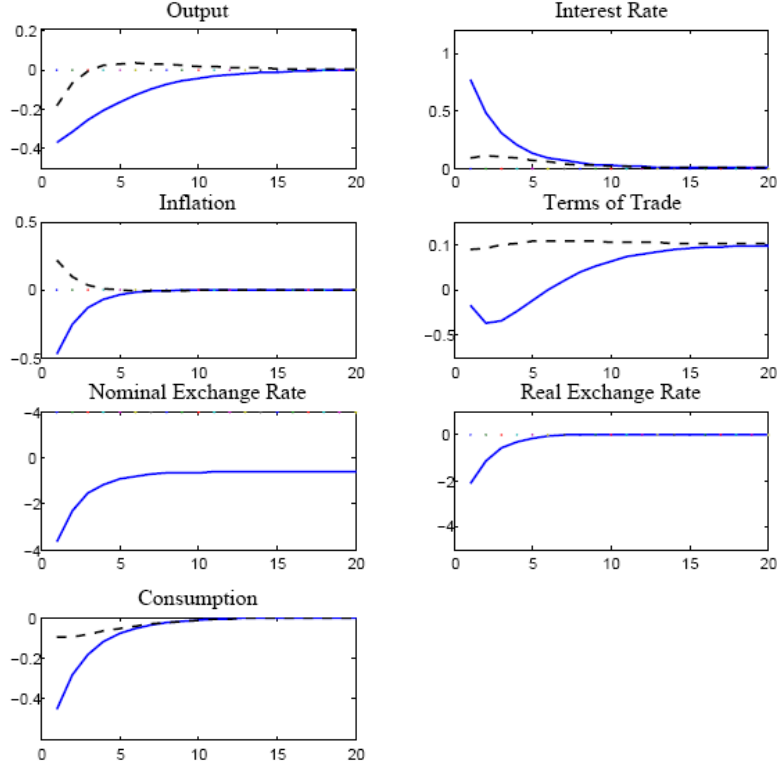


Figure 12: Responses to a Contractionary Monetary Shock under LCP and Complete Markets

in the case of LCP, making the demand effects much more dominant. This is reflected in output moving much closer across countries than in the case of PCP. Foreign output actually rises after a few periods. The LCP case effectively mutes the expenditure switching effect that causes a negative transmission of shocks across countries.

One interpretation of the positive comovement in output in the U.S. and other countries in the earlier sample is that the expenditure switching channel is weak, causing Foreign output to fall despite a depreciation of the Home currency. It is thus possible that the results from the earlier case is consistent with either the PCP case or the LCP case, so long as the expenditure switching effect is weak enough. This effect eases some of the fall in output in Foreign in the case of PCP, and thus predicts a smaller drop in output than in the case of LCP. Overall, the international transmission mechanism is very much consistent with standard predictions.

In the latter period lies the puzzle. With contractionary monetary policy shocks in the U.S. the output rises abroad. One may think that perhaps during this period the



expenditure switching effect may have become stronger—dominating the impact from the demand channel—thus giving credence to the PCP approach. However, the exchange rate behavior required for the operation of the expenditure switching effect is in fact exactly the opposite of what is observed from the data. The U.S. exchange rate *depreciates* rather than appreciates, thus killing all possibilities of a reversal of the fall in output in Foreign, and possibly exacerbating the conundrum as an appreciation exerts a further adverse impact on foreign output. In other words, the international transmission mechanism is even more puzzling *especially* when we get the exchange rate movements right (to depreciate).

**Government Spending Shocks** In the case of complete markets, it is evident that government spending shocks have identical effects on home and foreign variables. The reason is that government purchases both home and foreign goods—the composite good that is identical to the consumption good, and therefore a rise in a country’s government spending increases the demand for all goods produced in Home and Foreign. With complete markets, both countries share the wealth effect of financing this increased expenditure. Thus, as in Figure 13, both home and foreign output rise, and consumption falls. Interest rates rise by the same amount and there here are no exchange rate effects.

On the other hand, if government spending falls entirely on domestic goods, then the results can look quite different, even in the case of complete markets. In this case, the positive effect of government spending on output falls entirely on domestic goods, and the fall in world consumption causes foreign output to decline. Home interest rate rises as a result of the rise in Home output, and foreign interest rates fall, causing an exchange rate appreciation. Terms of trade improve for the Home economy, but the expenditure switching effect is not strong enough to generate a positive spillover onto foreign output. Output therefore diverges across economies in this case.

In the case of incomplete markets, an expansion of the home-country government spending now leads to a decrease in home’s consumption relative to foreign consumers, and a current account deficit. But apart from these differences, the output and exchange rate effects are almost identical to the complete markets case. Since government spending is a composite of both home and foreign produced goods, output and inflation (under PCP) almost move in synchrony in the two economies. There is minimal exchange rate movement because interest rate differential is small.

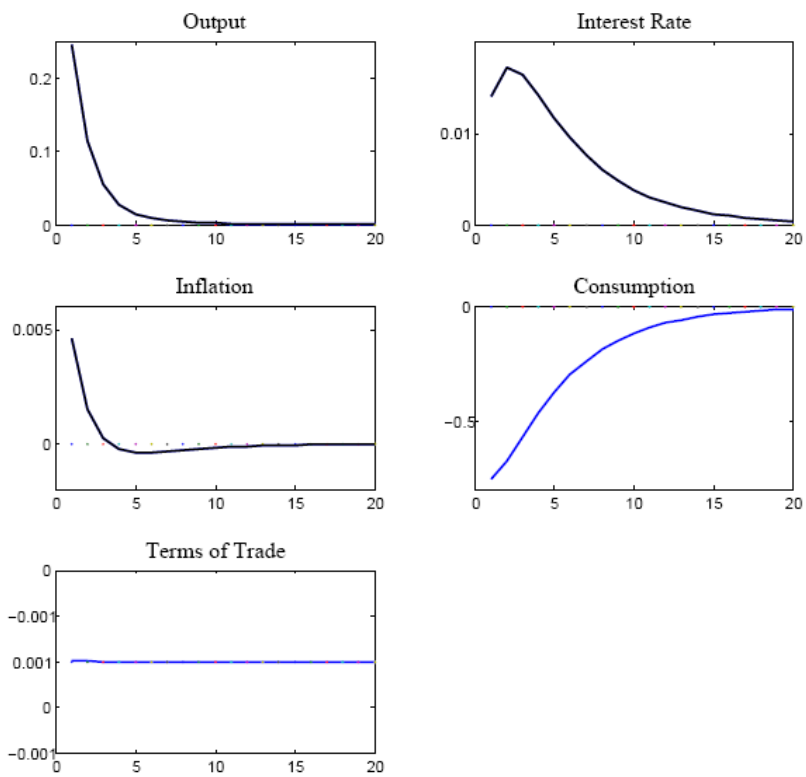


Figure 13: Responses to an Expansionary Government Spending Shock under PCP and Complete Markets

If government spending falls entirely on domestically produced goods, the results are very similar to the analogue case under complete markets. The fall in inflation at Home is driven by a strong negative demand effect, as consumption falls at Home by more than in foreign. A larger interest differential compared to the case without a home bias leads to larger interest rate differentials, causing a more significant nominal exchange rate appreciation in this case. Output falls in Foreign due to the fall in world consumption, and it does not benefit from the rise in demand due to government spending, which is accrued to Home. Output therefore diverges across the economies. In this case, even with a terms of trade improvement at Home, the expenditure switching effect is not enough to cause output to rise in Foreign.

In these simple cases, output may rise in Foreign but at the cost of a minimal movement in the exchange rate. When government spending is biased towards home goods, the appreciation of the exchange rate would be consistent with observations from the data, but at the cost of a declining output in Foreign. Nevertheless, we view the transmission of fiscal policy shocks to be less puzzling than the case of monetary shocks, as there are competing forces exerting on foreign output, and whether one can get both consistent exchange rate and output behavior is more of a quantitative rather than qualitative matter.

#### **Discussion** *Elasticity of substitution between Home and Foreign goods*

Altering the elasticity of substitution between Home and Foreign goods would either lead to a larger or a smaller terms of trade movement, but with no qualitative change in the transmission mechanisms. As the goods become more substitutable (high elasticity), the terms of trade movements are smaller but trade is larger between the two countries. If the goods are less substitutable (low elasticity), the terms of trade movements will be larger and the net trade between the two countries smaller. This can lead to quantitatively different but qualitatively similar results as the benchmark model.

#### *Nontradable Goods and Home Bias*

Home bias in consumption can only reduce the negative demand impact on Foreign output, as most of the drop in demand falls on Home rather than Foreign goods. This can potentially permit the TOT effect to dominate. In the case of PCP, the requirement is a nominal exchange rate appreciation. But in the data, the exchange rate depreciates, thereby leading to the possible expenditure switching effect operating in the wrong direction. The puzzle is therefore, especially pronounced when the exchange rate behaves according to the data.

In the case of LCP, the TOT expenditure switching effect is absent, and thus the reduction in the negative demand effect on Foreign output due to home bias can mitigate the fall in Foreign output. But to generate a rise in Foreign output would require a strong improvement in the TOT. The puzzle in this scenario therefore lies in (1) matching the exchange rate depreciation; (2) generating a strong opposite TOT effect. Both of these criterion still require a departure from existing models.

#### *Capital Accumulation*

Betts and Devereux (2000) incorporate capital accumulation into the benchmark two-country economy, allowing for both PCP and LCP price setting structures. Capital accumulation does not change qualitatively the transmission of shocks onto output and exchange rate. With contractionary monetary shocks, real interest rates rise in both economies, causing investment to fall. This tends to further reduce output in Foreign.

## **6 Conclusion**

Data suggests a dramatic change in the international propagation of policy shocks in the recent decades. Traditional frameworks that have been successful at explaining some key features of the data in the period prior to 1990 is in need of considerable modification, in order to be used as an appropriate theoretical reference point for many important issues at hand.

The subsequent steps, based on these findings that provide some empirical guidance for theoretical design, is thus clear. Understanding the nature of the shift in the international ramifications of policy shocks, and developing theories that fit with key empirical facts will help us better understand the precise nature of these transmission, thereby forming more reliable policy prescriptions for problems it is essentially set out to address.

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