Delayed Overshooting Puzzle: Does Systematic Monetary Policy Matter?*

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Abstract

We develop a novel identification strategy that combines sign and policy coefficient restrictions to estimate the exchange rate response to U.S. monetary policy shocks. Central to our approach is a restriction grounded in historical narratives: monetary policy systematically tightens following a depreciation of the U.S. dollar. This assumption, particularly relevant during the Volcker era, yields results consistent with exchange rate overshooting and a conditional form of uncovered interest parity. Unlike standard sign-restriction methods, our strategy delivers robust impulse responses across regimes, including both the Volcker and post-Volcker periods.

Keywords: Delayed overshooting puzzle, vector autoregressions, monetary policy rule, exchange rate dynamics, Volcker policy regime.

JEL codes: C32, E44, E52, F31, F41.

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1 Introduction

> *"I can't remember any incident during that period when the Federal Reserve, after the floating, either tightened or eased monetary policy in response to being influenced by the exchange rate until 1978. At that point, policy was tightened because of the sense of crisis in the exchange market. The market was overt and very clear."*
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> Paul A. Volcker, interview by Small et al. (2008), p. 262.

Background. According to Dornbusch's (1976) exchange rate overshooting hypothesis, countries should experience an immediate appreciation of their currencies followed by a gradual depreciation in response to an unexpected monetary policy tightening by the domestic central bank. This prediction is due to a mechanism present in models featuring expectations over future realizations of the exchange rate. In an environment characterized by sticky prices and forward-looking agents, an excess return on domestic assets driven by a monetary policy tightening requires, under a no-arbitrage condition at the international level, the exchange rate to appreciate on impact to allow for future, persistent depreciations.

While this mechanism is one of the building blocks of most open economy macroeconomic models, empirical investigations - typically conducted via vector autoregressions - have often rejected the overshooting hypothesis. In early contributions based on recursive identification, Eichenbaum and Evans (1995), Grilli and Roubini (1996), and Kim and Roubini (2000) find that the materialization of the peak response of the exchange rate can take between 2 and 3 years, an evidence termed "delayed overshooting puzzle" (DOP). This evidence is at the basis of theoretical research that has proposed mechanisms able to replicate the DOP, e.g., models featuring information rigidities (Gourinchas and Tornell (2004), Müller, Wolf, and Hettig (2021)), dispersed information (Candian (2019)), distorted beliefs (Candian and De Leo (2023)), bounded rationality (Kolasa, Ravgotra, and Zabczyk (2022)), or portfolio adjustment costs (Bacchetta and van Wincoop (2021)). Crucially, models featuring a delayed response of the exchange rate might imply a different monetary policy design with respect to models featuring exchange rate overshooting (Kolasa, Ravgotra, and Zabczyk (2022, 2025)).

As stressed by Cushman and Zha (1997), Faust and Rogers (2003), Scholl and Uhlig (2008), and Bjørnland and Thorsrud (2015), appropriate identification of monetary policy shocks is crucial for correctly establishing if Dornbusch's hypothesis is indeed rejected by data or not. Scholl and Uhlig (2008) tackle this identification issue by working with sign restrictions à la Uhlig (2005) to pin down the exchange rate response to a monetary policy shock. They find evidence against the overshooting hypothesis. Kim, Moon, and Velasco (2017) go a step further

and show that Scholl and Uhlig's (2008) findings are basically driven by observations related to the Volcker disinflation. Once such observations are omitted - i.e., if one focuses on post-Volcker observations -, evidence in favor of Dornbusch's hypothesis arises. They interpret this evidence as pointing to the importance of dealing with breaks in the Federal Reserve's policy conduct. The message arising from Kim, Moon, and Velasco (2017) is clear: Identification is crucially connected with monetary policy regimes.

Contribution. This paper proposes a novel identification strategy to pin down the exchange rate response to a monetary policy shock. The distinctive feature of our strategy is that we assume the Federal Reserve to engineer a monetary policy tightening (easing) in response to an exchange rate depreciation (appreciation), the idea being that such a depreciation could eventually be inflationary (deflationary). We argue that this requirement is consistent with the view of the Federal Reserve during Paul Volcker's mandate, in particular at the end of the 1970s and in the early 1980s. We report excerpts of interviews to Paul Volcker consistent with this view. Moreover, we show that exchange rate fluctuations possess predictive power over inflation, in particular at the end of the 1970s. We employ the above-indicated restriction on the policy coefficient linking the exchange rate and the policy rate on top of the set of well-established restrictions concerned with the sign of impulse responses to monetary policy shock in an open-economy context (e.g., Scholl and Uhlig (2008), Kim, Moon, and Velasco (2017)) and to those concerned with policy coefficients in a closed economy context (Arias, Caldara, and Rubio-Ramírez (2019)). The latter have been shown to be extremely effective in recovering the true macroeconomic responses to a monetary policy shock - again, in a closed economy context (Wolf (2020, 2022)).[1] Intuitively, our approach extends to the open-economy case the state-of-the-art set-identification strategy recently developed by Arias, Caldara, and Rubio-Ramírez (2019), which was originally designed for a closed-economy setting and relies on imposing sign restrictions on the Federal Reserve's systematic responses to inflation and real economic activity. We extend this framework to an open-economy context, explicitly incorporating the Federal Reserve's attention to exchange rate fluctuations.

Findings. Our main results are the following. First, we find robust support for the overshooting hypothesis, i.e., no delayed overshooting puzzle is detected conditional on our identification strategy. Second, our identification strategy supports the overshooting hypothesis across different policy regimes, including the Volcker one. Third, we show that working with sign restrictions imposed on impulse responses only leads the econometrician to retain rotations (interpretative models of the data) that are consistent with a monetary policy *tightening* in response to an

[1]For an early exploration on the link between the systematic component of monetary policy and monetary policy shocks, see Leeper, Sims, and Zha (1996).

exchange rate *appreciation*, which is counterintuitive. Moreover, and in line with Kim, Moon, and Velasco (2017), a standard identification strategy based on IRF restrictions would point to delayed overshooting when dealing with samples that include the Volcker regime. Fourth, we find that post-Volcker our identification strategy and the one based only on sign restrictions deliver very similar impulse responses.

What is behind the different evidence provided by our exercise vs. Kim et al.'s (2017) as far as the reaction of the exchange rate to a monetary policy shock is concerned? Intuitively, during the Volcker period the US economy contemporaneously experienced a large depreciation of the dollar and a massive monetary policy tightening. This is what makes the econometric effort of separating the systematic response of the Federal Reserve to exchange rate movements from the role played by systematic monetary policy shocks for exchange rate dynamics hard. This is precisely why imposing a policy coefficient restriction on the systematic response of the federal funds rate to exchange rate fluctuations is informative; it helps disentangle the systematic policy response to exchange rate fluctuations from the correlation between the federal funds rate and the exchange rate that arises conditionally on monetary policy shocks. In contrast, our policy coefficient restriction on the exchange rate is not binding in the post-Volcker period, in that retained rotations conditional on signs imposed only on impulse responses naturally deliver a description of the systematic policy response to exchange rate movements in line with economic intuition.

The last part of the paper deals with the implications of our impulse responses for the uncovered interest parity condition. Our identification strategy implies dynamic responses consistent with a *conditional* version of the uncovered interest parity condition. In other words, we find no clear evidence in favor of a forward premium. Interestingly, this result falls apart when only standard restrictions on impulse responses are considered.[2]

Interpretation of the role of the policy coefficient restriction on the exchange rate. Our results offer an interpretation for the evidence documented by Kim, Moon, and Velasco (2017). The Volcker regime was importantly characterized by a systematic monetary response to the exchange rate. If such a response is not considered among the set of restrictions imposed to achieve identification, spurious evidence in favor of a delayed overshooting puzzle in the '80s may arise. Consider the huge monetary policy shocks associated with Paul Volcker's monetary policy tightenings implemented in the late 1970s-early 1980s. According to standard economic theory, these monetary policy shocks - which imply an increase in the policy rate - should imply an *appreciation* of the US dollar (this is a conditional moment). On the other hand, these shocks

[2] Our analysis deals with the evidence on the *conditional* UIP. For a recent data exploration concerned with the unconditional UIP, see Şebnem Kalemli-Özcan and Varela (2021).

occurred in a phase characterized by a persistent depreciation of US dollar after the abandonment of the Bretton Woods system. In other words, during the Volcker disinflation, we observed (unconditionally) an increase in the policy rate and a *depreciation*. Hence, from an econometric standpoint, separating the *conditional* correlation between the policy rate and the exchange rate due to monetary policy shocks vs. the one due to all other shocks (that drive exchange rate movements and the policy response to such movements) is challenging if one relies only on standard sign restrictions on the impulse responses to a monetary policy shock. Imposing a policy coefficient restriction on the policy response to exchange rate movements is likely informative, specifically, during the Volcker monetary policy regime, to separate the systematic monetary policy component and the unsystematic one and correctly identify a monetary policy shock and its impact on the exchange rate.

Implications. Our results are relevant from a modeling standpoint and a policy one. From a modeling perspective, our findings suggest preserving mechanisms consistent with the exchange rate overshooting hypothesis. In this sense, it is important to stress that our results are not at odds with the established stylized fact on the persistence of the swings in the real exchange rates (Chari, Kehoe, and McGrattan (2002)). As pointed out by Steinsson (2008), new-Keynesian models featuring sticky prices can generate both a quick *conditional* response of the real exchange rate to a monetary policy shock - in line with the overshooting hypothesis - and a hump-shaped *unconditional* response of the exchange rate, this last one being generated by a combination of real shocks hitting the Phillips curve (productivity shocks, labor supply shocks, government spending shocks, shocks to the world demand for home-produced goods, and cost-push shocks). In other words, our empirical findings are not inconsistent with models featuring mechanisms that account for the slowly decaying exchange rate responses to macroeconomic shocks in general, e.g., financial shocks, which have recently been proposed as a possible explanation for a variety of open-economy puzzles (Itskhoki and Mukhin (2021)). Turning to the policy side, our results support policy interventions that are consistent with a rapid and strong response of exchange rates to monetary policy shock, i.e., models that do not necessarily rely on deviations from rational expectations to generate a delayed response of the exchange rate to a monetary policy shock. A discussion on optimal policies in an open economy framework and how their optimality changes depending on certain deviations from rational expectations is offered by Kolasa, Ravgotra, and Zabczyk (2022, 2025).

Literature. Our paper joins previous contributions that have proposed alternatives to recursive identification strategies to pin down the exchange rate response to a monetary policy shock. Bjørnland (2009) and Doko Tchatoka, Haque, and Terrell (2022) use a combination of short and long-run restrictions to study the exchange rate effects of monetary policy shocks in Australia,

Canada, New Zealand, and Sweden. They find evidence supporting the overshooting hypothesis. Bjørnland and Halvorsen (2014) work with a combination of sign and short-term (zero) restrictions, and find similar evidence at an international level. Forni and Gambetti (2010) employ a data-rich structural factor model and find evidence in favor of overshooting to a monetary policy shock identified via a recursive scheme. Inoue and Rossi (2019), Rüth (2020), Miranda-Agrippino and Rey (2020), Miranda-Agrippino and Ricco (2021), Degasperi, Hong, and Ricco (2021), and Rüth and Van der Veken (2022) work with instruments based on high-frequency information/financial data to pin down the exchange rate effects of unexpected variations in the policy rate, and also find support for the overshooting hypothesis.[3] Mumtaz and Surico (2009) model a large panel of data for 17 industrialized countries with a factor augmented VAR framework and identify monetary policy shocks with a mixture of sign and zero restrictions. Bjørnland, Brubakk, and Maffei-Faccioli (2024) shock interest rate differentials in a trend-cycle VAR that enable them to focus on the cyclical response of the exchange rate to monetary policy disturbances. These last two papers also find evidence in favor of the overshooting hypothesis.

Our paper adds to these contributions by proposing an identification strategy that enables us to: (i) focus on the systematic monetary policy component to achieve identification, something which we see as naturally connected with the narrative and empirical evidence on the attention posed by central banks to fluctuations in the exchange rates; (ii) unveil the implications of different sets of restrictions for the description of the US systematic monetary policy across different retained models, which is useful to reconcile the different findings in papers dealing with standard IRF-restrictions only vs. those obtained with our novel identification strategy; (iii) avoid the challenges one faces when dealing with long-run restrictions (Faust and Leeper (1997)); (iv) circumvent the weak-instrument issue that can potentially affect IV-regressions, above all across different samples; (v) naturally deal with model uncertainty (via set identification). While the investigation in this paper focuses on US monetary policy shocks, our proposal to identify monetary policy shocks in an open-economy context can be easily applied to other countries' data.[4] Finally, Faust and Rogers (2003) investigate the exchange rate effects of monetary policy

[3] A related paper is Rüth and Van der Veken (2022), who also propose a comparison with the exchange rate responses arising from a battery of set-identified SVARs.

[4] While writing the first draft of this paper, a related paper by Groshenny and Javed (2023) came to our attention. They also achieve monetary policy shock identification by imposing restrictions on policy coefficients (including the one associated with the exchange rate). There are several differences between our paper and theirs, though. First, we deal with US monetary policy shocks, while they focus on selected small-open economies (Australia, Canada, Norway, and Sweden). A second, related point is that we work with different subsamples as in Kim, Moon, and Velasco (2017) and unveil the reasons behind the absence (presence) of a delayed overshooting puzzle - with a focus on the Volcker period - when imposing policy coefficient (standard IRF) restrictions. Third, they deal with quarterly data, while we work with a higher frequency (monthly), which is likely to provide sharper information on the effects of monetary policy shocks. For a paper on Australia dealing with the identification

shocks by imposing a minimal set of sign restrictions on selected impulse responses. They find many rotations to be consistent with the DOP hypothesis, and notice that allowing for simultaneity among interest rates and exchange rates is the possible driver of this empirical finding. Our paper connects with theirs by exploring the role that the systematic policy response to exchange rates has for the DOP in different policy regimes.

Structure of the paper. The paper is structured as follows. Section 2 describes the data, introduces the VAR, and discusses the identification strategy. It also presents narrative and empirical evidence supporting the policy coefficient restriction involving the exchange rate. Section 3 documents our full-sample and Volcker-related results and compares them to those obtained with the standard IRF-related restrictions. It also provides narrative evidence on the attention posed by the Federal Reserve - in particular, under Volcker - to exchange rate movements and it documents the predictive power of exchange rate fluctuations for inflation. Section 4 documents the evidence in favor of a conditional UIP under our identification strategy. Section 5 concludes.

2 Data, VAR, identification strategy

2.1 Data

We follow Scholl and Uhlig (2008) and Kim, Moon, and Velasco (2017) and consider monthly data for the US economy and 14 of its trading partners, period: 1976M1-2007M7.[5] The beginning of the period is based on the idea of excluding the transitional early years of the floating exchange rate era (for a detailed account of those years, see Hansen and Hodrick (1983)). The end of the period is meant to avoid dealing with the acceleration of the financial crisis and the great recession, which would imply taking a position on how to separately identify conventional and unconventional monetary policy shocks. For the member countries of the European Monetary Union, data are available until 1998. For Germany, the sample is extended to 2007 by replacing the US-Germany exchange rate with the US-Euro one on the basis of the fixed Germany-Euro rate.

of monetary policy shocks with a combination of different restrictions that involve the sign of the exchange rate policy coefficient, see Read (2022). Braig, Rüth, and Van der Veken (2024) recently made us aware that a Monte Carlo exercise they conducted with a standard medium-scale open economy macroeconomic framework points to our identification strategy as the only one (among a variety) to solve the delayed overshooting puzzle.

[5]The list of US trading partners - representing in this analysis the rest-of-the-world (RoW) - includes Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom.

Macroeconomic indicators are aggregated across the 14 US trading partners by appealing to real GDP shares at purchasing power parity.[6] Two aggregates are considered. The first one - "AGG98" - employs all 14 trading partners prior to 1999. The "AGG" method extends the series until 2007 and is based on the non-EMU countries plus Germany, which is treated as representative of the EMU countries over the entire sample 1976-2007.

In line with Eichenbaum and Evans (1995), Scholl and Uhlig (2008), and Kim, Moon, and Velasco (2017), our baseline VAR models the following seven variables: US and foreign industrial production y and y^*, US and foreign 3-month interest rates i and i^*, the ratio of US nonborrowed to total reserves $nbrx$, US consumer price index (CPI) p, and the real exchange rate $rex = s + p^* - p$, where s is the US/RoW nominal exchange rate, and an increase in s represents a depreciation of the US dollar. In the VAR, all variables are modeled in logs, except for the interest rates, which are modeled in levels.

2.2 VAR

Following Arias, Caldara, and Rubio-Ramírez (2019), let us consider the following VAR representation:

$$\mathbf{y}_t'\mathbf{A}_0 = \sum_{l=1}^{v} \mathbf{y}_{t-l}'\mathbf{A}_l + \varepsilon_t' \tag{1}$$

In this representation, $\mathbf{y}_t$ is an n x 1 vector of endogenous variables, ε_t is an $n \times 1$ vector of structural shocks, $\mathbf{A}_0$ is an invertible $n \times n$ matrix of structural parameters, v is the number of lags of the VAR, l is the lag-indicator, and t is a time-index ranging from 1 to T, where T is the size of the considered sample. The vector ε_t, conditional on past information and initial conditions, is Gaussian with mean zero and covariance matrix $\mathbf{I}_n$ (the $n \times n$ identity matrix).

Post-multiplying the SVAR (1) by $\mathbf{A}_0^{-1}$, one can move to the reduced form representation:

$$\mathbf{y}_t' = \sum_{l=1}^{v} \mathbf{y}_{t-l}'\mathbf{A}_l\mathbf{A}_0^{-1} + \mathbf{u}_t' \tag{2}$$

where $\mathbf{B}_l = \mathbf{A}_l\mathbf{A}_0^{-1}$, $\mathbf{u}_t' = \varepsilon_t'\mathbf{A}_0^{-1}$, and $\mathrm{E}(\mathbf{u}_t\mathbf{u}_t') = \mathbf{\Sigma} = (\mathbf{A}_0\mathbf{A}_0')^{-1} = (\mathbf{A}_0\mathbf{Q}\mathbf{Q}'\mathbf{A}_0')^{-1}$, where $\mathbf{Q}$ is a conformable orthonormal matrix that rotates the $\mathbf{A}_0$ one.

As is well known, there are uncountable rotations of the $\mathbf{A}_0$ matrix all equally consistent with the data but that offer different interpretations of the economy (e.g., the macroeconomic effects

[6] Weights for each country are calculated by dividing the country's GDP by the total GDP at purchasing power parity values. Then, growth rates for each individual country are computed. Third, aggregate growth rates are computed by the weighted sum of the individual growth rates. Finally, levels are recovered by cumulating aggregate growth rates from the initial base year. Further details on this aggregation procedure can be found in Scholl and Uhlig (2008) and Kim, Moon, and Velasco (2017).

of a monetary policy shock). We then select rotations (interpretations) that are economically unpalatable by imposing a set of identifying restrictions that include constraints on the systematic monetary policy response to macroeconomic fluctuations. Given that - without loss of generality - we place the policy rate on top of the vector $\mathbf{y}_t$, the monetary policy equation reads as follows:

$$\mathbf{y}_t'\mathbf{a}_{0,1} = \sum_{l=1}^{v} \mathbf{y}_{t-l}'\mathbf{a}_{l,1} + \varepsilon_{1t} \tag{3}$$

Our policy coefficient-restrictions focus on the contemporaneous responses of the Federal Reserve to macroeconomic fluctuations, which are captured by:

$$i_t = \psi_y y_t + \psi_p p_t + \psi_{\text{rex}} rex_t + \psi_{y^*} y_t^* + \psi_{i^*} i_t^* + \psi_{\text{nbrx}} nbrx_t + \sigma\varepsilon_t^{MP} \tag{4}$$

We now present and discuss our identification strategy, where we will also present and discuss the restriction imposed on the policy coefficient ψ_{rex} that dictates the systematic response of the Federal Reserve to exchange rate movements.

2.3 Identification strategy

Our set-identification strategy is based on a combination of sign and zero restrictions. First and foremost, we exploit the proposal by Arias, Caldara, and Rubio-Ramírez (2019) and impose restrictions on the contemporaneous coefficients of the monetary policy function in the VAR. The idea is that of correctly specify the systematic monetary policy response to changes in relevant macroeconomic indicators to get the effects of unexpected changes in the policy rate right. Arias, Caldara, and Rubio-Ramírez (2019) impose a positive systematic response of the Federal Reserve (i.e., an increase in the federal funds rate) to price and industrial production increases. Moreover, they impose zero restrictions on the response of the policy rate to nonborrowed reserves. We borrow these restrictions, which are natural for a closed-economy context, and add extra policy coefficient restrictions that we believe to be sensible when modeling the Federal Reserve's attention to exchange rate fluctuations. In particular, we impose: (i) a positive sign on the response of the policy rate to exchange rate movements (i.e., a policy tightening in response to an exchange rate depreciation); (ii) zero restrictions on the impact of foreign industrial production and the Rest-of-the-World (RoW) interest rate on the US systematic policy. Restrictions (ii) are justified by the Federal Reserve's natural main focus on domestic economic conditions.[7] Restriction (i) is instead meant to capture the attention that the Federal Reserve has paid over time to fluctuations in the exchange rate, justified by e.g. the imported inflation that such fluctuations may

[7] Our results remain materially unchanged when dropping these zero restrictions.

bring along. Hence, going back to eq. (4), we impose a positive sign on ψ_y, ψ_p, and ψ_{rex}, and we also set to zero the coefficients ψ_{y^*}, ψ_{i^*}, and ψ_{nbrx}. Finally, we sharpen our set-identification by imposing traditional sign restrictions on the impulse responses to a US monetary policy shock. In particular, we impose a positive on-impact (i.e., contemporaneous) response of the policy rate and a negative on-impact response of prices, industrial production, and nonborrowed reserves over total reserves to an unexpected increase in the policy rate. These sign restrictions have often been used in the open-economy context to identify US monetary policy shocks (see, e.g., Scholl and Uhlig (2008), Kim, Moon, and Velasco (2017)). Following Canova and Paustian (2011), we impose these restrictions only on the on-impact impulse responses.

The above-described restriction on the policy coefficient is a crucial component of our identification strategy. Let us justify it further by offering narrative support.

Narrative support. Our sample covers three different chairmen of the Federal Reserve, i.e., Paul Volcker, Alan Greenspan, and Ben Bernanke. Evidence of the attention posed by the three of them to fluctuations in the US dollar while being members of the Federal Open Market Committee or chairmen can be easily found in a variety of official documents and accounts for that historical period, an example being the quote reported in the Introduction of this paper. Interestingly, and somewhat naturally, this attention was particularly high during the Volcker policy regime. A few instances covering the three chairmen in our sample follow.

In 1979, US President Jimmy Carter nominated New York Federal Reserve President Paul Volcker to become the next chairman of the Federal Reserve. This nomination was done in an attempt to regain control of inflation, which was on an upward trajectory. At the same time, there was concern about the US dollar, which had lost 12 percent of its value against major foreign currencies since late 1976.[8] In the hearing before the Committee on Banking, Housing, and Urban Affairs of the US Senate (Ninety-Sixth Congress, First Session, July 30, 1979), the soon-to-be Federal Reserve chairman Paul Volcker stated:

> *"I have spoken out and I expect to continue to speak out on the need for stability, broadly conceived — thinking of it in terms of our domestic inflation, thinking of it in terms of the value of the dollar internationally. I speak out of a very strong conviction that this sense of stability is necessary in order to assure the prosperity and growth of our economy at home and to deal with those problems of unemployment, poverty and all the others. I don't think we can build on a sense of instability—accelerating inflation, instability of the dollar abroad —if we want to deal constructively with those problems of the domestic economy."*

[8]For an account of that period, see https://www.federalreservehistory.org/essays/anti-inflation-measures.

Volcker was put under pressure by his peers right after his appointment. As reported by *The Atlantic* (October 30, 2018):

> *"Two months into his new job, Volcker attended a conference of central bankers in Belgrade and was shocked to find himself harangued by his peers. As he explains in his memoir, German Chancellor Helmut Schmidt, who was a friend, lectured Volcker for almost an hour "about waffling American policymakers who had let inflation run amok and undermined confidence in the dollar." A shaken Volcker cut his trip short, got his fellow Fed members on board, and called an unusual evening press conference. Most dramatically, he stressed that he was shifting his key policy tool to monetarism. As a hedge, he also raised the Fed's discount rate by a full point".*

Alan Greespan was also explicit on the need of tracking the stance of the US dollar and the influence that a depreciation of the US currency could have on the US monetary policy. In his remarks before the Banco de Mexico's 80th Anniversary International Conference (Mexico City, November 14, 2005), he stated:

> *"What could be the potential consequences should the dollar's status as the world's reserve currency significantly diminish, especially if foreign investors reduce their rate of accumulation of claims on U.S. residents? Most analysts would contend that U.S. interest rates were lowered by the world's accumulation of dollars. Accordingly, in the event of a significant diminishing of the dollar's reserve currency status, U.S. interest rates would presumably rise."*

Could a weakening of the US dollar pose a problem in terms of inflation and, therefore, the US policy conduct? Ben Bernanke offered his view on this topic in his remarks on the economic outlook at the International Monetary Conference held in Barcelona on June 3, 2008:

> *"In collaboration with our colleagues at the Treasury, we continue to carefully monitor developments in foreign exchange markets. The challenges that our economy has faced over the past year or so have generated some downward pressures on the foreign exchange value of the dollar, which have contributed to the unwelcome rise in import prices and consumer price inflation. We are attentive to the implications of changes in the value of the dollar for inflation and inflation expectations and will continue to formulate policy to guard against risks to both parts of our dual mandate, including the risk of an erosion in longer-term inflation expectations."*

In our view, these quotes are consistent with our identification restriction that imposes a positive response of the policy rate to a US dollar depreciation. Note that such a response need not be

uniform across different policy regimes. In fact, we will argue later that such an identification restriction is crucial only when modeling the Volcker regime.

We now turn to our empirical results.

3 Results

3.1 Full sample analysis

Figure 1 plots the impulse responses obtained by implementing our identification strategy in our VAR analysis.[9] Let us focus on the response of the real exchange rate first. Such a response suggests an immediate appreciation followed by a gradual, persistent depreciation. This response is exactly what the Dornbusch (1976) model predicts, i.e., an immediate appreciation of the US dollar in response to a monetary policy shock (an unexpected tightening) followed by a persistent depreciation. Notably, this evidence is based on the same dataset and reduced-form VAR model employed by Kim, Moon, and Velasco (2017), who find a delayed response of the real exchange rate, i.e., a delayed overshooting puzzle. We elaborate later on the differences and implications between our identification strategy and theirs.

Back to Figure 1, we note standard responses of domestic variables in response to a US monetary policy shock, i.e., a temporary but persistent deflation and an delayed peak effect on industrial production, whose impulse response follows a well-known hump-shape. Nonborrowed reserves react negatively to an unexpected hike in the short-term interest rate, a response in line with the well-known liquidity effect. RoW's short-term interest rate displays a temporary increase, a response potentially consistent with the uncovered interest parity condition. World real activity's response is uncertain. A possible interpretation is that different transmission channels may be jointly at work, i.e., with US domestic output and RoW's interest rate exerting contractionary pressures on the one hand, and the appreciation of the US dollar improving RoW's net exports and, therefore, its business cycle on the other hand. Finally, one can note a short-lived response of the policy rate to a monetary policy shock. This response is due to the influence of the Volcker period, where monetary adjustments were fast and abrupt. To fix ideas, the standard deviation of the 3-month US interest rate in the whole 1976M1-2007M7 sample is 3.05, which is similar to the 2.97 associated with the Volcker era (1979M8-1987M12). Differently, the post-Volcker period (1988M1-2007M7) was characterized by a much less volatile policy rate (standard deviation: 1.92). The fact that the policy rate during the Volcker period

[9]For the sake of brevity, we focus in the paper on the evidence obtained with the AGG dataset. Our results are fully confirmed when working with the AGG98 dataset - evidence available in our Appendix.

was very volatile (an unconditional moment) does not necessarily imply that it should be volatile also conditional on a policy shock. On the other hand, imposing sign restrictions on impulse responses only on impact as suggested by Canova and Paustian (2011) allows (without requiring) the policy rate to quickly revert to its pre-shock level if the data prefer so.

Our identification strategy imposes signs on the policy response to prices, industrial production, and the real exchange rate, but it is silent on the magnitude of such coefficients. Table 1 collects the posterior median estimates and the 68% credible sets. The coefficients reported at the top of the Table - those related to the entire sample - put in evidence that there is a large mass of realizations of the policy coefficient related to exchange rate fluctuations that suggest non-negligible attention posed by the Federal Reserve on fluctuations in the US dollar. Importantly, this evidence seems to be driven by the Volcker period (coefficients in the middle of the Table), although some evidence is also present for the post-Volcker era (bottom of the Table).

3.2 Volcker's monetary policy shocks and their effects on the exchange rate

Kim, Moon, and Velasco (2017) find the real exchange rate to display a delayed overshooting during the Volcker era. This result is appealing, because it can be connected with the different systematic policy behavior often detected in US data when moving from one policy regime to another (see, e.g., Clarida, Galí, and Gertler (2000), Lubik and Schorfheide (2004), Boivin and Giannoni (2006), and Benati and Surico (2009)). Kim, Moon, and Velasco (2017) achieve identification of the US monetary policy shock by working with a standard identification strategy based on restrictions on impulse responses (IRF-restrictions only henceforth). On the other hand, Volcker's monetary policy interventions at the end of the 1970s and in the early 1980s are typically interpreted as large unexpected movements in the policy rate, i.e., monetary policy shocks (see, e.g, Antolín-Díaz and Rubio-Ramírez (2018)). Is it possible that such large shocks trigger a delayed response of the exchange rate? Why do Kim, Moon, and Velasco (2017) find a delayed overshooting while we do not?

Kim, Moon, and Velasco (2017) identify monetary policy shocks by imposing restrictions à la Uhlig (2005) on the responses of the policy rate (that must increase) and prices, industrial production, and the nonborrowed/total reserves ratio (that all have to go down) over the first year after the shock.[10] As said, they do not impose any constraint on the systematic response of

[10]Following Kim, Moon, and Velasco (2017), these restrictions are imposed for horizons zero to eleven, i.e., one year. Differently, the restrictions of our proposed identification strategy are imposed only contemporaneously as suggested by Canova and Paustian (2011).

the Federal Reserve to exchange rate movements, while we do. In light of our discussion above on the attention paid by US policymakers to the fluctuations of the US dollar, it is of interest to unveil the role played by the restriction on the systematic policy response to the exchange rate implies for the systematic policy response to exchange rate movements. Relatedly, it is of interest if our findings, which support the overshooting hypothesis, fall apart when considering different samples associated with with different policy regimes. We then estimate the very same reduced-form VAR over three different samples: full sample (1976M1-2007M7), Volcker sample (1979M8-1997M12), and post-Volcker sample (1998M1-2007M7). Given that the data, reduced-form VAR, and investigated samples are the same as those Kim, Moon, and Velasco (2017) work with, differences in the exchange rate response to a monetary policy shock will be entirely due to differences in the adopted identification strategy.

Figure 2 plots the impulse responses of the exchange rate across the three different samples and over the two different identification strategies. The right column replicates the evidence documented by Kim, Moon, and Velasco (2017), i.e., samples containing Volcker-related observations are associated with evidence of a delayed overshooting puzzle, with the peak response of the exchange rate materializing after more than two years. Moving to the post-Volcker era, the response of the exchange rate is characterized by a strong, immediate appreciation of the exchange rate followed by a depreciation. Differently, our identification strategy points to a robust support of the overshooting hypothesis across the three investigated periods. Hence, a conclusion can be drawn here, i.e., these two different identification strategies imply a different description of the exchange rate dynamics after an unexpected increase in the US policy rate. Intriguingly, such a difference disappears when the post-Volcker era only is considered. In fact, the exchange rate impulse response produced via our proposed identification strategy is basically the same response estimated by Kim, Moon, and Velasco (2017).

As anticipated above, it is of interest to look at the estimates of the policy coefficients implied by the IRF-restrictions only identification strategy. Table 2 reports such coefficients. It is easy to notice that the two samples contaminated by the Volcker-related observations (full sample, Volcker era) are characterized by a negative median response to the real exchange rate, with a substantial mass in the negative territory as per the 68% credible set. This description of the US policy reaction function to exchange rate fluctuations is obviously in contrast with the narrative and empirical evidence discussed above.[11] Differently, the post-Volcker era is characterized by a positive median policy response to the exchange rate, with a negligible mass in the negative territory according to the 68% credible set. This finding offers a structural interpretation to the

[11]This evidence is robust to: (i) setting to zero the policy coefficients that regulate the systematic response to foreign output, interest rate, and the nonborrowed/total reserves ratio; (ii) imposing a negative sign to the on-impact response of industrial production to a monetary policy shock.

different evidence on the delayed overshooting puzzle (or the lack thereof) documented by Kim, Moon, and Velasco (2017) and our paper.

What is the contribution of a monetary policy shock for the volatility of the real exchange rate? According to our baseline model (which predicts an on-impact maximum response of the exchange rate), such a contribution is regime-dependent, with a peak volatility within a six-month horizon equal to 13.5 percent for the full period, 8 percent for the Volcker period, and 22.3 percent post-Volcker. Interestingly, and conditional on the "short-run" (horizons ranging from 0 to six months), these figures are larger than those one obtains via Kim et al.'s (2017) identification strategies when Volcker's observations are accounted for - 6.3 percent (full sample) and 5 percent (Volcker period) -, while we get basically the same figure obtained with our baseline model for the post-Volcker sample (23 percent). This last finding confirms that the restriction on the systematic policy response to the exchange rate is less crucial when the Volcker observations are dropped. This evidence squares well with the findings in Wolf (2020, 2022) on the identification via restrictions imposed on impulse responses being more challenging when the contribution of the shock one is after to the volatility of the variable of interest is lower. Finally, and in line with Kim et al.'s (2017) delayed-overshooting evidence, the peak contributions to the volatility of the real exchange rate by monetary policy shocks we obtain when replicating their results occur after about 5 years, and are estimated to be about 10 percent both for the Volcker-only sample and for the full sample.

Why Volcker? Why is it the case that our restriction is important only for the Volcker period? Volcker's regime was characterized by constant attention to the movements of the exchange rate, possibly because of its role as (one of the) driver(s) of inflation. A rich source of information is the *"Federal Reserve Board Oral History Project: Interview of Paul. A. Volcker"* document. The *Federal Reserve Board Oral History Project* was launched in connection with the centennial anniversary of the Federal Reserve in 2013. The Board undertook an oral history project to collect personal recollections of a range of former Governors and senior staff members. In the interview with Paul Volcker, one can find an informative exchange between David H. Small and the former chairman of the Federal Reserve:

> *Mr. Small: "Right before you became Chairman, the dollar was under attack. Inflation was headed up. I take it that the attack on the dollar was seen as all that more of an indication that inflation was getting out of control. The Board needed to—"*
>
> *Mr. Volcker: "I think the main focus was on domestic inflation. The exchange rate uncertainty certainly would have reinforced it."*

Our Appendix reports other quotes pointing to the attention posed by the Federal Reserve on the exchange rate during Volcker's mandate. Such attention was likely higher during Volcker's policy regime than after it. A simple textual analysis corroborates this statement. Taking once again the interviews of the Federal Reserve Board Oral History Project into account, we can easily compare the relative frequency of words such as "exchange rate" and "dollar" during Volcker's vs. Greenspan's regimes.[12] We found the former to be mentioned 26 times and the latter 73 times (in a 340-page-long document) in the interview with Volcker vs. (respectively) zero (!) and three times only in the interview with Greenspan (in a 230-page-long interview). While no more than *prima facie*, this evidence speaks loudly in favor of a substantially larger focus on exchange rate fluctuations during the Volcker regime.

Was the greater attention paid to the exchange rate in the late '70s-early '80s related to its predictive power over inflation? We verify our conjecture by considering two simple forecasting models. The first one predicts six-month-ahead year-on-year inflation with current and past realizations (up to twelve lags) of inflation and the real exchange rate. This parsimonious forecasting framework represents a natural benchmark for a first-pass on the ability of the real exchange rate to predict future inflation. The second model predicts six-month-ahead year-on-year inflation with current and past realizations (up to twelve lags) of inflation, year-on-year real GDP growth, year-on-year oil price growth, and the real exchange rate.[13] Real activity as a predictor of inflation is justified by the idea of inflationary demand pressures, which are typically associated with the presence of a supply curve (see, e.g., Stock and Watson (2007)). The presence of oil price changes is justified by their likely inflationary role (Kilian (2008)). These forecasting models are estimated by OLS, with standard errors calculated following Newey and West (1987). We assess the predictive power of the real exchange rate for inflation by running a joint test on the significance of all the lags of the exchange rate. To allow for a time-varying forecasting power of the exchange rate, we work with a 10-year rolling window.

Figure 3 reports the outcome of this predictive test by plotting the associated robust F statistics. The predictive power of the exchange rate is largely significant only during the Volcker period, while it drops dramatically when entering the late 1980s. This empirical analysis corroborates the possibility of a much lower weight attributed by the Federal Reserve to exchange rate fluctuations in its feedback function in the post-Volcker era.

[12]The interviews are available for the chairmen Volcker, Greenspan, and Yellen. They can be found here: https://www.federalreserve.gov/aboutthefed/centennial/federal-reserve-oral-history-interviews.htm .

[13]We use the Spot Crude Oil Price: West Texas Intermediate (WTI), downloaded from the online FRED dataset of the Federal Reserve Bank of St. Louis (mnemonics: WTISPLC). Results are robust to considering three-month-ahead forecasting exercises (instead of six-month-ahead) as well as modeling six lags (instead of twelve).

Robustess. Our Appendix documents the robustness of our results on the exchange rate response to a US monetary policy shock identified with our novel identification strategy to the following perturbations of our benchmark model: (i) forcing the response of foreign output to be negative on impact; (ii) modeling prices and industrial production (both domestic and foreign) in growth rates; (iii) adding the excess bond premium proposed (EBP) by Gilchrist and Zakrajek (2012) to the vector and imposing a positive response of EBP to a monetary policy shock; (iv) replacing the real exchange rate with its nominal counterpart.[14] This last exercise enables us to verify if a conditional UIP is in place. This is what we scrutinize in the next Section.

4 Conditional UIP: Does it hold when policy coefficient restrictions are imposed?

Kim, Moon, and Velasco (2017) document the empirical failure of the UIP during the Volcker era but not post-Volcker conditional on their identification of US monetary policy shock. While these two puzzles can be very well studied in isolation as stressed by Scholl and Uhlig (2008), it is of interest to understand if the evidence in favor/against the existence of a conditional UIP may depend on the identification strategy and - as a related question - if our identification strategy supports it. We follow Scholl and Uhlig (2008) and Kim, Moon, and Velasco (2017) and focus on the following equation, which defines the forward discount premium:

$$\rho_{j+3} = 4(s_j - s_{j+3}) + i_{j|3} - i^*_{j|3} \tag{5}$$

where s_j is the impulse response of the nominal exchange rate in period j, and $i_{j|3}$ ($i^*_{j|3}$) is that of the domestic (foreign) interest rate 3 periods ahead.

Consider the following trading strategy in response to a US contractionary monetary policy shock. An investor borrows in foreign currency for 3 months, exchanges it for the US dollar, holds US Treasury bills for 3 months, and exchanges the interest rate returns on the US dollar back for the foreign currency 3 months later. The return from this strategy in this 3-month period is exactly the forward discount premium in eq. (5). If the UIP holds (conditional on a monetary policy shock), ρ_{3l+3} should be equal to zero for all horizons l, and then $\rho^T = \sum_{l=0}^{T/3-1} \rho_{3l+3}$ should be equal to zero.

Figure 4 plots the evolution of the forward discount premium over horizons for three different samples (full sample, Volcker's, post-Volcker's) conditional on our proposed identification

[14]The correlation between the real and the nominal exchange rate in our sample is 0.77.

strategy vs. the one based on sign restrictions on impulse responses only. As one can see, while the former implies no clear evidence against the conditional UIP, the latter suggests a deviation from it, above all as far as the Volcker period is concerned. Once again, Volcker's turns out to be the driver of the full sample result. Given the difficulty to identify the exchange rate effects of a monetary policy shock during that period, we argue that imposing our policy coefficient restrictions is a sensible identification strategy also to deal with the forward discount puzzle.

5 Conclusions

This paper has proposed a novel identification strategy to pin down the response of the US real exchange rate to a monetary policy shock. Such a strategy involves restrictions on the policy coefficients and on the dynamic reaction of selected macroeconomic indicators to an unexpected hike in the policy rate. Among the restrictions imposed on policy coefficients, a crucial one is that requiring the Federal Reserve to implement a policy tightening following a depreciation of the US dollar. We offer narrative evidence consistent with such restrictions, which we also justify with a forecasting exercise documenting the predictive power of the exchange rate for future inflation. Both the narrative and the empirical evidence we provide is specifically associated with the Volcker policy regime. We put our identification strategy at work and model a set of standard macroeconomic indicators with a Bayesian vector autoregressive framework.

Our main findings support Dornbusch's (1976) overshooting hypothesis, i.e., we document an immediate appreciation of the US dollar followed by a gradual, persistent depreciation. This finding is robust to the employment of different samples, including those affected by observations related to the Volcker disinflation. Differently, a more traditional identification strategy based on restrictions on impulse responses only returns evidence of a delayed overshooting puzzle when the Volcker regime is part of the analyzed samples. Digging deeper, we unveil that this latter evidence is due to the implications of this more traditional identification strategy for the policy coefficient capturing the systematic policy response to exchange rate movements, i.e., restrictions on the impulse responses do not necessarily imply a policy tightening in responses to a depreciation of the domestic currency. We find the imposition of the policy coefficient restriction on the exchange rate to materially affect the response of the exchange rate during Volcker's period, which is the one driving the result when working with longer samples that include the late '70s-early '80s. Wrapping up, our identification strategy returns a response of the exchange rate that is robust across different samples and supportive of the standard overshooting mechanism and the existence of a conditional uncovered interest parity condition.

Our results bring along modeling implications that are relevant from a policy standpoint.

From a modeling standpoint, our results suggest that mechanisms generating expectations of a quick depreciation following an on-impact appreciation can still represent relevant references to build up empirically credible micro-founded open economy frameworks. In light of the importance of correctly understanding the exchange rate response to monetary policy shocks for correctly designing optimal policies (Kolasa, Ravgotra, and Zabczyk (2022, 2025)), our results call for further empirical investigations on the role played by monetary policy disturbances on the currency market.

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Full sample			
Coefficient	ψ_y	ψ_p	ψ_{rex}
Median	1.06	2.09	0.19
68% Prob. Interval	[0.55;2.25]	[0.86;4.95]	[0.05;0.68]
Volcker era			
Coefficient	ψ_y	ψ_p	ψ_{rex}
Median	1.10	2.03	0.21
68% Prob. Interval	[0.60;2.26]	[0.70;5.42]	[0.05;0.71]
Post-Volcker era			
Coefficient	ψ_y	ψ_p	ψ_{rex}
Median	0.69	0.88	0.13
68% Prob. Interval	[0.27;2.17]	[0.28;3.35]	[0.03;0.52]

Table 1: **Identification via policy coefficient-restrictions (this paper's identification strategy): Policy coefficients, estimates**. Identification strategy based on our proposed combination of restrictions imposed on policy coefficients and on impact realization of impulse responses, i.e., the requirement of positive (zero) contemporaneous policy coefficients related to prices, industrial production, and the exchange rate (foreign industrial production and foreign policy rate) in the VAR policy equation plus the requirement of an on-impact positive (negative) response of the policy rate (of prices, industrial production, and the nonborrowed/total reserves ratio) to a monetary policy shock. Samples: Full sample: 1976M1-2007M7; Volcker era: 1979M8-1987M12; post-Volcker era: 1988M1-2007M7.

Full sample						
Coefficient	ψ_y	ψ_p	ψ_{rex}	ψ_{y^*}	ψ_{i^*}	ψ_{nbrx}
Median	0.17	1.83	-0.03	0.18	1.01	0.03
68% Prob. Interval	[-1.14;1.45]	[-5.39;6.60]	[-0.43;0.32]	[-0.70;1.05]	[-3.62;5.02]	[-1.00;0.84]
Volcker era						
Coefficient	ψ_y	ψ_p	ψ_{rex}	ψ_{y^*}	ψ_{i^*}	ψ_{nbrx}
Median	-0.19	1.40	-0.09	0.10	-0.59	-0.13
68% Prob. Interval	[-1.66;1.83]	[-5.40;6.32]	[-0.53;0.37]	[-0.95;1.00]	[-4.72;4.54]	[-0.84;0.42]
Post-Volcker era						
Coefficient	ψ_y	ψ_p	ψ_{rex}	ψ_{y^*}	ψ_{i^*}	ψ_{nbrx}
Median	0.23	0.38	0.06	-0.09	0.94	0.18
68% Prob. Interval	[-0.01;0.61]	[0.10;1.11]	[-0.01;0.21]	[-0.38;0.04]	[0.26;1.99]	[0.04;0.55]

Table 2: **Identification via impulse response function-restrictions only: Policy coefficients, estimates**. Identification strategy based on the requirement of a positive (negative) response of the policy rate (of prices, industrial production, and the nonborrowed/total reserves ratio) to a monetary policy shock for the entire first year after the shock. Samples: Full sample: 1976M1-2007M7; Volcker era: 1979M8-1987M12; post-Volcker era: 1988M1-2007M7.

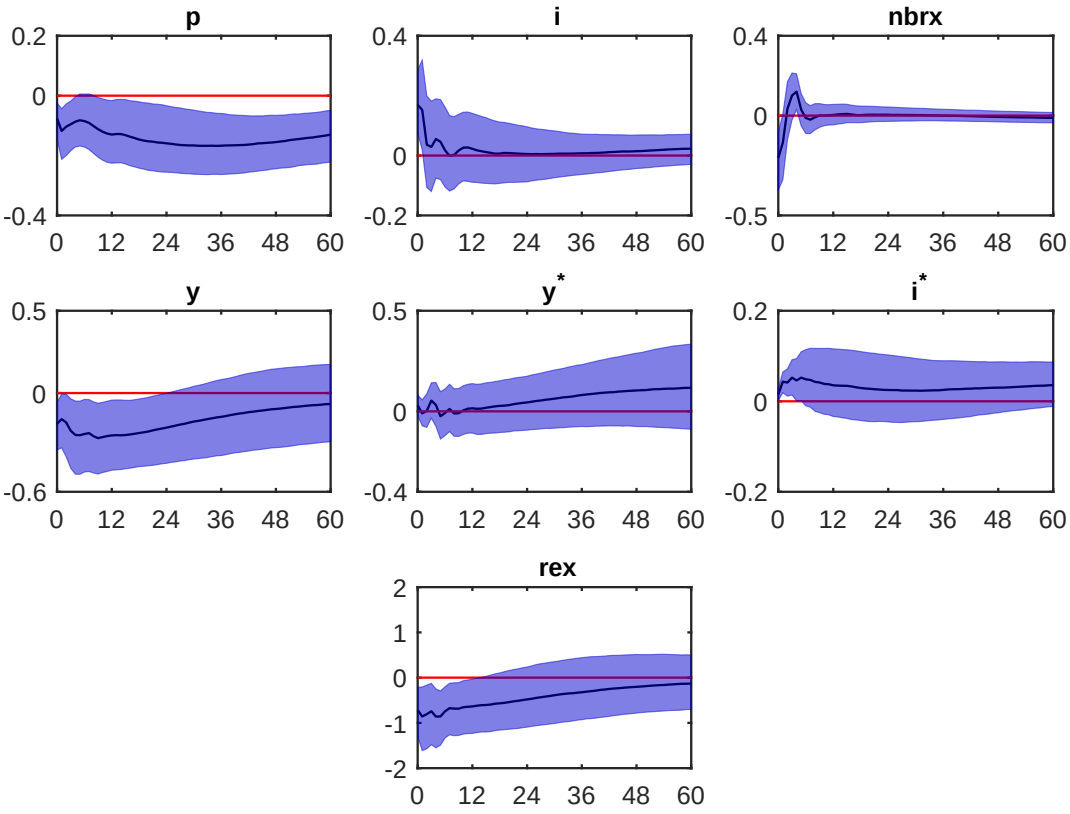

Figure 1: **Identification via policy coefficient-restrictions (this paper's identification strategy): Impulse responses**. Size of the shock: One-standard deviation. Identification strategy based on our proposed combination of restrictions imposed on policy coefficients and on-impact impulse responses, i.e., the requirement of positive (zero) contemporaneous policy coefficients related to prices, industrial production, and the exchange rate (foreign industrial production and foreign policy rate) in the VAR policy equation plus the requirement of an on-impact positive (negative) response of the policy rate (of prices, industrial production, and the nonborrowed/total reserves ratio) to a monetary policy shock.

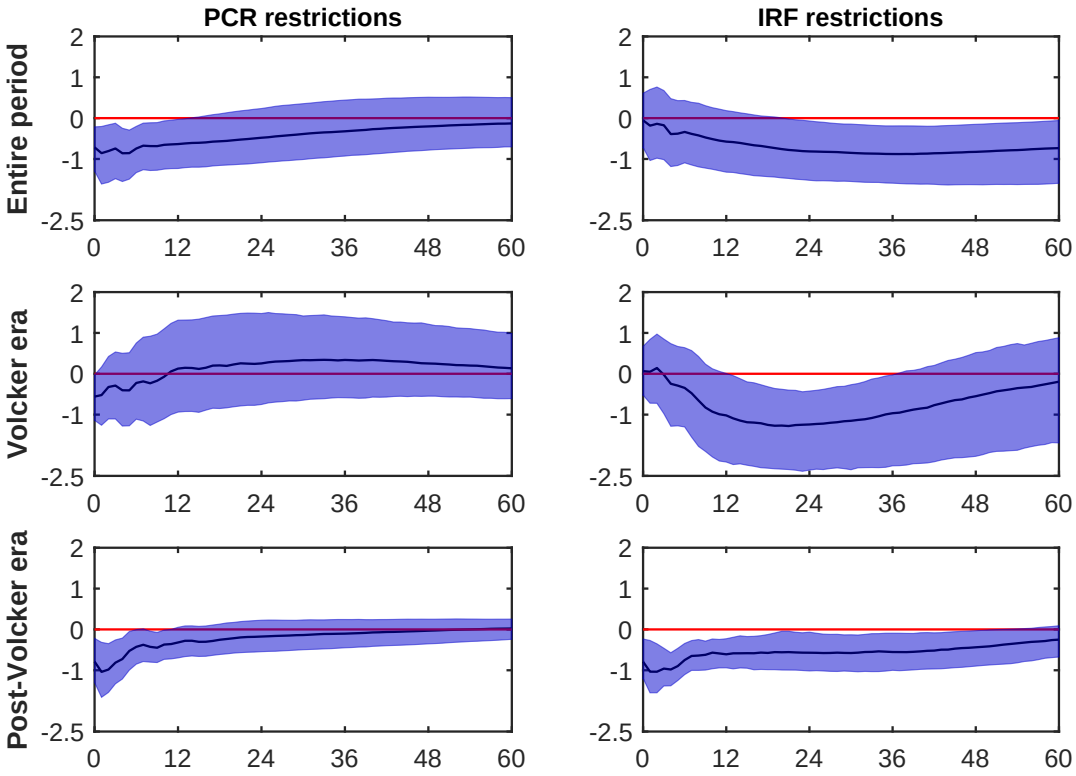

Figure 2: **Identification via policy coefficient-restrictions (this paper's identification strategy) vs. via restrictions only on impulse responses: Impulse responses across different periods.** Impulse responses plotted above refer to the real exchange rate. Left column: Identification strategy based on our proposed combination of restrictions (PCR restrictions) imposed on policy coefficients and on-impact impulse responses, i.e., the requirement of positive (zero) contemporaneous policy coefficients related to prices, industrial production, and the exchange rate (foreign industrial production and foreign policy rate) in the VAR policy equation plus the requirement of an on-impact positive (negative) response of the policy rate (of prices, industrial production, and the nonborrowed/total reserves ratio) to a monetary policy shock. Right column: Identification strategy based on restrictions over the first twelve horizons of the impulse responses (IRF restrictions) of the policy rate (which has to go up), the price level (down), and the nonborrowed/total reserves ratio (down). Samples: Full sample: 1976M1-2007M7; Volcker era: 1979M8-1987M12; post-Volcker era: 1988M1-2007M7.

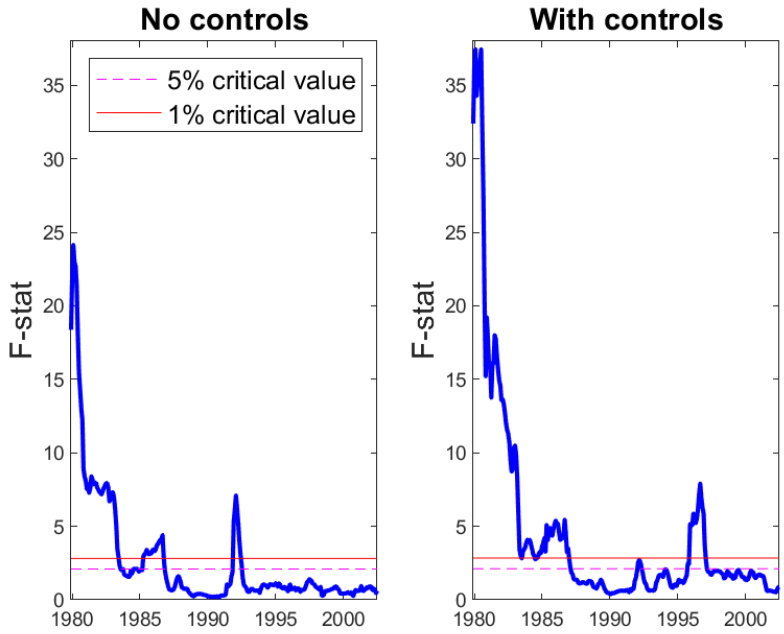

Figure 3: **Rolling-window six-months ahead predictive exercise: Test on the exchange rate as a predictor of inflation**. Figure documenting the outcome of Granger causality tests of the real exchange rate as a predictor of year-over-year inflation using a 10-year rolling-window approach. Predictive model estimated with 12 lags. Left panel: Predictive model that includes year-over-year inflation and real exchange rate. Right panel: Predictive model that includes year-over-year inflation, year-over-year GDP growth, year-over-year oil price inflation, and real exchange rate. Blue line: HAC robust F-statistic of the null hypothesis that the real exchange rate does not Granger-cause year-over-year inflation. Red solid (magenta dashed) line: critical value at the 1% (5%) significance level. Sample: 1973M1-2007M7. The date on the horizontal axis represents the mid-point of the rolling window.

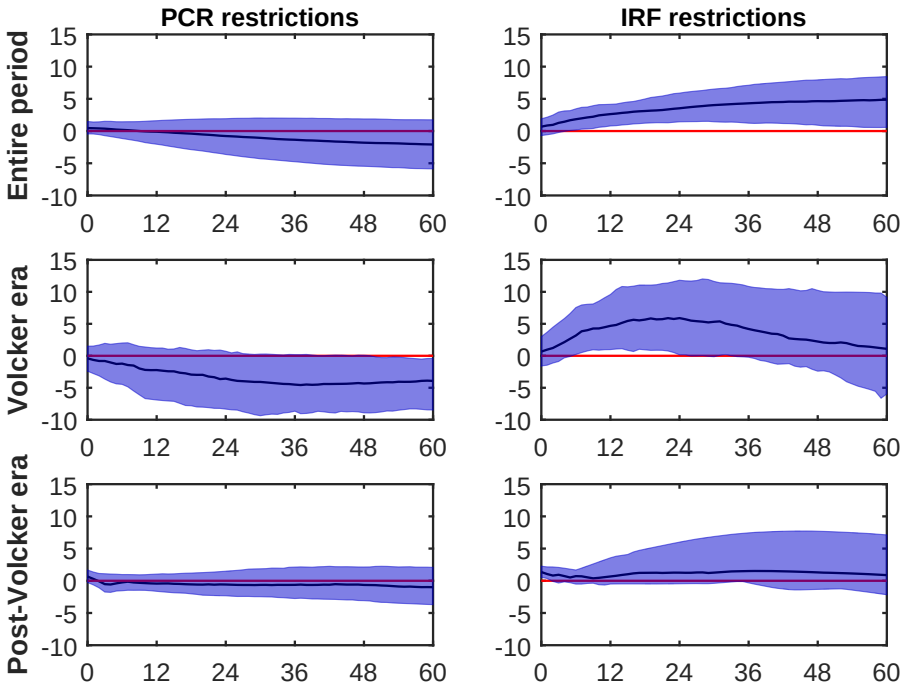

Figure 4: **Conditional UIP condition: Identification via policy coefficient-restrictions (this paper's identification strategy) vs. via restrictions only on impulse responses: Impulse responses across different periods**. Cumulated impulse responses of 3-month excess returns. Left column: Identification strategy based on our proposed combination of restrictions (PCR restrictions) imposed on policy coefficients and on-impact impulse responses, i.e., the requirement of positive (zero) contemporaneous policy coefficients related to prices, industrial production, and the exchange rate (foreign industrial production and foreign policy rate) in the VAR policy equation plus the requirement of an on-impact positive (negative) response of the policy rate (of prices, industrial production, and the nonborrowed/total reserves ratio) to a monetary policy shock. Right column: Identification strategy based on restrictions over the first twelve horizons of the impulse responses (IRF restrictions) of the policy rate (which has to go up), the price level (down), and the nonborrowed/total reserves ratio (down). Samples: Full sample: 1976M1-2007M7; Volcker era: 1979M8-1987M12; post-Volcker era: 1988M1-2007M7.

Appendix of the paper "Delayed Overshooting Puzzle: Does Systematic Monetary Policy Matter?" by Efrem Castelnuovo, Giovanni Pellegrino, Giovanni Primativo, and Giacomo Ranzato

A: Quotes from the "Federal Reserve Board Oral History Project: Interview of Paul. A. Volcker"

We report excerpts from the above interview that document the attention posed by the Federal Reserve to movements in the exchange rate during Paul Volcker's mandate.

Page 49. Mr. Kohn: *"On the Treasury–Fed relations in the early 1960s, there was Operation Twist and some of the reactions to the international pressures on the dollar."*

Mr. Volcker: *"In those days, I was on the fringes of the international side. I was much more on the domestic side when Roosa was there. When I was deputy undersecretary, then I got both. It's hard to re-create the atmosphere, but the $35 gold price was sacred—a matter of international commitment and credibility—and you couldn't talk about changing the exchange rate of the dollar. It was as if now we were talking about some great symbol, like a treaty obligation. If you wanted to say something about the exchange rate, you had to take people off in the corner and not admit your views to everyone else when the subject would come up."*

Page 201. Mr. Small: "Was the Volcker group mainly focused on exchange rate developments and flexibility, or did it get into international banking and regulation?"

Mr. Volcker: *"I don't think we did regulatory stuff. As I recall it, we dealt with IMF, exchange rates, adjustment process, liquidity provision—that kind of stuff.*

Pages 258-259. Mr. Small: *"Let me start with a simple question. Someone could say: "We have gone off gold and we have flexible exchange rates, so there's not much left for monetary policy to do regarding exchange rates. Let the markets handle them." Once we entered flexible exchange rates, what were the issues? What were the big camps or competing paradigms that policymakers debated and disagreed about?"*

Mr. Volcker. *"[...] I was brought up in the Roosa school. My concern was that while I thought we had to get the exchange rate changed and we had to go through some period of floating (I'm now skipping ahead a year or two), our experience with floating rates in the past had shown, and the future potentially would show, that they were quite unstable and disturbing, in terms of trade and monetary policy. [...] The crisis came in 1978, when the dollar was quite weak and we were in the midst of this inflationary process. The economy wasn't doing very well. The Administration got very concerned about the dollar, and the markets were concerned about the dollar. The Carter Administration put together—it was largely a Treasury initiative—a big rescue effort in October or November of 1978, which really took some new initiatives. That was the first time, I think, apart from swaps, when we borrowed in foreign currencies. And we raised the discount rate. I was president of the New York Fed at that time and the Treasury was in the lead, but I was in sympathy with what they were doing. The New York Reserve Bank took the lead in asking for an increase in the discount rate as part of the planned program. We borrowed foreign currencies. We intervened in the market heavily."*

Page 263. Mr. Small: *"Right before you became Chairman, the dollar was under attack. Inflation was headed up. I take it that the attack on the dollar was seen as all that more of an indication that inflation was getting out of control. The Board needed to—"*

Mr. Volcker: *"I think the main focus was on domestic inflation. The exchange rate uncertainty certainly would have reinforced it."*

Mr. Small: *"Then interest rates rose significantly, so the dollar strengthened. And you had an Administration that was saying, "Let's not intervene." "*

Mr. Volcker: *"Just to be clear, before Reagan became President in 1981, during the previous Democratic Administration, William Miller as Secretary of the Treasury bought a lot of foreign currencies as the dollar went up, which was a good thing—certainly reasonable. The Treasury was not averse to intervening at all. Neither was I. So we stocked up on some foreign currencies."*

Pages 264-295. Mr. Small: *"But then you enter the second term of Reagan, and you have a switch between the Chief of Staff and the Secretary of the Treasury. That was in early 1985, and by the fall of 1985 you have the Plaza Accord."*

Mr. Volcker: *"By then, the dollar had risen—perhaps too much. I think what tipped off the early intervention was excitement about the British pound getting so weak. I wasn't there, but presumably Prime Minister Thatcher called Reagan and said, "Please do something, Ronnie." Reagan spoke to Jim Baker, so we had some intervention to lower the dollar for the first time in*

a long time—January, February of 1985. [...] But the idea of the Plaza Agreement was consistent with the idea that exchange rates could or should be controlled or influenced within some wide band. But they had to get them down in the first place. [...] I don't know when Jim Baker first began thinking about this. Some weeks before Plaza, we had a lot of conversations about the strength of the dollar and what we could do."

Pages 266-267. Mr. Small: *"You had fought this great battle against inflation, and you wanted to lock in the credibility gains and the credibility of the Fed. So if you then embarked on a weaker dollar strategy, a lot of that gain could have been lost?"*

Mr. Volcker: *"Well, not the dollar. I was worried that—"*

Mr. Small: *"You were nodding "yes" to that?"*

Mr. Volcker: *" "Yes" in general. But I was concerned that, here we were, the world currency and so forth, and it was rather unusual to be knocking down your own currency deliberately. The dollar had gotten very high, there was no question about that. But I didn't want the decline to get out of hand and snowball and become uncontrollable on the low side and undercut inflation and credibility and all the rest. That was my concern."*

Page 266-267. Mr. Small: *"So coming out of the Plaza Accord in 1985, how would you describe how you and Baker came out?"*

Mr. Volcker: *"I thought the dollar was too high."*

Mr. Small: *"So there was no real tension?"*

Mr. Volcker: *"I thought it had been too high for a long time. I think I welcomed the idea that he was concerned about the exchange rates and willing to intervene. I just didn't want it to get out of hand."*

Mr. Small: *"A few months later, in January—"*

Mr. Volcker: *"Enough is enough, exactly. We went through a long waltz. I'd go up to Capitol Hill and testify and say, "Well, I think the dollar is down far enough. I don't want a weaker dollar." Baker would go up the next day and say, "Yes, let it go down some more." We never had a big fight about it, personally. From my point of view, it came out okay, because my testimony or press conference or whatever would always be, "Let's be cautious and stabilize," and his would be, "Let's make it weaker." It came out okay. Didn't go down, didn't go up, as I remember."*

Pages 268-269. Mr. Small: *"I want to bring you through this period, but I'm peeking ahead a month or two, and there's a revolt coming at the Board—the February 24 discount rate vote. You come back from London, and the press was playing up differences between you and Baker."*

Mr. Volcker: *"I was trying to get the Germans to move all through this period, because the European economy didn't look very strong to me. I thought it was important to get the Europeans to move—maybe the Japanese too, I don't remember. But, particularly in retrospect, I had been pretty outrageous in yelling at the Bundesbank in private."*

Mr. Small: *"You thought they had economic slack?"*

Mr. Volcker: *"Yes, I thought they ought to move, but it was also in my interest, because I wanted to take the downward pressure off the dollar to the extent there was any. The last thing I wanted to do was lead alone a parade of reductions in interest rates. The Germans didn't want to move—they resisted. But then, when it seemed clear the United States was going to move one way or the other in time, I made phone calls to Shijuro Ogata and Pöhl the next morning. I said that we better coordinate a reduction in interest rates, and they both agreed relatively quickly."*

B: VAR robustness checks

This section of the Appendix documents the robustness of our baseline results on the exchange rate response to a US monetary policy shock identified with our novel identification strategy to the following perturbations of our benchmark model: (i) forcing the response of foreign output to be negative on impact (Figure A1); (ii) modeling prices and industrial production (both domestic and foreign) in growth rates (Figure A2); (iii) adding the excess bond premium proposed (EBP) by Gilchrist and Zakrajek (2012) to the vector and imposing a positive response of EBP to a monetary policy shock (Figure A3);[15] (iv) replacing the real exchange rate with its nominal counterpart (Figure A4); (v) using the dataset "AGG98" as in Scholl and Uhlig (2008) and Kim, Moon, and Velasco (2017), which represents the Rest-of-the-World (RoW) by considering macroeconomic variables of 14 US trading partners prior to 1999 (Figures A5, A6, and A7).

[15]The restriction on the EBP response is justified based on the results of Gertler and Karadi (2015). However, the results on the exchange rate response to a US monetary policy shock hold true also when adding the EBP to our VAR without imposing any EBP-related sign.

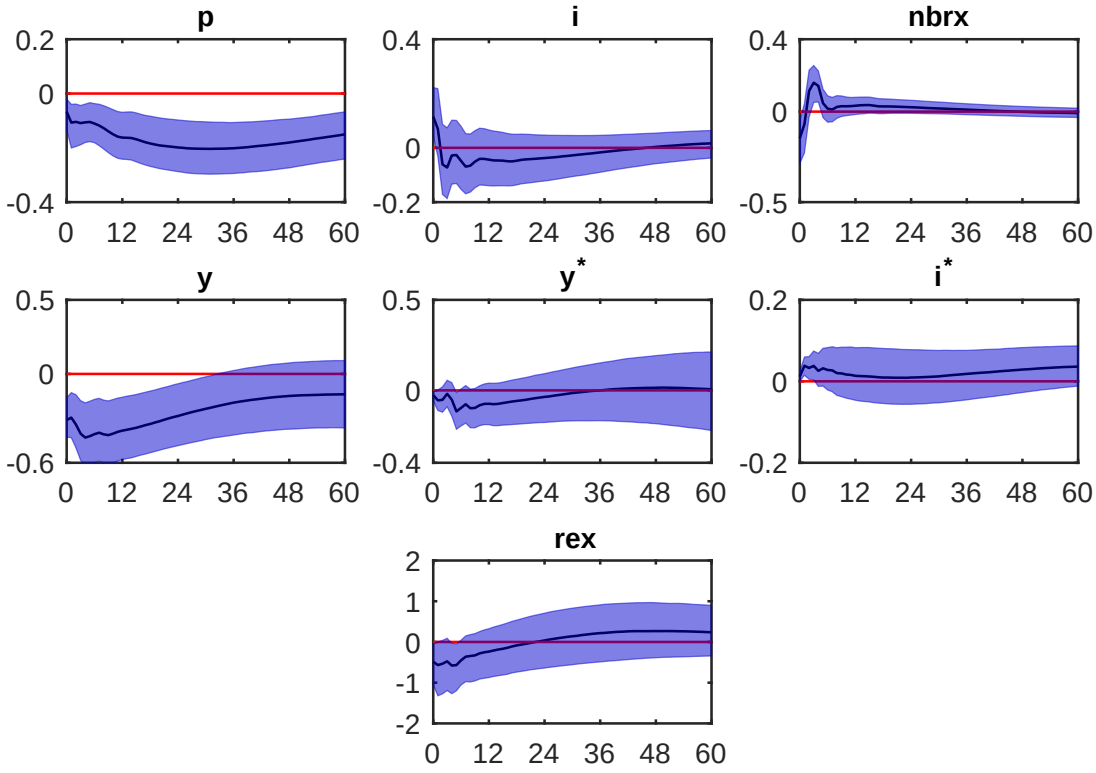

Figure A1: **Impulse responses implied by the identification via policy coefficient-restrictions (this paper's identification strategy): Extra restriction on foreign industrial production**. Size of the shock: One standard deviation. Identification strategy extending our baseline combination of restrictions imposed on policy coefficients and on-impact impulse responses, i.e., the requirement of positive (zero) contemporaneous policy coefficients related to prices, industrial production, and the exchange rate (foreign industrial production and foreign policy rate) in the VAR policy equation plus the requirement of an on-impact positive (negative) response of the policy rate (of prices, industrial production, and the nonborrowed/total reserves ratio) to a monetary policy shock. Extra restriction with respect to the baseline identification strategy: negative on-impact response of foreign industrial production to a monetary policy shock. Sample: 1976M1-2007M7.

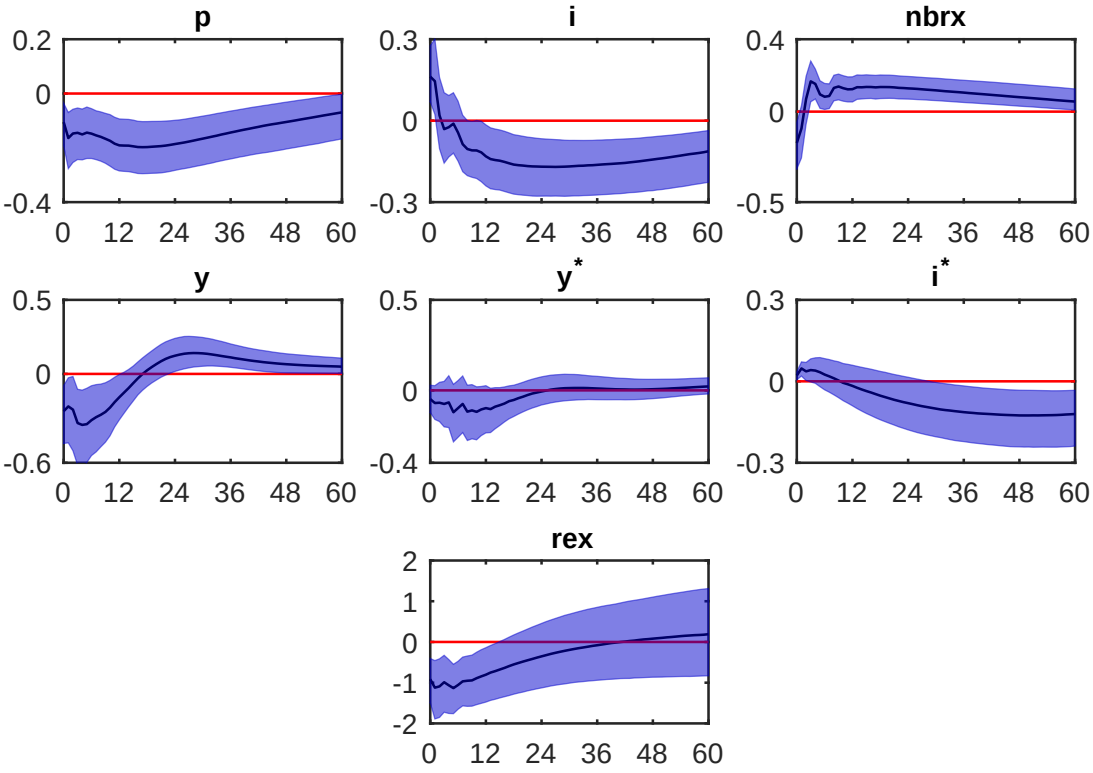

Figure A2: **Impulse responses implied by the identification via policy coefficient-restrictions (this paper's identification strategy): Modeling industrial production and prices in growth rates**. Size of the shock: One standard deviation. Identification strategy extending our baseline combination of restrictions imposed on policy coefficients and on-impact impulse responses, i.e., the requirement of positive (zero) contemporaneous policy coefficients related to prices, industrial production, and the exchange rate (foreign industrial production and foreign policy rate) in the VAR policy equation plus the requirement of an on-impact positive (negative) response of the policy rate (of prices, industrial production, and the nonborrowed/total reserves ratio) to a monetary policy shock. With respect to the baseline identification strategy: industrial production and prices (both domestic and foreign) are modeled in growth rates. Sample: 1976M1-2007M7.

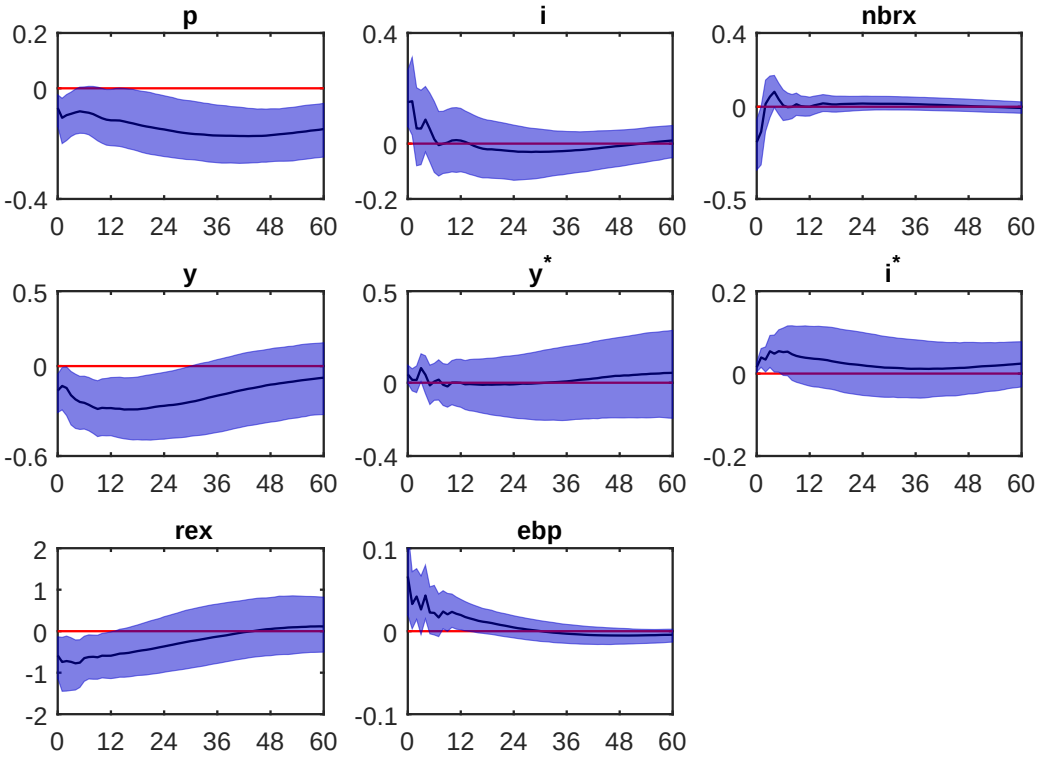

Figure A3: **Impulse responses implied by the identification via policy coefficient-restrictions (this paper's identification strategy): Controlling for the excess bond premium (EBP) proposed by Gilchrist and Zakrajek (2012)**. Size of the shock: One standard deviation. Identification strategy extending our baseline combination of restrictions imposed on policy coefficients and on-impact impulse responses, i.e., the requirement of positive (zero) contemporaneous policy coefficients related to prices, industrial production, and the exchange rate (foreign industrial production and foreign policy rate) in the VAR policy equation plus the requirement of an on-impact positive (negative) response of the policy rate (of prices, industrial production, and the nonborrowed/total reserves ratio) to a monetary policy shock. Extra restriction with respect to the baseline identification strategy: positive on-impact response of the EBP to a monetary policy shock. Sample: 1976M1-2007M7.

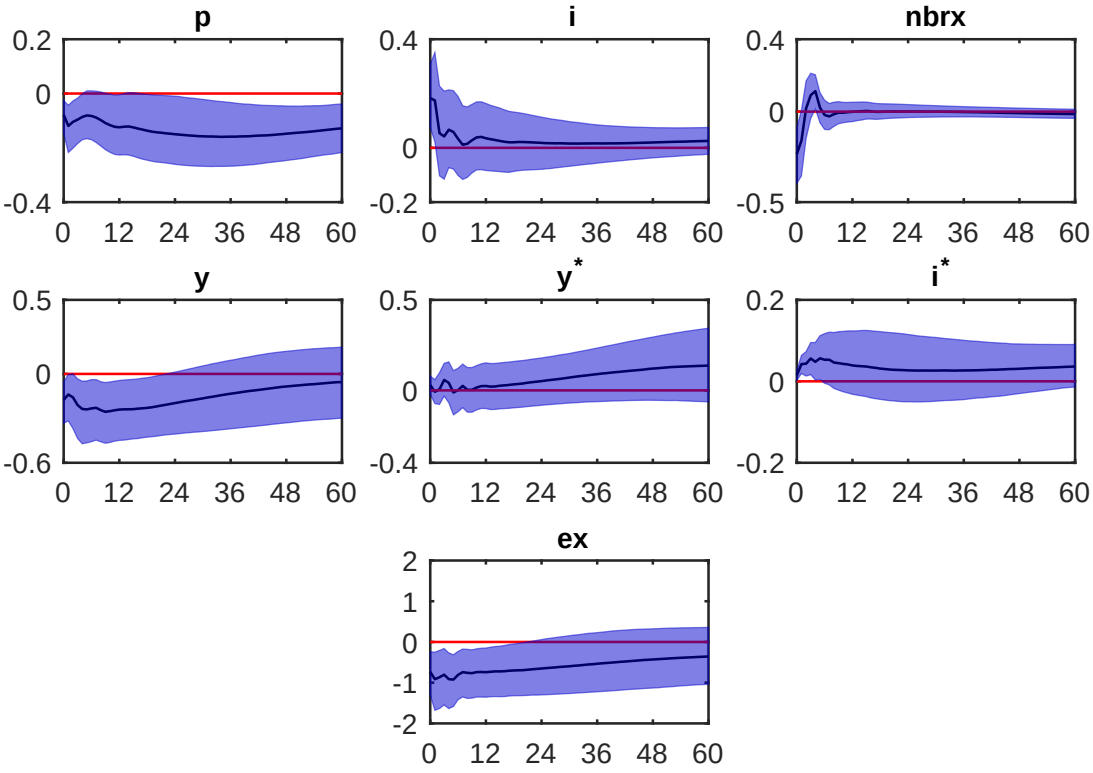

Figure A4: **Impulse responses implied by the identification via policy coefficient-restrictions (this paper's identification strategy): Modeling the nominal exchange rate instead of the real exchange rate**. Size of the shock: One standard deviation. Identification strategy extending our baseline combination of restrictions imposed on policy coefficients and on-impact impulse responses, i.e., the requirement of positive (zero) contemporaneous policy coefficients related to prices, industrial production, and the exchange rate (foreign industrial production and foreign policy rate) in the VAR policy equation plus the requirement of an on-impact positive (negative) response of the policy rate (of prices, industrial production, and the nonborrowed/total reserves ratio) to a monetary policy shock. With respect to the baseline identification strategy: The nominal exchange rate is used *in lieu* of the real exchange rate. Sample: 1976M1-2007M7.

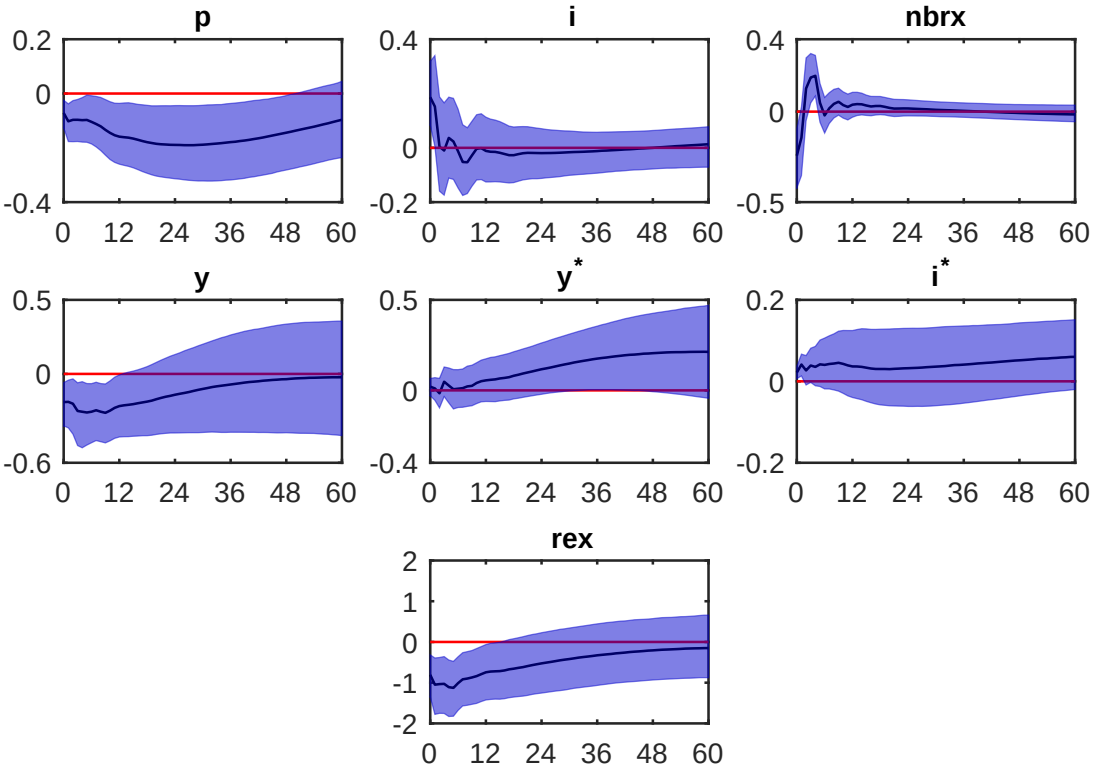

Figure A5: **Impulse responses implied by the identification via policy coefficient-restrictions (this paper's identification strategy): Rest-of-the-World as "AGG98".** Size of the shock: One-standard deviation. Identification strategy extending our baseline combination of restrictions imposed on policy coefficients and on-impact impulse responses, i.e., the requirement of positive (zero) contemporaneous policy coefficients related to prices, industrial production, and the exchange rate (foreign industrial production and foreign policy rate) in the VAR policy equation plus the requirement of an on-impact positive (negative) response of the policy rate (of prices, industrial production, and the nonborrowed/total reserves ratio) to a monetary policy shock. With respect to the baseline VAR specification: the aggregation "AGG98" is used, which employs 14 US trading partners prior to 1999 for calculating rest-of-the-world (RoW) macroeconomic variables. Sample: 1976M1-1998M12.

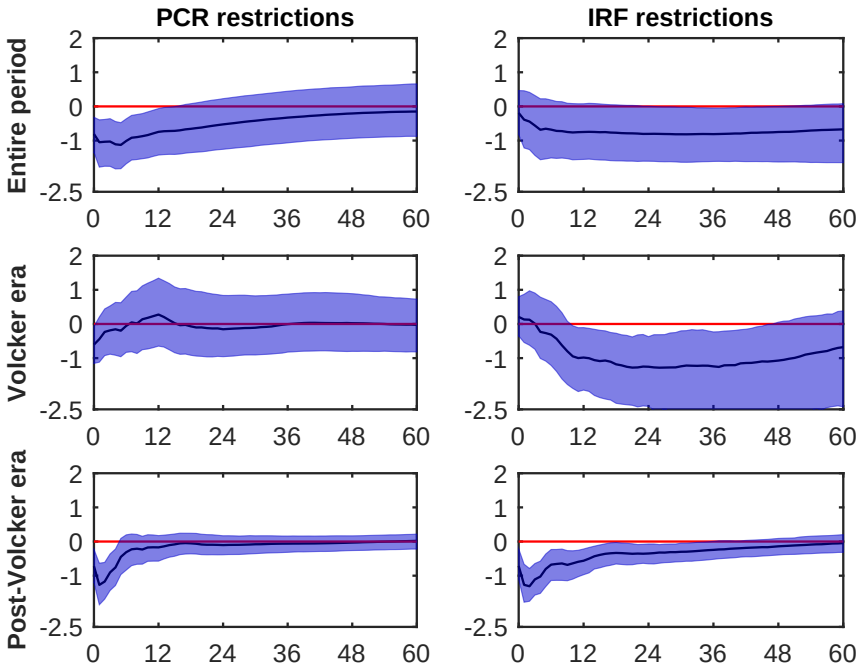

Figure A6: **Identification via policy coefficient-restrictions (this paper's identification strategy) vs. via impulse response-constraints only: Impulse responses across different periods, Rest-of-the-World as "AGG98"**. Impulse responses plotted above refer to the real exchange rate. Left column: Identification strategy based on our proposed combination of restrictions imposed on policy coefficients and on-impact impulse responses, i.e., the requirement of positive (zero) contemporaneous policy coefficients related to prices, industrial production, and the exchange rate (foreign industrial production and foreign policy rate) in the VAR policy equation plus the requirement of an on-impact positive (negative) response of the policy rate (of prices, industrial production, and the nonborrowed/total reserves ratio) to a monetary policy shock. Right column: Identification strategy based on restrictions over the first twelve horizons of the impulse responses of the policy rate (which has to go up), the price level (down), and the nonborrowed/total reserves ratio (down). With respect to the baseline VAR specification: the aggregation "AGG98" is used, which employs 14 US trading partners prior to 1999 for calculating rest-of-the-world (RoW) macroeconomic variables. Samples: Full sample: 1976M1-1998M12; Volcker era: 1979M8-1987M12; post-Volcker era: 1988M1-1998M12.

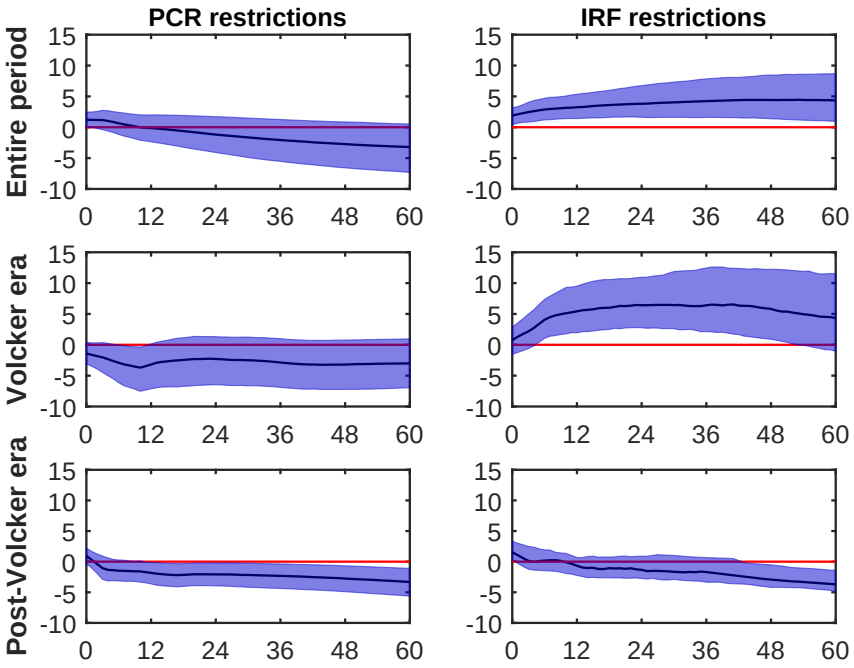

Figure A7: **Conditional UIP condition: Role of the identification strategy, Rest-of-the-World as "AGG98"**. Cumulated impulse responses of 3-month excess returns. Left column: Identification strategy based on our proposed combination of restrictions (PCR restrictions) imposed on policy coefficients and on-impact impulse responses, i.e., the requirement of positive (zero) contemporaneous policy coefficients related to prices, industrial production, and the exchange rate (foreign industrial production and foreign policy rate) in the VAR policy equation plus the requirement of an on-impact positive (negative) response of the policy rate (of prices, industrial production, and the nonborrowed/total reserves ratio) to a monetary policy shock. Right column: Identification strategy based on restrictions over the first twelve horizons of the impulse responses of the policy rate (which has to go up), the price level (down), and the nonborrowed/total reserves ratio (down). With respect to the baseline VAR specification: the aggregation "AGG98" is used, which employs 14 US trading partners prior to 1999 for calculating rest-of-the-world (RoW) macroeconomic variables. Samples: Full sample: 1976M1-1998M12; Volcker era: 1979M8-1987M12; post-Volcker era: 1988M1-1998M12.