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What are the Effects of Monetary Policy Shocks? Evidence from Dollarized Countries

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Analyzing the Effects of U.S. Monetary Policy Shocks in Dollarized Countries*

Tim Willems†

Abstract

Identifying monetary policy shocks is difficult. Therefore, instead of trying to do this perfectly, this paper exploits a natural setting that reduces the consequences of shock misidentification. It does so by basing conclusions upon the responses of variables in three dollarized countries (Ecuador, El Salvador, and Panama). They import U.S. monetary policy just as genuine U.S. states do, but have the advantage that non-monetary U.S. shocks are not imported perfectly. Consequently, this setting reduces the effects of any mistakenly included non-monetary U.S. shocks, while leaving the effects of true monetary shocks unaffected. Results suggest that prices fall after monetary contractions; output does not show a clear response.

JEL-classification: E52; E31; C32

Key words: Monetary policy effects; Price puzzle; Structural VARs; Identification; Block exogeneity

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1 Introduction

Since monetary policy is typically not executed in an erratic fashion, identifying random disturbances to monetary policy (the so-called "monetary policy shocks") is difficult. For this reason, the present paper has a different focus than the standard VAR exercise. Instead of trying to find the perfect shock identification scheme, this paper asks: if shock identification is so difficult, can't we find a natural setting that *reduces the consequences* of the almost inevitable misidentification of monetary shocks? The natural setting I exploit is the existence of dollarized countries. They import U.S. monetary policy, but, as I will argue below, they are not perfectly integrated with the U.S. economy. Consequently, non-monetary U.S. shocks do not survive the transmission process to these client economies undamaged, which makes this paper's findings less prone to monetary policy shock misidentification.

The fact that shock identification is difficult, might explain the presence of some ongoing debates in the structural VAR literature. Next to the fact that there is no consensus on the effects of monetary shocks on output, many studies find that prices *increase* after a monetary contraction, which goes against the predictions of most standard macroeconomic theories (such as the New Keynesian one). Even though this price response can be rationalized through the working capital channel,[1] it is generally referred to as "the price *puzzle*".

The present paper tries to shed light on the question whether economic theory should take this price puzzle seriously (which may call for incorporation of the cost channel into standard macroeconomic models[2]), or whether it is just an artifact of shock misidentification. It does so by using output and price data from dollarized countries, all located in Latin America. By unilaterally adopting the U.S. dollar, these countries have established a so-called "informal monetary union" with the U.S.

[1] *Cf.* Van Wijnbergen (1983), who obtained the price puzzle - *avant la lettre* - in a working capital model. There, firms need to borrow funds in order to be able to pay for their production factors, which makes the interest rate a determinant of real marginal costs.

[2] This development has actually started already: Barth and Ramey (2001, p. 199-200) state that "cost-side theories of monetary policy transmission deserve more serious consideration". Christiano, Eichenbaum and Evans (2005) did this by adding a working capital channel to their model. Ravenna and Walsh (2006) discuss how the cost channel affects the optimal monetary policy.

From a monetary perspective, these client countries are therefore not that different from genuine U.S. states: they use the U.S. dollar as legal tender (just like, say, Idaho does) and have no possibility to deviate from U.S. monetary policy, as there is no local currency to de- or revalue. Consequently, these countries rapidly import U.S. monetary shocks (primarily via the financial channel; see Canova (2005)), while there are no exchange rate considerations at play. The fact that the monetary union is only "informal" (thereby contrasting with formal monetary unions, such as the euro zone), does not matter in this respect.

Taking this geographical detour brings at least two advantages. Firstly, the resulting econometric restrictions enable one to analyze the effects of U.S. monetary shocks in the client economies, without imposing inertial or sign restrictions on the variables of interest.

Secondly, basing conclusions upon the responses of variables in dollarized countries makes this paper's findings less prone to the major concern any structural VAR exercise has to face: misidentification of the U.S. monetary shock. This is the case because the dollarized countries that are going to be considered (Ecuador, El Salvador, and Panama) are only imperfectly integrated with the U.S. economy. In particular, the economies of Ecuador and El Salvador are only moderately open in terms of trade-to-GDP ratios[3] and to the extent that the dollarized economies do trade internationally, most of it takes place with other countries than the U.S.[4] Consequently, non-monetary U.S. shocks can be expected to produce only rather limited output- and price fluctuations in these countries - especially at short horizons.[5]

Lindenberg and Westermann (2010) investigated this issue empirically and they

[3]As reported by the CIA World Factbook, the ratio of exports (imports) to GDP equaled 0.250 (0.249) for Ecuador in 2009. For El Salvador, these numbers are 0.183 and 0.318 and for Panama they equal 0.441 and 0.523. To compare: for a textbook open economy, such as Singapore, these ratios are 1.550 and 1.358, while the corresponding U.S. numbers equal 0.073 and 0.110.

[4]According to the Factbook, 66 percent of Ecuadorian exports (73 percent of their imports) went to (came from) other countries than the U.S. in 2009. For El Salvador, these numbers are 56 percent for exports and 70 percent for imports. Finally, Panama exported 82 percent (imported 88 percent) of their total to (from) non-U.S. trading partners.

[5]Non-monetary shocks are typically transmitted through the time-consuming trade channel, as a result of which they need a while to arrive at a different region. This idea goes back to at least Dornbusch (1976) and is confirmed in the empirical exercise by Canova (2005).

indeed find that Latin America does not share its business cycle with the U.S.[6] This suggests that these cycles are not driven by the same shocks, or that the shocks are only transmitted with a delay. In line with this, Canova (2005) even finds that non-monetary U.S. shocks do not tend to produce significant output or price fluctuations in Latin America at all.

All this suggests that even if the identified "monetary policy shock" includes some non-monetary U.S. components, the consequences of this mistake are contained in the dollarized countries, as the transmission of these non-monetary U.S. disturbances to Latin America is not instantaneous and perfect. This makes the approach work a bit like an ideal filter, as it reduces (or at the very minimum: delays) the effects of any mistakenly included non-monetary U.S. shocks on client country variables.

When one analyzes the effects of contractionary U.S. monetary shocks through dollarized economies, prices in all client countries fall on impact - so the price puzzle disappears. Quantitatively, prices in dollarized economies seem to have been pretty flexible over the sample period. Output does not show a clear response, so monetary neutrality cannot be rejected.

2 Identifying monetary policy shocks

Since monetary authorities typically *respond to* economic developments, the main challenge for empirical studies analyzing the effects of monetary policy shocks, is to identify true exogenous movements in the monetary instrument. This section starts by describing how traditional studies tend to deal with this issue (and the possible problems associated with those approaches), after which Section 2.2 explains how dollarized countries can be used to mitigate these problems.

[6] They report that the correlation in growth rates between the U.S. and El Salvador (Panama) equals only 0.23 (0.12). Ecuador is not included in their study, but in own calculations this correlation equals 0.30. To compare: for Canada and Mexico the correlations with U.S. growth rates equal 0.77 and 0.73, respectively. A similar result is reported by Alesina, Barro and Tenreyro (2002).

2.1 Traditional approach

As set out in Christiano, Eichenbaum and Evans (1999, henceforth CEE), a popular method to try and identify monetary policy shocks is by making assumptions that allow for the estimation of the monetary authority's feedback rule (which relates its actions to the state of the economy). Once this rule has been estimated, it becomes possible to identify the unpredicted shocks to the monetary instrument.

One way to advance along these lines (employed by CEE (1999)) is by assuming that the monetary authority is able to react to changes in output and prices within the period, while the output and price effects of monetary shocks can only show up after one period. Alternatively, one could go down the lines of Sims and Zha (2006) and assume the opposite by allowing for impact effects of monetary shocks, but assuming that contemporaneous values of output and prices are not in the Fed's information set. This assumption is motivated by the fact that gathering and processing the necessary data takes time, as a result of which monetary policy may not be able to respond to changes in these variables within the period.

The degree of realism of both restrictions can however be questioned: the majority of existing theoretical models imply that output and prices already respond on impact of a shock (which the CEE-scheme does not allow for), while the fact that now- and forecasts are likely to be in the monetary authority's information set makes the Sims-Zha approach debatable.[7] As Canova and Pina (2005) show, the imposition of both of these type of restrictions can lead to shock misidentification, as a result of which IRF coefficients can get the wrong sign - which may remind some of the price puzzle.

Alternatively, it has been argued that the price puzzle reflects the fact that the estimated VAR contains less information than available to the monetary authority. The idea is that when the monetary authority knows that inflation is about to arrive and contracts in response, prices will still rise, but by less than they would have without the contraction. Sims (1992) tries to correct for this by adding a commodity

[7] As Sims and Zha (2006, p. 249) themselves note, their identifying restriction "can never be more than an interesting working hypothesis, because policy makers obviously have other sources of information about the economy than the published data, and might have a strong interest in using it to get accurate current assessments of the state of the economy".

price index to the VAR and shows that this decreases the puzzle. Recently, however, this solution has been questioned. Hanson (2004) for example fails to find a correlation between the ability of variables to forecast inflation and the ability to reduce the price puzzle. Moreover, Hanson shows that including commodity prices in the VAR does not work for an early sample period, running from 1959 to 1979.[8] These findings suggest that either the price puzzle is not a puzzle (it is just the working capital channel at work), or that there is a different problem (like shock misidentification, which is for example argued by Canova and Pina (2005) and Carlstrom, Fuerst and Paustian (2009)).

To shed more light on these differing views, this paper takes advantage of the existence of dollarized countries and uses the latter to analyze the effects of monetary shocks in a way that will be explained below.

2.2 Adding dollarized countries

To address the aforementioned issues, this paper does not look at the responses of U.S. output and U.S. prices to federal funds rate shocks (henceforth referred to as Y^{US}, P^{US} and R^{US}, respectively), but uses their counterparts from dollarized countries instead (Y^D and P^D).

This approach takes advantage of the imperfect transmission of non-monetary U.S. shocks to Latin American countries (as documented in Canova (2005))[9], which provides the considered setup with some capacity to filter out non-monetary U.S. disturbances. In this sense, the present paper thus rests with the idea that perfect shock identification is probably not possible, and moves on to the exploitation of a natural setting that reduces the consequences of shock misidentification instead.

Related to this, the setting considered also has the ability to "convert" endogenous policy responses to non-monetary disturbances, into monetary policy shocks. To see

[8] As shown in Section 4, adding a commodity price index does not solve the U.S. price puzzle over the sample period considered in this paper either.

[9] Following suggestions of the referees, I also executed an analysis along the lines of Canova (2005) on my dataset, which supported his findings: U.S. supply and real demand shocks (identified via the sign restrictions suggested by Fry and Pagan (2011, Table 3)) only have a minor effect on dollarized country variables, especially in the short run. Detailed results are available upon request.

this, consider the following example:[10] say that the U.S. is hit by a non-monetary shock, in response to which the Fed immediately raises the interest rate. At this stage, U.S. variables are moved by both the direct effect of the non-monetary shock, as well as by an indirect effect, being the endogenous response of the monetary authority. But as this response took place within the period, the sum of the two effects will look like a monetary policy shock to the observer in standard VAR-specifications, which is wrong as there never was a monetary shock in reality (only the endogenous response to the non-monetary shock). However, output and prices in dollarized countries are unlikely to be moved within the period by the non-monetary U.S. shock. Hence, the direct effect gets killed in the transmission process and the full, unexpected interest rate increase is a true monetary policy shock from the perspective of the dollarized countries. So where standard VAR exercises need random variations in the monetary policy instrument, the current setting is able to provide us with monetary shocks (through the eyes of the client countries) even if the Fed just responds in a perfectly predictable way to unpredictable U.S. developments (under the proviso that the latter are not immediately transmitted to the dollarized economies).

As noted before, I am aware that the client economies considered are probably not fully insulated from non-monetary U.S. shocks (especially at longer horizons), and that next to those, there may also be aggregate world-wide shocks affecting both the client countries and the U.S. simultaneously. To address the latter point, Section 4 shows that results are robust to the inclusion of a commodity price index, which could be seen as an indicator of aggregate economic conditions. More generally, it seems reasonable to assume that the exploited setting at least reduces the consequences of shock misidentification - a conjecture that will be investigated in greater detail in Section 5 of this paper.

Another point of potential concern is the fact that the client countries were affected by idiosyncratic factors over the sample period, while they have also followed different fiscal policies. These issues however also apply to standard VAR exercises performed on the U.S. or the euro area (*cf.* the differences in fiscal policy between Northern and Southern Europe, while every euro area country/U.S. state is also hit

[10] I owe this example to Wouter den Haan.

by idiosyncratic shocks), so these concerns are not unique to the alternative route taken by this paper.

When estimating the system, this paper exploits the fact that the U.S. economy can be taken to be exogenous to the dollarized economies (as the latter are all small). In particular, one can make use of the fact that the Fed does not pay any attention to economic conditions in these client countries when designing its monetary policy. Building upon Lastrapes (2005), the remainder of this section sets out an estimation strategy that exploits this convenient natural setting. In particular, let Q_t be a vector stochastic process that is assumed to be generated by:

$$C_0 Q_t = \sum_{i=1}^{q} C_i Q_{t-i} + \epsilon_t \tag{1}$$

Here ϵ_t is a normalized, white noise vector process such that $\mathbb{E}\epsilon_t\epsilon_t' = I$. To simplify notation, I suppress the constant and linear time trend that are also included in the analysis. Since the data on dollarized countries are not seasonally adjusted, I also include quarterly dummies in the client country block to remove any possible seasonality in these series.

The corresponding reduced form of this model is:

$$Q_t = \sum_{i=1}^{q} F_i Q_{t-i} + v_t, \tag{2}$$

with $F_i = C_0^{-1}C_i,\ i = 1, ..., q,\ v_t = C_0^{-1}\epsilon_t$ and $\mathbb{E}v_t v_t' = \Omega = C_0^{-1}\left(C_0^{-1}\right)'$.

In estimating the reduced form, I impose two over-identifying restrictions. First, regarding the absorption of shocks, I assume that the correlation between output and prices in the client countries is solely due to their joint dependence on the U.S. variables.[11] This makes it possible to estimate the system efficiently by OLS (see Lastrapes (2005)). As one could debate the reasonableness of this assumption on theoretical grounds, I show in Section 4 that the results are robust to dropping

[11] That is: the equation for Y^D (*in casu* P^D) only contains its own lags (and lags of Y^{US}, P^{US} and R^{US}, of course). So lagged values of P^D do not enter the equation for Y^D and vice versa.

this restriction (in which case one must estimate the system by seemingly unrelated regressions).[12]

Second, with respect to the emission of shocks from dollarized countries, I assume that U.S. variables are block exogenous with respect to the variables in the dollarized countries. That is: whatever happens in the client country is assumed to have no impact on the U.S. economy, as the former is too small to affect the latter.[13]

Econometrically, these assumptions amount to the following: organize Q_t such that $Q_t = \left(Q_t^D, Q_t^{US}\right)'$, where $Q_t^D = (Y_t^D, P_t^D)'$ and $Q_t^{US} = (Y_t^{US}, P_t^{US}, R_t^{US})'$.[14] Block exogeneity of Q_t^{US} with respect to Q_t^D then implies that all C-matrices will be upper-triangular. That is:

$$C_i = \begin{pmatrix} C_{i,11} & C_{i,12} \\ \mathbf{0} & C_{i,22} \end{pmatrix}, \quad i = 0, ..., q \tag{3}$$

The assumption regarding the absorption of shocks implies that $C_{i,11}$ is diagonal. Partitioning the VAR into a dollarized country- and a U.S.-block gives:

$$\begin{pmatrix} Q_t^D \\ Q_t^{US} \end{pmatrix} = \sum_{i=1}^{q} \begin{pmatrix} F_{i,11} & F_{i,12} \\ \mathbf{0} & F_{i,22} \end{pmatrix} \begin{pmatrix} Q_{t-i}^D \\ Q_{t-i}^{US} \end{pmatrix} + \begin{pmatrix} v_{1,t} \\ v_{2,t} \end{pmatrix} \tag{4}$$

Lastrapes (2005) then shows that the associated variance-covariance matrix Ω can be partitioned into:

$$\Omega = \begin{pmatrix} \Omega_{11} & \Omega_{12} \\ \Omega_{12}' & \Omega_{22} \end{pmatrix} = \begin{pmatrix} H_{0,11}H_{0,11}' + H_{0,12}H_{0,12}' & H_{0,12}H_{0,22}' \\ H_{0,22}H_{0,12}' & H_{0,22}H_{0,22}' \end{pmatrix}, \tag{5}$$

where $H_k = \frac{\partial Q_{t+k}}{\partial \epsilon_t}$ represents the system's impulse response function (so H_0 is the impact response, while those H_k's with $k > 0$ can be obtained from it by iteration; H_k can be partitioned just like the other matrices, so $H_{k,11}$ represents the top-left

[12] An over-identifying restrictions test however fails to reject this restriction for all three dollarized countries considered in this paper.

[13] An over-identifying restrictions test also does not reject this restriction for any of the countries.

[14] Note that the empirical results that are to follow are invariant to the ordering of the output and price variables within each block, as I am only going to look at a shock to R_t^{US}.

entry of H_k, and so forth).

As Lastrapes (2005) shows, one can fully identify H_0 (and hence H_k) from (5). In particular, he notes that block exogeneity of Q^{US} implies that $H_{0,22}$ (which is where the U.S. monetary policy shock lives) can be identified in isolation from the Q^D block. Consequently, one can copy the attractive feature of the CEE-approach and allow for contemporaneous values of U.S. variables in the Fed's information set by assuming that $H_{0,22}$ is lower triangular. However, as set out in Section 2.1, this approach does not allow for a contemporaneous impact of U.S. monetary shocks on U.S. prices and output, which is hard to defend in reality. But this is where the dollarized countries come in handy: because the Fed does not pay any attention to conditions in these countries when designing its monetary policy, there is no need for an inertial assumption here. Consequently, we can just feed the U.S. monetary shock (fully located within the U.S. block of the system) through the estimated system for the dollarized economy, without imposing inertial or sign restrictions in the latter.

However, this is still no guarantee that the U.S. monetary policy shock is identified correctly. But, as argued before, the fact that the dollarized countries considered are only imperfectly integrated with the U.S. economy, reduces the role played by any mistakenly included non-monetary disturbances. Consequently, the route taken by this paper is less prone to misidentification of the monetary shock in the U.S. block of the system.

3 What are the effects of monetary policy shocks?

By now, we are in the position to analyze the effects of U.S. monetary shocks on output and prices in dollarized economies. Quarterly output and price data are available for three of the largest dollarized countries: Ecuador (dollarized since 2000q1), El Salvador (dollarized since 2001q1)[15] and Panama (dollarized since 1904, data avail-

[15] Prior to official dollarization in 2000, Ecuador was already effectively dollarized as its residents had started to use the U.S. dollar for daily transactions in the mid-1990s and made increasing use of U.S. dollar denominated loans and deposits since then (Beckerman, 2001). The former El Salvadorian currency (the colón) had already been pegged to the U.S. dollar in 1993. So in practice both Ecuador and El Salvador had already been importing U.S. monetary policy for some years

able since 1996q1). For these countries, the left panels of all figures that are to follow display the IRFs of output and prices to a one standard deviation, contractionary U.S. monetary shock. Note that these IRFs are obtained without imposing any restrictions on these variables. For comparison purposes, the right panels of all figures contain the IRFs of U.S. prices and output to the same shock - a procedure that does need to impose a zero response on impact under the current identification scheme.

Following Bernanke and Mihov (1998), I use data on the implicit GDP deflator and real GDP as proxies for U.S. prices and output, respectively. The federal funds rate is taken to be the monetary policy instrument. All U.S. data are from the St. Louis Fed website. For the dollarized economies the GDP deflator is not available and the CPI (taken from the IMF's IFS database) is used instead.[16] Data on real GDP is obtained from the central banks of Ecuador and El Salvador and from the Instituto Nacional de Estadística y Censo for Panama. All series (except the federal funds rate) are logged before they enter the VAR.

Results are based upon a VAR(2), where the lag-length was selected by Schwarz's Information Criterion.[17] The reported 95 percent confidence bands are obtained via a Monte Carlo procedure (with 5,000 replications), in which artificial data was generated by bootstrapping the estimated residuals. Instead of the point estimate (which is likely to suffer from the short sample of data used), I display the median bootstrapped response.[18]

Ecuador Ecuador dollarized its economy in January 2000 in response to a banking crisis that was accompanied by high inflation rates. This crisis intensified in 1998, after which the government decided to dollarize officially (see Beckerman

before they dollarized officially in the early 2000s.

[16]This only strengthens this paper's finding that the price puzzle disappears once one analyzes the effects of monetary shocks through dollarized countries, as Hanson (2004, p. 1390) reports that the price puzzle is most severe when the CPI is used to measure the price level.

[17]Results are robust to estimating a more common VAR(4), although somewhat less significant due to the reduction in degrees of freedom.

[18]I thank an anonymous referee for this suggestion. Basing inference upon the point estimate would not affect any conclusions though (the interested reader is referred to Figure 4 below, which does show the point estimates. As one can see from that figure, the only notable difference is that the point estimate of Panama's price response is more negative than its bootstrapped equivalent).

(2001)). Following dollarization inflation quickly came down, but Ecuador did suffer from double digit inflation rates in 2000 and part of 2001. Given the limited length of the time series available, results are based upon a VAR that is estimated on data covering the full dollarization period (*i.e.* from 2000q1 to 2010q3), but these results are robust to picking later starting dates that fully exclude the crisis episode (such as 2002q1 or 2003q1).

Figure 1 shows the outcome of this exercise for Ecuador. Its right panel confirms the puzzling findings of many earlier studies in this literature: following a monetary tightening, the U.S. price level increases significantly in a very persistent way, which is hard to reconcile with existing theories.[19] In addition, U.S. output goes up as well, so one could also speak of an "output puzzle" here.

But as shown in Canova and Pina (2005), these puzzling results may just be due to shock misidentification - caused by the fact that the imposed zero impact restrictions, necessary to obtain these IRFs, are not met in practice.

As set out before, including data from a dollarized country allows us to analyze the effects of this shock *without* imposing the zero response on impact, while it also helps to filter out the effects of any mistakenly included non-monetary elements of the shock. The results of this exercise are shown in the left panel of Figure 1.

Several things are to be noted about this. First, the puzzling price response of the standard approach is now reversed: the Ecuadorian price level falls quickly and significantly after a monetary contraction. Second, although output does not move significantly, the median indicates that it is depressed for a bit less than a year following the contraction. Observe that the negative response of prices is quite large: after three quarters, prices have for example already fallen by 0.5 percent. This suggests that prices were rather flexible in Ecuador over the sample period, which might explain why output does not show a clear and significant response.

Finally, one can also perform a forecast error variance decomposition exercise. The results of this exercise are shown in Table 1, from which one can infer that

[19] As noted before, the price puzzle can be rationalized through the working capital channel, but this channel only predicts a *short-lived* increase in the price level after a contractionary shock, which is inconsistent with the picture shown here.

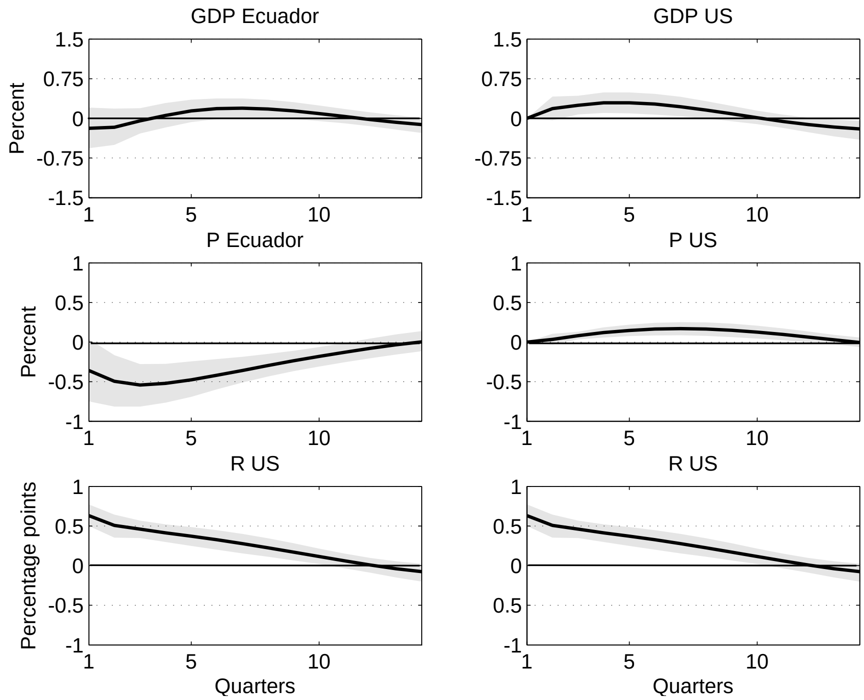

Figure 1: IRFs to a contractionary monetary policy shock for Ecuador and the U.S.

unpredicted monetary policy disturbances have had only a modest impact on output fluctuations in Ecuador over the sample period: less than 10 percent of the forecast error variance in Ecuador's GDP can be attributed to unexpected changes in U.S. monetary policy. The impact of U.S. monetary shocks on Ecuador's price level has been somewhat larger.

Horizon:	*1*	*5*	*10*	*15*	*20*
Y^{ECU}	1.72%	2.97%	4.04%	4.97%	7.30%
P^{ECU}	12.59%	31.43%	29.99%	28.77%	28.88%

Table 1: Forecast error variance decomposition for Ecuador

El Salvador Figure 2 contains the results of the same exercise, now applied to El Salvador (in which case the dataset runs from 2001q1 to 2010q3). El Salvador dollarized in 2001 under calm conditions (Towers and Borzutzky, 2004), so the introduction of the U.S. dollar was not accompanied by a structural break in any of their data series.

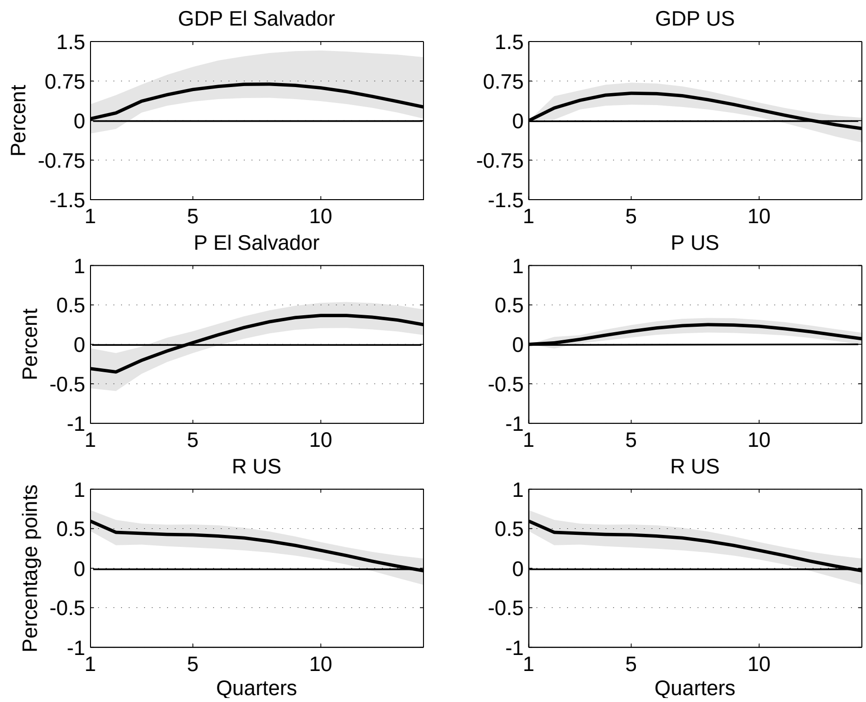

Figure 2: IRFs to a contractionary monetary policy shock for El Salvador and the U.S.

The right panel again shows the puzzling picture that emerges for the U.S. variables, where both prices and output increase after a monetary tightening. However, if one looks at the IRFs of the dollarized country, one concludes that prices fall after a contractionary monetary shock. GDP does not respond significantly on impact but goes up afterwards, even showing an output puzzle at longer horizons.[20]

[20] One should keep in mind that this paper's procedure is less suited for analyzing the responses

The latter finding may be reminiscent of the results in Uhlig (2005): he finds that there are quite a few "contractionary monetary shocks" (identified with sign restrictions on U.S. prices and monetary variables) that do not lead to a subsequent fall in output, which leads him to conclude that "contractionary monetary policy shocks do not necessarily seem to have contractionary effects on real GDP" (p. 385).

Table 2 shows the forecast error variance decomposition. In line with the results for Ecuador, this exercise suggests that unpredicted movements in U.S. monetary policy have had a substantial effect on El Salvador's price level. In contrast to Ecuador, however, U.S. monetary policy shocks also seem to have had a considerable impact on output in El Salvador.

Horizon:	*1*	*5*	*10*	*15*	*20*
Y^{ELS}	11.94%	16.85%	35.29%	38.26%	38.34%
P^{ELS}	0.10%	43.94%	39.71%	42.87%	43.01%

Table 2: Forecast error variance decomposition for El Salvador

Panama The economy of Panama has been officially dollarized since 1904 already. The necessary data are available since 1996 and the results of applying this paper's procedure to Panama (on data running from 1996q1 to 2010q3) are depicted in Figure 3.

The findings suggest that prices are initially depressed after a monetary tightening (although the response is not statistically different from zero), while output again does not show a significant response on impact.

The results of the forecast error variance decomposition exercise are shown in Table 3, from which one can infer that unpredicted shifts in U.S. monetary policy have had only a minor impact on both output and prices in Panama.

Summary The results for the dollarized countries thus suggest that prices fall immediately after a monetary contraction. This result is robust in a sense that it

at longer horizons, as part of the possibly included non-monetary U.S. shocks might have spilled over to the client countries by then.

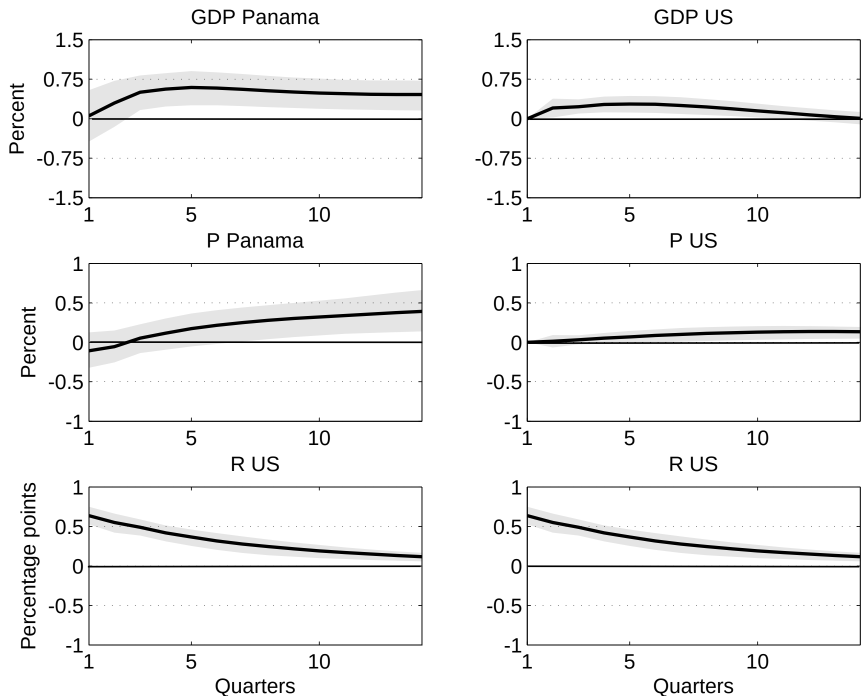

Figure 3: IRFs to a contractionary monetary policy shock for Panama and the U.S.

shows up across all countries as well as across different specifications (see Section 4). Output, on the other hand, does not show such a clear response: results for Ecuador suggest that output is depressed (insignificantly) for about a year after a monetary contraction, while El Salvador and Panama show an output puzzle at longer horizons. It is therefore hard to reject monetary neutrality based upon these results. In this light, the findings are quite similar to those reported by Faust, Swanson and Wright (2004) and Uhlig (2005), as they also find that contractionary monetary shocks do

Horizon:	*1*	*5*	*10*	*15*	*20*
Y^{PAN}	0.47%	3.11%	6.05%	5.06%	4.36%
P^{PAN}	11.33%	5.41%	1.16%	0.40%	0.17%

Table 3: Forecast error variance decomposition for Panama

not seem to have clear contractionary effects on real GDP. Corresponding results by Boivin and Giannoni (2006) indicate that this might be a characteristic of the sample period used, as they fail to find clear output effects of monetary shocks once they restrict their analysis to the post-1980 period.[21] Before 1980, they do find a clear contractionary effect, which suggests that the effects of monetary shocks on output have gone down over time.

Lessons for dollarized countries Next to the fact that Figures 1-3 tell us something about the effects of monetary policy shocks in general, they are also informative for countries that are (considering to become) dollarized. First, the results show no evidence for an important role of the working capital channel in the analyzed economies. This suggests that these countries do not have to be greatly concerned with possible stagflationary effects of monetary contractions (as for example warned for in Cavallo (1977) and Van Wijnbergen (1982)), although it should be noted that this paper is not able to test the working capital hypothesis formally due to the absence of data on credit flows.

Second, the analysis indicates that dollarized economies should be prepared for large spillovers from U.S. monetary shocks on especially their price level. There is less evidence for a clear spillover effect on output (except maybe for El Salvador - recall Table 2). This might be due to the fact that prices in the client countries seem to have been quite flexible over the sample period, as a result of which these countries were close to a situation of monetary neutrality.

4 Robustness

This section investigates the robustness of the reported results along certain dimensions of interest. First of all, as set out in Section 2.2, this paper's baseline estimates were obtained by assuming that the correlation between output and prices in the client countries is solely due to their joint dependence on the U.S. variables. Although a formal test does not reject this restriction, one could debate it upon

[21] In some specifications they also find an output puzzle (see their Figure A1).

theoretical grounds. When this assumption is dropped, $C_{i,11}$ in equation (3) can no longer assumed to be diagonal, which implies that lagged values of P^D now also enter the equation for Y^D and vice versa. In that case, OLS-estimation is no longer efficient and one should estimate the system by seemingly unrelated regressions (SUR, see Lastrapes (2005)). This was done to generate the IRFs in Figure 4.[22]

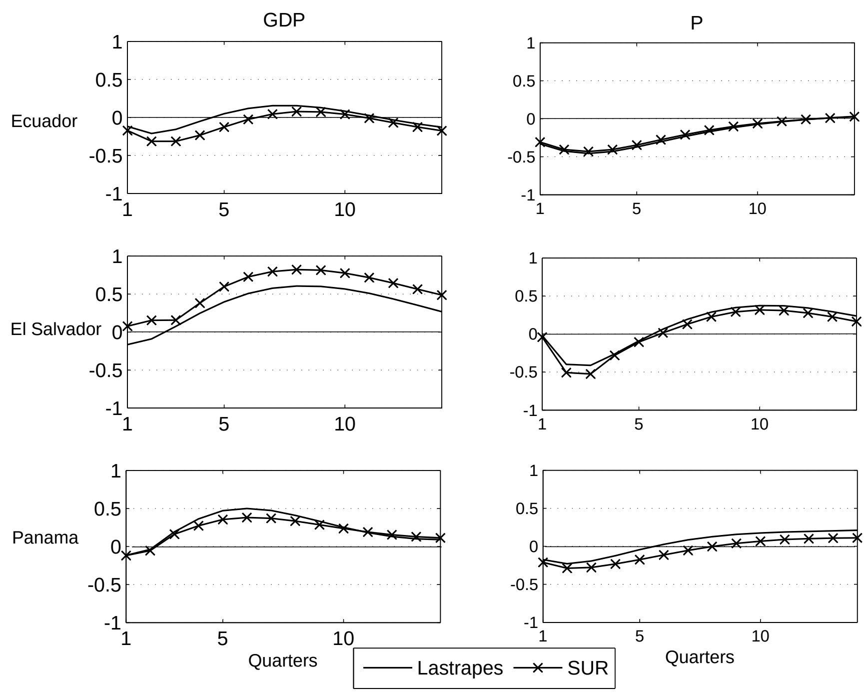

Figure 4: Point estimates of IRFs estimated via Lastrapes (2005) and via SUR

As the figure shows, results are hardly affected by the relaxation of this assumption, so the assumption that $C_{i,11}$ is diagonal seems to be a reasonable one for the case currently at hand. (The IRFs of the U.S. variables are not reported, as they are not affected by this robustness check at all.)

Secondly, one may wonder how stable this paper's findings are to the consideration of different subsamples. In the baseline exercise, the analysis for Panama includes

[22]Due to computational constraints, this figure compares point estimates rather than median bootstrapped responses.

the Latin American debt crisis of the late 1990s, while the financial crisis of the late 2000s is present in all time series. Unfortunately, omitting the entire financial crisis is not feasible for Ecuador and El Salvador, due to the limited length of the available data series (starting only in 2000q1 and 2001q1, respectively). However, to get an idea of the impact of the Great Recession, I have decreased the crisis' importance for Ecuador and El Salvador by ending their samples in 2008q3 (when the recession intensified following the collapse of Lehman Brothers). As Figures 6 and 7 in the Appendix show, this hardly affects the results for the dollarized countries (apart from increasing uncertainty, due to the reduction in the sample length), while it decreases the output and price puzzle somewhat for the U.S.

For Panama, there is more data available (since 1996q1) which enables one to exclude the entire crisis period by ending that sample in 2006q3. As one can see from Figure 8, this weakens the results: the price puzzle now also emerges in Panama (although not significantly), while it again decreases somewhat for the U.S. Figure 9 shows that excluding the Latin American debt crisis of 1997/8 by starting the sample in 1999q1 does not alter any conclusions.

In addition, it might be interesting to analyze the impact of the addition of a commodity price index (I use the index constructed by the IMF). After all, this variable can be seen as an indicator of aggregate world-wide conditions, while its addition is also a popular way to eliminate the price puzzle for the U.S. (recall the discussion in Section 2.1). However, as Figures 10-12 show, adding a commodity price index fails to eliminate the U.S. price puzzle over the sample period considered in this paper, while the IRFs for the dollarized countries are robust to its inclusion.

Finally, results are also robust to dropping the time trend and to adding M2 to the VAR (which was for example argued for by Leeper and Roush (2003); results of these exercises are available upon request).

5 Why are results different for the U.S.?

A key question the reader is probably left with at this stage, is why the IRFs to a monetary policy shock look so different for the U.S. and the dollarized countries. A first and easy explanation is that the economies of the U.S. on the one hand and those of Ecuador, El Salvador and Panama on the other, are so different, that they respond in completely opposite ways to a monetary shock. This would be the case if the working capital channel would be more important for the U.S., than it is for these dollarized countries. This is however hard to imagine. First, if anything, the working capital channel is probably more important *for emerging economies* than it is for the U.S., as short-term bank financing tends to be more important in the former (Van Wijnbergen, 1982: p. 134).[23] Second, the fact that the responses of U.S. variables are difficult to reconcile with any existing theory, makes them hard to believe (*cf.* footnote 19).

A second possible reason for the differences is shock misidentification. As shown by Carlstrom, Fuerst and Paustian (2009, henceforth CFP), the "monetary policy shock" identified via the CEE-scheme may very well include non-monetary components. In particular, they algebraically show that in a New Keynesian model, the CEE-procedure actually identifies a combination of the true innovation in monetary policy and a negative technology shock (the latter is CFP's explanation for the price puzzle). However, for all dollarized countries for which data are available, the results do not show any evidence for this type of shock confusion.[24] After all, in this paper's analysis, the identified shock (i) increases the federal funds rate, (ii) decreases the price level, and (iii) has no clear effect on output.

Apart from a contractionary monetary shock, it is hard to think of a shock that can have these three properties. In particular, CFP's negative technology shock would *increase* the price level, which is inconsistent with (ii). Additionally, a negative technology shock is inconsistent with (iii), as one would then expect a clear negative

[23] Also see Rabanal (2007): he estimates a DSGE-model on U.S. data using Bayesian methods (allowing for a role for the working capital channel), but finds that the posterior probability of observing an increase in inflation after a monetary tightening is zero - thereby suggesting that the working capital channel is not that important for the U.S. Results by Gobbi and Willems (2011) (briefly discussed in the conclusion of this paper) confirm this.

[24] If anything, the IRFs of output and prices in especially El Salvador look more like the response to a *positive* technology shock. This is, however, not only inconsistent with what is to be expected from theory (*cf.* CFP (2009)), but also with the response of the U.S. price level as that should fall after a positive technology shock, which it does not.

effect on output. On the other hand, the lack of a clear response in output to a monetary shock is in line with a standard model in which prices are rather flexible (as suggested by (ii)).

What may play a role here is the aforementioned situation that non-monetary U.S. shocks do not seem to produce significant output or price fluctuations in the client economies considered, which provides the exploited setup with some ability to filter out these non-monetary disturbances.

If one has a strong faith in the filtering capacity of the employed setting, any attempt to identify the U.S. monetary shock (currently done via the Choleski approach as in CEE (1999), to allow for contemporaneous values of output and prices in the Fed's information set) is not essential. After all, if non-monetary U.S. shocks are indeed not transmitted to the dollarized countries, then the reduced form innovations to the Fed's policy rule should produce very similar responses in these countries.

And as can be verified by looking at Figure 5, this is indeed the case: if one gives a one standard deviation, reduced form "monetary policy innovation" (which certainly is a combination of all sorts of structural shocks) to the dollarized countries, the median bootstrapped IRFs of especially Ecuador and El Salvador are very similar to the original ones. For Panama, the differences between the various IRFs are a bit larger at longer horizons, but this is consistent with the fact that Panama's economy is more open than those of Ecuador and El Salvador and therefore less isolated from non-monetary U.S. shocks.

6 Conclusion and directions for future research

This paper has presented an alternative way of analyzing the effects of U.S. monetary policy shocks. The approach is akin to the exploitation of a natural experiment - formed by the fact that there exist countries that have established an informal monetary union with the U.S. (thereby importing U.S. monetary shocks), while being only imperfectly integrated with the U.S. economy (as a result of which non-monetary

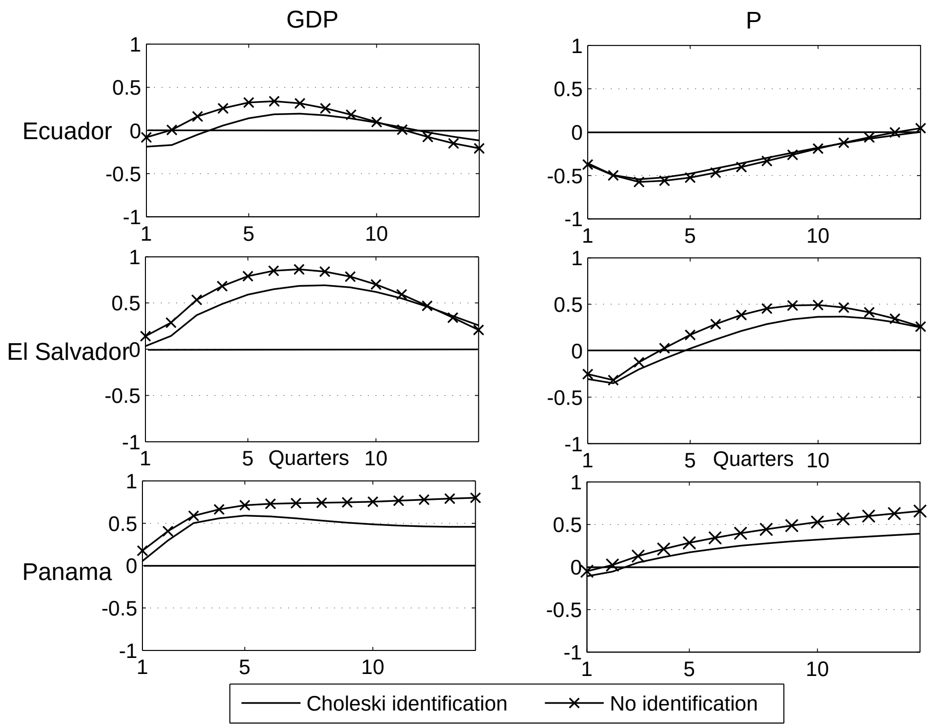

Figure 5: Median bootstrapped IRFs in dollarized countries to a "Choleski identified" U.S. monetary policy shock and to an innovation to the Fed's reaction function

U.S. shocks are not imported fully and instantaneously).[25] Consequently, basing conclusions upon the responses of variables in these dollarized economies, makes the procedure less vulnerable to misidentification of the monetary shock in the U.S. block of the system. In this sense, the natural setting that this paper exploits thus works a bit like a convenient filter that removes any mistakenly included non-monetary elements of the shock.

Results suggest that the U.S. "price puzzle" is due to monetary policy shock misidentification, as prices in all dollarized economies fall immediately after a con-

[25]The question why these countries chose to dollarize despite the fact that they do not seem to form an optimum currency area with the U.S. (*cf.* Lindenberg and Westermann (2010)) goes beyond the scope of this paper.

tractionary monetary shock. This finding supports the key identifying assumption that is typically made in studies employing sign restrictions. More generally, obtaining a better insight into the sign of the price response to monetary shocks is important as this determines whether monetary policy is able to stabilize the economy or not. After all: if prices would go up after a monetary contraction, the conventional policy of increasing the interest rate to fight inflation would be like throwing oil on fire.

Quantitatively, results indicate that the price effects of monetary shocks are large and show up quickly. This suggests that prices were relatively flexible in the dollarized economies over the sample period. Consistent with this, monetary shocks do not seem to have had a clear effect on output in the considered countries.

Investigating to what extent these findings carry over to the U.S. economy itself, could be a fruitful topic for further research: after all, the obvious cost of this paper's approach is that no attempt is made to identify the U.S. monetary shock and inference does not take place on U.S. variables.[26] Gobbi and Willems (2011) try to come up to this challenge by identifying U.S. monetary shocks through sign restrictions on prices in the dollarized countries only (leaving the responses of U.S. output and prices unrestricted). In line with this paper's results for the dollarized countries, they find that U.S. prices fall after a monetary contraction, while U.S. real GDP fails to show a clear response in their study as well.

Finally, it might also be interesting to estimate a panel-VAR that features U.S. variables along with variables of all dollarized countries simultaneously. This enables one to distinguish between country-specific and common shocks, which should be helpful in identifying U.S. monetary shocks (as the latter are common to all countries using the U.S. dollar). Once one has identified the U.S. monetary shock in such a setup, one can also analyze how the various real exchange rates respond to a monetary

[26] When translating this paper's results to the U.S. economy, one should distinguish between qualitative and quantitative findings. Qualitatively, results indicate that prices in dollarized countries fall after a monetary contraction. This is a strong result, as many previous studies (starting with Cavallo (1977)) have emphasized the potential importance of the cost channel for exactly these economies. Quantitatively, a key issue is how degrees of price stickiness compare. Morandé and Tejada (2008) conclude that emerging economies exhibit more price flexibility than the U.S. This suggests that the effects of monetary shocks on output (prices) may be larger (smaller) in the U.S. Differences in other rigidities (such as those in the labor market), will also play a role.

contraction which might produce interesting insights along that dimension.

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8 Appendix

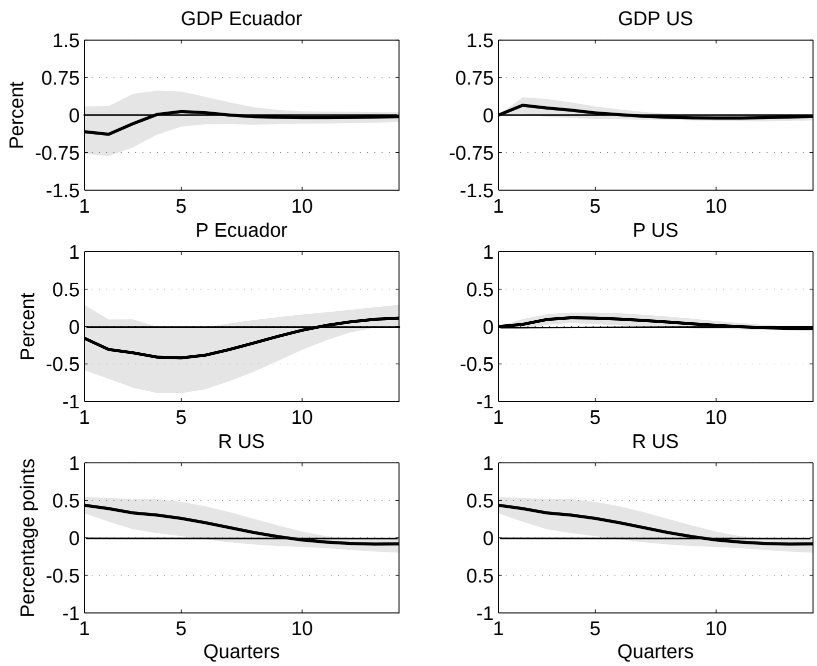

Figure 6: IRFs for Ecuador and the U.S. when the sample is ended in 2008q3

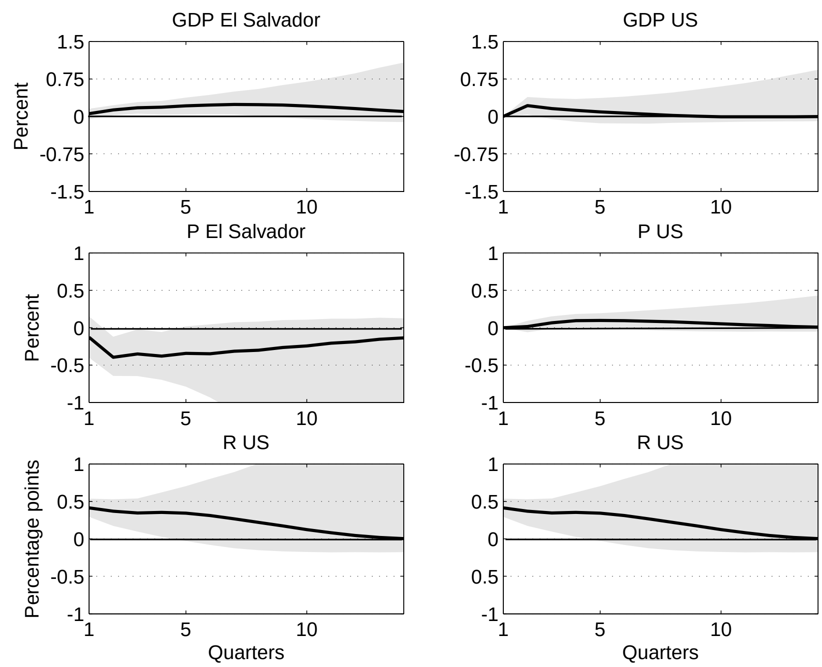

Figure 7: IRFs for El Salvador and the U.S. when the sample is ended in 2008q3

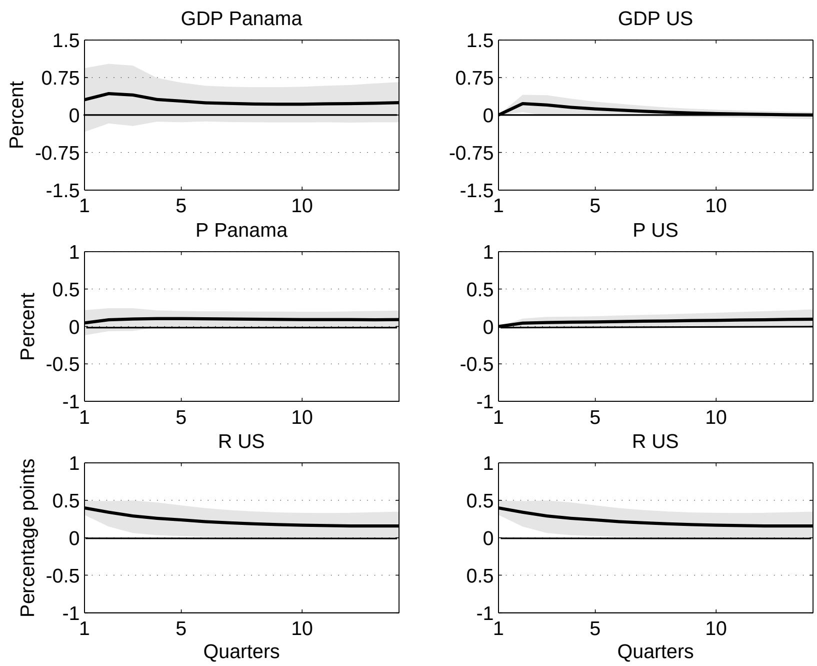

Figure 8: IRFs for Panama and the U.S. when the sample is ended in 2006q3

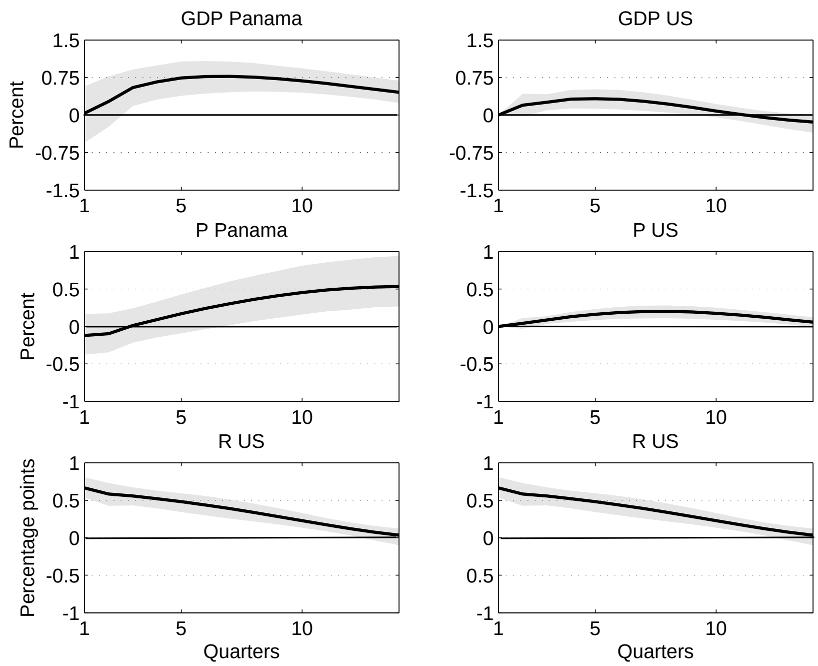

Figure 9: IRFs for Panama and the U.S. when only post-1999q1 data is used

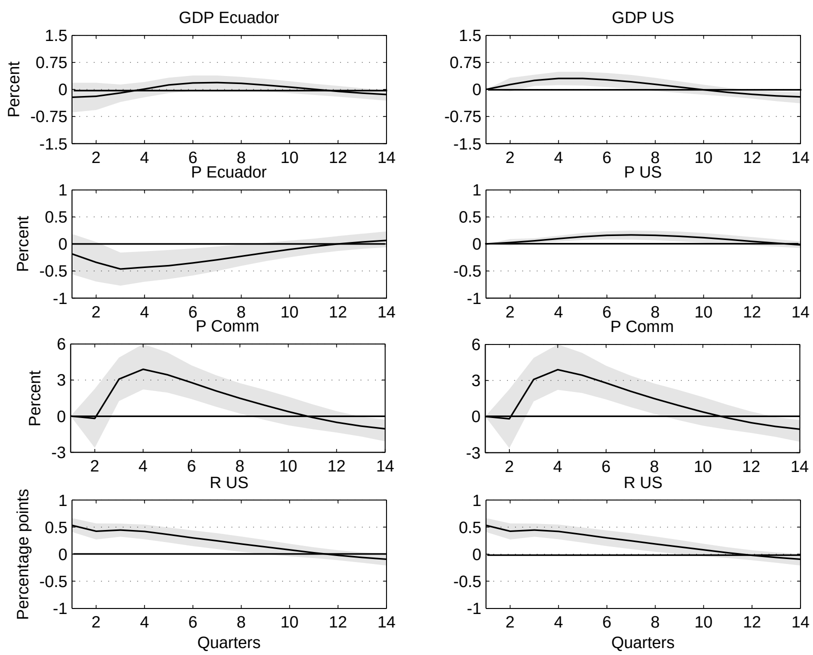

Figure 10: IRFs for Ecuador and the U.S. when a commodity price index is included

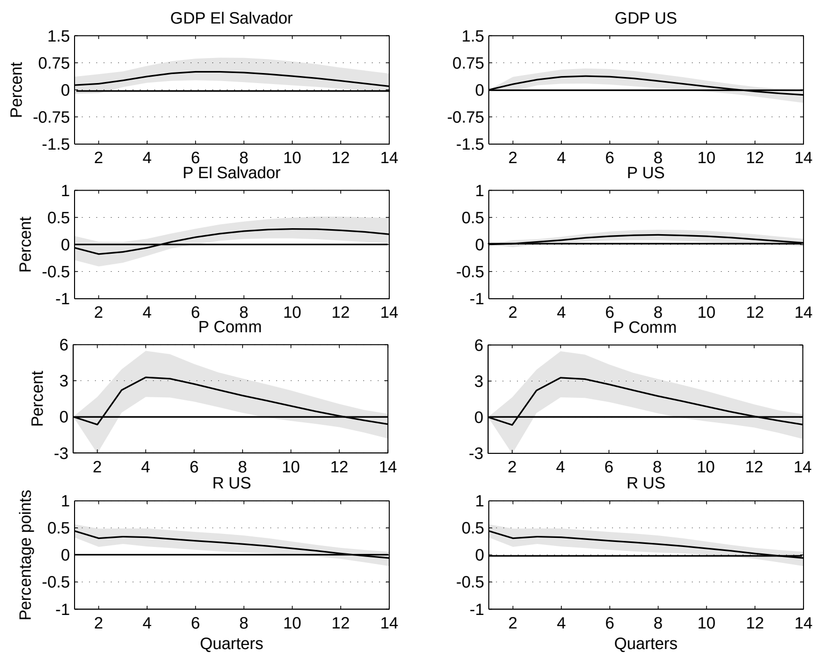

Figure 11: IRFs for El Salvador and the U.S. when a commodity price index is included

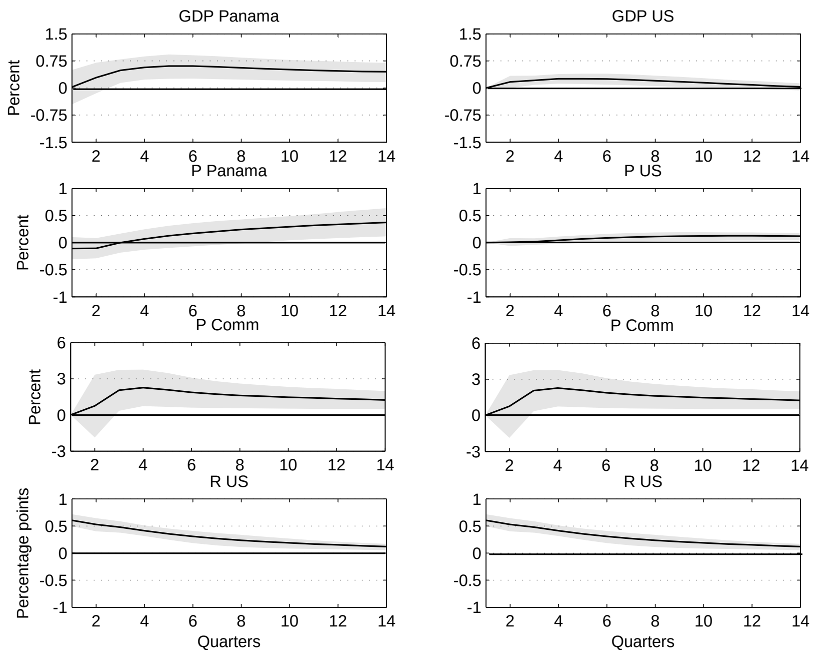

Figure 12: IRFs for Panama and the U.S. when a commodity price index is included