What Helps Forecast U.S. Inflation?—Mind the Gap!*

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This draft: January 28, 2015
(Preliminary and incomplete)

Abstract

In macroeconomic analysis and inflation forecasting, the traditional Phillips curve has been widely-used to exploit the empirical relationship between inflation and domestic economic activity. Atkeson and Ohanian (2001), among others, cast doubt on the performance of Phillips curve-based forecasts of U.S. inflation relative to naïve forecasts. This indicates a difficulty for policy-making and private sector's long-term nominal commitments which depend on inflation expectations. The literature suggests globalization may be one reason for this phenomenon. To test this, we evaluate the forecasting ability of global slack measures under an open economy Phillips curve. We find that global variables, such as G7 credit growth, G7 money supply growth, terms of trade, and the real effective exchange rate (REER) perform significantly better than domestic variables, and argue that they can serve as proxies for poor measures of global slack. Moreover, our forecasts based on the simulated data from a workhorse open economy New Keynesian model indicate that better monetary policy and good luck (i.e. a remarkably benign sample of economic shocks) can account for the empirical observations on forecasting accuracy, while globalization plays a secondary role.

JEL Classification: **F41**, **F44**, **F47, C53**, **F62**

KEY WORDS: Global Slack, New Open Economy Phillips Curve, Forecasting.

*We would like to thank Nathan Balke, Mark A. Wynne, Olivier Coibion, Yuriy Gorodnichenko, Refet Gürkaynak, Barbara Rossi and many seminar and conference participants at 19th Computing in Economics and Finance Conference, 88th Western Economic Association International Meetings, 2013 North American Summer Meeting of the Econometric Society, 83rd Annual Meeting of the Southern Economic Association, XXXVIII Symposium of the Spanish Economics Association, Conference on Advances in Applied Macro-Finance and Forecasting (Istanbul Bilgi University), Fudan University, Swiss National Bank, Tsinghua University, UT Austin, Koç University, for helpful suggestions, and the Dallas Fed President Richard Fisher for encouragement. This research was completed while Ayşe Kabukçuoğlu was a summer intern at the Federal Reserve Bank of Dallas, whose support is greatly appreciated. We acknowledge the excellent research assistance provided by Valerie Grossman. All remaining errors are ours alone. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Dallas, or the Federal Reserve System.

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1 Introduction

Forecasting inflation—accurately and reliably—plays a critical role for policy-making and for the decisions of the private sector in making long-term nominal commitments. In macroeconomic analysis and inflation forecasting, the traditional Phillips curve has been a widely used model that captures broadly the empirical relationship between inflation and unemployment rate, capacity utilization or output gap.

As documented by Atkeson and Ohanian (2001), the Phillips curve has flattened since 1984. Their finding was that the Phillips curve-based models did not yield more accurate forecasts than the naïve, 4 quarter random walk benchmark. Stock and Watson (2007) emphasized the role of lower volatility in inflation in the U.S. and in the world during this period. The risk of naïve forecasts, computed as the mean squared forecast error (MSFE), declined as well. Forecasts under a Phillips curve specification have become, in turn, less accurate by the MSFE metric. A survey by Stock and Watson (2008) suggests recent forecasts based on univariate specifications, including the Phillips curve, only occasionally performed well.

A prominent explanation to the break in the Phillips curve that is suggested in the literature is globalization—the integration of global markets in goods, labor, and capital. The recent literature postulates the 'global slack hypothesis', i.e. the hypothesis that foreign slack as well as domestic slack drives domestic inflation in the short-run, as a way to reconcile the Phillips curve relationship with the evidence in an increasingly more integrated world. Hence, a more relevant specification, the open economy Phillips curve that ties inflation to global measures of economic activity has become a focus of investigation.

However, the evidence on the role of global slack is mixed. Binyamini and Razin (2007) and Martínez-García and Wynne (2010) made theoretical explanations and Borio and Filardo (2007) provided empirical evidence for the global slack hypothesis. On the other hand, Milani (2010), Milani (2012) among others, argue that the foreign economic activity has a role on domestic supply and demand, but its effect on domestic inflation is negligible, finding weak evidence for the global slack hypothesis.

In this paper, we evaluate the open economy Phillips curves both theoretically and empirically. We suggest that in a workhorse open economy New Keynesian (NK) model, an open economy Phillips curve should be a relavant specification for forecasting inflation, but why it may not be a successful specification in practice is largely an issue that can be explained by imperfectly-measured output gap variables used in these forecasts. Hence, even when the theoretical validity of an open economy Phillips curve is assured, teasing out empirical support from the data and forecasting inflation under the open economy framework is a challenging task. It is, in general, difficult to find sufficiently long, reliable and robust time series of global slack—global output gap or capacity utilization. Quality and data availability concerns are discussed in the current paper as well as in previous studies. Therefore, it becomes particularly useful to find accurate proxies for global slack—and we show that global money growth, credit growth, terms of trade and REER can indeed be used as proxies for global slack.

Undoubtedly, it is also important to understand the theoretical basis for why a given variable would be useful for forecasting. In this regard, we first try to explain money growth might help forecast inflation. It might be appealing to relate the performance of money growth to the quantity theory of money, but would the quantity theory of money really help us understand money growth as a useful variable to forecast inflation? Woodford (2008) argues that even a strong empirical evidence in the long run relation between money growth and inflation does not necessarily imply that money growth will be useful for forecasting inflation. The main reason, as he explains, is that cointegration of money growth with the inflation rate would imply that in order to forecast the average inflation rate in the long run, it would be sufficient to know what the average growth rate of money will be in the long run; and therefore no other variables would be necessary to forecast the average inflation rate over the same horizon. However, one does not know the long run average money growth rate, as it is an endogenous variable with respect to the central bank's policy. If it were an exogenous variable, then it could make sense to detect long run trends from the moving averages of recent observations. Woodford (2008) also presents a small example with a simple New Keynesian model where, in theory, money growth will not outperform slack even in the long run.[1]

Even though the quantity theory of money, and the empirical evidence for it, may not imply that money has actual value in forecasting inflation, we believe that the empirical success of money measures is quite obvious in our findings and should not be ignored. Moreover, the primary mechanism underlying the high performance of money growth observed in our study, as well as in D'Agostino and Surico (2009), may be related to a different channel than the one posited by the conventional approach to quantity theory of money. We consider the following alternative argument in the New Keynesian tradition. In the context of the New Keynesian model, money moves as a result of changes in endogenous variables that are themselves related to the output gap. As Woodford (2008)) also argues, money demand is a residual in this model, however, it is one that we can measure more easily and that could still provide a signal for the output gap fluctuations that we can use to forecast future inflation. For instance, if we can say that in the context of this model the money growth in equilibrium is proportional to output gap, then money growth is a signal for a measure of slack that we actually do not observe properly (i.e. the output gap) and as such can still be exploited to forecast inflation. If money is tied to slack in equilibrium, then it might be used as a variable instead of slack which is easily defined in theory but cannot be measured perfectly in practice.

In a recent work, Martínez-García and Wynne (2010) suggested a similar role for terms of trade. They showed that under a variant of the open economy NK framework and in a standard representation of the open economy Phillips curve, global slack can be replaced with domestic slack and the terms of trade gap. Hence, the information content of terms of trade can be exploited to forecast domestic inflation without using the global slack, which is difficult to measure in practice. In principle, the particular open economy NK model we study implies that the real exchange rate is proportional to the terms of trade, so the forecasting performance of both variables should be the same. In more general models, the proportionality breaks down, but presumably we would still have a significant correlation between terms of trade and the REER that would explain if one variable is helpful to forecast inflation, the other one may be helpful, too. The similarity in the performances of terms of trade and REER confirms that both measures can help forecast inflation.[2]

The credit growth measures that we evaluate in the current paper have not been tested in the literature so far. Moreover, it is hard to understand, in theory, why it may work as a good forecasting variable, as standard models do not incorporate credit. Stock and Watson (1999b) evaluated the performances of some credit measures, which are either subcomponents of the monetary aggregates (like the monetary base or reserves) or related to commercial and industrial loans. The latter group includes the truly credit-related

[1]It might be arguable whether money growth will not outperform slack, but the statement is valid as far as a standard New Keynesian model is considered. Woodford (2008) also suggests that in theory, the usefulness of money growth depends on the framework one considers.

[2]Stock and Watson (1999b) and Stock and Watson (2008) evaluate the predictive ability of (nominal) US trade-weighted effective exchange rate as well as a set of foreign exchange rates (Stock and Watson (1999b)). They find that these variables do not improve upon the autoregressive process of inflation or the Phillips curve-based forecasts, unlike what our findings suggest.

variables in their analysis, but they are quite different than our measures of credit. Stock and Watson (1999b)'s focus on credit to firms is indeed sensible since credit to firms should be related with the tone of economic activity and the costs that the firms face. However, they do not find evidence that such a channel works very well to help forecast inflation. We look at credit to the overall private sector, including households, and our findings show that it matters for forecasting inflation. The intuition behind this would simply be that what really matters is the money that reaches the hands of consumers and allows them to finance purchases of goods. Putting more money in the hands of consumers chasing the same goods will surely put upward pressure on prices. We believe this explains why our results are so strong with credit to the private sector. However, a more detailed analysis still needs to be done and we leave this as an open question for future research.

Foreign factors for US inflation can be seen in both the important role that terms of trade or REER as well as global money or credit growth can play in predicting inflation. Both types of variables can be very useful as proxies for the imperfectly measured global slack, at least within the context of the open-economy New Keynesian model. Even if some of these variables have been used in testing their predictive performances for US inflation, the interpretation that we provide is novel. Our ultimate argument is that these measures can be helpful to forecast inflation because they could be proxies for the unobserved global slack. Our theoretical and empirical evidence suggest that global slack, in fact, has been an important factor driving the dynamics of inflation in the US, which the literature based on closed-economy Phillips curves has not recognized yet.

The proportionality of the global slack and macroeconomic measures discussed in the open economy NK framework might strengthen or weaken depending on changes in the model's parameters and therefore a realistic calibration of the parameters is needed to understand to see whether these theoretical linkages are quantitatively important. In particular, our strategy is to use a model that can capture the effects of two other competing or complementary hypotheses in addition to globalization—good luck and improved monetary policy— that are commonly discussed in the literature as plausible explanations for the observed strengths and weaknesses in the forecasting performances. To this end, we simulate data based on the model and use the data to conduct forecasts similar to those in the empirical section. We estimate mean square forecast errors (MSFEs) for many plausible parameter values that capture changes in trade openness, volatility in productivity or monetary policy shocks (which we call 'good luck') and effectiveness of monetary policy reflected in Taylor rule parameters. For most of these patterns of forecast accuracy, we find that greater openness has improved the performance of global macroeconomic variables, while increased anti-inflationary monetary policy and the decline in the volatility of productivity shocks seem to have improved the performance of both domestic and global measures.

In regards to our experiments, Inoue and Rossi (2011) come closest to ours in that it takes account of the parameter instability. They have a richer large-scale model and a recursive procedure that tests for parameter instability of individual parameters allowing for other parameters to be unstable at the same time. What they argue is that the literature in general follows a one-at-a-time analysis as a result of which they are more likely to conclude that the only plausible channel might be good luck because all other alternative explanations tend to cancel out among themselves. Our strategy builds on this idea and, therefore, explores the impact of instability in multiple parameters at a time. We estimate the key parameters independently but not through the full model and we find accordingly that some of these structural parameters indeed matter more than the previous literature had acknowledged.

Our empirical investigation of open economy Phillps curve forecasts starts with testing whether a set of global slack measures have predictive power for U.S. inflation. These measures are constructed by mostly theoretically-consistent output gap or capacity utilization series of the U.S. and several different groups of countries combined.

Our first finding is that one should really 'mind the gap'. Perhaps in agreement with the existing empirical literature, these global slack variables yield mixed results in predicting different inflation measures. In fact, we confirm a result that is also found in the literature that studies the closed economy Phillips curve-based forecasts. In theory, there should be no other current period variables that help us to forecast future inflation that can outperform the forecasts attained with current period output gap (and lagged inflation).[3] In practice, the difficulty of estimating the potential output and therefore deriving the output gap, makes slack measures less reliable. Therefore, it becomes key to consider other variables that can proxy for it in forecasting inflation and are more accurately measured in the data.

We then move on to an extensive evaluation of the predictive performances of a set of macroeconomic variables that can substitute global slack in forecasting inflation, as we show in our theoretical analysis. In particular, we test domestic and global money supply growth,[4] domestic and global credit growth, as well as variables tied to the open economy Phillips curve such as terms of trade, real effective exchange rates (REER) and domestic and global output gap. The striking finding is that all of these variables help improve upon the naïve forecasts obtained with the specification of a simple autoregressive process for inflation. We find particularly strong results for the late 1980s and onwards, the period of break in the Phillips curve pointed out by Atkeson and Ohanian (2001). The results are robust to various forecast horizons, inflation measures and estimation samples.

Our benchmark estimation and forecast periods are 1980:1-1991:4 and 1992:1-2011:4, respectively. The goal of these forecasts is to consider a wide range of relatively short series of slack[5] and other macroeconomic variables,[6] and compare their performances. We then look into some selected variables where we go back as far as 1947:1 and perform rolling window forecasts, to the extent that data series are available. Specifically, we test the predictive performances of: a domestic slack series (CBO US slack), two global slack series (OECD Total slack and FRBD G7 slack), a measure of domestic liquidity growth (US M2 growth) and global liquidity growth (G7 average of monetary aggregates), a measure of domestic credit growth (US non-financial lending from all sectors to the private sector), a measure of global credit growth (G7 average), and two measures of terms of trade (terms of trade and terms of trade ex. oil, filtered), and US trade-weighted real effective exchange rate (REER, filtered).

We conduct pseudo out-of-sample forecasts for eight measures of US inflation at horizons varying between 1-quarter to 12-quarters ahead. In particular, we use CPI, core CPI (all items ex. food and energy), PCE deflator, core PCE (all items ex. food and energy), GDP deflator, PPI, Sticky Prices (Sticky CPI), and Sticky Prices ex. shelter (Sticky core CPI).[7]

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[3]See Woodford (2008), and particularly an example on p. 1583 which shows that in a standard New Keynesian model, this is the case. The paper, among others, also points out to the problem of overestimating the potential output, as a pitfall in Phillips curve-based policy making.

[4]See, for example, D'Agostino and Surico (2009) on the forecasting value of money growth.

[5]Our domestic slack measures include the CBO, FRBD, OECD, IMF U.S. slack measures as well as HP-filtered U.S real GDP. Our global slack measures are FRBD G7, FRBD G39, OECD G7, OECD Total and IMF Advanced. More details on the data can be found in the Appendix.

[6]In particular, we use measures of domestic and global money growth, terms of trade, and REER.

[7]We use these two Sticky Price measures only in the benchmark forecasts.

Our metric for forecast accuracy is the MSFE of a reduced form of a new open economy Phillips curve with distributed lags of inflation and any of the measures of slack (or proxies for it) that we investigate, relative to the MSFE of the 'restricted' forecast derived from a univariate, autoregressive process of inflation. (Hence we consider nested models.) We compute bootstrap standard errors for the MSFEs following Clark and McCracken (2006). We report the following stylized facts:

- Forecasts with the domestic slack measure perform significantly better than the simple AR process of inflation until late 1980s and particularly at short horizons. The global slack measures only outperform the simple AR process significantly in the late 1980s and at short horizons.
- Forecasts using terms of trade measures perform significantly better relative to the naive forecasts, during the late 1980s. However, we observe switches in the performances of the two measures; in general, terms of trade ex. oil performs well whenever terms of trade does not and vice versa. Due to limited data availability, we cannot observe the performances of terms of trade ex. oil during the 1960s, but this is a period where terms of trade significantly outperforms the naive forecasts followed by a break during late 1970s and early 1980s.
- Forecasts with REER exhibit similar patterns with terms of trade: based on the relatively short time series we observe that they perform well after the mid-1980s.
- Forecasts with money exhibit a highly significant and accurate pattern and, in general, global money growth outperforms its domestic counterpart. With an exception in PPI inflation and for recent years in the GDP deflator, the results are robust to all inflation measures and especially over medium-to-long horizons.
- Both domestic and global measures of credit growth are very successful variables to forecast US inflation in the late 1980s. Global credit growth exhibits an even more accurate path in forecasting inflation than the US credit growth.

These extensive forecasting exercises reveal that, especially for the period starting after the break in the Phillips curve, several measures of economic activity help improve upon forecasts with the autoregressive process of inflation. These measures also outperform the closed economy Phillips curve-based forecasts. While the global counterparts of the money, credit and slack variables seem to be more useful for forecasting than the domestic measures, it is also interesting that other variables regarding the global economic activity, such as terms of trade and REER yield highly accurate forecasts compared to the Phillips curve-based forecasts.[8]

2 Insights from Theory

In this section, we briefly describe the building blocks of the workhorse open economy NK model in Martínez-García and Wynne (2010) which is a variant of the model of Clarida et al. (2002). The model maintains the assumption of a zero-inflation steady state, but is augmented to incorporate a time-varying

[8] In a recent work, Eickmeier and Pijnenburg (2013) showed evidence from 24 OECD countries that the common component of changes in unit labor costs has an important effect on inflation. They also considered movements in import price inflation, world interest rate as well as foreign competition and found that these global variables affect inflation.

inflation target for the central bank in the short-run. Since the setup of the model we use is otherwise extensively discussed in Martínez-García and Wynne (2010) and Appendix A, here we shall put the emphasis on the key equations of its log-linearized representation and their economic interpretation.

At the core of this model we encounter an explicit open-economy version of the Phillips curve relating domestic inflation and global slack together. First, we show the key theoretical relationships relevant for forecasting inflation implied by the model. We illustrate here how the closed-economy Phillips curve is not the appropriate modelling specification for forecasting domestic inflation whenever the economy is integrated with the rest of the world through trade. Second, based on simulated forecasts from the model, we investigate the role of a number of competing hypothesis—good luck, changes in the conduct of monetary policy and greater openness to trade—to explain a potential decline in the forecasting performance for domestic inflation of traditional Phillips-curve-based forecasting models that rely solely on domestic slack.

2.1 The Workhorse Open-Economy NK Model

There are two countries, *Home* and *Foreign*, of equal size size. The core structure of the model consists of three log-linearized equations for each country and two fundamental exogenous shocks (productivity shocks and monetary shocks). That system of equations fully characterizes the dynamics of aggregate output, inflation, and the short-term nominal interest rate in both the Home and Foreign countries.

All other endogenous variables which describe the aggregate behavior of the economy in each country can be expressed as linear functions of the two fundamental shocks, aggregate output, inflation, and the short-term interest rate. We denote Foreign variables with an asterisk (*), and express all variables, V_t, in logs as $v_t \equiv \ln(V_t)$. To denote the deviation of a variable, V_t, in logs from its steady state, V, we use the notation $\hat{v}_t \equiv \ln(V_t/V)$. Similarly, we denote the deviation of the potential (or frictionless) value of that same variable from its steady state as $\hat{v}_t^n \equiv \ln(V_t^n/V^n)$.

The model of Martínez-García and Wynne (2010) highlights the extent of the international transmission mechanism that arises through trade in goods, while keeping the simplicity and tractability of the workhorse (closed-economy) New Keynesian model.

Aggregate demand is described by a pair of equations that links the output gaps, $\widehat{x}_t$ and $\widehat{x}_t^*$, to shifts in consumption demand over time and across countries, domestic and foreign real interest rates, $\widehat{r}_t$ and $\widehat{r}_t^*$, natural (real) rates $\widehat{\overline{r}}_t$ and $\widehat{\overline{r}}_t^*$, and inflation $\widehat{\pi}_t$ and $\widehat{\pi}_t^*$,

$$\gamma(1-2\xi)\left(\mathbb{E}_t\left[\widehat{x}_{t+1}\right]-\widehat{x}_t\right) \approx \left((1-2\xi)+\Gamma\right)\left[\widehat{r}_t-\widehat{\overline{r}}_t\right]-\Gamma\left[\widehat{r}_t^*-\widehat{\overline{r}}_t^*\right], \quad (1)$$

$$\gamma(1-2\xi)\left(\mathbb{E}_t\left[\widehat{x}_{t+1}^*\right]-\widehat{x}_t^*\right) \approx -\Gamma\left[\widehat{r}_t-\widehat{\overline{r}}_t\right]+\left((1-2\xi)+\Gamma\right)\left[\widehat{r}_t^*-\widehat{\overline{r}}_t^*\right], \quad (2)$$

where the real interest rates in the Home and Foreign country are defined by the Fisher equation as $\widehat{r}_t \equiv \widehat{i}_t - \mathbb{E}_t\left[\widehat{\pi}_{t+1}\right]$ and $\widehat{r}_t^* \equiv \widehat{i}_t^* - \mathbb{E}_t\left[\widehat{\pi}_{t+1}^*\right]$ respectively, and $\widehat{i}_t$ and $\widehat{i}_t^*$ are the Home and Foreign short-term nominal interest rates. The natural real rates that would prevail under flexible prices are denoted as $\widehat{\overline{r}}_t$ for the Home country and as $\widehat{\overline{r}}_t^*$ for the Foreign country.

Price stickiness introduces a wedge in the open-economy IS equations between the real interest rate and the natural real rate of interest that captures its distortionary effects on aggregate demand as shown in Eqs. $(1)-(2)$. However, the Calvo parameter α, which determines the degree of nominal rigidities assumed by the model, does not appear explicitly in these equations. The share of imported goods ξ plays a prominent role in the open-economy IS equations as it directly affects the contributions of demand distortions arising in the local and export markets to the dynamic of the output gap of each country.

Aggregate supply is represented with an open-economy Phillips curve relating each country's inflation gap—defined as the actual inflation relative to the central bank's inflation target—to domestic and foreign output gaps,

$$\widehat{\pi}_t \approx \beta \mathbb{E}_t \left(\widehat{\pi}_{t+1}\right) + \left(\frac{(1-\alpha)(1-\beta\alpha)}{\alpha}\right)\left[\left((1-\xi)\varphi + \Theta\gamma\right)\widehat{x}_t + \left(\xi\varphi + (1-\Theta)\gamma\right)\widehat{x}_t^*\right]. \tag{3}$$

As shown in a previous work by Martínez-García and Wynne (2010), under the producer currency pricing (PCP) assumption, it is possible to express the dynamics of the domestic (cyclical) inflation, $\widehat{\pi}_t$, in terms of the domestic output gap, $\widehat{x}_t$, and the terms of trade gap, $\widehat{z}_t$, as follows,

$$\widehat{\pi}_t \approx \beta \mathbb{E}_t \left(\widehat{\pi}_{t+1}\right) + \left(\frac{(1-\alpha)(1-\beta\alpha)}{\alpha}\right)\left[\left((1-\xi)\varphi + \Theta\gamma\right)\widehat{x}_t + \Psi_{\pi,z}\widehat{z}_t\right] \tag{4}$$

Monetary policy rule is expressed à la Taylor (1993),

$$\widehat{i}_t \approx \left[\Psi_\pi \widehat{\pi}_t + \Psi_x \widehat{x}_t\right] + \widehat{v}_{t.} \tag{5}$$

Domestic money growth is derived by first differencing the *ad hoc* log-linear *money demand* equation

$$\Delta\widehat{m}_t \approx \Delta\widehat{y}_t - \eta\Delta\widehat{i}_t + \widehat{\pi}_t. \tag{6}$$

We also define the natural interest rate as the weighted average of expected domestic and foreign productivity growth,

$$\widehat{\overline{r}}_t \approx \gamma\left(\frac{1+\varphi}{\gamma+\varphi}\right)\left[\left(\Theta\Lambda + (1-\Theta)(1-\Lambda)\right)\mathbb{E}_t\left[\Delta\widehat{a}_{t+1}\right] + \left(\Theta(1-\Lambda) + (1-\Theta)\Lambda\right)\mathbb{E}_t\left[\Delta\widehat{a}^*_{t+1}\right]\right] \tag{7}$$

the potential output as the weighted average of domestic and foreign productivity gap,

$$\widehat{\overline{y}}_t \approx \left(\frac{1+\varphi}{\gamma+\varphi}\right)\left[\Lambda\widehat{a}_t + (1-\Lambda)\widehat{a}_t^*\right] \tag{8}$$

the output gap as

$$\widehat{x}_t = \widehat{y}_t - \widehat{\overline{y}}_t \tag{9}$$

and finally, the terms of trade and terms of trade gap as

$$\widehat{tot}_t \approx \frac{(\widehat{y}_t - \widehat{y}_t^*)}{\sigma - (\sigma - \frac{1}{\gamma})(1-2\xi)^2} \text{ and } \widehat{z}_t \approx \frac{(\widehat{x}_t - \widehat{x}_t^*)}{\sigma - (\sigma - \frac{1}{\gamma})(1-2\xi)^2} \tag{10}$$

respectively. Note that in this model real exchange rate is proportional to terms of trade

$$\widehat{rs}_t = \widehat{rs}_t(1-2\xi)^2 \tag{11}$$

For Foreign, the equations of the model can be described symmetrically.

Finally, the law of motion for productivity shocks and monetary shocks is governed by

$$\begin{pmatrix} \hat{a}_t \\ \hat{a}_t^* \end{pmatrix} \approx \begin{pmatrix} \delta_a & \delta_{a,a^*} \\ \delta_{a,a^*} & \delta_a \end{pmatrix} \begin{pmatrix} \hat{a}_{t-1} \\ \hat{a}_{t-1}^* \end{pmatrix} + \begin{pmatrix} \hat{\varepsilon}_t^a \\ \hat{\varepsilon}_t^{a*} \end{pmatrix} \tag{12}$$

$$\begin{pmatrix} \hat{\varepsilon}_t^a \\ \hat{\varepsilon}_t^{a*} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_a^2 & \sigma_a \sigma_a^* \rho_{a,a^*} \\ \sigma_a \sigma_a^* \rho_{a,a^*} & \sigma_{a^*}^2 \end{pmatrix} \right) \tag{13}$$

$$\begin{pmatrix} \hat{v}_t \\ \hat{v}_t^* \end{pmatrix} \approx \begin{pmatrix} \delta_m & 0 \\ 0 & \delta_m \end{pmatrix} \begin{pmatrix} \hat{v}_{t-1} \\ \hat{v}_{t-1}^* \end{pmatrix} + \begin{pmatrix} \hat{\varepsilon}_t^v \\ \hat{\varepsilon}_t^{v*} \end{pmatrix} \tag{14}$$

$$\begin{pmatrix} \hat{\varepsilon}_t^v \\ \hat{\varepsilon}_t^{v*} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_v^2 & \rho_{v,v^*} \sigma_v \sigma_{v^*} \\ \rho_{v,v^*} \sigma_v \sigma_{v^*} & \sigma_{v^*}^2 \end{pmatrix} \right) \tag{15}$$

The composite parameters of the model are given below,

$$\begin{gathered} \Theta \equiv (1-\xi) \left[\frac{\sigma\gamma - (\sigma\gamma-1)(1-2\xi)}{\sigma\gamma - (\sigma\gamma-1)(1-2\xi)^2} \right] \\ \Lambda \equiv 1 + (\sigma\gamma - 1) \left[\frac{\gamma\xi 2(1-\xi)}{\varphi\left(\sigma\gamma - (\sigma\gamma-1)(1-2\xi)^2\right) + \gamma} \right] \\ \Gamma \equiv \xi \left[\sigma\gamma + (\sigma\gamma - 1)(1-2\xi) \right] \\ \Psi_{\pi,z} \equiv -\sigma\xi(\varphi+\gamma) + (\sigma - \tfrac{1}{\gamma})(1-2\xi)(\varphi\xi(1-2\xi) - \gamma(1-\xi)) \end{gathered}$$

Key Implications for Forecasting Inflation

Proposition 1 *No variables other than domestic and foreign slack should help improve the forecast of changes in global inflation. The forecasting relationship for domestic inflation implied by the workhorse Open-Economy New Keynesian model of Martínez-García and Wynne (2010) can be expressed as,*

$$\begin{aligned} \mathbb{E}_t\left(\widehat{\pi}_{t+j}\right) &= \widehat{\pi}_t - \frac{1}{2}\left(\frac{\lambda^W}{\mu^W} + \frac{\lambda^R}{\mu^R}\right)\widehat{x}_t - \frac{1}{2}\left(\frac{\lambda^W}{\mu^W} - \frac{\lambda^R}{\mu^R}\right)\widehat{x}_t^* & (16)\\ &= \widehat{\pi}_t - \frac{\lambda^W}{\mu^W}\widehat{x}_t + \left(\frac{\lambda^W}{\mu^W} - \frac{\lambda^R}{\mu^R}\right)\frac{1}{2}\widehat{x}_t^R & (17)\\ &= \widehat{\pi}_t - \frac{\lambda^R}{\mu^R}\widehat{x}_t - \left(\frac{\lambda^W}{\mu^W} - \frac{\lambda^R}{\mu^R}\right)\widehat{x}_t^W, & (18) \end{aligned}$$

where global slack and differential slack can be proxied by the global real money demand gap and the terms of trade gap (or real exchange rate gap) as follows,

$$\begin{aligned} \widehat{x}_t^W &\equiv \frac{1}{2}\widehat{x}_t + \frac{1}{2}\widehat{x}_t^* \approx \frac{1}{\chi}\widehat{m}_t^{g,W}, \\ \widehat{x}_t^R &\equiv \widehat{x}_t - \widehat{x}_t^* \approx \frac{1}{\kappa^{tot}}\left(\widehat{tot}_t - \widehat{\overline{tot}}_t\right) \approx \frac{1}{\kappa^{rs}}\left(\widehat{rs}_t - \widehat{\overline{rs}}_t\right), \end{aligned}$$

where $\chi \equiv \left(1 - \eta\left(-\psi_\pi \frac{\lambda^W}{\mu^W} + \psi_x\right)\right)$, $\kappa^{tot} \equiv \left[\frac{\gamma}{\sigma\gamma - (\sigma\gamma-1)(1-2\xi)^2}\right]$ *and* $\kappa^{rs} \equiv (1-2\xi)\left[\frac{\gamma}{\sigma\gamma - (\sigma\gamma-1)(1-2\xi)^2}\right]$.

2.2 Calibration and Simulation

Calibration The model parameters are summarized in Table 1a below.[9] We calibrate the two countries to the U.S. and Europe. Our calibration strategy is two-fold. For parameters that are of particular interest for our study, we use the (median) values of historical estimates of these parameters. For the remaining parameters, we refer to the literature. We set $\beta = 0.99$, $\gamma = \varphi = 5$, and $\alpha = 0.75$, in light of Chari et al. (2002).[10] This is also similar to the closed economy model in Neiss and Nelson (2003) and Neiss and Nelson (2005). We assume that countries are equal in population, $n = 0.5$, and the allocation of home and foreign goods in the consumption basket of each country is symmetric, $\xi = 1 - \xi^*$. We set $\eta = \eta^* = 4$, as described in Galí (2008). We assume that the cross-country spillover of the productivity shocks, δ_{aa^*}, is zero. The correlations of domestic and foreign productivity innovations ρ_{a,a^*} are set as zero, while the correlation of domestic and foreign monetary innovations, ρ_{v,v^*}, is set as 0.5, following Chari et al. (2002).[11] We assume further that the monetary and productivity innovations are uncorrelated with each other.

For the remaining parameters which are key for our analysis, we conduct rolling window estimations. We use the median of these estimates in the benchmark calibration for 2004:Q1-2008:Q2. Our calibration strategy is summarized in Table 1b. (See the appendix for the details of the estimation and the results.) Our results suggest the presence of structural shifts on a number of key parameters. This motivates us to explore three channels on the forecasting performance of standard leading variables from open-economy Phillips curves for US inflation. In particular, we are interested in explaining how good luck, changes in the conduct of monetary policy, and the effects of globalization play a role in determining the observed forecasting performances. In order to obtain the historical estimates, we conduct 20-year rolling window regressions on the processes underlying the behavior of the Solow residual, the Taylor rule and the monetary policy shock, as well as the import shares and the price elasticity of trade. These estimates are solely based on U.S. data and abstract from some aspects that are essential in the model for lack of comparable data—like the extent of international linkages, for instance, in the case of estimating spillovers and covariances for the Solow residual. (However, our forecast results are also robust to parameter values suggested by the literature for cross-country spillovers and covariances). The choice of the starting and ending dates of these periods are determined by the observed structural breaks as well as limitations on data.[12] Hence, we suggest that there are two periods that need to be considered, 1973:Q4-1983:Q4 and 2004:Q1-2008:Q2.[13] Therefore, we put the emphasis in understanding, broadly, what happened between the late 1960s and prior to the 2008 recession, covering most of the Great Moderation. While the first period is characterized by a very large probability that the policy rule violated the Taylor principle,[14] we think it is beyond the scope of this model to analyze the forecasting performance during the period of indeterminacy prior to that. Accordingly, we assume that

[9] An alternative could be to estimate the model, as in Benati and Surico (2008). One possible argument in favor of calibration, however, is that the model may be too simplified. Hence one may be concerned that estimating it would lead to misspecification bias and, therefore, would complicate the interpretation of parameter estimates and our subsequent experiments even more.

[10] Chari et al. (2002) considers an aggregate of France, Germany, Italy, and the UK for 1973:1-1994:4.

[11] We also tried other values for these parameters, where we set $\delta_{aa^*} = 0.025$ and $\rho_{a,a^*} = 0.25$, as suggested by Heathcote and Perri (2002), and found the results are robust to this alternative parameterization.

[12] We mark important dates for monetary policy changes as follows. The period for Volcker's Policy of Targeting Monetary Aggregates is October 1979 - October 1982. Greenspan took office in August of 1987. Also note that the 2001 recession started in the first quarter; and that the 2008 recession started officially in the fourth quarter of 2007 in the US but it did not became severe until the second or third quarter of 2008.

[13] Hence our historical estimates for model's parameters use data between 1984Q1-2008Q2, and 1953Q4-1983Q4.

[14] Although the Taylor principle is neither necessary nor sufficient for determinacy in this open economy model, it is a very good short-hand approximation for the region of the parameter space where the model would be determinate as shown in Martínez-García and Wynne (2010)

the Taylor rule is noninertial and the policy rule is identical in both countries. We use the U.S. data and obtain the two policy rule parameter estimates $\Psi_\pi = 1.76$ and $\Psi_x = 0.74$. The persistence and volatility parameters of AR(1) monetary shock process are $\delta_v = 0$ and $\sigma_v = 1.31$, respectively. For the productivity shock, the persistence and volatility parameters are $\delta_a = 0.81$ and $\sigma_a = 0.69$, respectively. The parameters of shock processes are the same for the two countries. The Europe share of goods in the U.S. consumption basket $\xi = 0.08$. The elasticity of substitution between U.S. and European goods, σ, is set at 0.97.

Table 1a: Model parameters	
Structural parameters	
Intertemporal discount factor	$0 < \beta < 1$
Inverse of the intertemporal elasticity of substitution	$\gamma > 0$
Inverse of the Frisch elasticity of labor supply	$\varphi > 0$
Interest semi-elasticity of money demand	$\eta > 0$
Elasticity of substitution across varieties within a country	$\theta > 1$
Elasticity of substitution between Home and Foreign bundles	$\sigma > 0$
Share of Home goods in the Home basket	$0 < \xi < 1$
Share of Home goods in the Foreign basket	$0 < \xi^* < 1$
Home population size, Mass of Home varieties	$0 < n < 1$
Foreign population size, Mass of Foreign varieties	$0 < 1 - n < 1$
Calvo (1983) price stickiness parameter	$0 < \alpha < 1$
Monetary policy parameters	
Monetary policy inertia	$0 < \rho_i < 1$
Sensitivity to deviations from the inflation target	$\Psi_\pi > 1$
Sensitivity to deviations from the potential output target	$\Psi_x > 0$
Shock parameters	
Persistence of the productivity shock	$-1 < \delta_a < 1$
Cross-country spillover of the productivity shocks	$-1 < \delta_{aa^*} < 1$
Volatility of the productivity shock	$\sigma_a > 0$
Correl. between Home and Foreign productivity innovations	$-1 < \rho_{a,a^*} < 1$
Persistence of the monetary policy shock	$-1 < \delta_v < 1$
Cross-country spillover of the monetary policy shock	$-1 < \delta_{v,v^*} < 1$
Volatility of the monetary policy shock	$\sigma_v > 0$
Correl. between Home and Foreign monetary innovations	$-1 < \rho_{v,v^*} < 1$

While we calibrate the model to the median values of the parameter estimates for the (benchmark) 2004:Q1-2008:Q2 period, we also consider other plausible values that lie within the upperbounds and lowerbounds of these parameter values using the 95% confidence bands of the estimates in this period as well as in the (counterfactual) 1973:Q4-1983:Q4 period.

To produce data, we run a Monte Carlo simulation of the model with 100 trials and with a subsample of 160 periods for each trial. We split the 160 periods equally between the estimation sample and the pseudo out-of-sample forecast sample to be consistent with our empirical analysis.

Using the simulated data, we forecast inflation using two-variable and three-variable recursive forecasts.

We run $1-$,$4-$, and $12-$quarters ahead inflation forecasts we test the various forms of the Phillips curve. In particular, we calculate the (relative) mean square forecast errors (MSFEs) at a grid of points that spans the space for selected parameters, while keeping other parameters at their benchmark values. We conduct the grid search symmetrically for the two countries. In these 100 trials, we evaluate forecasting performance based on the median (relative) MSFE, median p-value of the hypothesis that the relative MSFE is greater than or equal to 1, and the fraction of statistically significant trials with p-values less than or equal to 5 percent. (The details of our forecast methodology are described in the next section.) The analyses conducted here can be grouped under three main experiments: *i)* Good luck, *ii)* Monetary policy, and *iii)* Openness.

i) Good luck[15] experiment focuses on how forecasting performance of the regressors listed above is altered when the parameters of innovations, specifically the volatility of shocks, σ_v and σ_a take on different values. We perform this exercise symmetrically for both countries: $\sigma_v = \sigma_{v^*}$, and the parameter value varies within $[1.06, 1.88]$ and $\sigma_a = \sigma_{a^*}$ taking values within $[0.59, 1.83]$.

ii) Our *monetary policy* experiments pay attention to forecasting performance under changes in the monetary policy parameters Ψ_π and Ψ_x.We discard estimates that lie in the indeterminacy region. Hence, for Ψ_π, we try values of grid points in the interval $(1, 3.76]$ and Ψ_x, in the interval $(0, 0.99]$.

iii) The final experiment, *trade openness*, involves a grid search over the parameters of share of foreign goods in the home basket, ξ and elasticity of substitution between Home and Foreign bundles, σ. For ξ we try the values in the intervals $(0, 0.5]$ **(in our final experiments)**, hence, under the case ξ is close to 0, the economy is almost closed and there is home bias, while under $\xi = 0.5$ there is no bias between consumption and production and the economy is open. For σ, we try values within the range $[0.16, 1.81]$. Note that $\sigma = 1$ implies the consumption aggregator is Cobb-Douglas type.

[15] In the current terminology, 'good luck' is used in order to explore the possibility of exogenous changes in the distribution of the shock process. These changes might cause a draw of unusually benign shocks to the economy. Good luck might be the result of an unusual draw of shocks from the right-tail of distribution but that is not the interpretation we give here. Rather, we interpret good luck as the shift in the distribution of shocks.

Calibration		1973Q4-1983Q4 (Counterfactuals)	2004:1-2008:2 (Benchmark)
Good luck	σ_a	$[1.12, 1.91]$	$[0.59, 0.97]$
	σ_v	$[0.31, 0.93]$	$[1.10, 1.88]$
Monetary policy	$\Psi\pi$	$(1, 3.76]$	$[1.30, 2.42]$
	Ψ_x	$[0.48, 1)$	$(0, 0.99]$
Openness	σ	$(0, 1.13]$	$[0.16, 1.81]$
	ξ	$[0.035, 0.055]$	$[0.048, 0.096]$
	σ_a	1.30	0.69
	σ_v	1.41	1.31
	$\Psi\pi$	1.02	1.76
Benchmark values	Ψ_x	0.37	0.74
(period averages)	σ	0.81	0.97
	ξ	0.03	0.08
	ρ_i	0.00	0.00
	δ_a	0.93	0.81
	δ_v	0.00	0.00
	δ_{aa^*}	0.00	0.00
	ρ_{aa^*}	0.00	0.00
	ρ_{vv^*}	0.50	0.50

2.3 Simulation

2.3.1 Forecast Models

Stock and Watson (1999a), Stock and Watson (1999b) and Stock and Watson (2008) provide some empirical evidence in favor of the Phillips curve as a forecasting tool, suggesting that inflation forecasts produced by the Phillips curve generally are more accurate than forecasts based on other macroeconomic variables (including interest rates, money, and commodity prices). Following Stock and Watson (2003a), we refer the models with explanatory variables as economic models and we assess to what extent these economic models represent an improvement over the univariate model of forecasting inflation in theory.

In order to test the global slack hypothesis in theory, we use global slack and variables that are proportional to global slack as shown in our theoretical results under the Martínez-García and Wynne (2010) framework.

First, we consider the traditional backward-looking Phillips curve relating inflation to aggregate real economic activity, as typically specified by the previous empirical literature in order to test the performance of domestic slack (and money growth, as a proxy for slack)

$$\hat{\pi}^h_{t+h|t} = a_1 + \lambda_{11}(L)\hat{\pi}_t + \lambda_{12}(L)\hat{x}_t + \hat{\epsilon}_{1,t+h}. \quad \text{(Model 1)}$$

By denoting the quarterly forecast horizon as h, it is possible to forecast h-quarter ahead inflation, $\hat{\pi}^h_{t+h|t}$, with the distributed lag of earlier inflation rates, $\hat{\pi}_t$ as a proxy for expected inflation, and the distributed lag of the domestic measure, $\hat{x}_t$. We define h-quarter ahead (annualized) inflation $\hat{\pi}^h_{t+h|t} = \frac{400}{h} \times [log(P_{t+h}/P_t)]$, and forecast inflation for horizons ranging from 1 quarter-ahead to 12-quarters ahead. The number of lags for each variable is selected based on SIC. To keep the model parsimonious, and since the frequency of the variables is defined as quarterly, the maximum possible lags allowed for each variable is set as four.

In order to test the performance of global slack (as described by two variables, domestic and foreign slack) and its proxies (domestic slack and terms of trade gap, domestic and foreign money growth) we introduce an alternative forecast model as given below

$$\hat{\pi}^h_{t+h|t} = a_2 + \lambda_{21}(L)\hat{\pi}_t + \lambda_{22}(L)\hat{x}_t + \lambda_{23}(L)\hat{z}_t + \hat{\epsilon}_{2,t+h}. \qquad \text{(Model 2)}$$

Under this specification, $\hat{x}_t$ and $\hat{z}_t$ denote, respectively, either (i) domestic and foreign slack, (ii) domestic slack and terms of trade gap, or (iii) domestic and foreign money growth. We underline some important points here. First, we use first-differenced terms of trade as a terms of trade gap measure, rather than using the theoretically-consistent variable because the theoretical terms of trade gap does not exist in practice. The first-differenced terms of trade can still proxy the true terms of trade gap in theory, and this is supported by our quantitative experiments. Second, there is no need to test the performance of real exchange rate gap as it would yield the same results with terms of trade gap.[16] Third, the model does not differentiate between terms of trade and terms of trade ex. oil and we leave the analyses of these different variables to the empirical section. And finally, we use world (nominal) money growth to proxy for world real money gap which is shown to be proportional to global slack. One could argue that real world money growth should be used as a proxy for the world real money gap instead, but then real world money growth could be expressed in terms of the difference between the nominal world money growth and world inflation. Therefore, one could view that nominal world money growth alone should be a sufficient proxy for global slack and has information content for inflation.

Finally, in order to compare the performance of these models against a benchmark, we introduce the 'restricted' model specified as a univariate autoregressive (AR) process

$$\hat{\pi}^h_{t+h|t} = a_3 + \lambda_3(L)\hat{\pi}_t + \hat{\epsilon}_{3,t+h}. \qquad \text{(Model 3)}$$

2.3.2 Forecast Scheme

We perform forecasts based on the pseudo out-of-sample forecasting method and particularly focus on recursive samples. Therefore, at any given date t, we forecast inflation at date $t + h$ using all available data up to date t. The models are estimated by OLS.

We assess the multi-step pseudo out-of-sample forecasting performance of a model that incorporates the variables commonly thought as contemporaneous or leading indicators of inflation relative to the forecast of a univariate autoregressive process. Our forecast evaluation metric, the relative MSFE, is the ratio of MSFE of the economic model (Model 1 or Model 2) relative to that of the benchmark AR model (Model 3). Let T_0 denote the starting date of the data series and T_1 denote the end. The estimation sample starts at T_0 and ends in t_0. We start by using all data up to date t_0 to forecast inflation at date $t_0 + h$. By adding data to the estimation sample, we keep estimating the parameters of the model of interest. The $h-$step

[16] Obviously, there is a pronounced discrepancy between terms of trade and REER results in the empirical section we will present later, since the two variables are defined and measured differently in practice.

recursive forecast continues until period $T_1 - h$ with a total of $T_1 - h - t_0 + 1$ steps. For a given model j, this procedure yields a sequence of forecast errors which helps us construct the MSFE of the model at horizon h and from date t_0 to $T_1 - h$

$$MSFE_j(h) = \frac{1}{T_1 - h - t_0 + 1} \sum_{t=t_0}^{T_1-h} \hat{\hat{\epsilon}}_{j,t+h}^2$$

2.3.3 Inference and Samples

Inference is based on the F-statistics against critical values based on a bootstrap algorithm described in Clark and McCracken (2006).[17] This procedure involves resampling from the residuals of vector autoregressive (VAR) equations. In order to test the predictive ability of a single variable forecast as in Model 1, we define an equation for inflation (as governed by the restricted model) and an equation for the predicting variable, where the lag length for the predicting variable and inflation are separately determined based on SIC. The equations of the data generation process (DGP) are estimated by OLS with a number of bootstrap iterations equal to 5000. (The details of the bootstrap algorithm with two variables are described in the appendix.) We have a one-sided test with the null hypothesis that an economic model (Model 1 or Model 2) does not yield more accurate forecasts than the AR process (Model 3), i.e. $MSFE_{AR} \leq MSFE_{EM}$, against the alternative $MSFE_{AR} > MSFE_{EM}$. Throughout the paper, we report the MSFE of the benchmark model and the relative MSFEs of a particular economic model and the benchmark. The null hypothesis is expressed as 'the relative MSFE is greater than or equal to 1'. We report the p-values of the F-test at 1%, 5% and 10% significance levels.

2.4 Results and Interpretation

In light of our quantitative analyses, we show that an open economy Phillips curve helps forecast US inflation and moreover, given a plausible calibration of the model, global slack and other global economic variables seem to have gained value in forecasting inflation. Hence these variables appear to be good forecasting variables and most importantly, they can be used as proxies for global slack. Figures 7a-e, 8a-e, and 9a-e in the Appendix illustrate the simulated forecast results regarding good luck, monetary policy and openness experiments, respectively. The figures report results under all historically plausible values for the parameters of interest, while we also mark the median values to facilitate a comparison between Period 2 (benchmark) and Period 1 (counterfactual).

- The key results from good luck experiments (in Figures 7a-e) are summarized as follows. All Phillips curve-based forecasts (constructed with domestic or domestic and foreign variables), have gained accuracy relative to the naive forecasts during the great moderation period compared to the pre-great moderation period due to the declines in the volatility of productivity shocks, σ_a. However, a decline in monetary policy shocks, σ_v, all else equal, seems to have reduced forecast accuracy in general, but this effect is offset by the effect of productivity shocks.

[17] The construction of F-statistics as well as t-statistics are described in Clark and McCracken (2001b), Clark and McCracken (2001a) and Clark and McCracken (2002) Inference can also be based on t-statistics, however, as suggested in these papers, F-type tests are more powerful than the corresponding t-type tests, and therefore we focus on F-statistics only.

- The monetary policy experiments (in Figures 8a-e) suggest that it is the parameter on the deviation from the inflation target, Ψ_π, rather than the output gap, Ψ_x, that matters for the changes in forecast accuracy given the plausible ranges for the parameter values. All else held constant, a higher anti-inflationary bias improves forecasts for both closed and open-economy Phillips curves, and for short horizons.
- Our results from the *openness* experiment are shown in Figures 9a-e. Increases in both the input shares, ξ, and elasticitiy of substitution between exports and imports, σ, improves the performance of open-economy Phillips curve-based forecasts only (relative to naïve forecasts).
- In Table 1c below, we show a summary of the simulation results.

Table 1c: Predictive performances of variables

		Domestic slack	Domestic & foreign slack (theoretical)	Domestic slack (theoretical) &ToT (FD)	Domestic money growth	Domestic & foreign money growth
Good luck	σ_v					
	σ_a	✓	✓	✓	✓	✓
Monetary policy	Ψ_π	✓	✓	✓	✓	✓
	Ψ_x					
Openness	ξ		✓	✓		✓
	σ		✓	✓		✓

Note: This table reports whether changes in a given parameter have a statistically significant impact on predictive ability of a variable (at least at 5% significance level) in at least 50% of the trials of the experiment.

3 Empirical Analysis

Having established the main findings from the simulated forecasts, we aim to test these results empirically. We perform these forecasting exercises here to readdress the role of some of these measures in order to provide with a comparison with our main forecasting strategy and to also make an extensive robustness analysis of the earlier work. We evaluate the predictive ability of open economy Phillips curves using global output gap measures, as well as variables that can be shown to be proportional to global slack in theory: (i) global money growth, (ii) global credit growth, (iii) domestic slack and terms of trade gap (iv) domestic slack and real exchange rate gap.

The issue of how to measure the output gap—both domestic and foreign—has been known as a major challenge. For purely statistical approaches which in most cases derive potential output using actual (real) output series through a filtering technique (most commonly the HP filter), the choice of the filter is usually an arbitrary decision. In addition, applying these techniques are known to create end-point problems. For structural estimates of the output gap, relying on a production function (such as Cobb-Douglas) and quantifying the total factor productivity, the capital stock or labor employed tend to pose measurement problems (Gerlach (2011)).

Measuring the foreign output gap, however, is an even more challenging task since for the emerging market economies that are believed to potentially affect the U.S. inflation, the data series to measure unemployment rates or capacity utilization in manufacturing are usually either too short or they are not available. Furthermore, there is also not a clear idea on how the dynamics of foreign output gap affects the domestic inflation. Therefore, estimating the open-economy Phillips curve based on the combination of domestic and foreign slack as a measure of the global slack becomes a difficulty.

This problem has been addressed also in an earlier work by Martínez-García and Wynne (2010) where they defined global slack in reduced form as a combination of domestic slack and terms of trade gap. In theory, terms of trade gap in addition to domestic output gap has information content for forecasting domestic inflation, as formulated in an open economy Phillips curve. Since terms of trade gap and real exchange rate are proportional in theory, one can replace terms of trade measures by real exchange rate measures. We apply one-sided filters (first-differencing and HP filter) on terms of trade and real effective exchange rate series to obtain terms of trade and real exchange rate gap measures.

The long-run relationship between the growth rate of monetary aggregates and the rate of inflation is explained in the literature by the quantity theory of money, and these measures of money growth are suggested to have information content for inflation forecasting. However, we take a different view here on the predictive ability of money and suggest that money has information content because it is related to output gap, if one considers a standard NK model.[18] A similar argument could be made intuitively for credit growth, as well—even though it is not modelled in a standard open-economy NK framework. Under this framework, real world money gap is shown to be proportional to global slack. In order to proxy for real world money gap, we use global money growth measures (and global credit growth measures, similiarly.)

3.1 Data

Figures 1a and 1b plot the series employed throughout the paper. The U.S. inflation rate is calculated as annualized log-differences of quarterly series of six price indices in our benchmark and rolling window forecasts: consumer price index (CPI), core CPI (CPI ex. food and energy), personal consumption expenditure deflator (PCE), core PCE (PCE ex. food and energy), GDP deflator and producer price index (PPI). In addition, we consider two short inflation series: The Atlanta Fed sticky price and sticky price ex. shelter which are used only in the benchmark analysis.

We perform inflation forecasts using a wide range of domestic and global slack measures. Our domestic measures consist of: CBO U.S. slack, FRBD U.S. slack, OECD U.S. slack, IMF U.S. slack and HP-filtered U.S. real GDP. For global slack measures, we use: FRBD G7, FRBD G39, OECD G7, OECD Total and IMF Advanced series. All series are available quarterly, except for the IMF measures of domestic and global slack, which is available in annual frequency. Therefore, we disaggregate these series into quarterly frequency using the quadratic match average method.

The terms of trade series is calculated as the ratio of the U.S. export price index of goods and services to the U.S. import price of goods and services. For terms of trade ex. oil, however, we use the price indices

[18] In particular, global real money growth is shown to be proportional to global output gap in the standard NOEM model studied in this paper.

for exported goods and nonpetroleum imported goods, due to limited data availability. We use 1-sided filters (first differences, HP filter) in order to obtain a measure of the terms of trade gap. We use U.S. trade-weighted real effective exchange rate series and apply these filters to obtain real exchange rate gap measures.

We define global money growth as the average of the percentage growth rates of monetary aggregates in G7 countries. While we pick the series for monetary aggregates that are most similar in definition, we are constrained by quarterly data availability for Canada, France, Germany, Italy and Japan particularly for late 1960s or early 1970s. Since we would like to extend the robustness analysis of forecasting experiments to a large estimation sample, we make our primary decision on selection based on data availability.

We construct a measure of global credit growth, by calculating the G7 average of credit growth rates. We consider quarterly, long series on credit to non-financial sectors in G7 countries. We particularly focus on credit from all sectors to the private sector. (A more detailed explanation is available in the appendix.)

3.2 Forecast Models

Our forecast strategy for the empirical forecasts is the same as in the simulated forecasts. In this section however, we only consider bivariate forecasts and a univariate AR process for a benchmark specification, as described by Model 1 and Model 3, respectively. The bivariate economic models are used in order to evaluate the forecast accuracy of domestic slack and global slack, domestic and global liquidity growth[19], domestic and global credit growth, and terms of trade and real effective exchange rate gap measures.[20]

In our benchmark experiments, the estimation sample begins in the 1980:Q1 and ends in 1991:Q4 and the pseudo out-of-sample forecasting period begins in 1992:Q1 and 2011:Q4 leaving us with an estimation sample of 48 quarters and the pseudo out-of-sample forecasting sample of 80 quarters.[21]

In addition to our benchmark forecasting experiment, we conduct a series of other experiments going back in time to the extent that the series are available in order to make a robustness analysis. More specifically, starting with the initial observation in the sample, we shift the estimation and forecast samples backward by one quarter and obtain the relative MSFEs of the forecasts for each 'rolling window'.[22] Each window spans 48 quarters of an estimation sample and 48 quarters of a forecasting sample.

The regression equation for open economy Phillips curves that use domestic output gap and terms of trade (or REER) can be described as in Model 2. In an initial assessment, we found mixed results from forecasting inflation with a domestic output gap and terms of trade gap (measured as first-differenced terms

[19] D'Agostino and Surico (2009) evaluate the forecasting performance of the average growth rate of broad money in G7 economies and find that the results are significantly more accurate compared to forecasts with US money growth.

[20] Canova (2007) evaluated the performance of nominal and real money growth across G7 economies for the 1996Q1-2000Q4 period (or the subperiods) and found these results are comparable to Phillips curve based forecasts.

[21] Our selection of the size of the estimation and pseudo out-of-sample forecasting samples in the benchmark experiments follow that of D'Agostino and Surico (2009) which enables us to compare the measures used to forecast inflation with their measures of money. In our robustness analyses, we make a symmetric allocation of the observations for the two samples.

[22] While we adopt the bootstrap algorithm of Clark and McCraken (2006) for empirical inference with recursive forecasts we did also consider the implementation of the fluctuations test of Giacomini and Rossi (2010) using Giacomini and White (2006) test statistic (Giacomini and Rossi (2010) refer to this as the GW test). This test statistic is also equivalent to Diebold and Mariano (1995) and West (1996) test statistics. Clark and McCracken (2013) note that the Diebold-Mariano-West framework is not supposed to be valid in general for the case of nested models that we have considered in this paper, although it may still work in finite samples. However, Giacomini and Rossi (2010) show in Monte Carlo experiments that the full sample GW test seems to have very low power—so conditional on the null hypothesis of equal forecast accuracy being false, the probability of rejecting such null is very low. That is essentially what our implementation of the GW test, whose results are available upon request, would suggest. In finite samples with the data we have, we generally find that the GW test imposes a threshold to detect differences in forecasting performance harder to cross than the test of **?**) does.

of trade),[23] and obtained stronger results with one variable forecasts of terms of trade gap or REER gap. In this regard, weak empirical evidence on some measures of global slack does not necessarily invalidate the global slack hypothesis, but may indicate that measures available are prone to well-known measurement errors.[24]

Hence we use the bivariate specification (Model 1) to test the predictive ability of all Phillips forecasts. We also note that some of the global slack variables that we use come from international organizations such as the IMF and OECD that use their own aggregation methods. The Dallas Fed measures are based on constant PPP-adjusted GDP weights. For our global money supply growth measure, we use a simple arithmetic average followingD'Agostino and Surico (2009). For global credit growth, we follow the same aggregation technique. We recognize that there are different aggregation schemes for different variables. However, what we are doing is using indicators most of which have been already introduced in the literature or that have become standard for use in applied work. Even if we adopted a common aggregation scheme, for instance, we would not be able to decompose most of the global slack measures into domestic and foreign components. Therefore, we just accept that differences in aggregation may be another contributing factor explaining the empirical evidence that we find. Hence, in the empirical part, we only focus on bivariate forecasts.

3.3 Empirical Findings

The results of the pseudo out-of-sample forecast with one variable over the benchmark sample are reported in Tables 2-4. Our findings can be listed as follows:

1. Based on the one-variable forecast results, it is not possible to say that global slack measures outperform the domestic slack measures. In general, both measures almost equally yield more accurate predictions compared to an AR process when the inflation measure is core CPI and core PCE. For other measures of inflation, however, we conclude that the AR process of inflation performs better.

2. Global money growth (measured as G7 average) exhibits a better forecasting performance relative to U.S. money growth, at all horizons for CPI, core CPI and PCE deflator. Both variables have a significantly poor performance compared to the AR process in all other inflation measures. Under the forecasts of CPI and PCE inflation, G7 money growth also does better compared to domestic or global slack measures. However, this is not true for the other measures of inflation.[25]

3. Forecasting performance of terms of trade is comparable to those of domestic and global slack measures. Terms of trade ex. oil has no significant improvement over the AR specification across any of the inflation measures and at any horizon.[26]

[23]Similar results can be confirmed when terms of trade is replaced by real effective exchange rate (first-differenced).

[24]Clark and McCracken (2006) suggest that in asymptotically nested models, there is a trade-off to adding regressors to the forecast model: the fit may improve with the additional regressor while estimation error variance increases. This may be another concern for multivariate forecasts, but we mainly focus on that measurement problems of regressors, particularly the slack measures.

[25]While real money growth measure is theoretically relevant, the nominal money measures help forecast inflation more accurately (relative to the naive specification) based on our initial assessments. Hence we restrict our analysis to nominal measures throughout the paper.

[26]We also observe high forecasting performances by two oil price indices, West Texas Intermediate and Saudi Arabian Light, and especially with headline inflation measures. However, we do not report these results in the current paper as oil prices are beyond the scope of our framework.

We also perform rolling window experiments for three groups of variables: a domestic slack measure vs. two global slack measures; terms of trade vs. terms of trade ex. oil, domestic vs. global money supply growth and domestic vs. global credit growth. Among several alternatives, we choose CBO measure as the domestic slack variable and 'OECD Total' and 'FRBD G7' as our global slack measures. Our selection of the two measures is based mainly on the length of the series and the relatively better performance compared to other slack measures at hand. In Figures 2a-6b, we show how the forecasting performances of these pairs of variables evolve over time. In these figures, several interesting points emerge:

1. Terms of trade and terms of trade ex. oil produce a successful pattern in terms of forecasting performance starting in mid-1980s (Figures 2a-3b). There is not a regular pattern as to whether terms of trade or terms of trade ex. oil performs better, but usually we observe only one definition of terms of trade performing well. REER series seem to perform almost as well as terms of trade (Figures 4a-b).

2. For the CBO U.S. measure of output gap, we confirm the literature following Atkeson and Ohanian (2001), where domestic slack does not help forecast inflation relative to the simple AR process of inflation starting in mid-1980s (Figures 5a-b). In forecasts starting from 1960s through 1970s (where global slack measures are not available), the CBO measure of U.S. slack has a significantly better performance than the AR specification, especially at short horizons. The global slack measures, FRBD G7 and OECD Total, seem to perform only well in forecasting CPI inflation during late 1980s.

3. The predictive ability of money growth measures (Figures 6a-b) are significantly higher compared to the previous measures considered so far in this paper. With some occasional breaks, the US money supply growth outperforms the naive forecasts, especially starting late 1970s, over long horizons, and across several inflation measures. G7 money supply growth yields even more accurate forecasts over the same sample and horizons than its US counterpart across all inflation measures with the exception in GDP deflator and PPI inflation where we see a break in late 1980s. This is interesting because our empirical results based on the benchmark sample are in line with those in D'Agostino and Surico (2009) where they analyze the 1990:1-2006:2 period and show that global money growth-based forecasts seem to be more accurate than the domestic money which beats the naive forecasts of inflation. However, the results in the rolling window forecasts (where we increase the sample size at each roll) reveal that these findings do not seem to be robust to sample selection after 1980s. Therefore, at least for the two measures of inflation, it may still be questioned whether the information content of money is reflected only in the global measure of liquidity growth, rather than the domestic measure.

4. Credit growth measures, for both the US and G7 (Figures 7a-b), appear to be highly successful forecasting variables for US inflation. Both variables outperform the simple AR process of inflation and yield low relative MSFEs especially during mid-1980s. And unlike in the case of the money growth measures, the information content of credit growth is particularly reflected in the global measure rather than the domestic counterpart, and the G7 credit growth yields highly accurate forecasts across all inflation measures, over all horizons after mid-1980s.

In the next section, we aim to investigate the causes behind these patterns. Some of these variables, such as domestic and global credit, are not present in the model at hand and therefore, we would like to particularly shed light on the patterns for slack, money and terms of trade.

4 Relating theory to stylized facts

Now we compare and contrast theoretical and empirical results to explain how major episodes for the U.S. economy can be related to forecasting performances. We analyze figures (2a-4b) paying particular attention to CPI inflation, since the model at hand is consistent with this measure of inflation. (However, forecasting patterns are robust to other measures of inflation to a great extent.)

The high performance of the Phillips curve-based simulated forecasts is observed at the relatively short horizons (i.e. 1- or 4-quarter ahead forecasts). However, what is interesting is that this observation is also valid for the forecasts with money growth measures—both domestic and global. Indeed, our model based on the short-run open-economy Phillips curve suggests that money as a proxy for the unobserved output gap should perform well at short-horizons. It is less clear whether it should perform well or not at longer horizons: money growth is incorporated into the model through a money demand equation), but it does not perform well at 12-quarter ahead forecasts that we consider in the simulations. Based on our empirical results, it is also important to note that money performs well at longer horizons. This observation may be connected with the quantity theory of money (i.e. with a purely monetarist interpretation).[27] The model explains the short-run, and at shorter horizons money is a good explanatory variable to forecast inflation because it is a good proxy for the unobserved measures of slack. However, the model does not fully flesh out the long-run implications, so it cannot offer much guidance on that dimension. Still, the fact that it empirically turns out to be the case reinforces the value of these monetary aggregates in forecasting inflation.

These results also show that domestic slack and terms of trade (first-differenced) serve together as a good proxy for global slack. This would be true for real exchange rate (first-differenced), which is proportional to terms of trade in the model, and therefore we do not report these results here. In all experiments, forecasts with domestic slack and terms of trade outperform the naive forecasts around the benchmark parameterization, at relatively short horizons. This indicates that by first differencing the terms of trade series, we obtain a good proxy for the unobserved, model-consistent terms of trade gap. However, our empirical analysis yields mixed results with domestic slack (CBO measure) and terms of trade or REER,[28] and better results with terms of trade or REER alone. In light of the simulations, we view this as a measurement issue primarily for output gap observed in the data.

Finally, the model suggests that domestic slack alone is a good forecasting variable and that the experiments show that all three channels have improved the performance of forecasts with domestic slack over time. Note that these results are markedly different than the empirical forecasts (with CBO slack) which accentuates evidence for (i) output gap series at hand are less perfect than the theoretically-based slack measures and (ii) there might be other channels outside the model that could deteriorate the performance of these forecasts over time.

Therefore, in order to circumvent the measurement problems to which we alluded before, the current open-economy NK model is particularly useful to show that global slack can be represented by (or proportional to) not only domestic and foreign slack but also combinations of *i)* domestic slack and terms of trade gap, and *ii)* domestic and foreign money growth.

[27] Also, in a recent study, Sargent and Surico (2011) provide results on the empirical evidence of the quantity theory of money that may explain the performance of US money growth in forecasting US inflation.

[28] We do not report these results, but they can be provided upon request.

5 Conclusion

It has become a difficult task to beat the naive forecasts of U.S. inflation under a traditional Phillips curve specification over the past three decades. We find theoretical and empirical support for the validity of the global slack hypothesis. To the extent that one uses reliable macroeconomic measures rather than poor measures of global slack, open economy Phillips curves can yield better forecasts than naive forecasts. Specifically, variables such as global money and credit growth, terms of trade and REER, are successful variables for forecasting U.S. inflation. Moreover, these variables perform well compared to forecasts with many conventional and domestic measures: domestic slack, global slack, domestic money supply growth and domestic credit growth.

Our quantitative analysis using empirically plausible parameter values of the open-economy NK model show that open economy Phillips curves have gained more value in forecasting inflation not only through greater openness to trade but also due to changes in the conduct of monetary policy, with a higher anti-inflationary bias and good luck—an unusually benign sample of small shocks hitting the economy, productivity shocks, in particular.

6 Appendix

A Inflation Dynamics in the Open-Economy NK Model

In order to clarify the dynamics of the two-country model in Martínez-García and Wynne (2010), we use the decomposition method into aggregates and differences advocated by Aoki (1981) and Fukuda (1993) to re-express the core linear rational expectations system that characterizes the log-linearized solution into two separate sub-systems. Productivity shocks enter into the dynamics of the model only through their impact on the dynamics of the natural (real) rates in this economy, $\widehat{\overline{r}}_t$ and $\widehat{\overline{r}}_t^*$. The Home and Foreign monetary shock processes $\widehat{v}_t$ and $\widehat{v}_t^*$ enter through the specification of the Taylor monetary policy rule of each country and capture the central bank's expected real rate.

The two countries are assumed to be symmetric in every respect, except on their consumption basket due to the assumption of home-product bias in consumption. Even so, the specification of the home-product bias is inherently symmetric as well since the share of local goods in the local consumption basket is the same in both countries and determined by the parameter ξ. Hence, we define the world aggregate and the difference variables $\widehat{g}_t^W$ and $\widehat{g}_t^R$ as,

$$\widehat{g}_t^W \equiv \frac{1}{2}\widehat{g}_t + \frac{1}{2}\widehat{g}_t^*, \tag{19}$$

$$\widehat{g}_t^R \equiv \widehat{g}_t - \widehat{g}_t^*, \tag{20}$$

which implicitly takes into account that both countries are identical in size (with the same share of the household population and varieties located in each country). We re-write the country variables $\widehat{g}_t$ and $\widehat{g}_t^*$

as,

$$\widehat{g}_t = \widehat{g}_t^W + \frac{1}{2}\widehat{g}_t^R, \tag{21}$$

$$\widehat{g}_t^* = \widehat{g}_t^W - \frac{1}{2}\widehat{g}_t^R. \tag{22}$$

If we characterize the dynamics for $\widehat{g}_t^W$ and $\widehat{g}_t^R$, the transformation above backs out the corresponding variables for each country $\widehat{g}_t$ and $\widehat{g}_t^*$. Naturally, these transformations can be applied to any of the endogenous and exogenous variables in the model. Then, under this transformation, we can orthogonalize the original two-country model of Martínez-García and Wynne (2010) into one aggregate (or world) economic system and one difference system that can be studied independently.

The World Economy. The global system describes the world economy, as if it were a closed economy, based on the following system of three equations,

$$\widehat{\pi}_t^W \approx \beta \mathbb{E}_t\left[\widehat{\pi}_{t+1}^W\right] + \left(\frac{(1-\alpha)(1-\beta\alpha)}{\alpha}\right)(\varphi+\gamma)\,\widehat{x}_t^W, \tag{23}$$

$$\gamma\left(\mathbb{E}_t\left[\widehat{x}_{t+1}^W\right] - \widehat{x}_t^W\right) \approx \left(\widehat{i}_t^W - \mathbb{E}_t\left[\widehat{\pi}_{t+1}^W\right]\right) - \widehat{\overline{r}}_t^W, \tag{24}$$

$$\widehat{i}_t^W \approx \left[\psi_\pi \widehat{\pi}_t^W + \psi_x \widehat{x}_t^W\right] + \widehat{v}_t^W, \tag{25}$$

which can be expressed more compactly in two equations as,

$$\widehat{\pi}_t^W \approx \beta \mathbb{E}_t\left[\widehat{\pi}_{t+1}^W\right] + \left(\frac{(1-\alpha)(1-\beta\alpha)}{\alpha}\right)(\varphi+\gamma)\,\widehat{x}_t^W, \tag{26}$$

$$\gamma \mathbb{E}_t\left[\widehat{x}_{t+1}^W\right] - (\gamma+\psi_x)\,\widehat{x}_t^W \approx \left(\psi_\pi \widehat{\pi}_t^W - \mathbb{E}_t\left[\widehat{\pi}_{t+1}^W\right]\right) + \left(\widehat{v}_t^W - \widehat{\overline{r}}_t^W\right). \tag{27}$$

To close the world economy system, we derive the world forcing processes $\widehat{\overline{r}}_t^W$ and $\widehat{v}_t^W$ as follows,

Lemma 1 *Given the derivation of the natural rates for each country and the assumptions on the monetary shock shocks, the world forcing processes for $\widehat{\overline{r}}_t^W$ and $\widehat{v}_t^W$ can be described as follows,*

$$\begin{pmatrix} \widehat{\overline{r}}_t^W \\ \widehat{v}_t^W \end{pmatrix} = \begin{pmatrix} \delta_a + \delta_{a,a^*} & 0 \\ 0 & \delta_m \end{pmatrix} \begin{pmatrix} \widehat{\overline{r}}_{t-1}^W \\ \widehat{v}_{t-1}^W \end{pmatrix} + \begin{pmatrix} \widehat{\varepsilon}_t^{rW} \\ \widehat{\varepsilon}_t^{vW} \end{pmatrix}, \tag{28}$$

$$\begin{pmatrix} \widehat{\varepsilon}_t^{rW} \\ \widehat{\varepsilon}_t^{vW} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_r^2\left(\frac{1+\rho_{r,r^*}}{2}\right) & 0 \\ 0 & \sigma_v^2\left(\frac{1+\rho_{v,v^*}}{2}\right) \end{pmatrix}\right), \tag{29}$$

where the volatility term for the world natural rate can be tied to parameters of the productivity shock and other structural parameters of the model as,

$$\sigma_r^2\left(\frac{1+\rho_{r,r^*}}{2}\right) = \sigma_a^2\left(\frac{1+\rho_{a,a^*}}{2}\right)\left[\gamma\left(\frac{1+\varphi}{\gamma+\varphi}\right)(\delta_a+\delta_{a,a^*}-1)\right]^2. \tag{30}$$

The Difference Economy. The difference system defines how far apart each country is from the other. Then, the difference system can be characterized as follows,

$$\widehat{\pi}_t^R \approx \beta \mathbb{E}_t \left[\widehat{\pi}_{t+1}^R \right] + \left(\frac{(1-\alpha)(1-\beta\alpha)}{\alpha} \right) ((1-2\xi)\varphi + (2\Theta-1)\gamma) \widehat{x}_t^R, \tag{31}$$

$$\gamma (1-2\xi) \left(\mathbb{E}_t \left[\widehat{x}_{t+1}^R \right] - \widehat{x}_t^R \right) \approx ((1-2\xi)+2\Gamma) \left[\left(\widehat{i}_t^R - \mathbb{E}_t \left[\widehat{\pi}_{t+1}^R \right] \right) - \widehat{\overline{r}}_t^R \right], \tag{32}$$

$$\widehat{i}_t^R \approx \left[\psi_\pi \widehat{\pi}_t^R + \psi_x \widehat{x}_t^R \right] + \widehat{v}_t^R, \tag{33}$$

which can be expressed more compactly in two equations as,

$$\widehat{\pi}_t^R \approx \beta \mathbb{E}_t \left(\widehat{\pi}_{t+1}^R \right) + \left(\frac{(1-\alpha)(1-\beta\alpha)}{\alpha} \right) ((1-2\xi)\varphi + (2\Theta-1)\gamma) \widehat{x}_t^R, \tag{34}$$

$$\begin{aligned} &\gamma (1-2\xi) \mathbb{E}_t \left[\widehat{x}_{t+1}^R \right] - ((\gamma+\psi_x)(1-2\xi) + 2\psi_x \Gamma) \widehat{x}_t^R \\ &\quad \approx ((1-2\xi)+2\Gamma) \left[\left(\psi_\pi \widehat{\pi}_t^R - \mathbb{E}_t \left[\widehat{\pi}_{t+1}^R \right] \right) + \left(\widehat{v}_t^R - \widehat{\overline{r}}_t^R \right) \right]. \end{aligned} \tag{35}$$

Here, the degree of openness ξ plays an important role in the difference system of equations and so does the elasticity of substitution between Home and Foreign consumption bundles σ (through the composite parameters Θ and Γ).

To close the difference economy system, we derive the difference forcing processes $\widehat{\overline{r}}_t^R$ and $\widehat{v}_t^R$ as follows,

Lemma 2 *Given the derivation of the natural rates for each country and the assumptions on the monetary shocks, the difference forcing processes for $\widehat{\overline{r}}_t^R$ and $\widehat{v}_t^R$ can be described as follows,*

$$\begin{pmatrix} \widehat{\overline{r}}_t^R \\ \widehat{v}_t^R \end{pmatrix} = \begin{pmatrix} \delta_a - \delta_{a,a^*} & 0 \\ 0 & \delta_v \end{pmatrix} \begin{pmatrix} \widehat{\overline{r}}_{t-1}^R \\ \widehat{v}_{t-1}^R \end{pmatrix} + \begin{pmatrix} \widehat{\varepsilon}_t^{rR} \\ \widehat{\varepsilon}_t^{vR} \end{pmatrix}, \tag{36}$$

$$\begin{pmatrix} \widehat{\varepsilon}_t^{rR} \\ \widehat{\varepsilon}_t^{vR} \end{pmatrix} \sim N \left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 2\sigma_r^2 \left(1-\rho_{r,r^*}\right) & 0 \\ 0 & 2\sigma_v^2 \left(1-\rho_{v,v^*}\right) \end{pmatrix} \right), \tag{37}$$

where the volatility term for the difference natural rate can be tied to parameters of the productivity shock and other structural parameters of the model as,

$$2\sigma_r^2 \left(1-\rho_{r,r^*}\right) = 2\sigma_a^2 \left(1-\rho_{a,a^*}\right) \left[\gamma \left(\frac{1+\varphi}{\gamma+\varphi} \right) (2\Theta-1)(2\Lambda-1)(\delta_a - \delta_{a,a^*} - 1) \right]^2. \tag{38}$$

A.1 Dynamics of World Inflation

We build our empirical model on the basis of the work on global slack of Martínez-García and Wynne (2010) and Martínez-García (2014). In their model the world economy can be described with three equations as can be seen in (23) − (25) that have the same basic structure as one would find in the standard three-equation, closed-economy New Keynesian (NK) model.

The world economy NK model of Martínez-García (2014) is described with a New Keynesian Philips curve (NKPC), a log-linearized world Euler equation, and an interest-rate-setting rule for monetary policy.

The NKPC can be cast into the following augmented form,

$$\widehat{\pi}_t^W - \overline{\pi}_t^W = \beta \mathbb{E}_t \left(\widehat{\pi}_{t+1}^W - \overline{\pi}_{t+1}^W \right) + k^W \widehat{x}_t^W, \tag{39}$$

where $\mathbb{E}_t(.)$ refers to the expectation formed conditional on information up to time t, $\widehat{x}_t^W$ is the global output gap, $\widehat{\pi}_t^W$ is global inflation, and $\overline{\pi}_t^W$ is the global trend inflation. Moreover, $k^W \equiv \left(\frac{(1-\alpha)(1-\beta\alpha)}{\alpha} \right) (\varphi + \gamma) > 0$ is the slope of the global output gap that depends on the deep structural parameters of the model such as the frequency of price adjustment $0 < \alpha < 1$, and the intertemporal discount rate $0 < \beta < 1$. The NKPC describing the dynamics of aggregate world inflation arises in a two-country model with staggered price-setting à la Calvo (1983), and can be augmented to include a time-varying global trend for inflation with a standard extension to incorporate price indexation in the price-setting decision of firms as in **?**). In such an environment, firms that do not re-optimize their prices would automatically increase them at the trend inflation rate of the county where they reside.

The log-linearization of the Euler equation is given by,

$$\widehat{x}_t^W = \mathbb{E}_t \left[\widehat{x}_{t+1}^W \right] - \frac{1}{\gamma} \left(\widehat{i}_t^W - \mathbb{E}_t \left[\widehat{\pi}_{t+1}^W \right] - \widehat{\overline{r}}_t^W \right), \tag{40}$$

where $\widehat{i}_t^W$ is the aggregate short-term nominal interest rate (an aggregate of the riskless one-period interest rates of both countries), and $\widehat{\overline{r}}_t^W$ is the aggregate natural interest rate—the real interest rate that the economy would have experienced absent nominal rigidities, given the same realization of the real shocks. Potential output and the natural (real) interest rate are both functions of exogenous real factors (technology).

We specify a general form of the monetary policy with a Taylor (1993) rule where the central bank of each country targets their domestic short-term nominal interest rate with the same reaction function. The world Taylor rule can be cast in the following form,

$$\widehat{i}_t^W = \widetilde{\pi}_t^W + \psi_\pi \left(\widehat{\pi}_t^W - \widetilde{\pi}_t^W \right) + \psi_x \widehat{x}_t^W + \widehat{v}_t^W, \tag{41}$$

where $\widetilde{\pi}_t^W$ is the aggregate of both countries' central bank's inflation target and $\widehat{\overline{r}}_t^W$ can be interpreted as the aggregate of each country's central bank's own forecast of the economy's natural (real) interest rate. We assume that the inflation target for each country follows a randow walk so that the aggregate itself, $\widetilde{\pi}_t^W$, also follows a random walk, i.e.

$$\widetilde{\pi}_t^W = \widetilde{\pi}_{t-1}^W + \widetilde{\varepsilon}_t, \tag{42}$$

where $\widetilde{\varepsilon}_t$ is an i.i.d. shock with zero mean. In our implementation with simulated data we collapse the target rate to a constant and normalize it to zero to be consistent with the simple scenario of a zero inflation steady state. However, we maintain the generality of the specification here for illustration purposes.

In this setting, the aggregate trend inflation $\overline{\pi}_t^W$ corresponds in equilibrium to the aggregate of the central bank's inflation target $\widetilde{\pi}_t^W$. To see that, one can interpret the aggregate indexation rate $\overline{\pi}_t^W$ as the Beveridge-Nelson (stochastic) trend of the global inflation process,

$$\overline{\pi}_t^W = \lim_{j \to \infty} \mathbb{E}_t \left(\widehat{\pi}_{t+j}^W \right). \tag{43}$$

The world inflation rate $\widehat{\pi}_t^W$ in this model fluctuates around a stochastic trend given by the aggregate central bank's inflation target. Hence, since we assume in (42) that the target is a random walk, it follows that $\mathbb{E}_t\left(\widetilde{\pi}_{t+j}^W\right) = \widetilde{\pi}_t^W$ at any period $j > 0$. In that case, it results from the definition in (43) that $\overline{\pi}_t^W = \widetilde{\pi}_t^W$ at every point in time and this confirms that trend and target inflation must be equal in equilibrium.

Using the aggregate monetary policy rule in (41) to replace $\widehat{i}_t^W$ in $(39) - (40)$, the system of equations that determines world inflation and global slack can be written in the following form,

$$\widehat{z}_t^W = A^W \mathbb{E}_t\left(\widehat{z}_{t+1}^W\right) + a^W\left(\widehat{\overline{r}}_t^W - \widehat{v}_t^W\right), \tag{44}$$

where,

$$\widehat{z}_t^W \equiv \begin{bmatrix} \widehat{\pi}_t^W - \overline{\pi}_t^W \\ \widehat{x}_t^W \end{bmatrix}, \tag{45}$$

where A^W is a 2×2 matrix and a^W is a 2×1 matrix of structural coefficients. We assume that the process for the aggregate central bank's predicted real rate $\widehat{\overline{r}}_t^W$ is stochastic and exogenous. Under the assumption that the aggregate interest rate gap $\left(\widehat{\overline{r}}_t^W - \widehat{v}_t^W\right)$ is stationary, then the system in (44) has a unique nonexplosive solution in which both $\widehat{x}_t^W$ and $\widehat{\pi}_t^W - \overline{\pi}_t^W$ are stationary whenever both eigenvalues of the matrix A^W are inside the unit circle. A variant of the Taylor principle which requires that $\psi_\pi + \left(\frac{1-\beta}{k^W}\right)\psi_x > 1$ suffices to ensure the uniqueness and existence of the nonexplosive solution for the world aggregates. Assuming this condition is satisfied, the solution can be characterized as follows,

$$\begin{pmatrix} \widehat{\pi}_t^W \\ \widehat{x}_t^W \end{pmatrix} = \begin{pmatrix} \overline{\pi}_t^W \\ 0 \end{pmatrix} + \sum_{j=0}^{\infty}\left(A^W\right)^j a^j \mathbb{E}_t\left(\widehat{\overline{r}}_{t+j}^W - \widehat{v}_{t+j}^W\right). \tag{46}$$

Hence, world inflation is determined by the world inflation target and by current and expected future discrepancies between the aggregate natural rate of interest and the aggregate of the central bank's own target for the natural rate.

We assume that the central banks adjust their policy rule to track changes in the natural rate of interest that are forecastable one period in advance implying for the aggregate that,

$$\widehat{v}_t^W = \mathbb{E}_{t-1}\left(\widehat{\overline{r}}_t^W\right). \tag{47}$$

Alternatively, we can simply assume—as most of the literature implicitly does—that $\widehat{v}_t^W = \widehat{\overline{r}}_t^W + \widehat{\varepsilon}_t^m$, where $\widehat{\overline{r}}_t^W$ corresponds to the global natural interest rate and $\widehat{\varepsilon}_t^v$ is an i.i.d. disturbance that captures non-persistent and unanticipated shocks to monetary policy. In either case, the world interest rate gap $\left(\widehat{\overline{r}}_t^W - \widehat{v}_t^W\right)$ is viewed as white noise and the solution to the global system in (44) becomes,

$$\widehat{\pi}_t^W = \overline{\pi}_t^W + \lambda^W\left(\widehat{\overline{r}}_t^W - \widehat{v}_t^W\right) = \overline{\pi}_t^W - \lambda^W \widehat{\varepsilon}_t^m, \tag{48}$$

$$\widehat{x}_t^W = \mu^W\left(\widehat{\overline{r}}_t^W - \widehat{v}_t^W\right) = -\mu^W \widehat{\varepsilon}_t^m, \tag{49}$$

where the composite coefficients λ^W and μ^W depend on the deep structural parameters of the model. If aggregate inflation evolves as predicted by this solution, then optimal forecasts of future global inflation at any horizon $j \geq 1$ must be given by,

$$\mathbb{E}_t\left(\widehat{\pi}^W_{t+j}\right) = \overline{\pi}^W_t = \widehat{\pi}^W_t - \frac{\lambda^W}{\mu^W}\widehat{x}^W_t, \tag{50}$$

or, simply re-arranging, by,

$$\mathbb{E}_t\left(\widehat{\pi}^W_{t+j} - \widehat{\pi}^W_t\right) = -\frac{\lambda^W}{\mu^W}\widehat{x}^W_t. \tag{51}$$

More generally, using the fact that $\widehat{\pi}^{W,h}_{t+h|t} \approx \frac{400}{h}\sum_{j=1}^{h}\widehat{\pi}^W_{t+j}$, we can write the forecast $h-$periods ahead as follows,

$$\mathbb{E}_t\left(\widehat{\pi}^{W,h}_{t+h|t}\right) = \frac{400}{h}\sum_{j=1}^{h}\mathbb{E}_t\left(\widehat{\pi}^W_{t+j}\right) = \frac{400}{h}\sum_{j=1}^{h}\mathbb{E}_t\left(\overline{\pi}^W_{t+j}\right) = 400\left(\widehat{\pi}^W_t - \frac{\lambda^W}{\mu^W}\widehat{x}^W_t\right). \tag{52}$$

This implies that no other variable should improve our forecast of changes in the global inflation if global slack and the current global inflation rate are included in the forecasting model. This feature is noted in **?**) as well and we use it as our key identifying restriction in order to construct a reduced-form specification (an ADL model) for forecasting inflation that is consistent with the NKPC.

Forecasting future global inflation using the global output gap alone would not be accurate since global inflation potentially has a stochastic trend while global slack is stationary; one needs to include among the regressors some variable with a similar stochastic trend to that of inflation. But this need not be money growth; current global inflation itself has the same stochastic trend, so including it to forecast future inflation takes care of the trend component without the need to include any other regressors to attempt to track the stochastic trend.

What we need apart from current global inflation is additional regressors that are stationary and highly correlated with the current deviations of inflation from its stochastic trend. In theory, the global output gap is one such stationary variable with that property. More generally, the thing that matters is which variables are most useful for tracking relatively high-frequency (or cyclical) variations in inflation. This is true regardless of the horizon over which one wishes to forecast inflation. In this sense, we find that money can be a relevant variable to help us forecast inflation.

The aggregate money demand equations can be expressed as follows,

$$\widehat{m}^{d,W}_t - \widehat{p}^W_t \approx \widehat{c}^W_t - \eta\widehat{i}^W_t, \tag{53}$$

where aggregate world consumption is given by $\widehat{c}^W_t \approx \widehat{y}^W_t$. Under the solution described here and the implication that the global inflation trend and the aggregate inflation target for the central banks must equate, we know that the aggregate Taylor rule implies the following path for the nominal short-term interest rate,

$$\widehat{i}^W_t = \overline{\pi}^W_t + \left(-\psi_\pi\frac{\lambda^W}{\mu^W} + \psi_x\right)\widehat{x}^W_t + \widehat{v}^W_t. \tag{54}$$

When we express the counterpart of the aggregate money demand in (53) absent nominal rigidities, we use the fact that $\hat{\bar{i}}_t^W = \overline{\pi}_t^W + \hat{v}_t^W$ and write it as follows,

$$
\begin{aligned}
\hat{m}_t^{g,W} &\equiv \left(\hat{m}_t^{d,W} - \hat{p}_t^W\right) - \left(\hat{\overline{m}}_t^{d,W} - \hat{\overline{p}}_t^W\right) \approx \left(\hat{c}_t^W - \hat{\overline{c}}_t^W\right) - \eta\left(\hat{i}_t^W - \hat{\bar{i}}_t^W\right) \\
&\approx \left(\hat{y}_t^W - \hat{\overline{y}}_t^W\right) - \eta\left(\hat{i}_t^W - \hat{\bar{i}}_t^W\right) \\
&\approx \left(1 - \eta\left(-\psi_\pi \frac{\lambda^W}{\mu^W} + \psi_x\right)\right)\hat{x}_t^W. \qquad (55)
\end{aligned}
$$

In other words, the gap in real money demand ought to be proportional to global slack and, therefore, can be used for forecasting. Similarly, we will look at the terms of trade to obtain information that could be helpful for forecasting inflation in place of the global slack.

Proposition 2 *World real money gap $\hat{m}_t^{g,W}$ is proportional to global slack,*

$$
\hat{m}_t^{g,W} \approx \chi \hat{x}_t^W, \qquad (56)
$$

where $\chi \equiv \left(1 - \eta\left(-\psi_\pi \frac{\lambda^W}{\mu^W} + \psi_x\right)\right)$.

Under a Taylor rule specification such as the one we adopt here, the price level is known to be indeterminate even when a solution for the model can be shown to exist and be unique (see, e.g., **?**)). Using the aggregate money demand equation and the aggregate Fisher equation, we can write the following expression in terms of the price level,

$$
\begin{aligned}
\hat{m}_t^{d,W} - \hat{p}_t^W &\approx \hat{y}_t^W - \eta\left(\hat{r}_t^W + \mathbb{E}_t\left[\hat{\pi}_{t+1}^W\right]\right) \\
&= \hat{y}_t^W - \eta\left(\hat{r}_t^W + \mathbb{E}_t\left[\hat{p}_{t+1}^W\right] - \hat{p}_t^W\right), \qquad (57)
\end{aligned}
$$

or, simply,

$$
\hat{p}_t^W \approx \frac{\eta}{1+\eta}\mathbb{E}_t\left[\hat{p}_{t+1}^W\right] - \frac{1}{1+\eta}\left(\hat{y}_t^W - \eta\hat{r}_t^W\right) + \frac{1}{1+\eta}\hat{m}_t^{d,W}. \qquad (58)
$$

Solving it forwards, we obtain the following expression under the no-bubbles assumption (i.e. $\lim_{T\to\infty}\left(\frac{\eta}{1+\eta}\right)^T \mathbb{E}_t\left[\hat{p}_{t+T}^W\right] = 0$),

$$
\hat{p}_t^W \approx \sum_{k=0}^{\infty}\left(\frac{\eta}{1+\eta}\right)^k \mathbb{E}_t\left[-\frac{1}{1+\eta}\left(\hat{y}_{t+k}^W - \eta\hat{r}_{t+k}^W\right)\right] + \sum_{k=0}^{\infty}\left(\frac{\eta}{1+\eta}\right)^k \mathbb{E}_t\left[\frac{1}{1+\eta}\hat{m}_{t+k}^{d,W}\right]. \qquad (59)
$$

Given the derivation of the natural rates and potential output for each country, the world processes for the corresponding aggregates $\hat{\overline{r}}_t^W$ and $\hat{\overline{y}}_t^W$ can be described as follows,

$$
\begin{aligned}
\hat{\overline{r}}_t^W &= \left(\delta_a + \delta_{a,a^*}\right)\hat{\overline{r}}_{t-1}^W + \hat{\varepsilon}_t^{rW},\ \hat{\varepsilon}_t^{rW} \sim N\left(0, \sigma_a^2\left(\frac{1+\rho_{a,a^*}}{2}\right)\left[\gamma\left(\frac{1+\varphi}{\gamma+\varphi}\right)\left(\delta_a + \delta_{a,a^*} - 1\right)\right]^2\right), \qquad (60) \\
\hat{\overline{y}}_t^W &= \left(\delta_a + \delta_{a,a^*}\right)\hat{\overline{y}}_{t-1}^W + \hat{\varepsilon}_t^{yW},\ \hat{\varepsilon}_t^{yW} \sim N\left(0, \sigma_a^2\left(\frac{1+\rho_{a,a^*}}{2}\right)\left[\frac{1+\varphi}{\gamma+\varphi}\right]^2\right). \qquad (61)
\end{aligned}
$$

Hence, the expression for the global price level can be re-written as follows,

$$\widehat{p}_t^W \approx \frac{1}{1+\eta}\left(\widehat{y}_t^W - \eta \widehat{r}_t^W\right) - \frac{1}{1+\eta}\left(\frac{\eta\left(\delta_a + \delta_{a,a^*}\right)}{1+\eta\left(1-\left(\delta_a+\delta_{a,a^*}\right)\right)}\right)\left(\widehat{\overline{y}}_t^W - \eta \widehat{\overline{r}}_t^W\right) + \sum_{k=0}^{\infty}\left(\frac{\eta}{1+\eta}\right)^k \mathbb{E}_t\left[\frac{1}{1+\eta}\widehat{m}_{t+k}^{d,W}\right], \tag{62}$$

where,

$$\begin{aligned}
\widehat{y}_t^W &= \widehat{\overline{y}}_t^W + \mu^W\left(\widehat{\overline{r}}_t^W - \widehat{m}_t^W\right) = \widehat{\overline{y}}_t^W + \widehat{x}_t^W, \\
\widehat{r}_t^W &\equiv \widehat{i}_t^W - \mathbb{E}_t\left[\widehat{\pi}_{t+1}^W\right] = \left(-\psi_\pi \frac{\lambda^W}{\mu^W} + \psi_x\right)\widehat{x}_t^W + \widehat{m}_t^W \\
&= \widehat{\overline{r}}_t^W - \left(1 - \left(-\psi_\pi \frac{\lambda^W}{\mu^W} + \psi_x\right)\mu^W\right)\left(\widehat{\overline{r}}_t^W - \widehat{m}_t^W\right) \\
&= \widehat{\overline{r}}_t^W - \left(1 - \left(-\psi_\pi \frac{\lambda^W}{\mu^W} + \psi_x\right)\mu^W\right)\frac{1}{\mu^W}\widehat{x}_t^W.
\end{aligned}$$

Simple manipulations allow us to write the difference equation for the price level more compactly as follows,

$$\widehat{p}_t^W \approx \vartheta_1 \widehat{x}_t^W + \vartheta_2\left(\widehat{\overline{y}}_t^W - \eta \widehat{\overline{r}}_t^W\right) + \sum_{k=0}^{\infty}\left(\frac{\eta}{1+\eta}\right)^k \mathbb{E}_t\left[\frac{1}{1+\eta}\widehat{m}_{t+k}^{d,W}\right], \tag{63}$$

where ϑ_1 and ϑ_2 are composite coefficients derived from the structural parameters of the model. Notice that the expression $\vartheta_1 \widehat{x}_t^W + \vartheta_2\left(\widehat{\overline{y}}_t^W - \eta \widehat{\overline{r}}_t^W\right)$ is a weighted sum of two processes that are stationary (one is a white noise while the other is an autorregressive process of order one).

Adopting the representation proposed by Campbell and Shiller (1987) for this present-value formula, the price level can be expressed alternatively as,

$$\widehat{p}_t^W \approx \vartheta_1 \widehat{x}_t^W + \vartheta_2\left(\widehat{\overline{y}}_t^W - \eta \widehat{\overline{r}}_t^W\right) + \sum_{k=1}^{\infty}\left(\frac{\eta}{1+\eta}\right)^k \mathbb{E}_t\left[\Delta \widehat{m}_{t+k}^{d,W}\right] + \widehat{m}_t^{d,W}, \tag{64}$$

which can be re-expressed in terms of the real demand for money balances as,

$$\widehat{m}_t^{d,W} - \widehat{p}_t^W \approx -\vartheta_1 \widehat{x}_t^W - \vartheta_2\left(\widehat{\overline{y}}_t^W - \eta \widehat{\overline{r}}_t^W\right) - \sum_{k=1}^{\infty}\left(\frac{\eta}{1+\eta}\right)^k \mathbb{E}_t\left[\Delta \widehat{m}_{t+k}^{d,W}\right]. \tag{65}$$

Although the price level is indeterminate, this equation constraints the path of the money demand for any given price level. The way in which it has been re-written indicates that the money demand in real terms must reflect all discounted expected future additions to the stock of money apart from current factors affecting such as $\widehat{x}_t^W$, $\widehat{\overline{y}}_t^W$ and $\widehat{\overline{r}}_t^W$.

A.2 Dynamics of Differential Inflation

We build our empirical model on the basis of the work on global slack of Martínez-García and Wynne (2010) and Martínez-García (2014). In their model the difference economy can be described with three equations as can be seen in $(31) - (33)$ that have the same basic structure as one would find in the standard three-equation, closed-economy New Keynesian (NK) model.

The difference economy NK model of Martínez-García (2014) is described with a New Keynesian Philips curve (NKPC), a log-linearized world Euler equation, and an interest-rate-setting rule for monetary policy. The NKPC can be cast into the following augmented form,

$$\widehat{\pi}_t^R - \overline{\pi}_t^R = \beta \mathbb{E}_t \left(\widehat{\pi}_{t+1}^R - \overline{\pi}_{t+1}^R \right) + k^R \widehat{x}_t^R, \tag{66}$$

where $\mathbb{E}_t(.)$ refers to the expectation formed conditional on information up to time t, $\widehat{x}_t^R$ is the difference in the current output gap between the two countries, $\widehat{\pi}_t^R$ is the difference in inflation, and $\overline{\pi}_t^R$ is the difference in trend inflation. Moreover, $k^R \equiv \left(\frac{(1-\alpha)(1-\beta\alpha)}{\alpha} \right) \left((1-2\xi)\varphi + (2\Theta - 1)\gamma \right)$ is the slope of the difference output gap that depends on the deep structural parameters of the model such as the frequency of price adjustment $0 < \alpha < 1$, and the intertemporal discount rate $0 < \beta < 1$. The NKPC describing the dynamics of the difference in inflation arises in a two-country model with staggered price-setting à la Calvo (1983), and can be augmented to include a time-varying global trend for inflation with a standard extension to incorporate price indexation in the price-setting decision of firms as in **?**). In such an environment, firms that do not re-optimize their prices would automatically increase them at the trend inflation rate of the county where they reside.

The log-linearization of the Euler equation is given by,

$$\widehat{x}_t^R = \mathbb{E}_t \left[\widehat{x}_{t+1}^R \right] - \frac{1}{\gamma} \left(\frac{(1-2\xi) + 2\Gamma}{1-2\xi} \right) \left(\widehat{i}_t^R - \mathbb{E}_t \left[\widehat{\pi}_{t+1}^R \right] - \widehat{\overline{r}}_t^R \right), \tag{67}$$

where $\widehat{i}_t^R$ is the difference in the short-term nominal interest rate (the difference between the riskless one-period interest rates of each country), and $\widehat{\overline{r}}_t^R$ is the difference natural interest rate—the real interest rate differential that the economy would have experienced absent nominal rigidities, given the same realization of the real shocks. Potential output and the natural (real) interest rate are both functions of exogenous real factors (technology).

We specify a general form of the monetary policy with a Taylor (1993) rule where the central bank of each country targets their domestic short-term nominal interest rate with the same reaction function. The world Taylor rule can be cast in the following form,

$$\widehat{i}_t^R = \widetilde{\pi}_t^R + \psi_\pi \left(\widehat{\pi}_t^R - \widetilde{\pi}_t^R \right) + \psi_x \widehat{x}_t^R + \widehat{v}_t^R, \tag{68}$$

where $\widetilde{\pi}_t^R$ is the difference between both countries' central bank's inflation target and $\widehat{\overline{r}}_t^R$ can be interpreted as the difference between both country's central bank's own forecast of the economy's natural (real) interest rate. We assume that the inflation target for each country follows a randow walk so that the difference itself, $\widetilde{\pi}_t^R$, also follows a random walk, i.e.

$$\widetilde{\pi}_t^R = \widetilde{\pi}_{t-1}^R + \widetilde{\varepsilon}_t^*, \tag{69}$$

where $\widetilde{\varepsilon}_t^*$ is an i.i.d. shock with zero mean. In our implementation with simulated data we collapse the target rate to a constant and normalize it to zero to be consistent with the simple scenario of a zero inflation steady state. However, we maintain the generality of the specification here for illustration purposes.

In this setting, it also follows that the difference trend inflation $\overline{\pi}_t^R$ corresponds in equilibrium to the difference of the central bank's inflation target $\widetilde{\pi}_t^R$. To see that, one can interpret the aggregate indexation rate $\overline{\pi}_t^R$ as the Beveridge-Nelson (stochastic) trend of the differential inflation process,

$$\overline{\pi}_t^R = \lim_{j \to \infty} \mathbb{E}_t \left(\widehat{\pi}_{t+j}^R \right). \tag{70}$$

The differential inflation rate $\widehat{\pi}_t^R$ in this model fluctuates around a stochastic trend given by the aggregate central bank's inflation target. Hence, since we assume in (69) that the target is a random walk, it follows that $\mathbb{E}_t \left(\widetilde{\pi}_{t+j}^R \right) = \widetilde{\pi}_t^R$ at any period $j > 0$. In that case, it results from the definition in (70) that $\overline{\pi}_t^R = \widetilde{\pi}_t^R$ at every point in time and this confirms that trend and target inflation must be equal in equilibrium also for the differential economy.

Using the differential monetary policy rule in (68) to replace $\widehat{i}_t^R$ in $(66) - (67)$, the system of equations that determines the inflation differential and slack differential can be written in the following form,

$$\widehat{z}_t^R = A^R \mathbb{E}_t \left(\widehat{z}_{t+1}^R \right) + a^R \left(\widehat{\overline{r}}_t^R - \widehat{v}_t^R \right), \tag{71}$$

where,

$$\widehat{z}_t^R \equiv \begin{bmatrix} \widehat{\pi}_t^R - \overline{\pi}_t^R \\ \widehat{x}_t^R \end{bmatrix}, \tag{72}$$

where A^R is a 2×2 matrix and a^R is a 2×1 matrix of structural coefficients. We assume that the process for the aggregate central bank's predicted real rate $\widehat{v}_t^R$ is stochastic and exogenous. Under the assumption that the interest rate gap differential $\left(\widehat{\overline{r}}_t^R - \widehat{v}_t^R \right)$ is stationary, then the system in (44) has a unique nonexplosive solution in which both $\widehat{x}_t^R$ and $\widehat{\pi}_t^R - \overline{\pi}_t^R$ are stationary whenever both eigenvalues of the matrix A^R are inside the unit circle. A variant of the Taylor principle which requires that $\psi_\pi + \left(\frac{1-\beta}{k^R} \right) \psi_x > 1$ suffices to ensure the uniqueness and existence of the nonexplosive solution for the differential aggregates. Assuming this condition is satisfied, the solution can be characterized as follows,

$$\begin{pmatrix} \widehat{\pi}_t^R \\ \widehat{x}_t^R \end{pmatrix} = \begin{pmatrix} \overline{\pi}_t^R \\ 0 \end{pmatrix} + \sum_{j=0}^{\infty} \left(A^R \right)^j a^R \mathbb{E}_t \left(\widehat{\overline{r}}_{t+j}^R - \widehat{v}_{t+j}^R \right). \tag{73}$$

Hence, the inflation differential is determined by the inflation target differential across both countries and by current and expected future discrepancies between the natural rate of interest differential and the differential of the central bank's own target for the natural rate.

We assume that the central banks adjust their policy rule to track changes in the natural rate of interest that are forecastable one period in advance implying for the differential that,

$$\widehat{v}_t^R = \mathbb{E}_{t-1} \left(\widehat{\overline{r}}_t^R \right). \tag{74}$$

Alternatively, we can simply assume—as most of the literature implicitly does—that $\widehat{v}_t^R = \widehat{\overline{r}}_t^R + \widehat{\varepsilon}_t^{v*}$, where $\widehat{\overline{r}}_t^R$ corresponds to the natural interest rate differential and $\widehat{\varepsilon}_t^{v*}$ is an i.i.d. disturbance that captures non-persistent and unanticipated shocks to monetary policy. In either case, the interest rate gap differential

$\left(\widehat{\overline{r}}_t^R - \widehat{v}_t^R\right)$ is viewed as white noise and the solution to the differential system in (71) becomes,

$$\widehat{\pi}_t^R = \overline{\pi}_t^R + \lambda^R \left(\widehat{\overline{r}}_t^R - \widehat{v}_t^R\right) = \overline{\pi}_t^R - \lambda^R \widehat{\varepsilon}_t^{v*}, \tag{75}$$

$$\widehat{x}_t^R = \mu^R \left(\widehat{\overline{r}}_t^R - \widehat{v}_t^R\right) = -\mu^R \widehat{\varepsilon}_t^{v*}, \tag{76}$$

where the composite coefficients λ^R and μ^R depend on the deep structural parameters of the model. If inflation differential evolve as predicted by this solution, then optimal forecasts of future differential inflation at any horizon $j \geq 1$ must be given by,

$$\mathbb{E}_t \left(\widehat{\pi}_{t+j}^R\right) = \overline{\pi}_t^R = \widehat{\pi}_t^R - \frac{\lambda^R}{\mu^R} \widehat{x}_t^R, \tag{77}$$

or, simply re-arranging, by,

$$\mathbb{E}_t \left(\widehat{\pi}_{t+j}^R - \widehat{\pi}_t^R\right) = -\frac{\lambda^R}{\mu^R} \widehat{x}_t^R. \tag{78}$$

More generally, using the fact that $\widehat{\pi}_{t+h|t}^{R,h} \approx \frac{400}{h} \sum_{j=1}^{h} \widehat{\pi}_{t+j}^R$, we can write the forecast $h-$periods ahead as follows,

$$\mathbb{E}_t \left(\widehat{\pi}_{t+h|t}^{R,h}\right) = \frac{400}{h} \sum_{j=1}^{h} \mathbb{E}_t \left(\widehat{\pi}_{t+j}^R\right) = \frac{400}{h} \sum_{j=1}^{h} \mathbb{E}_t \left(\overline{\pi}_{t+j}^R\right) = 400 \left(\widehat{\pi}_t^R - \frac{\lambda^R}{\mu^R} \widehat{x}_t^R\right). \tag{79}$$

This implies that no other variable should improve our forecast of changes in the differential inflation if differential slack and the current inflation differential rate are included in the forecasting model. This feature is noted in **?**) as well and we use it as our key identifying restriction in order to construct a reduced-form specification (an ADL model) for forecasting inflation that is consistent with the NKPC.

Forecasting future differential inflation using the differential output gap alone would not be accurate since differential inflation potentially has a stochastic trend while differential slack is stationary; one needs to include among the regressors some variable with a similar stochastic trend to that of inflation. But this need not be money growth; current differential inflation itself has the same stochastic trend, so including it to forecast future differential inflation takes care of the trend component without the need to include any other regressors to attempt to track the stochastic trend.

What we need apart from current differential inflation is additional regressors that are stationary and highly correlated with the current deviations of the inflation differential from its stochastic trend. In theory, the differential output gap is one such stationary variable with that property. More generally, the thing that matters is which variables are most useful for tracking relatively high-frequency (or cyclical) variations in inflation differentials. This is true regardless of the horizon over which one wishes to forecast the inflation differential. In this sense, we find that terms of trade or the real exchange rate can be a relevant variable to help us forecast the inflation differential.

Taking the equilibrium conditions that characterize the terms of trade and the real exchange rate, i.e.

$$\widehat{tot}_t \approx \left[\frac{\gamma}{\sigma\gamma - (\sigma\gamma - 1)(1-2\xi)^2}\right](\widehat{y}_t - \widehat{y}^*_t), \tag{80}$$

$$\widehat{rs}_t \approx (1-2\xi)\,\widehat{tot}_t = (1-2\xi)\left[\frac{\gamma}{\sigma\gamma - (\sigma\gamma - 1)(1-2\xi)^2}\right](\widehat{y}_t - \widehat{y}^*_t), \tag{81}$$

and re-defining them in terms of deviations from their corresponding potential levels absent any nominal rigidities, we obtain that,

$$\begin{aligned}\left(\widehat{tot}_t - \widehat{\overline{tot}}_t\right) &\approx \left[\frac{\gamma}{\sigma\gamma - (\sigma\gamma - 1)(1-2\xi)^2}\right]\left(\left(\widehat{y}_t - \widehat{\overline{y}}_t\right) - \left(\widehat{y}^*_t - \widehat{\overline{y}}^*_t\right)\right) \\ &\approx \left[\frac{\gamma}{\sigma\gamma - (\sigma\gamma - 1)(1-2\xi)^2}\right]\widehat{x}^R_t,\end{aligned} \tag{82}$$

$$\begin{aligned}\left(\widehat{rs}_t - \widehat{\overline{rs}}_t\right) &\approx (1-2\xi)\left[\frac{\gamma}{\sigma\gamma - (\sigma\gamma - 1)(1-2\xi)^2}\right]\left(\left(\widehat{y}_t - \widehat{\overline{y}}_t\right) - \left(\widehat{y}^*_t - \widehat{\overline{y}}^*_t\right)\right) \\ &\approx (1-2\xi)\left[\frac{\gamma}{\sigma\gamma - (\sigma\gamma - 1)(1-2\xi)^2}\right]\widehat{x}^R_t.\end{aligned} \tag{83}$$

In other words, the terms of trade and real exchange rate gap ought to be proportional to the slack differential and, therefore, can be used for forecasting inflation differentials—a fact already noted in Martínez-García and Wynne (2010).

Proposition 3 *Domestic terms of trade gap* $\left(\widehat{tot}_t - \widehat{\overline{tot}}_t\right)$ *and real exchange rate gap* $\left(\widehat{rs}_t - \widehat{\overline{rs}}_t\right)$ *are proportional to relative slack,*

$$\left(\widehat{tot}_t - \widehat{\overline{tot}}_t\right) \approx \kappa^{tot}\widehat{x}^R_t, \tag{84}$$

$$\left(\widehat{rs}_t - \widehat{\overline{rs}}_t\right) \approx \kappa^{rs}\widehat{x}^R_t, \tag{85}$$

where $\kappa^{tot} \equiv \left[\frac{\gamma}{\sigma\gamma-(\sigma\gamma-1)(1-2\xi)^2}\right]$ *and* $\kappa^{rs} \equiv (1-2\xi)\left[\frac{\gamma}{\sigma\gamma-(\sigma\gamma-1)(1-2\xi)^2}\right]$.

A.3 Dynamics of Country-Level Inflation

We describe the dynamics of the domestic economy for the Home country only, but the approach is analogous to derive the same implications for the Foreign country inflation. We can express the forecast for domestic inflation in terms of the forecasts of global inflation and the inflation differential that we have derived before with the following transformation,

$$\mathbb{E}_t\left(\widehat{\pi}_{t+j}\right) = \mathbb{E}_t\left(\widehat{\pi}^W_{t+j}\right) + \frac{1}{2}\mathbb{E}_t\left(\widehat{\pi}^R_{t+j}\right).$$

Using the forecasting implications for global inflation and inflation differentials, it follows that,

$$\begin{aligned}
\mathbb{E}_t\left(\widehat{\pi}_{t+j}\right) &= \overline{\pi}_t^W + \frac{1}{2}\overline{\pi}_t^R \\
&= \left(\widehat{\pi}_t^W - \frac{\lambda^W}{\mu^W}\widehat{x}_t^W\right) + \frac{1}{2}\left(\widehat{\pi}_t^R - \frac{\lambda^R}{\mu^R}\widehat{x}_t^R\right) \\
&= \widehat{\pi}_t - \frac{\lambda^W}{\mu^W}\widehat{x}_t^W - \frac{1}{2}\frac{\lambda^R}{\mu^R}\widehat{x}_t^R.
\end{aligned}$$

Simply re-arranging, we can also express this forecasts as follows,

$$\mathbb{E}_t\left(\widehat{\pi}_{t+j} - \widehat{\pi}_t\right) = -\frac{\lambda^W}{\mu^W}\widehat{x}_t^W - \frac{1}{2}\frac{\lambda^R}{\mu^R}\widehat{x}_t^R. \tag{86}$$

Given the definitions of the slack differential ($\widehat{x}_t^R \equiv \widehat{x}_t - \widehat{x}_t^*$) and the global slack ($\widehat{x}_t^W \equiv \frac{1}{2}\widehat{x}_t + \frac{1}{2}\widehat{x}_t^* = \widehat{x}_t - \frac{1}{2}\widehat{x}_t^R$), we can write this forecasting formula alternatively as follows,

$$\mathbb{E}_t\left(\widehat{\pi}_{t+j}\right) = \widehat{\pi}_t - \frac{1}{2}\left(\frac{\lambda^W}{\mu^W} + \frac{\lambda^R}{\mu^R}\right)\widehat{x}_t - \frac{1}{2}\left(\frac{\lambda^W}{\mu^W} - \frac{\lambda^R}{\mu^R}\right)\widehat{x}_t^* \tag{87}$$

$$= \widehat{\pi}_t - \frac{\lambda^W}{\mu^W}\widehat{x}_t + \left(\frac{\lambda^W}{\mu^W} - \frac{\lambda^R}{\mu^R}\right)\frac{1}{2}\widehat{x}_t^R \tag{88}$$

$$= \widehat{\pi}_t - \frac{\lambda^R}{\mu^R}\widehat{x}_t - \left(\frac{\lambda^W}{\mu^W} - \frac{\lambda^R}{\mu^R}\right)\widehat{x}_t^W, \tag{89}$$

where $\widehat{x}_t$ stands for domestic slack.

More generally, using the fact that $\widehat{\pi}_{t+h|t}^h \approx \frac{400}{h}\sum_{j=1}^h \widehat{\pi}_{t+j}$, we can write the actual forecast $h-$periods ahead for domestic inflation as follows,

$$\mathbb{E}_t\left(\widehat{\pi}_{t+h|t}^h\right) = \frac{400}{h}\sum_{j=1}^h \mathbb{E}_t\left(\widehat{\pi}_{t+j}\right) = \frac{400}{h}\sum_{j=1}^h \mathbb{E}_t\left(\overline{\pi}_{t+j}\right)$$

$$= 400\left(\widehat{\pi}_t - \frac{1}{2}\left(\frac{\lambda^W}{\mu^W} + \frac{\lambda^R}{\mu^R}\right)\widehat{x}_t - \frac{1}{2}\left(\frac{\lambda^W}{\mu^W} - \frac{\lambda^R}{\mu^R}\right)\widehat{x}_t^*\right) \tag{90}$$

$$= 400\left(\widehat{\pi}_t - \frac{\lambda^W}{\mu^W}\widehat{x}_t + \left(\frac{\lambda^W}{\mu^W} - \frac{\lambda^R}{\mu^R}\right)\frac{1}{2}\widehat{x}_t^R\right) \tag{91}$$

$$= 400\left(\widehat{\pi}_t - \frac{\lambda^R}{\mu^R}\widehat{x}_t - \left(\frac{\lambda^W}{\mu^W} - \frac{\lambda^R}{\mu^R}\right)\widehat{x}_t^W\right). \tag{92}$$

This implies that no other variable should improve our forecast of domestic inflation if domestic slack and foreign slack are included in the forecasting model. This feature is similarly noted in **?**) for a closed-economy, and we use it as our key identifying restriction in order to construct a reduced-form specification (an ADL model) for forecasting inflation that is consistent with the open-economy NKPC of Martínez-García and Wynne (2010).

Forecasting future inflation using the foreign and domestic output gaps alone would not be accurate since domestic inflation potentially has a stochastic trend while foreign and domestic slack are stationary; one needs to include among the regressors some variable with a similar stochastic trend to that of domestic inflation. But this need not be money growth or the terms of trade; current inflation itself has the same stochastic trend, so including it to forecast future inflation takes care of the trend component without the need to include any other regressors to attempt to track the stochastic trend. However, based on our previous analysis we can use the real world money demand gap to replace the hard-to-measure global slack and forecast domestic inflation with domestic slack and the global real money balances gap. In turn, we can use the terms of trade or real exchange rate gap instead of the slack differential and equally forecasting domestic inflation with the help of domestic slack and the terms of trade gap (or the real exchange rate gap). The key insight is summarized in the following lemma,

Proposition 4 *No variables other than domestic and foreign slack should help improve the forecast of changes in global inflation. The forecasting relationship for domestic inflation implied by the workhorse Open-Economy New Keynesian model of Martínez-García and Wynne (2010) can be expressed as,*

$$\mathbb{E}_t\left(\widehat{\pi}_{t+j}\right) = \widehat{\pi}_t - \frac{1}{2}\left(\frac{\lambda^W}{\mu^W} + \frac{\lambda^R}{\mu^R}\right)\widehat{x}_t - \frac{1}{2}\left(\frac{\lambda^W}{\mu^W} - \frac{\lambda^R}{\mu^R}\right)\widehat{x}_t^* \tag{93}$$

$$= \widehat{\pi}_t - \frac{\lambda^W}{\mu^W}\widehat{x}_t + \left(\frac{\lambda^W}{\mu^W} - \frac{\lambda^R}{\mu^R}\right)\frac{1}{2}\widehat{x}_t^R \tag{94}$$

$$= \widehat{\pi}_t - \frac{\lambda^R}{\mu^R}\widehat{x}_t - \left(\frac{\lambda^W}{\mu^W} - \frac{\lambda^R}{\mu^R}\right)\widehat{x}_t^W, \tag{95}$$

where global slack and differential slack can be proxied by the global real money demand gap and the terms of trade gap (or real exchange rate gap) as follows,

$$\widehat{x}_t^W \equiv \frac{1}{2}\widehat{x}_t + \frac{1}{2}\widehat{x}_t^* \approx \frac{1}{\chi}\widehat{m}_t^{g,W},$$

$$\widehat{x}_t^R \equiv \widehat{x}_t - \widehat{x}_t^* \approx \frac{1}{\kappa^{tot}}\left(\widehat{tot}_t - \widehat{\overline{tot}}_t\right) \approx \frac{1}{\kappa^{rs}}\left(\widehat{rs}_t - \widehat{\overline{rs}}_t\right),$$

where $\chi \equiv \left(1 - \eta\left(-\psi_\pi \frac{\lambda^W}{\mu^W} + \psi_x\right)\right)$, $\kappa^{tot} \equiv \left[\frac{\gamma}{\sigma\gamma - (\sigma\gamma - 1)(1-2\xi)^2}\right]$ *and* $\kappa^{rs} \equiv (1-2\xi)\left[\frac{\gamma}{\sigma\gamma - (\sigma\gamma - 1)(1-2\xi)^2}\right]$.

B Tables and Figures

Table 1 - Open-Economy New Keynesian Model: Core Equations

	Home Economy
Phillips curve	$\widehat{\pi}_t \approx \beta \mathbb{E}_t\left(\widehat{\pi}_{t+1}\right) + \left(\frac{(1-\alpha)(1-\beta\alpha)}{\alpha}\right)\left[\left((1-\xi)\varphi + \Theta\gamma\right)\widehat{x}_t + \left(\xi\varphi + (1-\Theta)\gamma\right)\widehat{x}_t^*\right]$
Output gap	$\gamma\left(1-2\xi\right)\left(\mathbb{E}_t\left[\widehat{x}_{t+1}\right] - \widehat{x}_t\right) \approx \left((1-2\xi)+\Gamma\right)\left[\widehat{r}_t - \widehat{\overline{r}}_t\right] - \Gamma\left[\widehat{r}_t^* - \widehat{\overline{r}}_t^*\right]$
Monetary policy	$\widehat{i}_t \approx \left[\psi_\pi \widehat{\pi}_t + \psi_x \widehat{x}_t\right] + \widehat{v}_t$
Fisher equation	$\widehat{r}_t \equiv \widehat{i}_t - \mathbb{E}_t\left[\widehat{\pi}_{t+1}\right]$
Natural interest rate	$\widehat{\overline{r}}_t \approx \gamma\left[\Theta\left(\mathbb{E}_t\left[\widehat{\overline{y}}_{t+1}\right] - \widehat{\overline{y}}_t\right) + (1-\Theta)\left(\mathbb{E}_t\left[\widehat{\overline{y}}_{t+1}^*\right] - \widehat{\overline{y}}_t^*\right)\right]$
	$\widehat{\overline{r}}_t \approx \gamma\left(\frac{1+\varphi}{\gamma+\varphi}\right)\left[\left(\Theta\Lambda + (1-\Theta)(1-\Lambda)\right)\mathbb{E}_t\left[\Delta\widehat{a}_{t+1}\right] + \left(\Theta(1-\Lambda) + (1-\Theta)\Lambda\right)\mathbb{E}_t\left[\Delta\widehat{a}_{t+1}^*\right]\right]$
Potential output	$\widehat{\overline{y}}_t \approx \left(\frac{1+\varphi}{\gamma+\varphi}\right)\left[\Lambda\widehat{a}_t + (1-\Lambda)\widehat{a}_t^*\right]$
	Foreign Economy
Phillips curve	$\widehat{\pi}_t^* \approx \beta \mathbb{E}_t\left(\widehat{\pi}_{t+1}^*\right) + \left(\frac{(1-\alpha)(1-\beta\alpha)}{\alpha}\right)\left[\left(\xi\varphi + (1-\Theta)\gamma\right)\widehat{x}_t + \left((1-\xi)\varphi + \Theta\gamma\right)\widehat{x}_t^*\right]$
Output gap	$\gamma\left(1-2\xi\right)\left(\mathbb{E}_t\left[\widehat{x}_{t+1}^*\right] - \widehat{x}_t^*\right) \approx -\Gamma\left[\widehat{r}_t - \widehat{\overline{r}}_t\right] + \left((1-2\xi)+\Gamma\right)\left[\widehat{r}_t^* - \widehat{\overline{r}}_t^*\right]$
Monetary policy	$\widehat{i}_t^* \approx \left[\psi_\pi \widehat{\pi}_t^* + \psi_x \widehat{x}_t^*\right] + \widehat{v}_t^*$
Fisher equation	$\widehat{r}_t^* \equiv \widehat{i}_t^* - \mathbb{E}_t\left[\widehat{\pi}_{t+1}^*\right]$
Natural interest rate	$\widehat{\overline{r}}_t^* \approx \gamma\left[(1-\Theta)\left(\mathbb{E}_t\left[\widehat{\overline{y}}_{t+1}\right] - \widehat{\overline{y}}_t\right) + \Theta\left(\mathbb{E}_t\left[\widehat{\overline{y}}_{t+1}^*\right] - \widehat{\overline{y}}_t^*\right)\right]$
	$\widehat{\overline{r}}_t^* \approx \gamma\left(\frac{1+\varphi}{\gamma+\varphi}\right)\left[\left((1-\Theta)\Lambda + \Theta(1-\Lambda)\right)\mathbb{E}_t\left[\Delta\widehat{a}_{t+1}\right] + \left((1-\Theta)(1-\Lambda) + \Theta\Lambda\right)\mathbb{E}_t\left[\Delta\widehat{a}_{t+1}^*\right]\right]$
Potential output	$\widehat{\overline{y}}_t^* \approx \left(\frac{1+\varphi}{\gamma+\varphi}\right)\left[(1-\Lambda)\widehat{a}_t + \Lambda\widehat{a}_t^*\right]$
	Exogenous, Country-Specific Shocks
Productivity shock	$\begin{pmatrix}\widehat{a}_t \\ \widehat{a}_t^*\end{pmatrix} \approx \begin{pmatrix}\delta_a & \delta_{a,a^*} \\ \delta_{a,a^*} & \delta_a\end{pmatrix}\begin{pmatrix}\widehat{a}_{t-1} \\ \widehat{a}_{t-1}^*\end{pmatrix} + \begin{pmatrix}\widehat{\varepsilon}_t^a \\ \widehat{\varepsilon}_t^{a*}\end{pmatrix}$ $\begin{pmatrix}\widehat{\varepsilon}_t^a \\ \widehat{\varepsilon}_t^{a*}\end{pmatrix} \sim N\left(\begin{pmatrix}0 \\ 0\end{pmatrix}, \begin{pmatrix}\sigma_a^2 & \rho_{a,a^*}\sigma_a^2 \\ \rho_{a,a^*}\sigma_a^2 & \sigma_a^2\end{pmatrix}\right)$
Monetary shock	$\begin{pmatrix}\widehat{v}_t \\ \widehat{v}_t^*\end{pmatrix} \approx \begin{pmatrix}\delta_v & 0 \\ 0 & \delta_v\end{pmatrix}\begin{pmatrix}\widehat{v}_{t_{-1}} \\ \widehat{v}_{t-1}^*\end{pmatrix} + \begin{pmatrix}\widehat{\varepsilon}_t^v \\ \widehat{\varepsilon}_t^{v*}\end{pmatrix}$ $\begin{pmatrix}\widehat{\varepsilon}_t^v \\ \widehat{\varepsilon}_t^{v*}\end{pmatrix} \sim N\left(\begin{pmatrix}0 \\ 0\end{pmatrix}, \begin{pmatrix}\sigma_v & \rho_{v,v^*}\sigma_v^2 \\ \rho_{v,v^*}\sigma_v^2 & \sigma_v^2\end{pmatrix}\right)$
	Composite Parameters
	$\Theta \equiv (1-\xi)\left[\frac{\sigma\gamma - (\sigma\gamma-1)(1-2\xi)}{\sigma\gamma - (\sigma\gamma-1)(1-2\xi)^2}\right]$
	$\Lambda \equiv 1 + (\sigma\gamma - 1)\left[\frac{\gamma\xi 2(1-\xi)}{\varphi\left(\sigma\gamma - (\sigma\gamma-1)(1-2\xi)^2\right)+\gamma}\right]$
	$\Gamma \equiv \xi\left[\sigma\gamma + (\sigma\gamma-1)(1-2\xi)\right]$

Table 2 - Open-Economy New Keynesian Model: Non-Core Equations	
	Home Economy
Output	$\widehat{y}_t = \widehat{\overline{y}}_t + \widehat{x}_t$
Consumption	$\widehat{c}_t \approx \Theta \widehat{y}_t + (1-\Theta)\, \widehat{y}_t^*$
Employment	$\widehat{l}_t \approx \widehat{y}_t - \widehat{a}_t$
Real wages	$(\widehat{w}_t - \widehat{p}_t) \approx \gamma \widehat{c}_t + \varphi \widehat{l}_t \approx (\varphi + \gamma\Theta)\, \widehat{y}_t + \gamma\,(1-\Theta)\, \widehat{y}_t^* - \varphi \widehat{a}_t$
Real Money Demand	$\widehat{m}_t^d - \widehat{p}_t \approx \widehat{c}_t - \eta \widehat{i}_t$
	Foreign Economy
Output	$\widehat{y}_t^* = \widehat{\overline{y}}_t^* + \widehat{x}_t^*$
Consumption	$\widehat{c}_t^* \approx (1-\Theta)\, \widehat{y}_t + \Theta \widehat{y}_t^*$
Employment	$\widehat{l}_t^* \approx \widehat{y}_t^* - \widehat{a}_t^*$
Real wages	$(\widehat{w}_t^* - \widehat{p}_t^*) \approx \gamma \widehat{c}_t^* + \varphi \widehat{l}_t^* \approx \gamma\,(1-\Theta)\, \widehat{y}_t + (\varphi + \gamma\Theta)\, \widehat{y}_t^* - \varphi \widehat{a}_t^*$
Real Money Demand	$\widehat{m}_t^{d*} - \widehat{p}_t^* \approx \widehat{c}_t^* - \eta \widehat{i}_t^*$
	International Relative Prices and Trade
Real exchange rate	$\widehat{rs}_t \approx (1-2\xi)\, \widehat{tot}_t$
Terms of trade	$\widehat{tot}_t \approx \left[\frac{\gamma}{\sigma\gamma - (\sigma\gamma-1)(1-2\xi)^2}\right] (\widehat{y}_t - \widehat{y}_t^*)$
Home real exports	$\widehat{exp}_t \approx \Xi \widehat{y}_t + (1-\Xi)\, \widehat{y}_t^*$
Home real imports	$\widehat{imp}_t \approx -(1-\Xi)\, \widehat{y}_t - \Xi \widehat{y}_t^*$
Home real trade balance	$\widehat{tb}_t \equiv \widehat{y}_t - \widehat{c}_t = (1-\xi) \left(\widehat{exp}_t - \widehat{imp}_t\right) \approx (1-\Theta)\, (\widehat{y}_t - \widehat{y}_t^*)$
	Composite Parameters
	$\Theta \equiv (1-\xi) \left[\frac{\sigma\gamma - (\sigma\gamma-1)(1-2\xi)}{\sigma\gamma - (\sigma\gamma-1)(1-2\xi)^2}\right]$
	$\Xi \equiv \left[\frac{\sigma\gamma + (\sigma\gamma-1)(1-2\xi)\xi}{\sigma\gamma - (\sigma\gamma-1)(1-2\xi)^2}\right]$

C Historical estimates of the model's parameters

We also provide an extensive analysis on the evolution of the estimates of the model's parameters. The estimates suggest the presence of structural shifts on a number of key parameters. This motivates us to explore three channels on the forecasting performance of standard leading variables from open-economy Phillips curves for US inflation. In particular, we are interested in explaining how good luck, changes in the conduct of monetary policy, and the effects of globalization play a role in determining the observed forecasting performances. In order to obtain historical estimates of the parameters, we conduct 20-year rolling window regressions on the processes underlying the behavior of the Solow residual, the Taylor rule and the monetary policy shock, as well as the import shares and the price elasticity of trade. These estimates are solely based on U.S. data and abstract from some aspects that are essential in the model for lack of comparable data—like the extent of international linkages, for instance, in the case of estimating spillovers and covariances for the Solow residual. (However, our results are also robust to parameter values suggested by the literature for cross-country spillovers and covariances). We focus on two periods: 2004Q1-2008Q2 for our baseline analysis and 1973Q4-1983Q4 for our counterfactuals. The choice of the starting and ending dates of these periods are determined by the observed structural breaks as well as limitations on data.[29] The estimation procedure and results are given as follows.

C.1 Productivity shock process parameters

The estimates are based on the Solow residual, which is calculated as in Martínez-García (2014). The Solow residual reflects the private total factor productivity, excluding government and it is computed as the residual not accounted for with hours worked and capital. Our model excludes government as well, but does not model capital explicitly. Figure 1 shows that the measured productivity persistence is high (top panel). The initial period is relatively lower, but we do not put too much emphasis on it because it could be contaminated by the errors in the pre-1954 period. The volatility (bottom panel) is the parameter for which we analyze in our simulated experiments. There is a very significant decline in the volatility of the productivity shock. It goes from around 1.5 at the beginning to half that amount around since 1996. We drop cross-country spillovers, and calibrate the covariance between the innovations at the value conventionally assigned in the literature. The literature on Great Moderation also provides important empirical findings on the evolution of these variables over time. The Great Moderation era is mainly characterized by reductions in the conditional variance in time-series models. The variance reduction is generally attributed to a smaller error variance, not to changes in the autoregressive coefficients, as documented by Stock and Watson (2003b), Ahmed et al. (2004), Blanchard and Simon (2001) and McConnell and Pérez-Quirós (2000), among others. Stock and Watson (2003b) calculated a sharp decline in the volatility of the U.S. GDP growth in the first quarter of 1984. Volatility is highest in 1970s, and considerably high in 1960s and early 1980s.[30] Moreover, it is also documented that the moderation is not limited to the US. Stock and Watson (2003b)

[29] We mark important dates for monetary policy changes as follows. The period for Volcker's Policy of Targeting Monetary Aggregates is October 1979 - October 1982. Greenspan took office in August of 1987. Also note that the 2001 recession started in the first quarter; and that the 2008 recession started officially in the fourth quarter of 2007 in the US but it did not became severe until the second or third quarter of 2008.

[30] Stock and Watson (2003b) report the standard deviations of four-quarter growth rate of real GDP. The standard deviation in the post-1984 period is 0.59 times that of the pre-1984 period. (Standard deviation in the 1970-1980 period is highest, but still comparable to its 1960-1970 level.) They also calculate similar volatility declines in macroeconomic variables, including nominal variables such as inflation (GDP deflator) and 90-day T-bill rate.

showed evidence from G7 countries, Fogli and Perri (2006) documented it for a group of OECD(?) countries.

C.2 Policy rule parameters

Since each estimate at a point in time uses data of the previous 20 years, the baseline period estimates use data starting with the Volcker era. The period of Volcker's Policy of Targeting Monetary Aggregates (October 1979 - October 1982) can be excluded from the sample (as in Coibion and Gorodnichenko (2011) and Carlstrom et al. (2009)), but we do not see much difference in the results whether we include that period or not, and therefore include this period. The Taylor rule is computed assuming that the policy rate is the effective Federal Funds rate, as customarily done. However, the Federal Funds rate starts on 1954Q3, which means we have a slightly shorter sample in the initial estimates reported. Often, researchers concentrate on the post-Korean War period because the data prior to that is subject to many of the distortions remaining from World War II, so we do not believe that it would be an issue to simply ignore the first 6 years in all our structural estimates.

A major problem with the estimation of the Taylor rule and more generally with our simulated results is that the model is not well-suited to account for nonlinearities such as setting monetary policy at the zero-lower bound. While we keep the data up to 2011 as in our empirical forecasts, we abstract from the period after 2008 for the evaluation of the forecasting performance and for the analysis of our model—as this is an unusual episode unlike any other in the post-Korean War era.

For consistency with the model and our forecasting exercise, we look at quarter-over-quarter, annualized inflation rates on PCE and the CBO measure of the output gap in my estimates of the Taylor rule.[31] The advantage of using the CBO data is that it gives us the longest possible time-series without having to estimate the trend directly, while at the same time giving us quite robust results. The downside is that the CBO measure does not reflect private output only, but is total output including the contribution of government. In terms of the inflation measures, using PCE, CPI or the GDP deflator gives similar results. We use the PCE because it is more consistent with the way we define the relative prices in the import equations.

To be consistent with the policy rule in the model, we adopt the same specification as in equation (4), with the assumption of no inertia, $\rho_i = 0$ and no serial correlation of the monetary policy shocks, $\delta_m = 0$. We abstract from a richer specification of the policy rule to keep our analysis as tractable as possible while we obtain similar qualitative results with the literature.

Figure 2 below depicts the historical estimates of the Taylor rule parameters which *(i)* include inflation response,Ψ_π (top left), *(ii)* output gap response, Ψ_x **(**top right), *(iii)* the volatility of the monetary policy shock, σ_v (bottom left), and *(iv)* the implied probability of violating the Taylor rule (bottom right)**.** It provides evidence on the instability of the point estimates for the responses to inflation and output gap, especially on the response to inflation. The implied probability of violating the Taylor principle is positive until the late 1990s with the inflation and output gap responses moving into the indeterminacy region. A remarkable result is on the size of the volatility of the monetary shock: it has changed over this period going from below 0.5 to more than 6 times greater between 68 and 80, staying above 2 through mid-1990s, and then abruptly declining afterwards. This proves a strong case for variation in the volatility that needs

[31] Interestingly, the year-over-year inflation rates offer a more stark representation of the Taylor rule with a very consistent estimate for the inflation parameter until 2008, however, the metric is somewhat inconsistent with those used in the forecasts.

to be explored.

Coibion and Gorodnichenko (2011), among others,[32] also provide historical estimates of the coefficients of a generalized Taylor rule.[33] Their estimates of Ψ_x do not show much variation from late 1960s to early 2000s. They indicate that both the inertia of the monetary policy and the parameter on inflation gap have increased recently. Their time varying estimate for Ψ_π is relatively high in late 1960s as well as early 1980s and onwards, but low during 1970s. Rudebusch (2006) provides evidence that for 1990s, a positive inertia parameter in the policy rule is more plausible. However, a noninertial policy rule is a common benchmark in the literature (e.g. Taylor (1993) and Feldstein et al. (2004)) and is therefore a natural case to investigate.

Stock and Watson (2003b) provide a helpful comparison of the monetary policy shock volatilities for the pre-1983 and post-1984 era. Using structural VAR and implementing the methodologies of Christiano et al. (1997) and Bernanke and Mihov (1998),[34] they compute the implied monetary policy innovations. Volatility of these shocks exhibited a decline in the great moderation era, following high volatility in 1960-83 and having a peak during 1979-83.[35] Similarly, Smets and Wouters (2007), report a decline in the volatility of monetary policy shocks (as well as productivity shocks) in the U.S. in an extended DSGE model for the Great Moderation era (1984-2004) relative to the Great Inflation era (1966-79), consistent with the evolution of our estimates.

C.3 Trade parameters

We estimate an import equation that would be consistent with virtually any IRBC or open-economy NK model that we can write which features CES aggregation of foreign and domestic goods, including the one in Martínez-García and Wynne (2010). The import demand relationship up to a first-order approximation is given in log deviations from steady state by,

$$imp_t \approx -sigma * (P_t - P_t^{imp}) + (cons_t + inv_t)$$

where imp_t represents the demand for real imports, the estimated elasticity parameter is $-sigma$ (where $sigma$ is the structural parameter of our model), P_t represents the price index for domestic absorption, P_t^{imp} is the price index corresponding to the imported goods, and $cons_t + inv_t$ represents the domestic absorption. In order to estimate this regression we assume a linear trend as well, which is equivalent to detrending the data prior to the estimation. Since we do not have enough detailed data to distinguish between imports by the private and public sector, we assume that the elasticity of substitution would be the same for both; hence incorporate government consumption and investment in the measure of absorption. However, we do have data for a sub-period on imports of goods excluding oil and the literature has documented that the price elasticity for oil is significantly lower than for other traded goods. We take advantage of the data available and report estimates for both total imports and non-oil imports of goods (and in the regression use their corresponding deflators).

[32]For other historical estimates of Taylor Rule coefficients for the U.S., see also Judd and Rudebusch (1998), Taylor (1999) and Clarida et al. (1999).

[33]The policy rule includes time-varying parameters (with a response to output growth) as well as time-varying trend inflation and interest smoothing of order two.

[34]They take into account that the monetary policy shifted over the sample period.

[35]Volatility of money shocks during 1984-2001 is about 0.50 times the volatility in 1960-1983 and about 0.76 times the volatility in 1960-1978 period according to CEE methodology.

Values traditionally reported for the estimation of sigma range from the classic IRBC value of 1.5 for the elasticity of substitution between domestic and foreign goods (Backus et al. (1994)) to as high as 6 (Anderson and van Wincoop (2004), based on the trade literature). Our findings seem consistent for most of the sample with the estimates in the lower end of that range, around 1.5. Figure 3 depicts results for the openness parameter estimates. Accordingly, total imports have gone up over time from around 5% at the beginning of the sample to around 15% at the end. If we exclude services and oil, then the share drops to less than 10% by the end of the sample. Therefore, the 6% that we had originally selected in our calibration seems consistent with this finding. Also, the relevant trade elasticities should be the ones that exclude oil, to be consistent with the model. In that case, we see that for most of the sample we cannot reject the null hypothesis that they are equal to 1, which is a little lower than our original calibration. This means that a Cobb-Douglas aggregator, rather than a CES aggregator, would work in this situation. There is an anomaly at the end of the sample that can easily be due to the effects of the financial recession.

The fact that there is no data for us to identify the same structural parameters in the rest of the world means that we are very limited in the kinds of experiments that we can realistically conduct. Still, we believe we make an informed evaluation of the mechanics of the model that would be consistent with standard practice and would help us gain insight on the forecasting performance of the variables of interest.

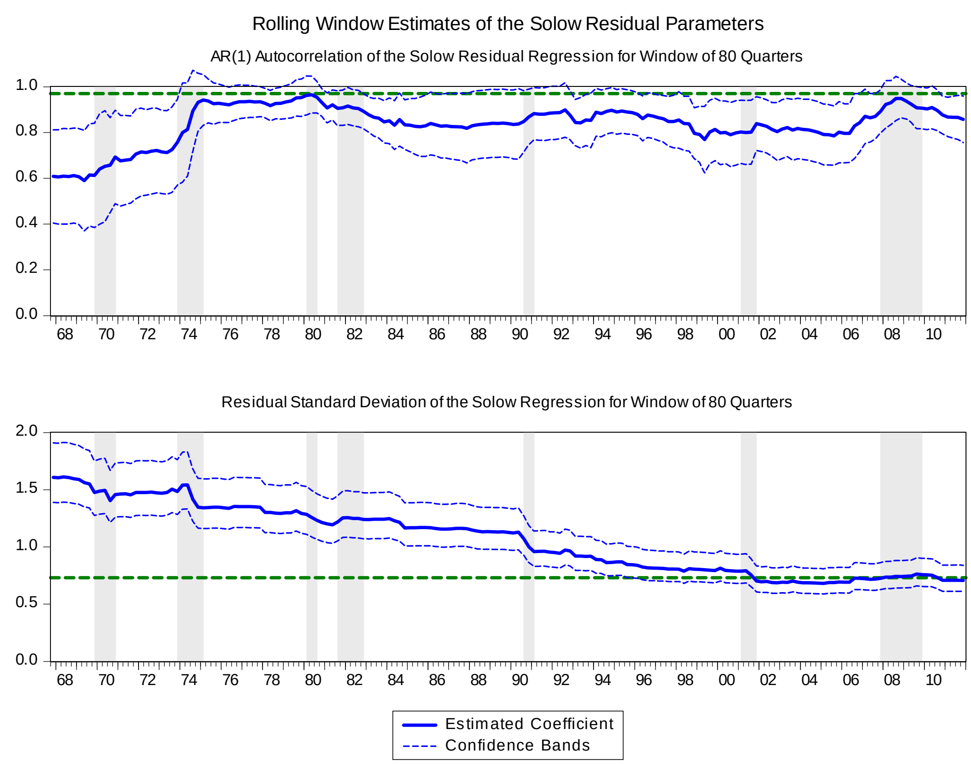

FIGURE 1. Evolution of the Solow residual parameters

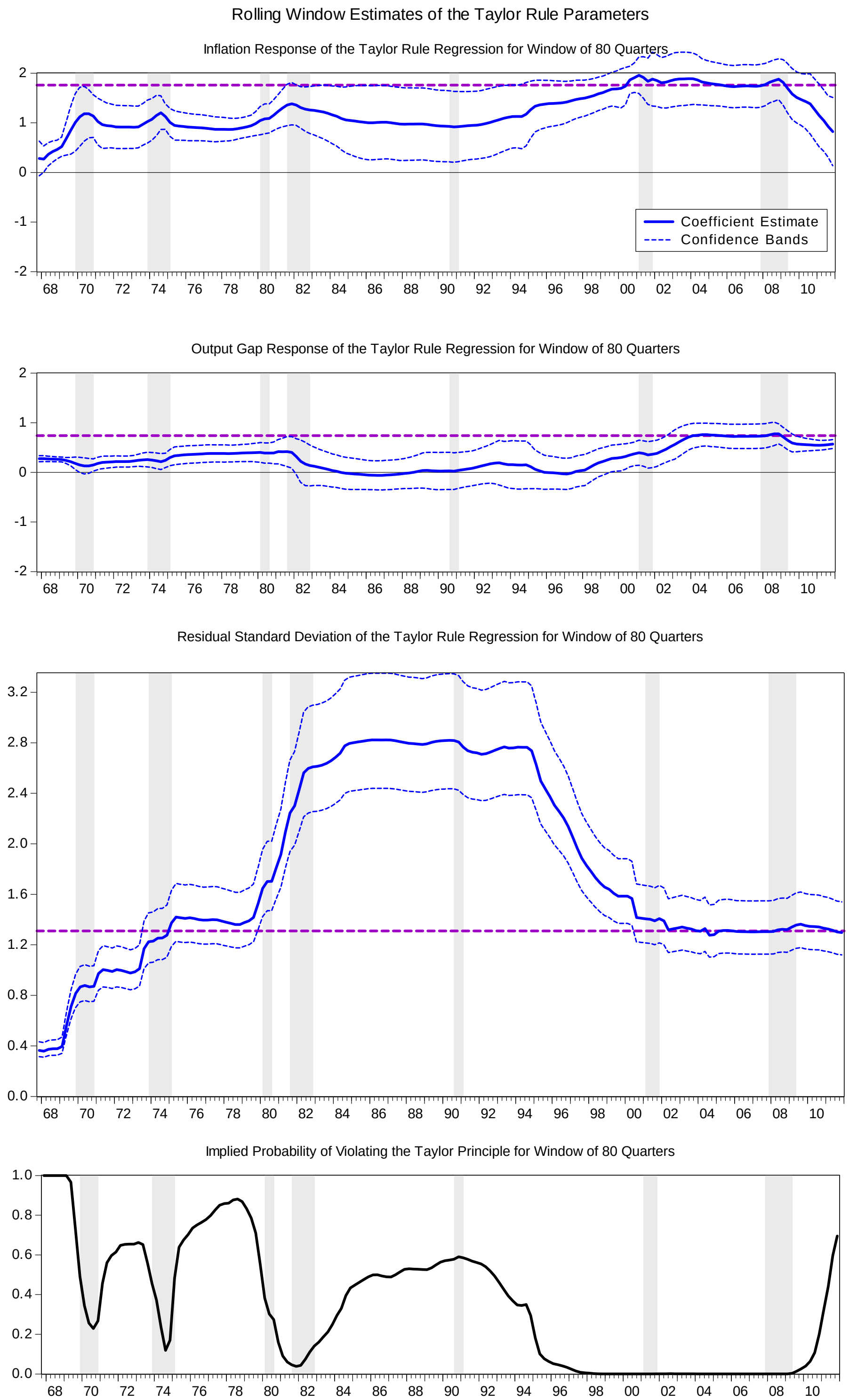

FIGURE 2. Evolution of the Taylor rule parameters

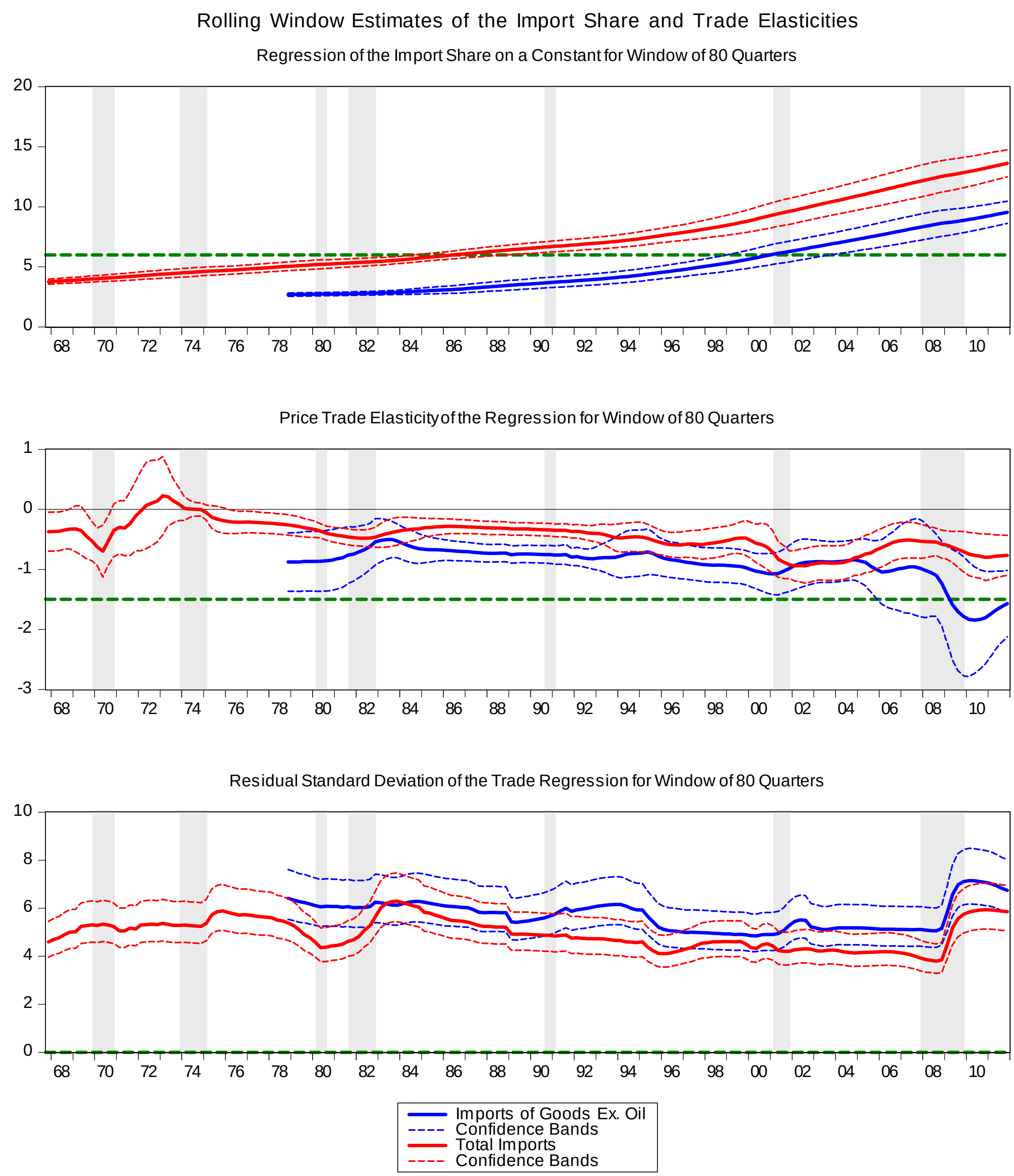

FIGURE 3. Evolution of the openness parameters

D Data Description

Abbreviations

BEA = U.S. Bureau of Economic Analysis; BLS = U.S. Bureau of Labor Statistics; BBK =German Federal Bank; BIS = Bank for International Settlements; CAO = Cabinet Office (Japan); CBO = Congressional Budget Office; FRB = Federal Reserve Board; FRBD = Federal Reserve Bank of Dallas; FRED = Federal Reserve Economic Data (St. Louis Fed); IMF = International Monetary Fund; INSEE = National Institute of Statistics and Economic Studies (France); ISTAT = Istituto Nazionale Di Statistica (Italy); OECD= Organisation for Economic Cooperation and Development; OECDMEI= OECD Main Economic Indicators; ONS = Office for National Statistics (UK); SAAR = Seasonally adjusted at an annual rate; SA=Seasonally adjusted; SCAN = Statistics Canada; WK= Wright Killen & Company; WSJ = Wall Street Journal.

All series are quarterly unless indicated otherwise and obtained from Haver Analytics. In general, we indicate the original source if the series is available outside Haver Analytics. While we try to be consistent in terms of the definitions across countries, under cases in which data availability is limited, we use the series with the closest definition.

1. **Price series**

Series used for U.S. inflation: All series are seasonally adjusted. Start dates of the series vary across different measures and they all end in 2011:4. Base years are set such that 2005:1-1005:4=100. Start dates of each series are indicated in parentheses. We take CPI (all items) (1947:1) from the BLS, core CPI (all items ex. food and energy) (1957:1) from the BLS, GDP implicit price deflator (1947:1) from the BEA; PCE chain price index (1947:1) from the BEA, Core PCE (all items ex. food and energy) chain price index (1977:1) from the BEA and PPI (finished goods) (1947:2) from the BLS, Sticky Prices (Sticky CPI) (1967:1) from the Atlanta Fed, Sticky Prices ex. shelter (Core sticky CPI) (1967:1) from the Atlanta Fed. *Series used for terms of trade:* We use exports and imports under the heading 'price indexes for GDP' in National Income and Product Accounts in the BEA to calculate U.S. terms of trade. Both series are seasonally adjusted, with the base year 2005=100 and cover periods 1947:1-2011:4. Terms of trade series is calculated as 100 $\times$export price index/import price index. Terms of trade ex. oil is calculated using imports of non-petroleum goods (chain price index) and exports of goods (chain price index) from the BEA (1967:2-2011:4). *Oil prices:* We use West Texas Intermediate spot oil price ($/barrel, prior '82=posted price) from WSJ (1946:1) and Saudi Arabian Light Crude spot oil price ($/barrel) from WK.

We apply two filtering (detrending) techniques on terms of trade, terms of trade ex. oil, WTI and SAL prices: a one-sided Hodrick-Prescott (HP) filter and first differencing. The HP filter (smoothing parameter=1600) is applied as described in Stock and Watson (1999b). This is a one-sided HP filter derived using the Kalman filter to optimally filter the series that renders the standard two-sided filter optimal. First differenced terms of trade is calculated simply as $\Delta ToT_t = ToT_t - ToT_{t-1}$, and similarly for all other series.

2. **Monetary aggregates**

All series are seasonally adjusted and quarterly (end-of-period aggregates of monthly series). Our U.S. series are from FRED, for 1948:1-2011:4. For UK, we have M4 series available from OECD (1963:1-2011:4). For other countries, data become limited for certain periods and sources and therefore we splice two series. Therefore we obtain M3 for Canada from BIS (1962:1-1981:4) and OECD (1982:1- 2011:4); M2 for Germany from BIS (1963:1-1990:4) and BBK (1980:1-2011:4); two spliced M2 series for Italy from Bank of Italy (1948:4-1998:4/1997:1-2011:4); M2 for Japan from Bank of Japan (1963:1-1966:4) and FRED (1967:1-2011:4). For France, we splice three series, M2 from NBER (http://papers.nber.org/books/darb83-1), M2R, and M3 from BIS (1963:1-1969:4 and 1970:1-2011:4, respectively). For France, Germany and Italy, the first part of the series is converted from the national currency to Euros using the European Currency Unit (1999). These series help us construct a G7 money growth series starting in 1955:2 by taking the average of money growth rate of G7 countries.

3. **Slack measures**

All measures used cover the period 1980:1-2011:4 unless stated otherwise.

CBO U.S. slack: Defined as 'Output Gap in Percentage of Real GDP', and is calculated as

$$\frac{100 \times \ (RPGDP_t - RGDP_t)}{RGDP_t}$$

where $RPGDP_t$ and $RGDP_t$ are real potential GDP and real GDP at quarter t, respectively (SAAR, Billions of Chained 2005 Dollars). We take our real GDP series from BEA and real potential GDP series from CBO. U.S. HP-filtered series is simply quarterly U.S. real GDP series with HP filter applied. Then the logs of the cyclical component is taken and multiplied by 100.

FRBD U.S. slack: The series is constructed by the FRBD, and the methodology can be described as follows. First, the Phillips Curve is estimated with annualized quarterly inflation (specifically, core CPI) and unemployment rate/capacity utilization rate. The regression equation for this is specified as is constructed as follows.

The regression is specified as

$$\pi_t = \alpha_1 + \alpha_2 \pi_{t-1} + \alpha_3 \pi_{t-2} + \alpha_4 \pi_{t-3} + (1 - \alpha_2 - \alpha_3 - \alpha_4)\pi_{t-4} + \alpha_5 ur_t + \epsilon_t$$

where $\pi_t = 400 \times \log(p_t/p_{t-1})$, p_t is the price index, ur_t is unemployment rate where we define the potential unemployment rate as $ur^* = -\hat{\alpha}_1/\hat{\alpha}_5$. We run a similar regression with capacity utilization rate, $capu_t$ and define the potential rate of capacity utilization, $capu^* = -\hat{\alpha}_1/\hat{\alpha}_5$, similarly.

Then the slack measure is computed by running the following regression

$$\pi_{t+4} - \pi_t = -\beta_1(ur_t - ur^*) + (1 - \beta_1)(capu_t - capu^*) + \epsilon_t$$

and the slack measure is calculated as $slack_t = -\hat{\beta}_1(ur_t - ur^*) + (1 - \hat{\beta}_1)(capu_t - capu^*)$.

FRBD G7 slack [more explanation will be added-we used capacity utilization series calculated by Cette (1990)): Produced by the FRBD and calculated by applying the procedure described above for each member of the G7 economies. After obtaining the 'domestic slack measure for a given country, the GDP shares of each country is calculated so that for country i at quarter t, $share_{i,t}$=$GDP_{i,t}$ / $\sum_i GDP_{i,t}$. The G7 slack is the GDP-weighted average of the slack measures of individual countries.

The data series we use here are as follows:

- GDP series to construct the GDP shares of each country (sources indicated in parentheses): Canada (SCAN), France (INSEE), Germany (BBK), Italy (ISTAT), Japan (CAO), UK (ONS), U.S. (BEA).

All series are in billions of U.S. Dollars, seasonally adjusted (1978:1-2011:4). For France, Germany and Italy, the series are working day adjusted.

- Manufacturing capacity utilization rates (%) come from manufacturing surveys, covering the period 1978:1-2011:4 and are seasonally adjusted for the following countries: France, Germany and U.S. For Italy, the data come from OECDMEI; for Japan, we use manufacturing operation rate; for Canada, we do splicing for capacity utilization rate from OECDMEI (1978:1-1986:4) and the manufacturing survey from SCAN (1987:1-2011:4); while we apply a similar procedure for UK with capacity utilization rate series from Datastream (1978:1-1985:1) and the manufacturing survey from OECDMEI (1985:2-2011:4).

- As a measure of inflation, we use core CPI. All series are seasonally adjusted, come from OECDMEI and the base year is 2005=100 for all countries with the exception that the base year is 2010=100 for Japan and 82-84=100 for the U.S..

FRBD G39 Slack: This measure is calculated by HP filtering ($\lambda = 1600$) of FRBD G39 index which uses constant 2005 (PPP adjusted) weights to aggregate GDP series of the 39 countries: Argentina, Australia, Austria, Belgium, Brazil, Canada, China, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Indonesia, Italy, Ireland, Japan, Korea, Luxembourg, Malaysia, Mexico, Netherlands, New Zealand, Norway, Peru, Poland, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, UK and U.S. GDP series used are quarterly; and for some countries for which only disaggregated (annual) data are available, we apply the quadratic match average method to interpolate these series. We use 2005 PPP data from the IMF.

IMF U.S. and IMF Advanced Slack: Both slack measures are defined as 'Output Gap in Percentage of Real GDP (%)' for the U.S. and for a group of advanced countries (Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, UK and U.S.). These measures are published by IMF WEO, annually and available between 1980-2011. Therefore we interpolate the series by the quadratic match average method to disaggregate into quarterly frequency.

OECD U.S., OECD G7 and OECD Total Slack: All three measures are defined as the 'Output Gap of the Total Economy (%)', published by OECD Economic Outlook. OECD Total consists of 30 OECD countries: Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, UK and U.S. and the series go back to 1970:4.

U.S. HP-filtered GDP: Calculated using quarterly U.S. real GDP series from BEA. First, the logs of the series is taken and multiplied by 100 and then Hodrick-Prescott filter is applied.

4. **Credit series**

We use end-of-period, quarterly, long series on credit to non-financial sectors from the BIS for G7 countries. While data for various borrower-lender combinations are available, we choose lenders from 'all sectors' and borrowers from 'private sector' in order to be able to go back in time as much as possible. The series are adjusted for breaks for all countries except for the US where only unadjusted series are available. For the UK the series start in 1963:1 (Pound Sterling), for Italy in 1960:4 (Euro), for the US in 1952:1 (US

Dollar), for Japan in 1964:4 (Japanese Yen), for France 1969:4 (Euro), for Germany 1948:4 (Euro), and for Canada in 1954:1 (Canadian Dollar) and all series are available until 2011:4. For the period 1965:1-1969:4, we use all countries except France to calculate global average credit growth. For 1970:1 onwards, we use G7 countries to calculate the average credit growth.

5. **REER series**

We use the BIS series for US REER (narrow definition) since it is the longest series available. The series covers the1964:1-2011:4 period, with the base year set as 2005=100 (average). For our forecasts, we use the first differenced and HP-filtered (1-sided) REER series.

E The bootstrap algorithm in three-variable forecasts

To forecast $h-$quarter ahead inflation, $\hat{\pi}^h_{t+h|t}$, we evaluate the predictive ability of pairs of variables in the general form

$$\hat{\pi}^h_{t+h|t} = \alpha_1 + \alpha_{21}(L)\hat{\pi}_t + \alpha_{22}(L)\hat{x}_{1t} + \alpha_{23}(L)\hat{x}_{2t} + \hat{\epsilon}_{t+h}$$

where $\hat{x}_{1t}$ and $\hat{x}_{2t}$ denote either (i) domestic slack and foreign slack, (ii) domestic slack and terms of trade (first differenced), or (iii) domestic money supply growth and foreign money supply growth.

We calculate MSFE-F statistics to test the null hypothesis that the MSFE of the naive forecast is higher than or equal to the MSFE of the augmented model above. We calculate critical values based on a simple parametric bootsrap algorithm with 5000 replacements.[36] In this case, the DGP involves the estimation of a 3-equation VAR and uses the residuals. The first equation is the AR process of inflation, $\hat{\pi}_t$. The remaining two equations are the equations for the predictors where we include the distributed lags of all three variables

$$\hat{\pi}_t = \beta_1 + \beta_2(L)\hat{\pi}_t + \hat{\epsilon}_{1,t}$$

$$\hat{x}_{1t} = \theta_1 + \theta_{11}(L)\hat{\pi}_t + \theta_{12}(L)\hat{x}_{1t} + \theta_{13}(L)\hat{x}_{2t} + \hat{\epsilon}_{2,t}$$

$$\hat{x}_{2t} = \gamma_1 + \gamma_{11}(L)\hat{\pi}_t + \gamma_{12}(L)\hat{x}_{1t} + \gamma_{13}(L)\hat{x}_{2t} + \hat{\epsilon}_{3,t}$$

The lag length is limited to four for each regressor and selected based on SIC.

F Tables and Figures

[36] As suggested by Clark and McCracken (2006) in nested models the F-statistics have non-standard, asymptotic distributions and therefore a bootstrap procedure is needed to calculate the empirical critical values.

Table 2. Relative MSFEs– 1992Q1:2011Q4

Horizon	1	4	6	8	10	12	1	4	6	8	10	12
	Consumer Price Index						**Consumer Price Index (ex. Food & Energy)**					
Autoregressive	4.704	1.881	1.334	1.164	1.065	0.958	0.295	0.418	0.626	0.828	0.954	1.036
CBO U.S. Slack	0.990*	1.042	1.059	1.070	1.100	1.168	1.135	0.974*	0.873**	0.827**	0.840**	0.870*
FRBD U.S. Slack	0.878***	0.936*	0.924*	0.936*	1.001	1.073	1.333*	0.955**	0.788**	0.737**	0.733**	0.751**
IMF U.S. Slack	1.005	1.054	1.068	1.072	1.101	1.170	1.060	1.110	1.106	1.082	1.073	1.079
OECD U.S. Slack	0.984*	1.028	1.038	1.046	1.068	1.118	1.018	0.801***	0.741***	0.739**	0.768**	0.798**
U.S. HP-filtered	0.966	0.980	1.009	1.062	1.086	1.072	0.860***	0.778***	0.811**	0.854**	0.877*	0.889*
U.S. Money Growth	0.996**	1.017	1.030	1.075	1.100	1.147	1.059	1.048	1.090	1.124	1.150	1.183
	PCE Price Index						**Core PCE Price Index**					
Autoregressive	2.329	1.190	0.930	0.885	0.875	0.899	0.337	0.283	0.310	0.386	0.484	0.599
CBO U.S. Slack	0.999	1.026	1.041	1.051	1.069	1.082	0.949**	0.972	0.989	0.999	1.016	1.026
FRBD U.S. Slack	1.006	1.032	1.037	1.030	1.024	1.023	1.022	1.074	1.096	1.086	1.062	1.033
IMF U.S. Slack	1.005	1.024	1.032	1.038	1.055	1.067	0.997	1.016	1.035	1.045	1.048	1.043
OECD U.S. Slack	0.995	1.012	1.020	1.027	1.040	1.048	0.927***	0.920*	0.921*	0.924*	0.946	0.966
U.S. HP-filtered	0.987*	1.022	1.043	1.065	1.071	1.071	0.987*	1.007	1.024	1.041	1.046	1.056
U.S. Money Growth	1.002	1.020	1.045	1.078	1.091	1.125	0.996	1.077	1.132	1.162	1.178	1.196
	GDP Deflator						**Producer Price Index**					
Autoregressive	0.508	0.376	0.423	0.498	0.545	0.575	19.431	7.829	4.724	3.127	2.207	1.786
CBO U.S. Slack	1.005	0.996	1.030	1.040	1.055	1.066	0.980*	1.007	1.032	1.039	1.073	1.119
FRBD U.S. Slack	0.949**	0.910**	0.962*	0.997	1.036	1.050	1.005	1.064	1.102	1.137	1.188	1.250
IMF U.S. Slack	1.037	1.057	1.059	1.048	1.057	1.065	0.996	1.024	1.053	1.082	1.143	1.227
OECD U.S. Slack	0.970**	0.951*	0.999	1.022	1.037	1.047	0.974**	0.989	1.001	0.999	1.006	1.013
U.S. HP-filtered	0.980*	0.980	1.032	1.062	1.069	1.077	0.991	1.023	1.016	1.019	0.988	0.926*
U.S. Money Growth	1.004	1.033	1.057	1.074	1.090	1.108	1.000	1.011	1.035	1.068	1.101	1.157
	Sticky Price						**Sticky Price ex. Shelter**					
Autoregressive	0.048	0.048	0.072	0.096	0.111	0.120	0.049	0.062	0.092	0.115	0.129	0.137
CBO U.S. Slack	1.085	1.087	1.068	1.055	1.044	1.034	1.807	0.871**	0.775**	0.753**	0.748**	0.755**
FRBD U.S. Slack	1.144	0.919**	0.871**	0.788**	0.738**	0.706**	1.387	0.802**	0.735***	0.709**	0.688**	0.678**
IMF U.S. Slack	1.179	0.943	0.838	0.806	0.791	0.782	1.369	0.857***	0.759***	0.717**	0.707**	0.703
OECD U.S. Slack	1.034	1.026	1.024	1.029	1.032	1.032	1.619	0.779	0.708	0.712	0.722	0.739
U.S. HP-filtered	0.921***	0.822**	0.812**	0.841**	0.861*	0.882*	0.952**	0.808**	0.804**	0.821**	0.838**	0.855*
U.S. Money Growth	1.015	1.050	1.076	1.102	1.120	1.130	1.084	1.059	1.082	1.108	1.129	1.147

Note: This table reports the forecasting performances with an estimation sample covering 1980Q1:1991Q4 and a pseudo out-of-sample forecasting sample over 1992Q1:2011Q4. The first row of each panel shows the MSFEs of forecasts with the simple univariate AR process of inflation (restricted model) and are therefore in absolute terms. The remaining entries are the MSFEs of the forecasts under the unrestricted model relative to the MSFEs of the restricted model. Asterisks denote that the relative MSFEs are statistically different and (more accurate) than the MSFEs of the benchmark (restricted) model at 1 (***), 5 (**), and 10 (*) percent significance levels.

Table 3. Relative MSFEs– 1992Q1:2011Q4

Horizon	1	4	6	8	10	12	1	4	6	8	10	12
	Consumer Price Index						Consumer Price Index (ex. Food & Energy)					
Autoregressive	4.704	1.881	1.334	1.164	1.065	0.958	0.295	0.418	0.626	0.828	0.954	1.036
FRBD G7	0.977*	1.049	1.014	1.017	1.049	1.076	0.947**	0.912**	0.776**	0.740**	0.745**	0.769**
FRBD G28	0.969**	0.974	1.006	1.080	1.121	1.104	0.896***	0.819**	0.852**	0.899*	0.921*	0.927
IMF Adv.	1.005	1.050	1.054	1.046	1.041	1.059	1.018	1.054	1.058	1.039	1.023	1.014
OECD G7	0.981	1.036	1.049	1.060	1.067	1.087	0.905***	0.769***	0.680***	0.668***	0.699**	0.735**
OECD Total	0.989*	1.045	1.061	1.073	1.081	1.101	0.968**	0.816***	0.701***	0.677***	0.703**	0.738**
G7 Money Growth	1.010	0.908**	0.854**	0.832**	0.783**	0.736***	0.971**	0.864**	0.898***	0.813**	0.848**	0.860**
	PCE Price Index						Core PCE Price Index					
Autoregressive	2.329	1.190	0.930	0.885	0.875	0.899	0.337	0.283	0.310	0.386	0.484	0.599
FRBD G7	0.934***	1.059	1.045	1.083	1.130	1.131	1.018	1.039	1.032	1.023	1.008	1.099
FRBD G28	0.989*	1.010	1.048	1.110	1.135	1.131	0.982*	0.995	1.041	1.093	1.103	1.094
IMF Adv.	1.006	1.013	0.993	0.977	0.966	0.960	1.005	1.015	1.016	1.020	1.010	1.001
OECD G7	0.994	1.018	1.018	1.017	1.016	1.014	0.951**	0.964	0.967	0.976	0.989	1.009
OECD Total	0.999	1.024	1.023	1.022	1.022	1.021	0.966**	0.980	0.984	0.993	1.006	1.026
G7 Money Growth	1.001	0.845***	0.852**	0.840**	0.785***	0.782***	0.991	0.932**	0.973	0.931*	0.939*	0.951
	GDP Deflator						Producer Price Index					
Autoregressive	0.508	0.376	0.423	0.498	0.545	0.575	19.431	7.829	4.724	3.127	2.207	1.786
FRBD G7	1.053	0.989	0.991	1.013	1.059	1.074	1.009	1.050	1.052	1.061	1.050	1.023
FRBD G28	0.968**	0.986	1.053	1.111	1.134	1.136	0.994	1.016	1.048	1.111	1.147	1.110
IMF Adv.	0.996	0.780***	0.811**	0.887*	0.951	1.000	0.990*	1.020	1.051	1.078	1.106	1.134
OECD G7	0.992	1.001	1.026	1.026	1.029	1.029	0.964**	0.994	1.018	1.031	1.039	1.034
OECD Total	1.005	1.015	1.035	1.032	1.037	1.038	0.971**	1.003	1.027	1.040	1.047	1.041
G7 Money Growth	1.030	0.973*	0.951*	0.928*	0.915*	0.909*	1.019	0.999	1.001	1.020	1.041	1.020
	Sticky Price						Sticky Price ex. Shelter					
Autoregressive	0.048	0.048	0.072	0.096	0.111	0.120	0.049	0.062	0.092	0.115	0.129	0.137
FRBD G7	1.046	1.044	1.016	0.983	0.944	0.906	1.070	0.878**	0.822**	0.808**	0.805**	0.808**
FRBD G28	0.925***	0.872**	0.877**	0.908*	0.932*	0.952	0.959**	0.871**	0.878**	0.898*	0.918*	0.933
IMF Adv.	1.051	1.054	1.032	0.999	0.963	0.925	1.075	1.035	1.025	1.004	0.976	0.948
OECD G7	0.986*	0.973	0.997	1.014	1.017	1.011	1.614	0.731***	0.637***	0.650***	0.676**	0.706**
OECD Total	0.999	0.992	1.009	1.021	1.021	1.013	1.630	0.773***	0.664***	0.665***	0.687**	0.718**
G7 Money Growth	0.943***	0.870**	0.835**	0.866**	0.898**	0.906*	1.051	0.873**	0.857**	0.896**	0.931*	0.944

Note: This table reports the forecasting performances with an estimation sample covering 1980Q1:1991Q4 and a pseudo out-of-sample forecasting sample over 1992Q1:2011Q4. The first row of each panel shows the MSFEs of forecasts with the simple univariate AR process of inflation (restricted model) and are therefore in absolute terms. The remaining entries are the MSFEs of the forecasts under the unrestricted model relative to the MSFEs of the restricted model. Asterisks denote that the relative MSFEs are statistically different and (more accurate) than the MSFEs of the benchmark (restricted) model at 1 (***), 5 (**), and 10 (*) percent significance levels.

Table 4. Relative MSFEs– 1992Q1:2011Q4

Horizon	1	4	6	8	10	12	1	4	6	8	10	12
	Consumer Price Index						**Consumer Price Index (ex. Food & Energy)**					
Autoregressive	4.704	1.881	1.334	1.164	1.065	0.958	0.295	0.418	0.626	0.828	0.954	1.036
ToT FD	1.011	0.979*	0.989	0.996	0.997	1.011	1.031	0.988	0.983*	0.989	0.995	1.002
ToT HP1	1.009	1.009	1.041	1.047	1.030	0.993	0.945**	0.959*	0.969	0.985	0.989	0.968
ToT ex. oil FD	1.019	1.024	1.014	0.987	0.954**	0.899***	1.094	1.135	1.113	1.063	1.034	1.005
ToT ex. oil HP1	1.023	0.991	0.931*	0.874*	0.787**	0.711**	1.042	1.058	1.050	1.017	0.979	0.936
	PCE Price Index						**Core PCE**					
Autoregressive	2.329	1.190	0.930	0.885	0.875	0.899	0.337	0.283	0.310	0.386	0.484	0.599
ToT FD	1.006	0.988*	0.990	0.998	0.999	1.008	0.944***	1.011	0.999	0.993	0.989	0.992
ToT HP1	1.009	1.035	1.042	1.027	0.977	0.899**	0.958**	0.960*	0.884**	0.834**	0.804***	0.756***
ToT ex. oil FD	1.025	0.998	0.962**	0.927**	0.874***	0.831***	1.057	0.958**	0.915**	0.894***	0.853***	0.844***
ToT ex. oil HP1	1.012	0.913**	0.831**	0.750**	0.645**	0.566***	0.989	0.901**	0.837**	0.792**	0.747**	0.712**
	GDP Deflator						**PPI**					
Autoregressive	0.508	0.376	0.423	0.498	0.545	0.575	19.431	7.829	4.724	3.127	2.207	1.786
ToT FD	0.979*	0.957**	0.985*	1.005	1.007	1.005	1.020	0.996	1.013	1.019	1.037	1.035
ToT HP1	0.929***	0.932**	0.952*	0.949*	0.910**	0.852**	1.070	1.116	1.204	1.378	1.594	1.649
ToT ex. oil FD	0.985*	1.020	0.986	0.964*	0.926**	0.904***	1.081	1.060	1.126	1.152	1.233	1.303
ToT ex. oil HP1	0.976*	0.952*	0.898*	0.849*	0.782**	0.720**	1.033	1.042	1.066	1.090	1.146	1.195
	Sticky Price						**Sticky Price ex. Shelter**					
Autoregressive	0.048	0.048	0.072	0.096	0.111	0.120	0.049	0.062	0.092	0.115	0.129	0.137
ToT FD	1.041	0.970**	0.978*	0.994	1.003	1.007	1.086	0.974**	0.977**	0.992	1.002	1.005
ToT HP1	0.897***	0.907**	0.966	0.993	0.991	0.973	0.910***	0.923**	0.964	0.990	0.988	0.969
ToT ex. oil FD	1.069	1.074	1.076	1.052	1.029	1.008	1.066	1.069	1.057	1.042	1.025	1.004
ToT ex. oil HP1	1.019	1.004	0.990	0.970	0.939	0.904	1.028	1.010	0.997	0.979	0.953	0.923

This table reports the forecasting performances with an estimation sample covering 1980Q1:1991Q4 and a pseudo out-of-sample forecasting sample over 1992Q1:2011Q4. The first row of each panel shows the MSFEs of forecasts with the simple univariate AR process of inflation (restricted model) and are therefore in absolute terms. The remaining entries in each panel report the relative MSFEs of the univariate forecasts with terms of trade measures. Asterisks denote that the relative MSFEs are statistically different and (more accurate) than the MSFEs of the restricted model at 1 (***), 5 (**), and 10 (*) percent significance levels.

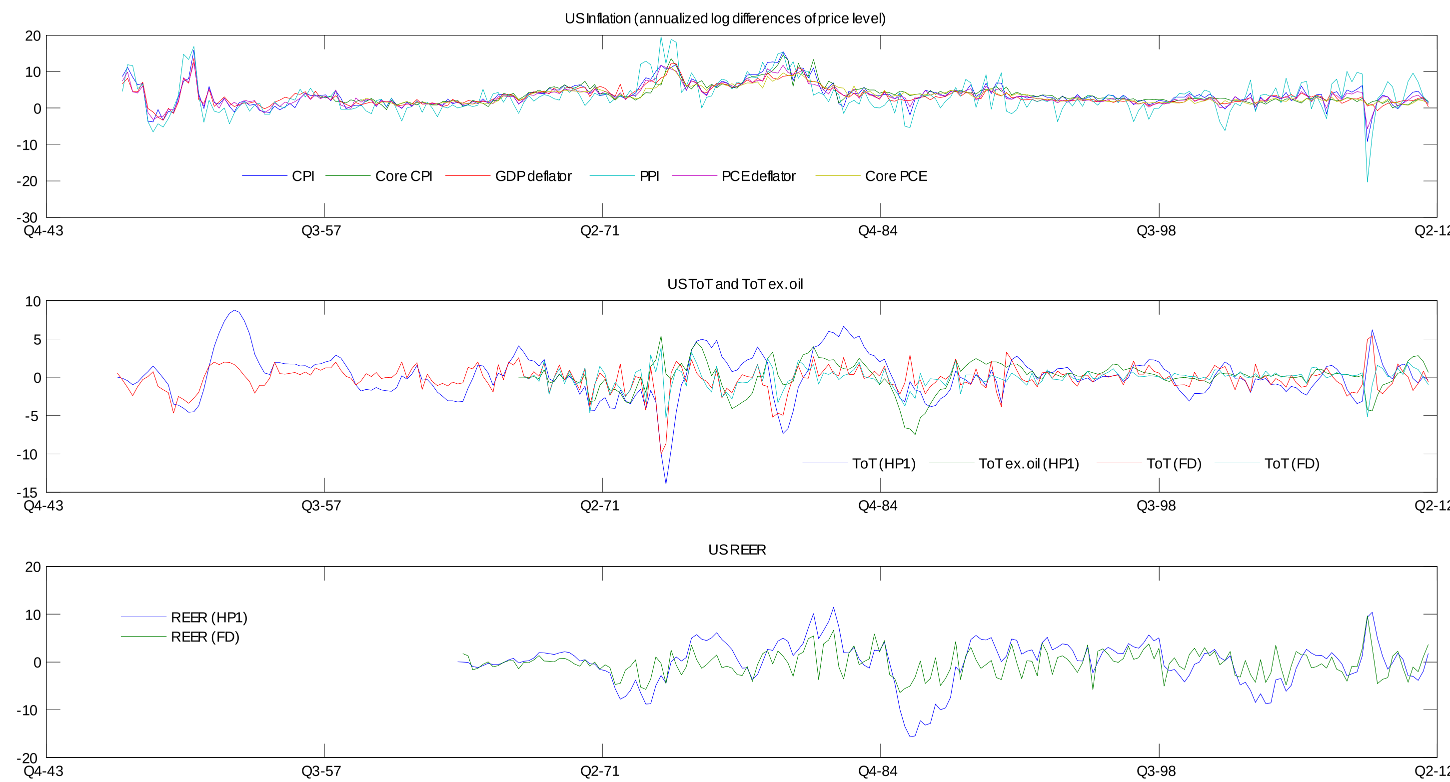

FIGURE 1A. Time series plots of the data

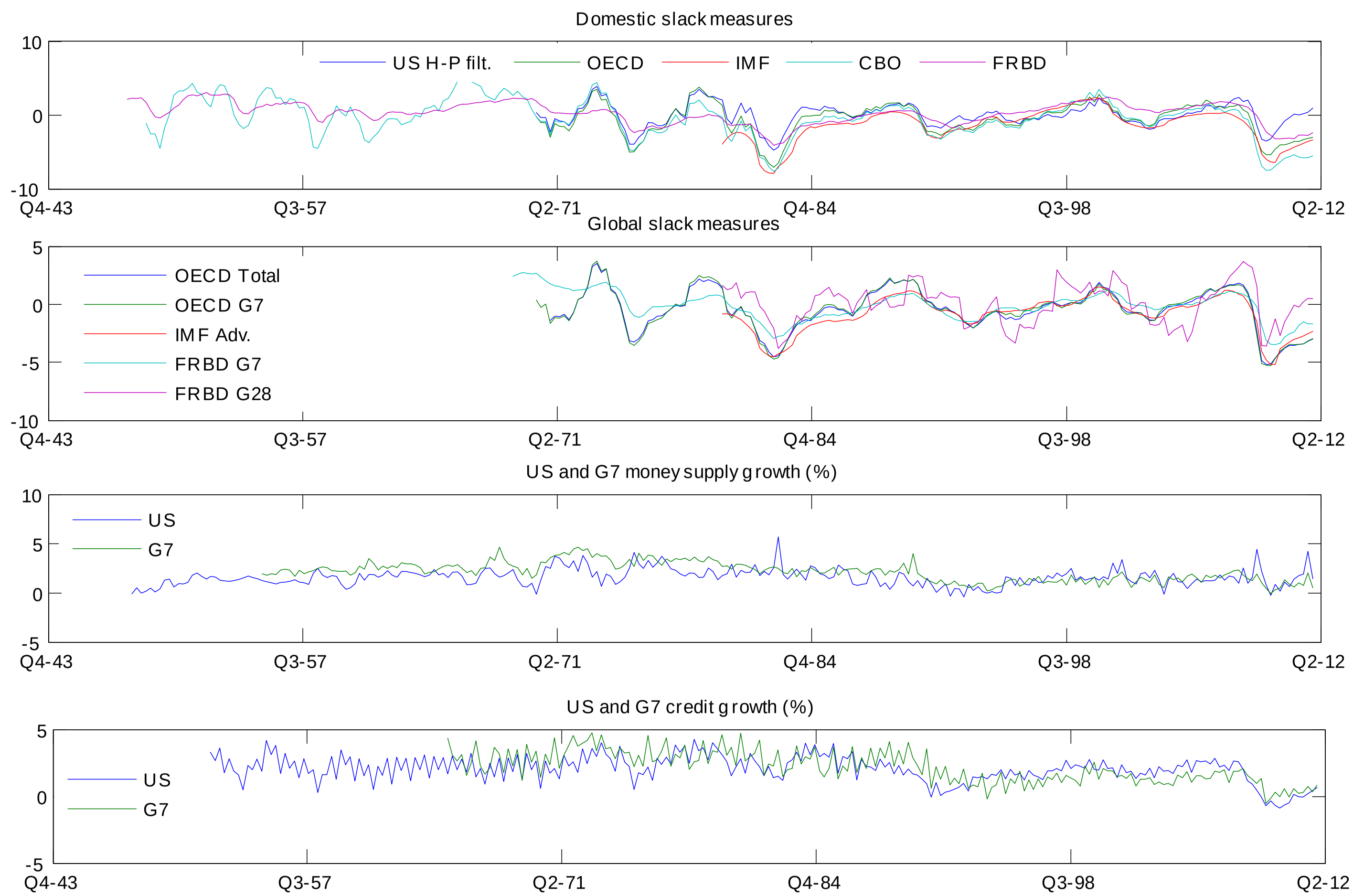

FIGURE 1B. Time series plots of the data

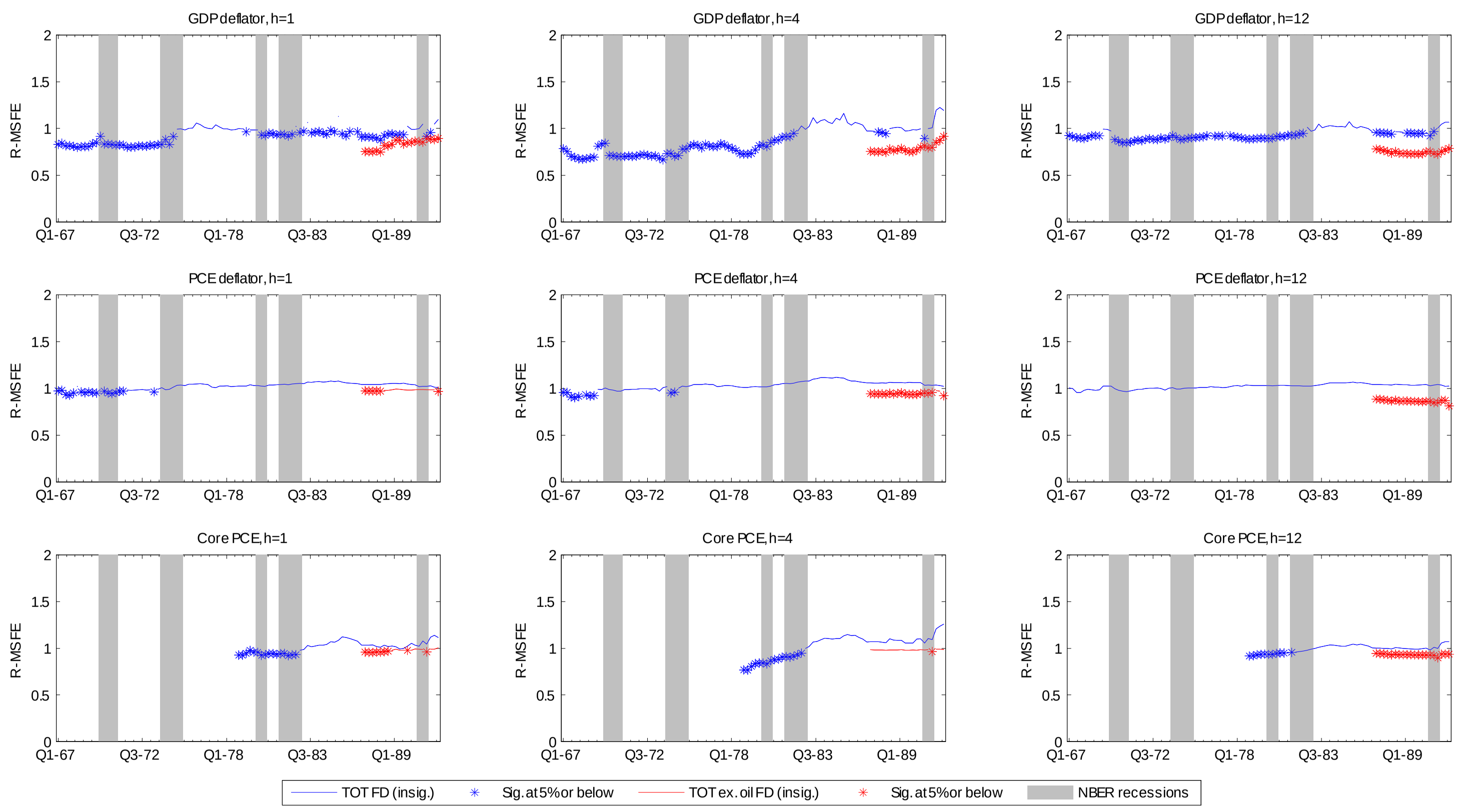

FIGURE 2A. Evolution of the relative MSFEs of the forecasts with the terms of trade vs. terms of trade ex. oil (first differenced)

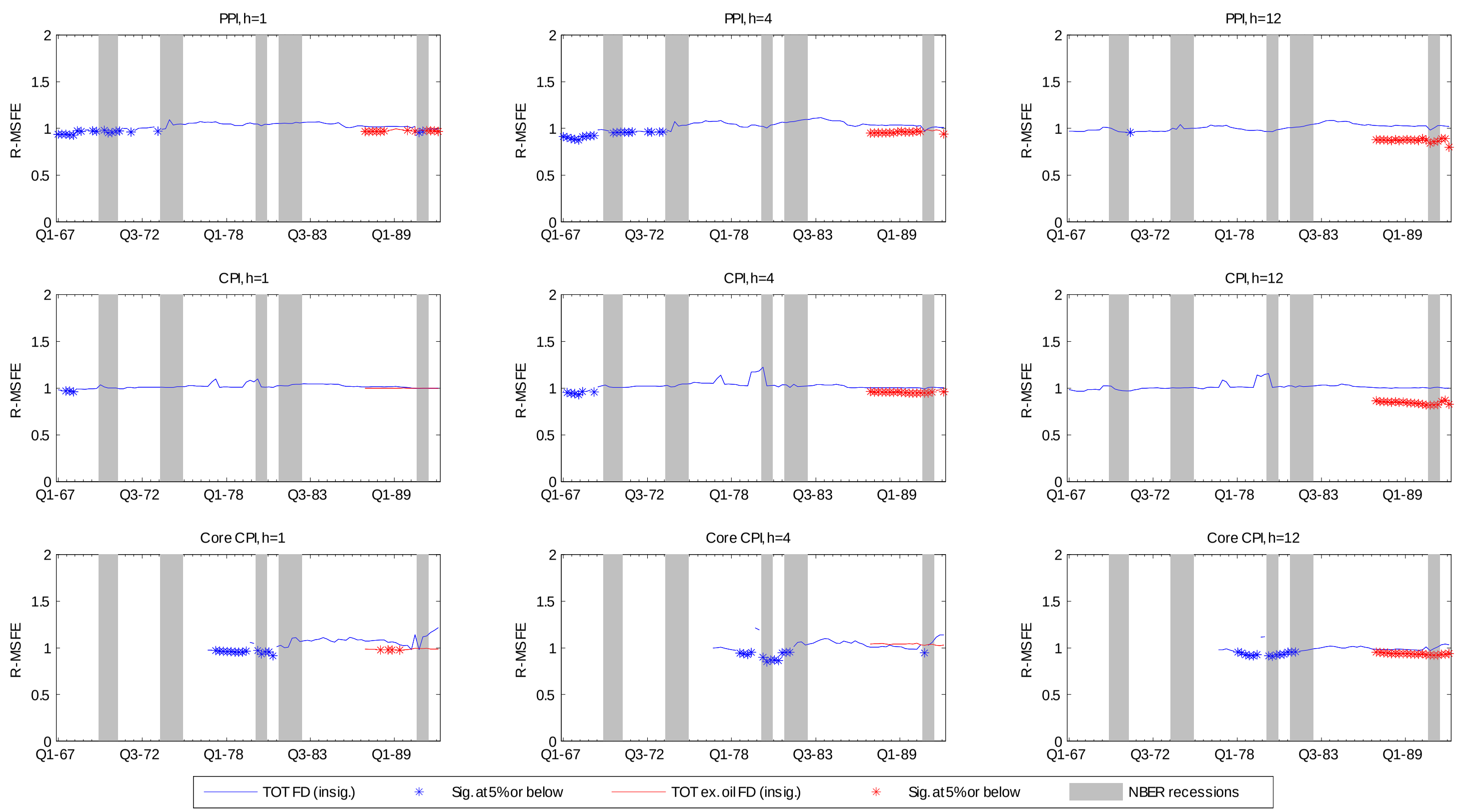

FIGURE 2B. Evolution of the relative MSFEs of the forecasts with the terms of trade vs. terms of trade ex. oil (first differenced)

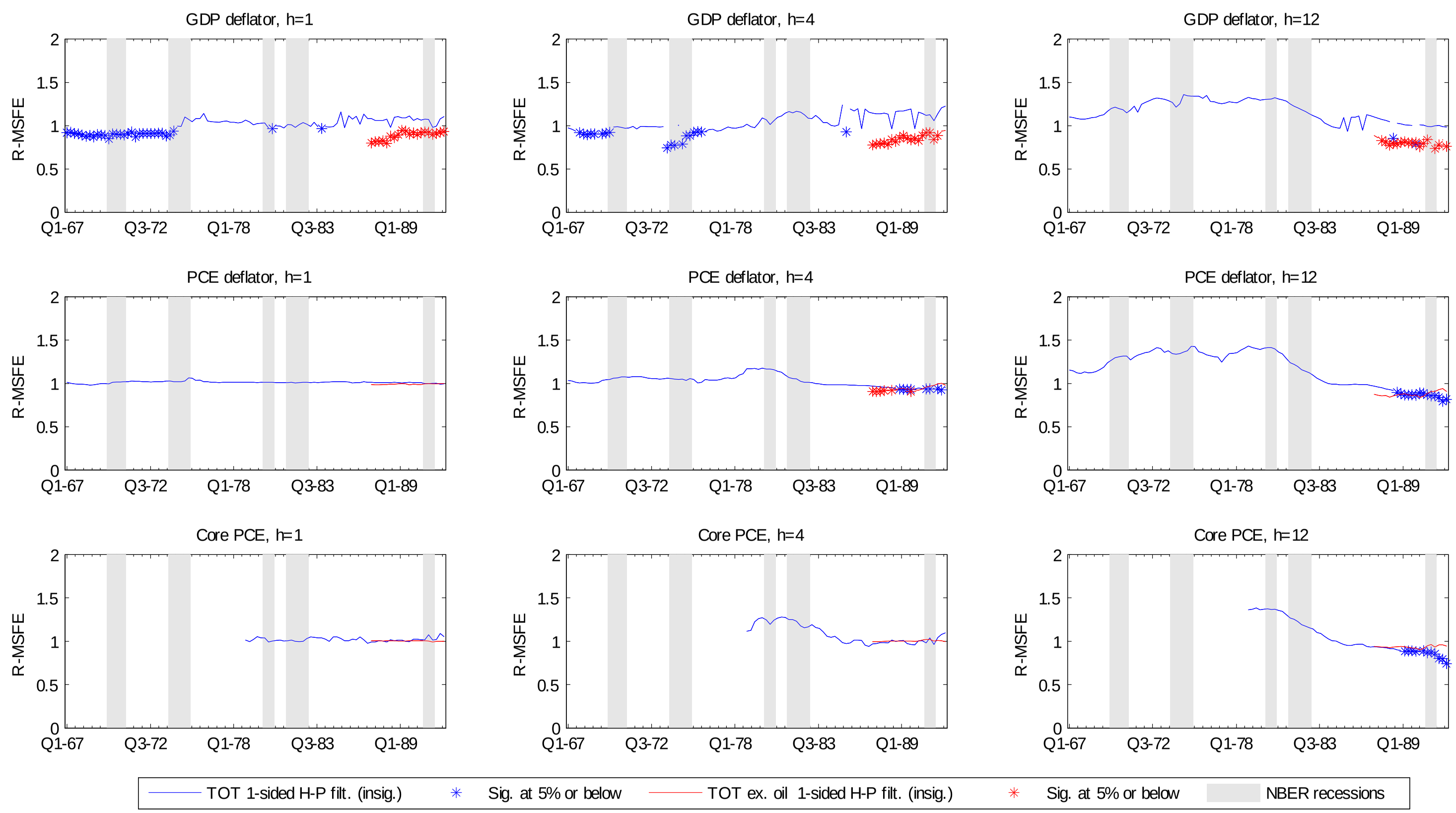

FIGURE 3A. Evolution of the relative MSFEs of the forecasts with the terms of trade vs. terms of trade ex. oil (1-sided Hodrick-Prescott filtered)

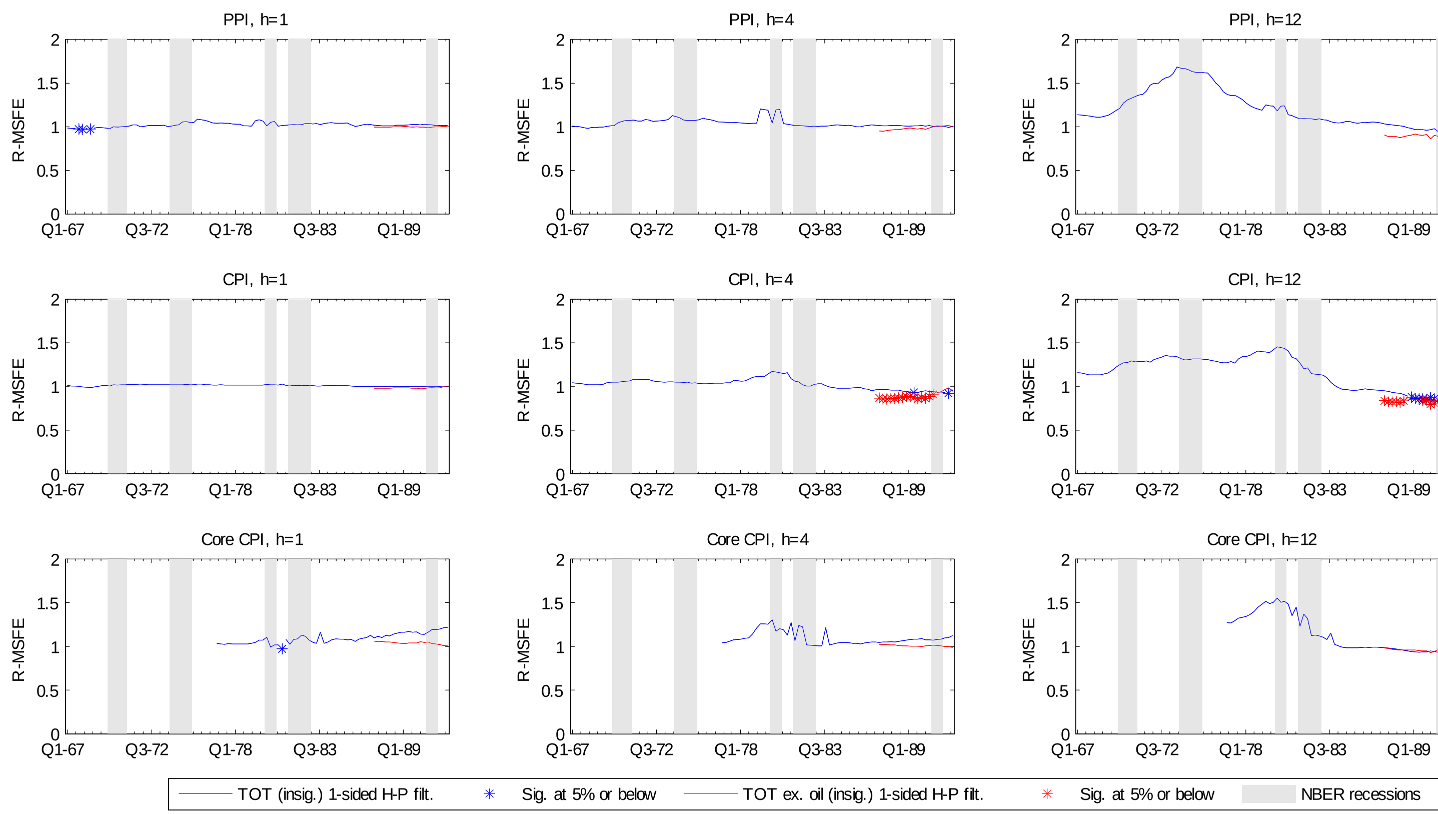

FIGURE 3B. Evolution of the relative MSFEs of the forecasts with the terms of trade vs. terms of trade ex. oil (1-sided Hodrick-Prescott filtered)

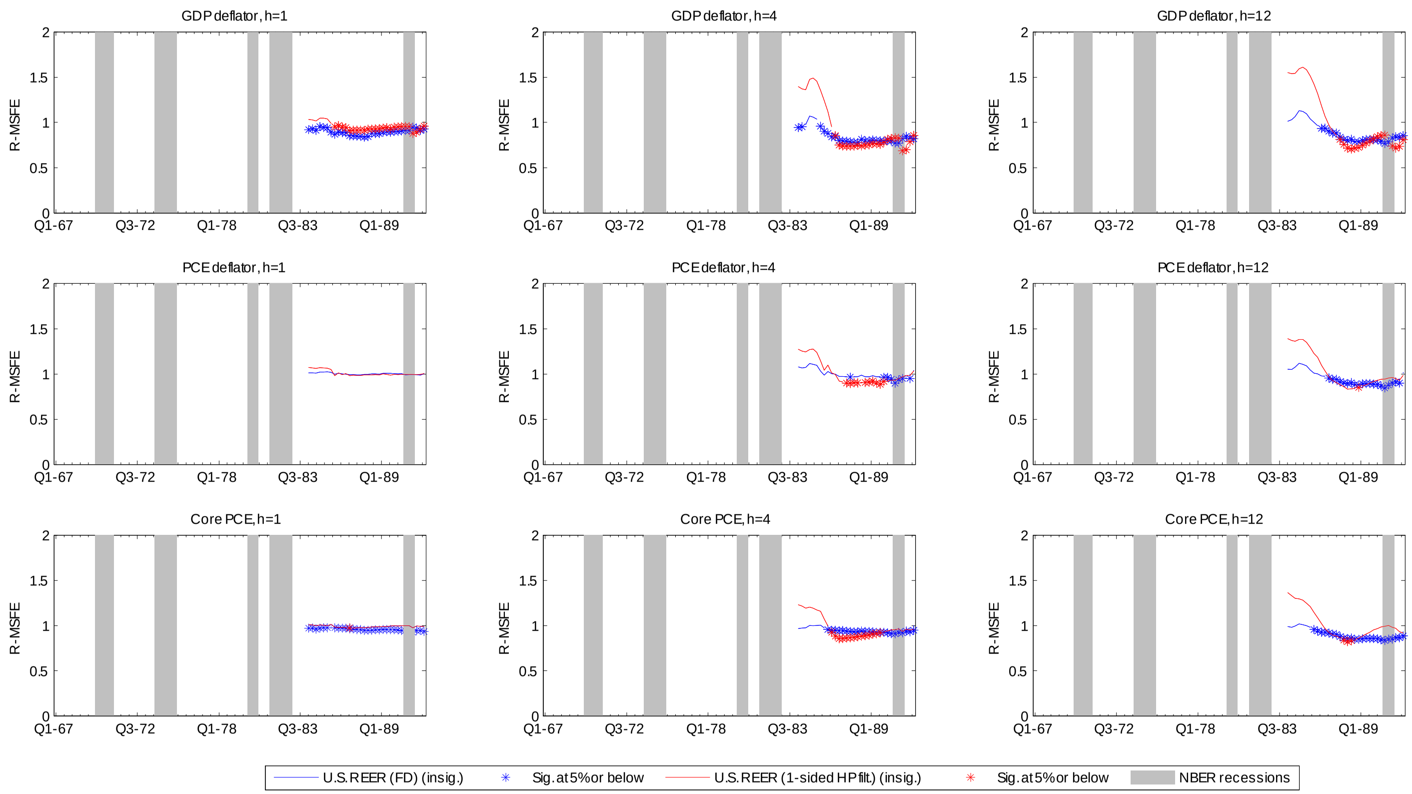

FIGURE 4A. Evolution of the relative MSFEs of the forecasts with the REER (first differences) vs. REER (1-sided Hodrick-Prescott filtered)

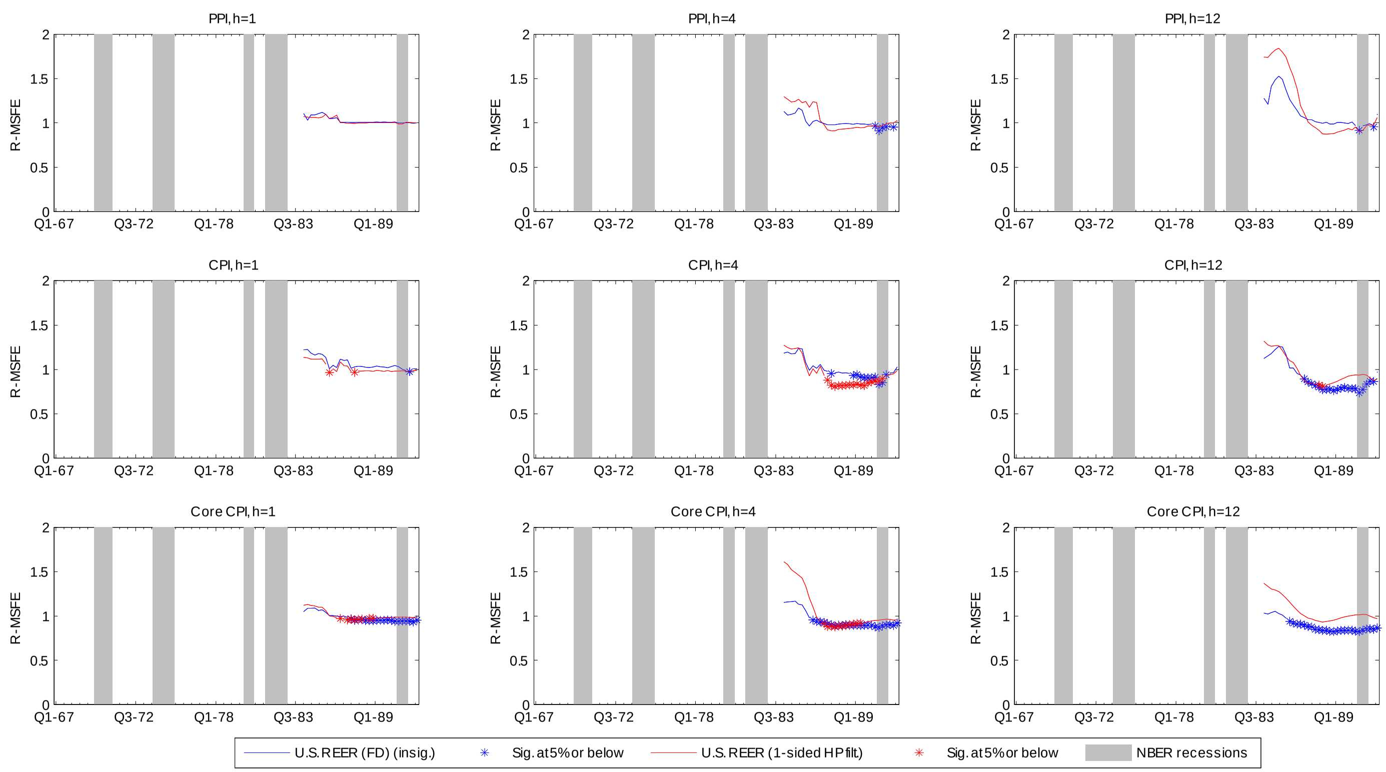

FIGURE 4B. Evolution of the relative MSFEs of the forecasts with the REER (first differences) vs. REER (1-sided Hodrick-Prescott filtered)

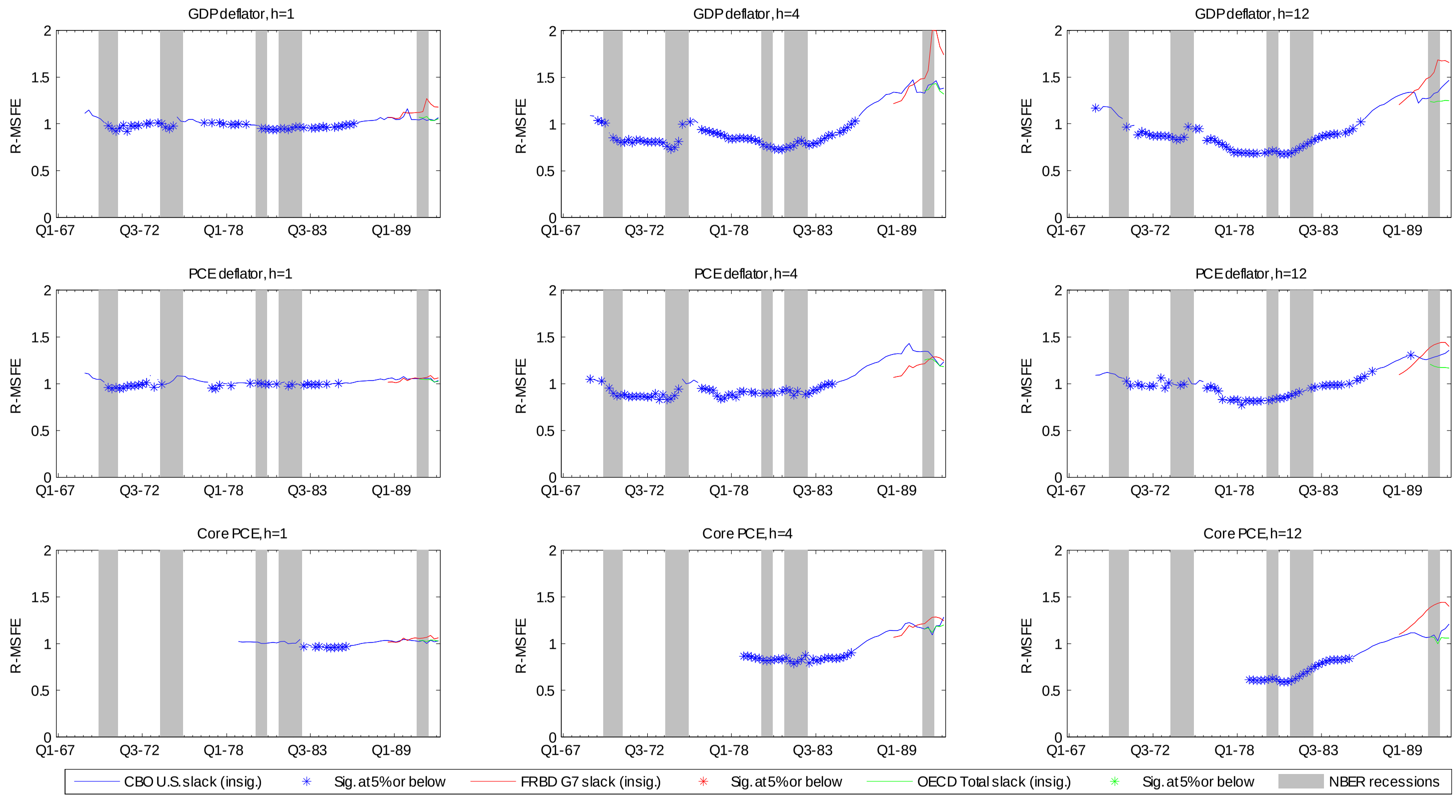

FIGURE 5A. Evolution of the relative MSFEs of the forecasts with CBO US, FRBD G7, and OECD Total Slack

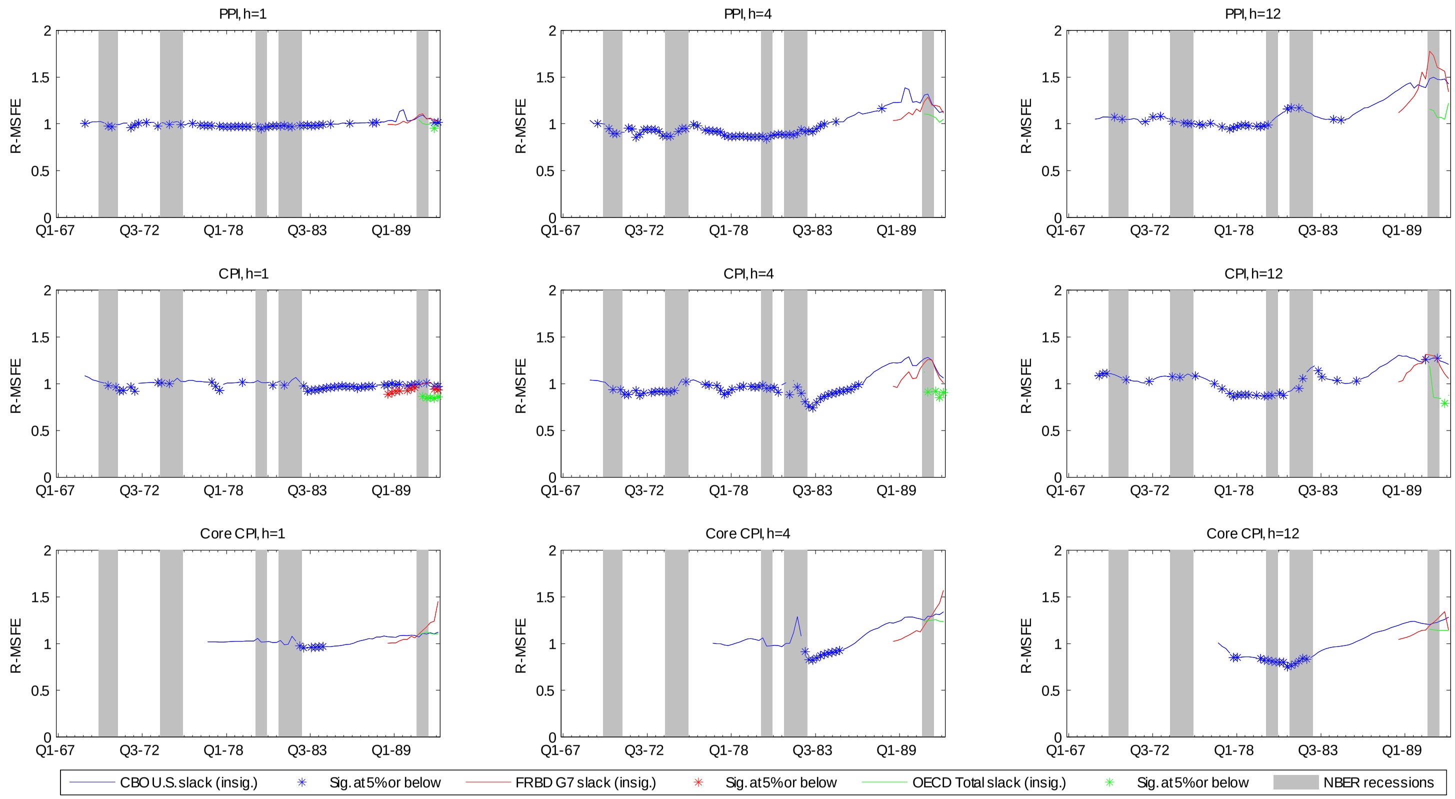

FIGURE 5B. Evolution of the relative MSFEs of the forecasts with the CBO US, FRBD G7, and OECD Total Slack

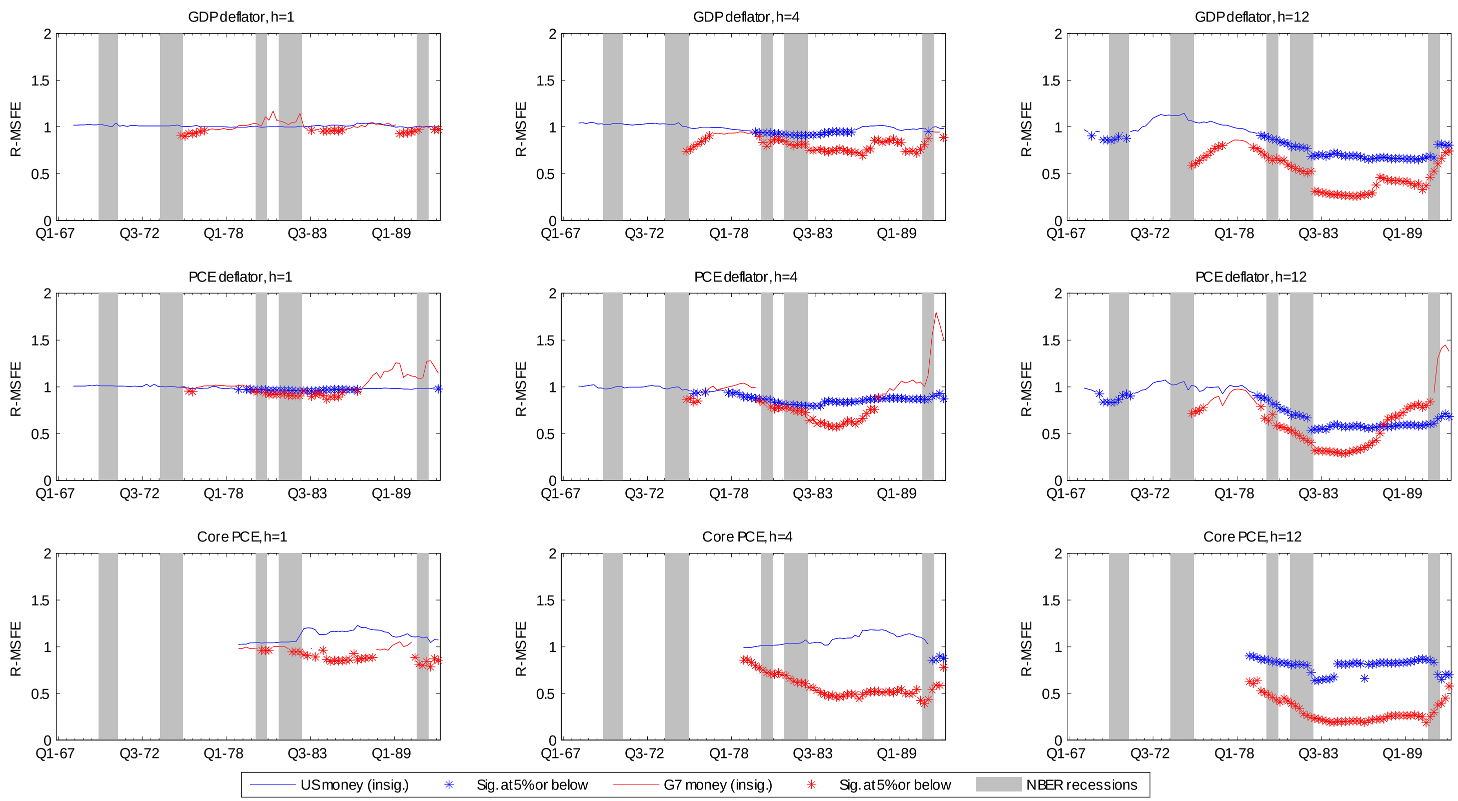

FIGURE 6A. Evolution of the relative MSFEs of the forecasts with US and G7 money supply growth

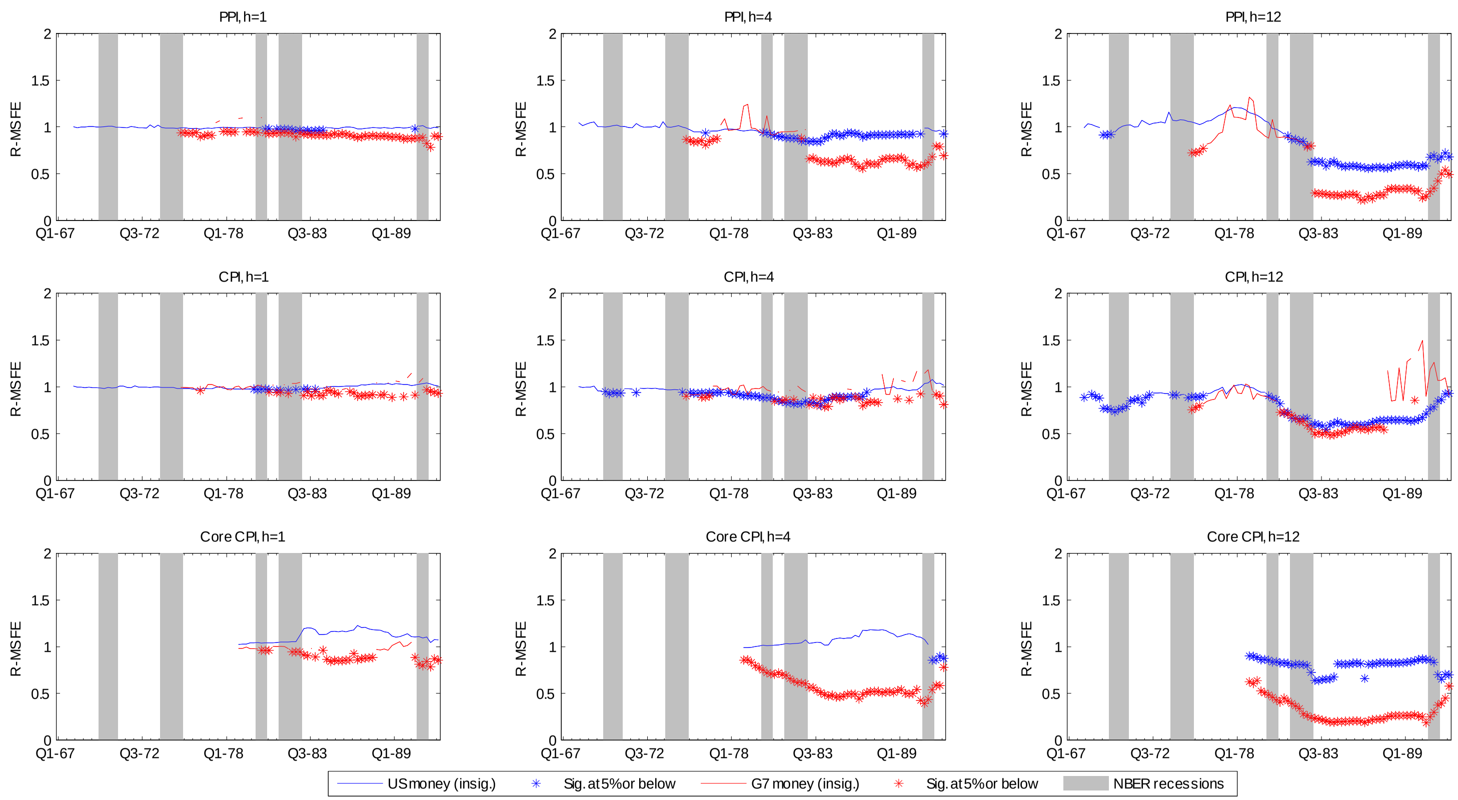

FIGURE 6B. Evolution of the relative MSFEs of the forecasts with US and G7 money supply growth

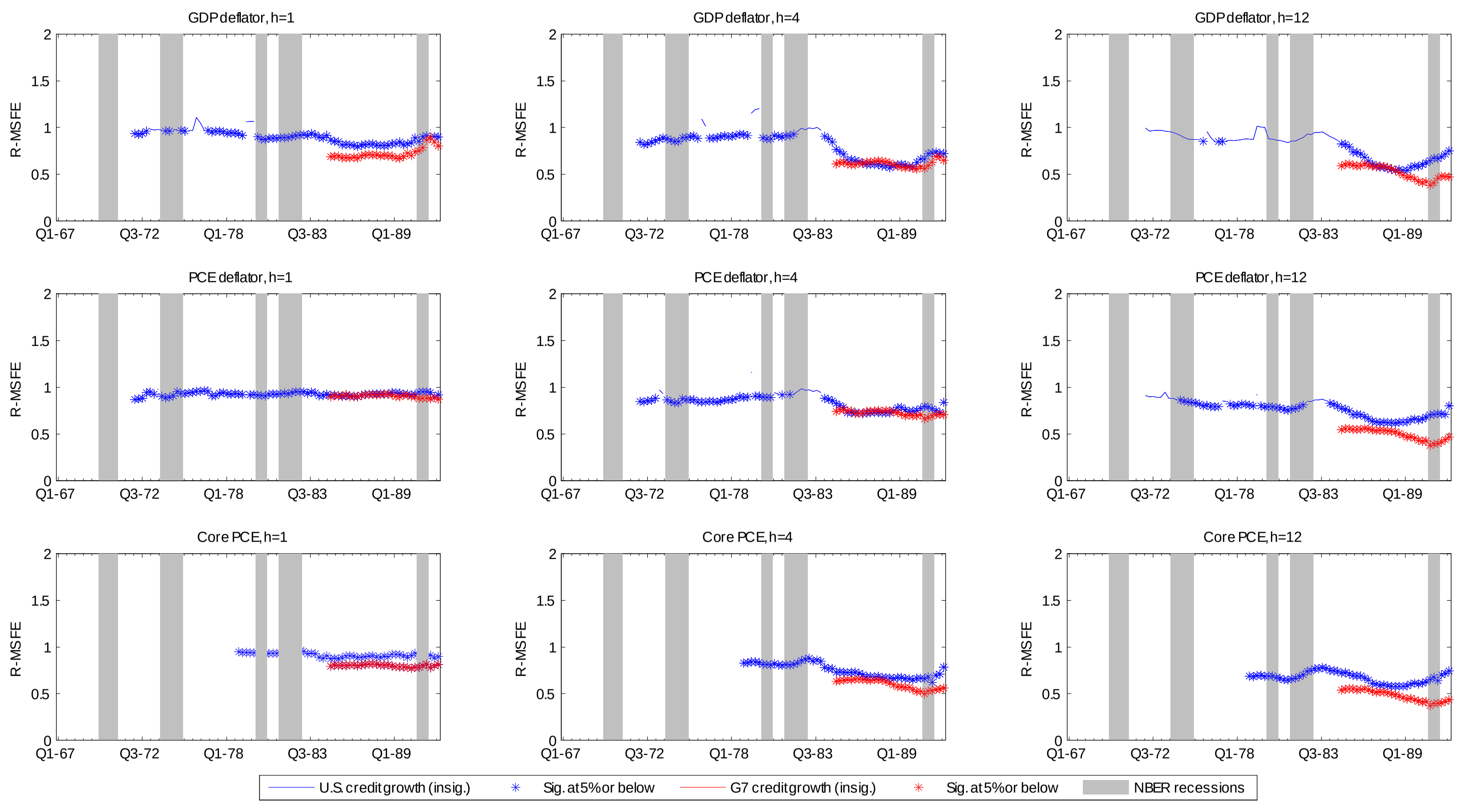

FIGURE 7A. Evolution of the relative MSFEs of the forecasts with US and G7 credit growth

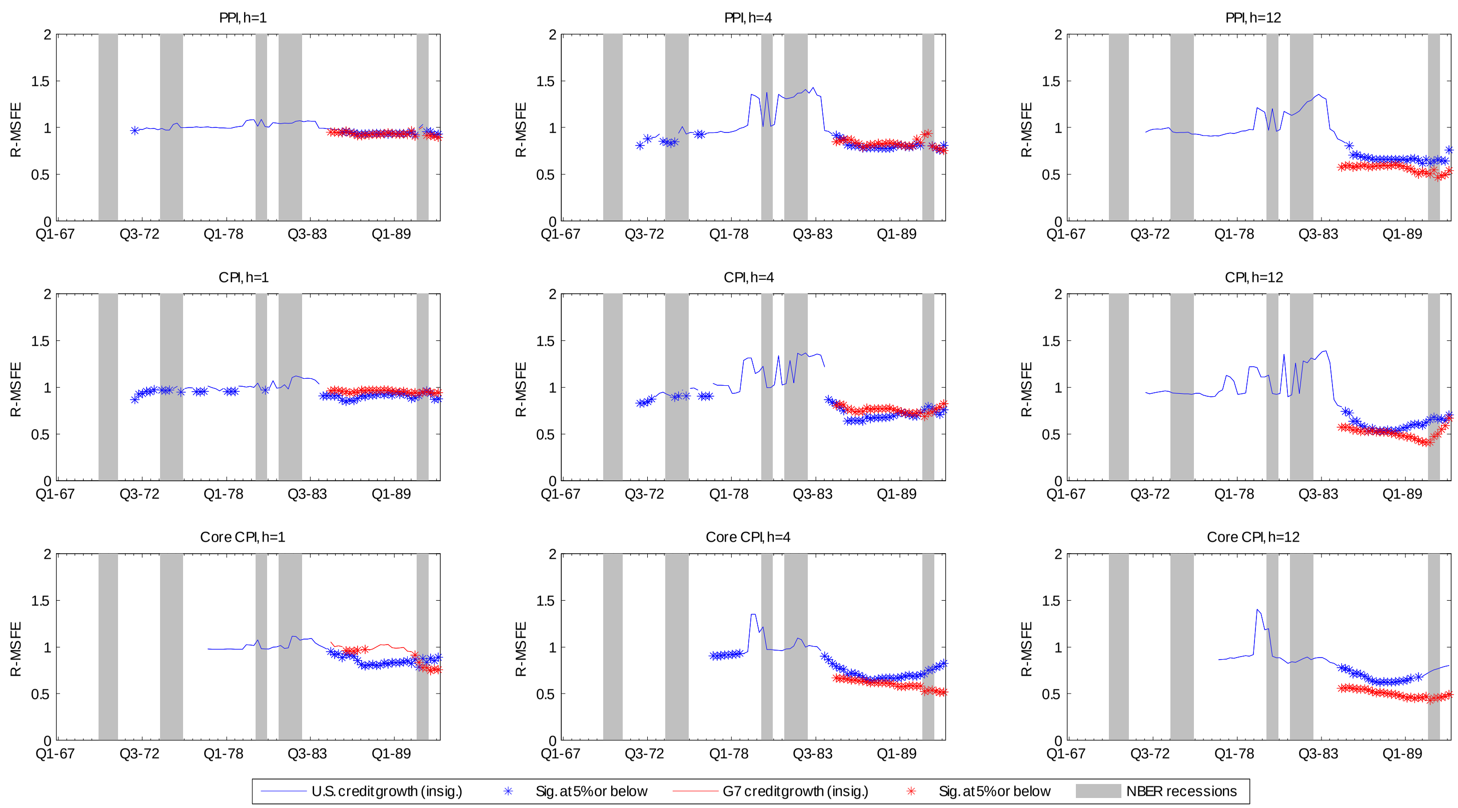

FIGURE 7B. Evolution of the relative MSFEs of the forecasts with US and G7 credit growth

F.1 Results

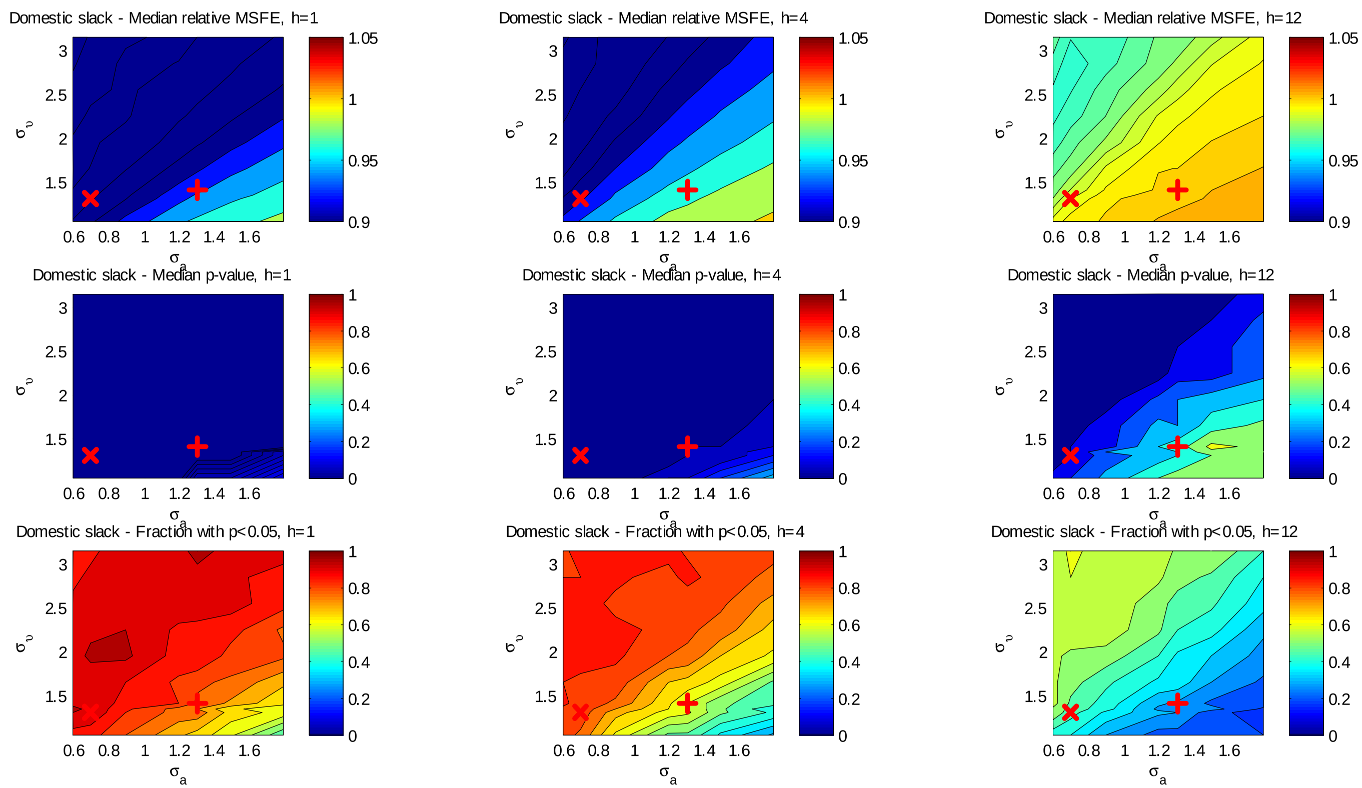

FIGURE 7A. Model's prediction of the relative MSFEs of forecasts with domestic slack as a function of the parameters of *good luck*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).
Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.
Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

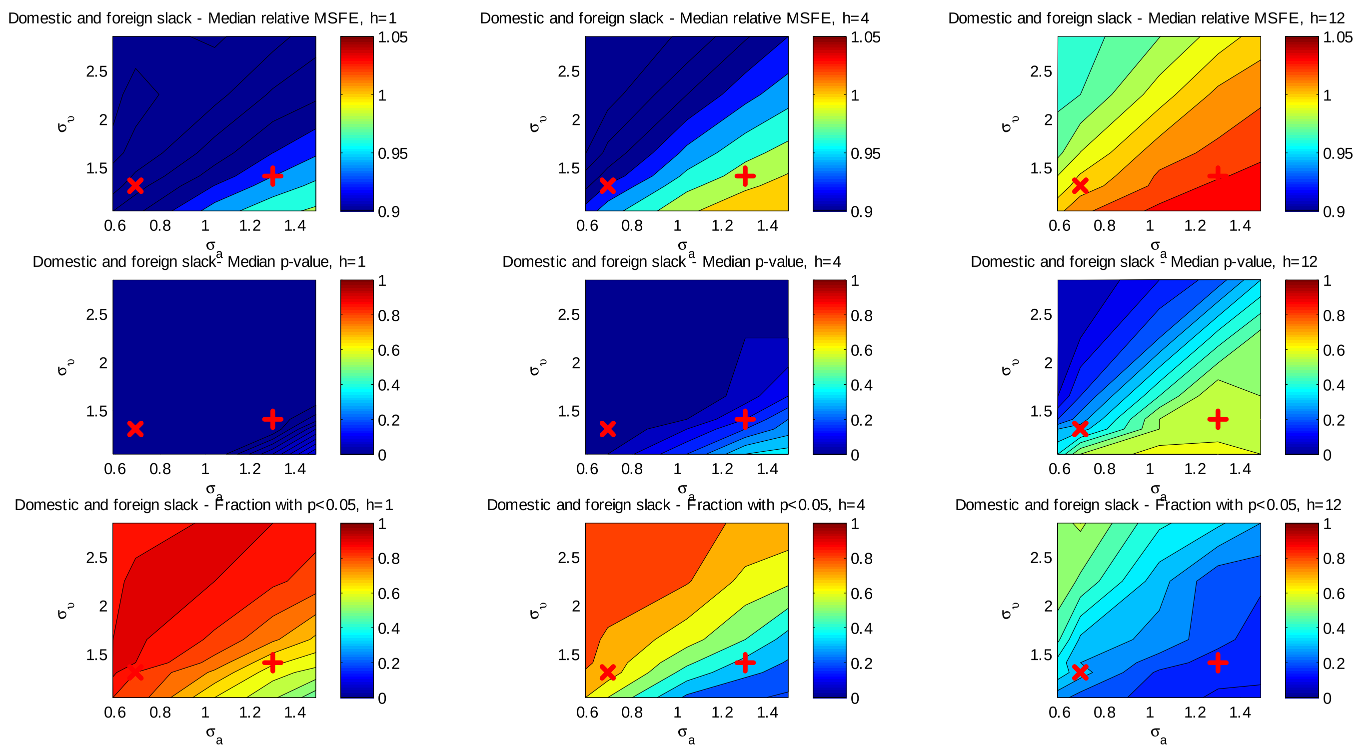

FIGURE 7B. Model's prediction of the relative MSFEs of forecasts with domestic and foreign slack as a function of the parameters of *good luck*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).
Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.
Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

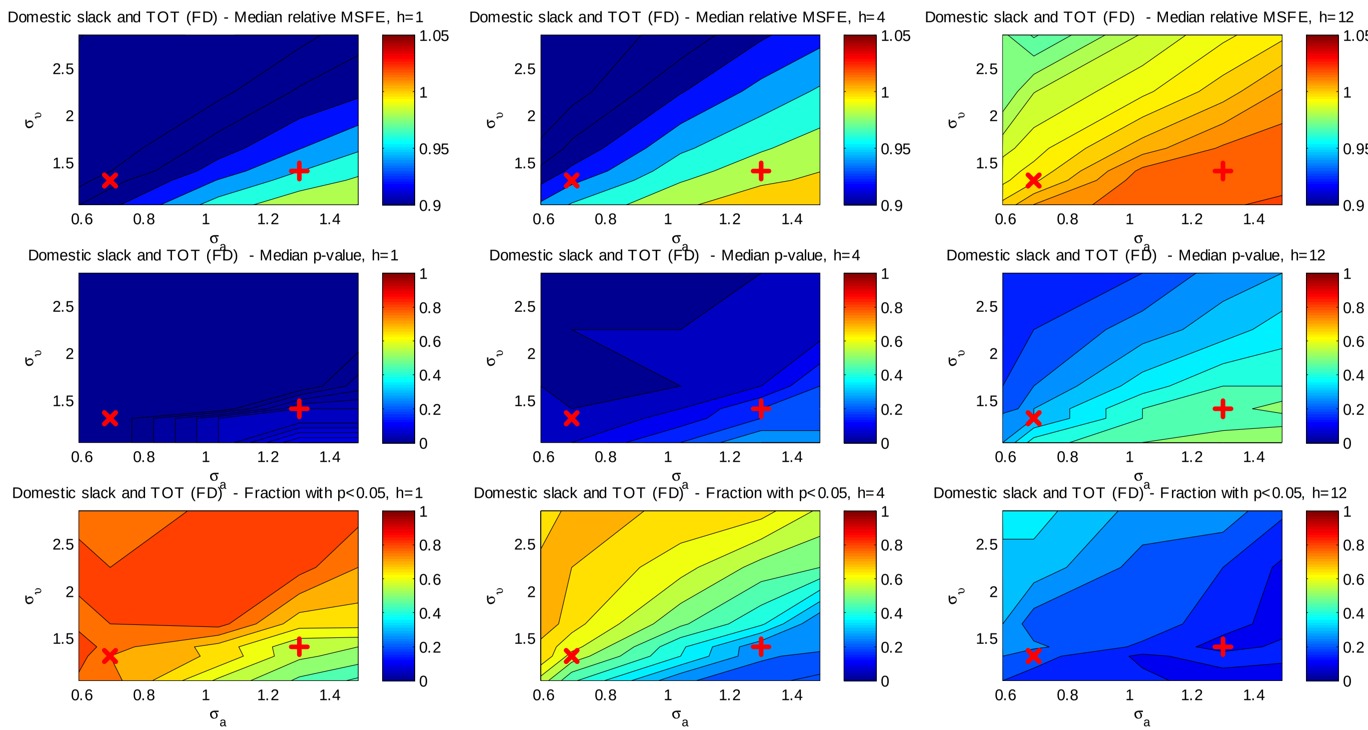

FIGURE 7C. Model's prediction of the relative MSFEs of forecasts with domestic slack and TOT (FD) as a function of the parameters of *good luck*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).
Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.
Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

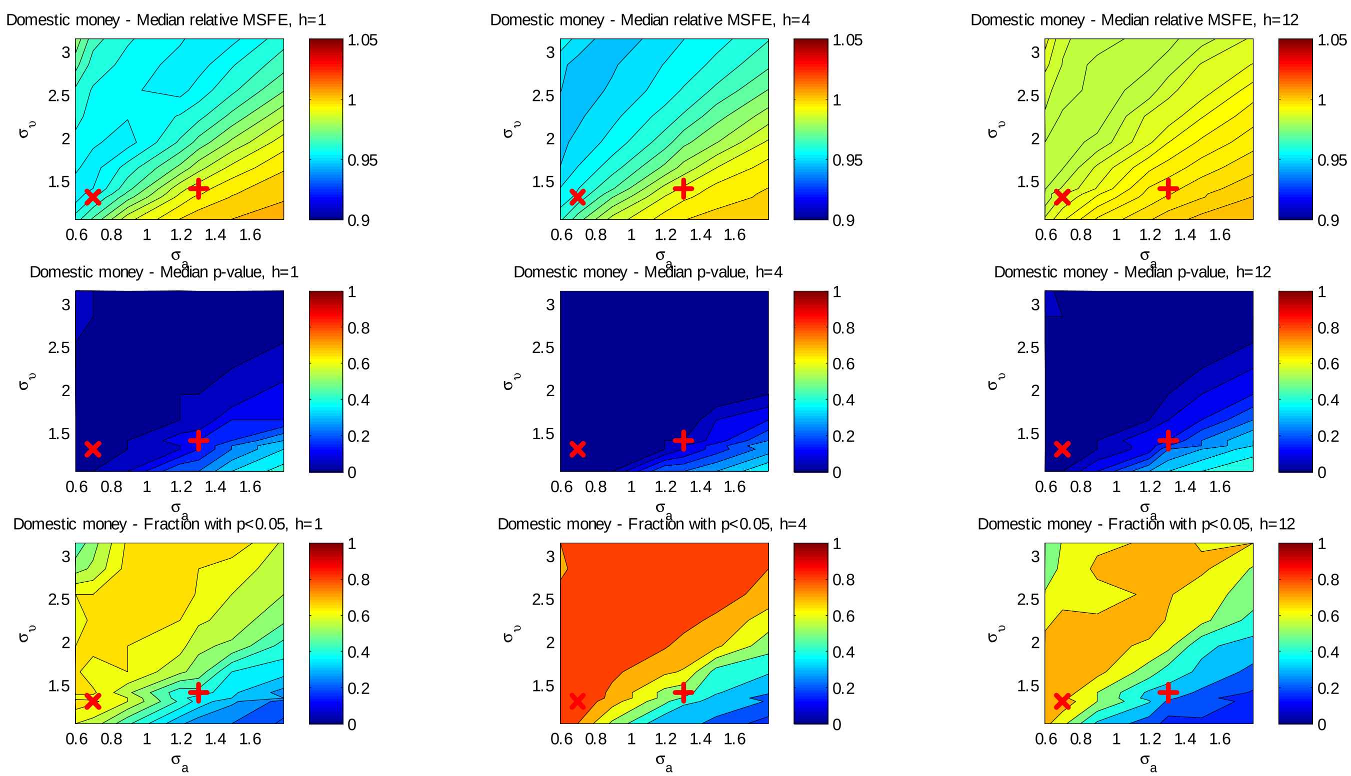

FIGURE 7D. Model's prediction of the relative MSFEs of forecasts with domestic money supply growth as a function of the parameters of *good luck*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).

Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

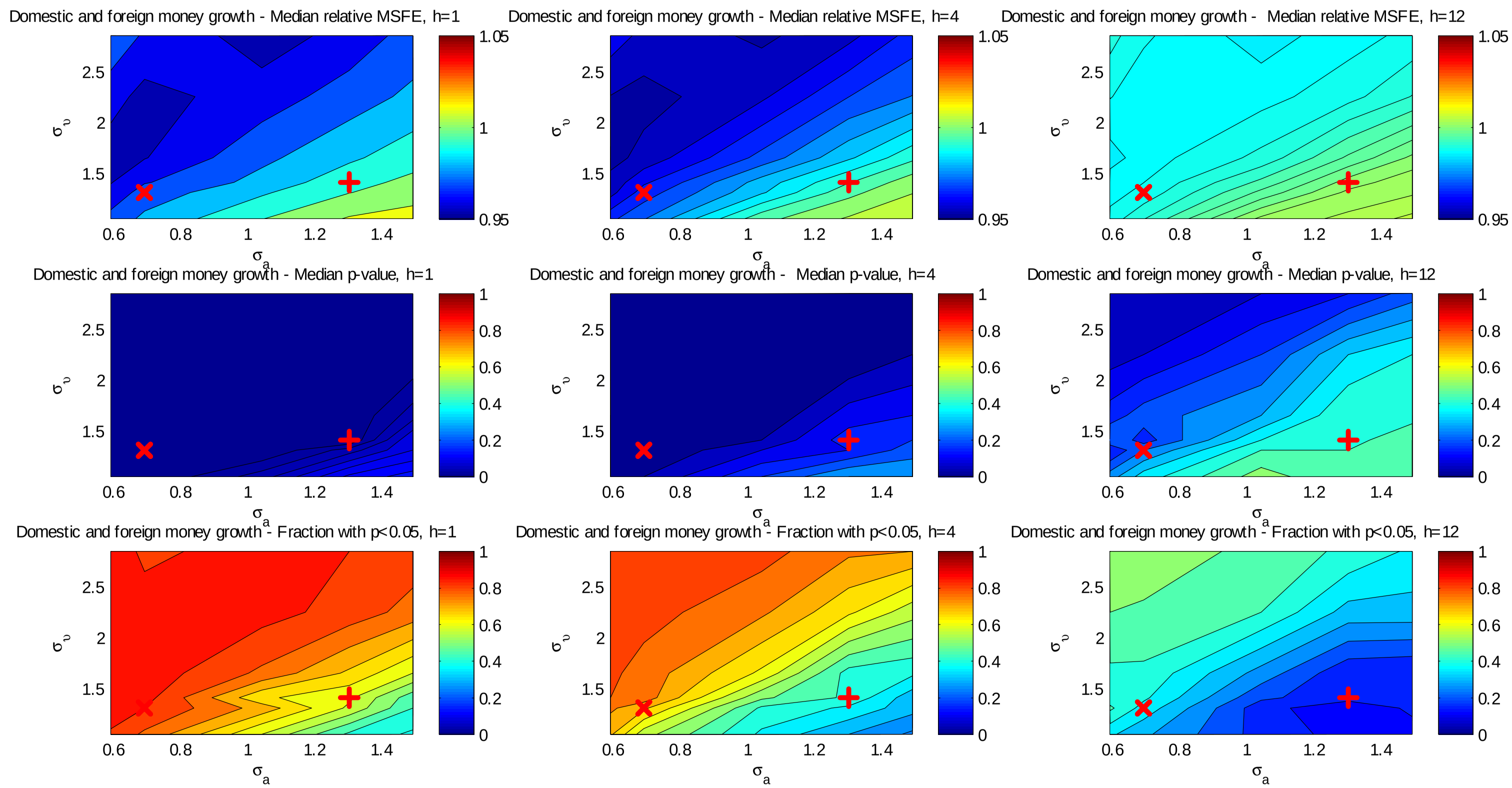

FIGURE 7E. Model's prediction of the relative MSFEs of forecasts with domestic and foreign money supply growth as a function of the parameters of *good luck*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).

Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

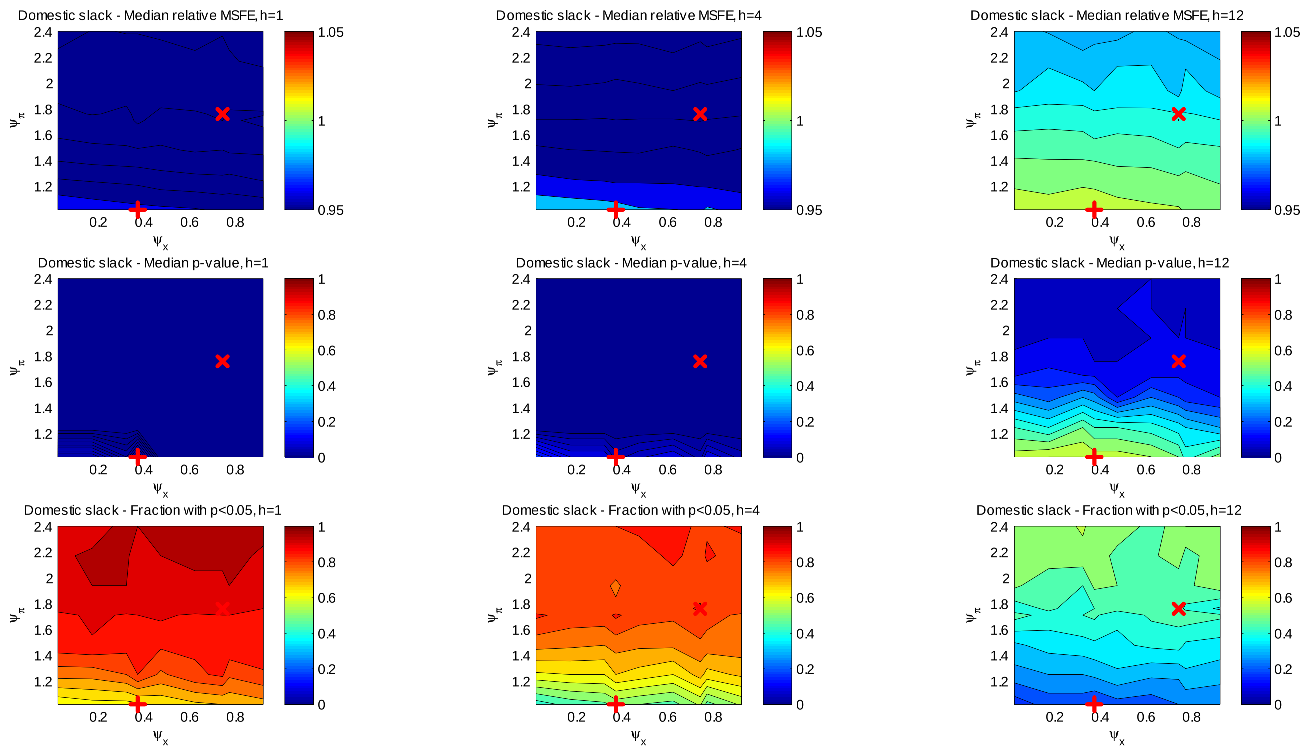

FIGURE 8A. Model's prediction of the relative MSFEs of forecasts with domestic slack as a function of the parameters of *monetary policy*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).

Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

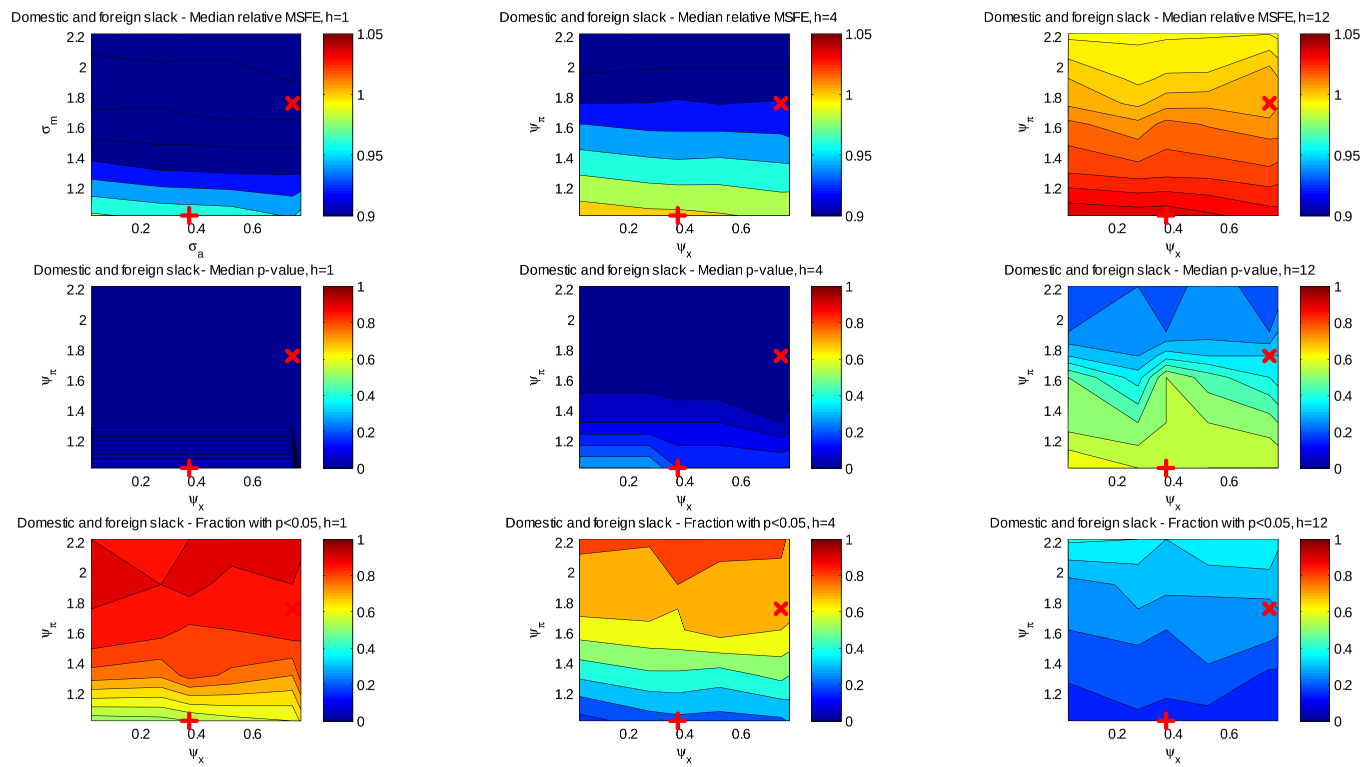

FIGURE 8B. Model's prediction of the relative MSFEs of forecasts with domestic and foreign slack as a function of the parameters of *monetary policy*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).

Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported. Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

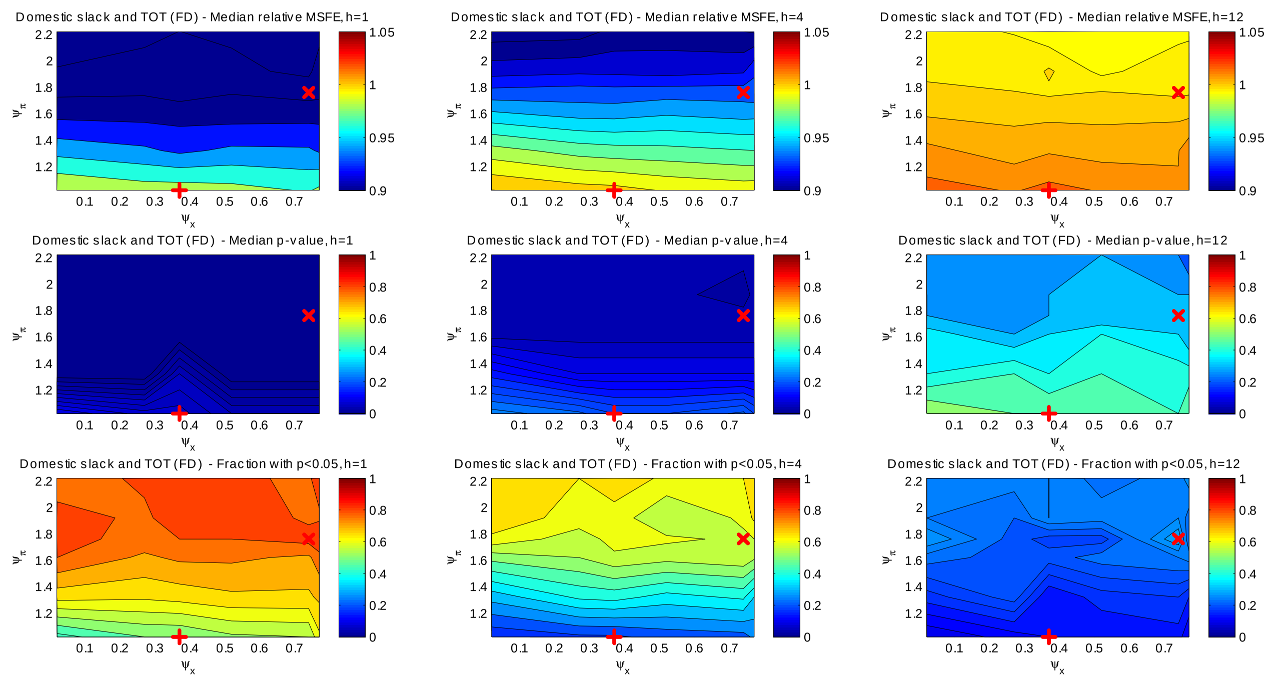

FIGURE 8C. Model's prediction of the relative MSFEs of forecasts with domestic slack and TOT (FD) as a function of the parameters of *monetary policy*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).

Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

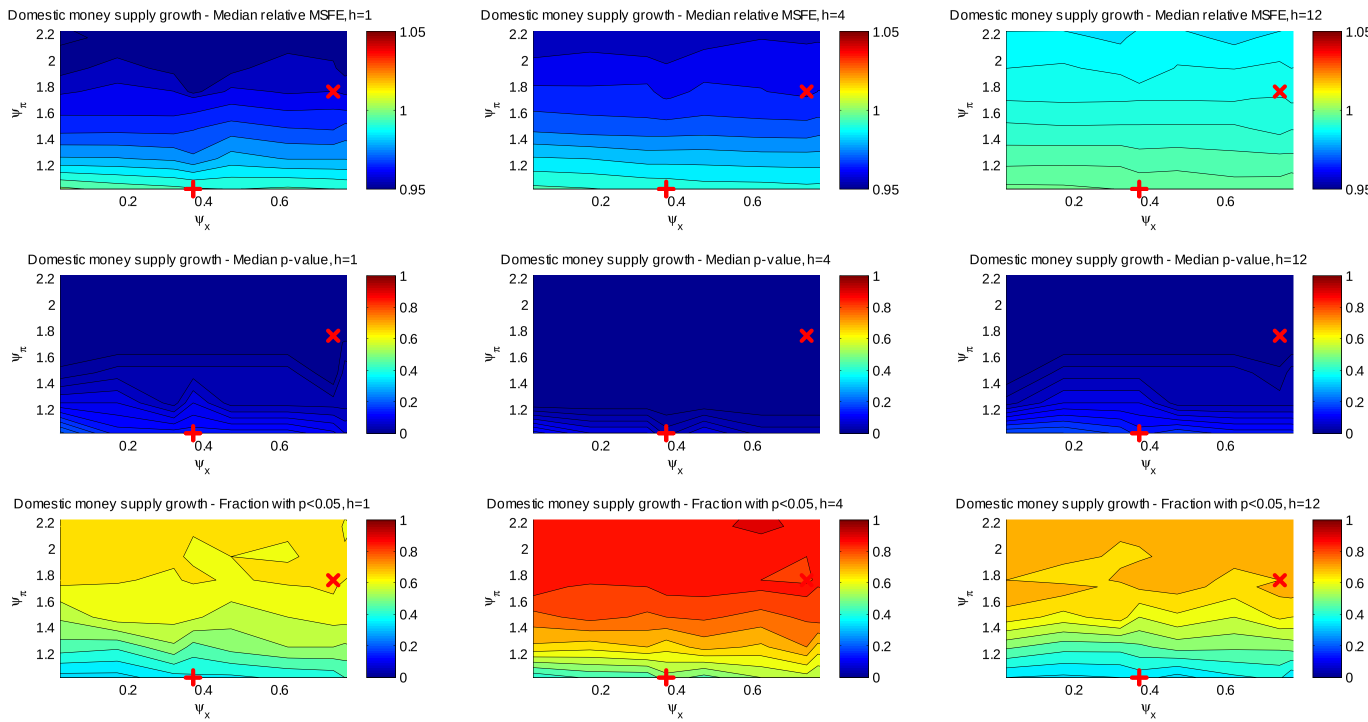

FIGURE 8D. Model's prediction of the relative MSFEs of forecasts with domestic money supply growth as a function of the parameters of *monetary policy*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).

Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

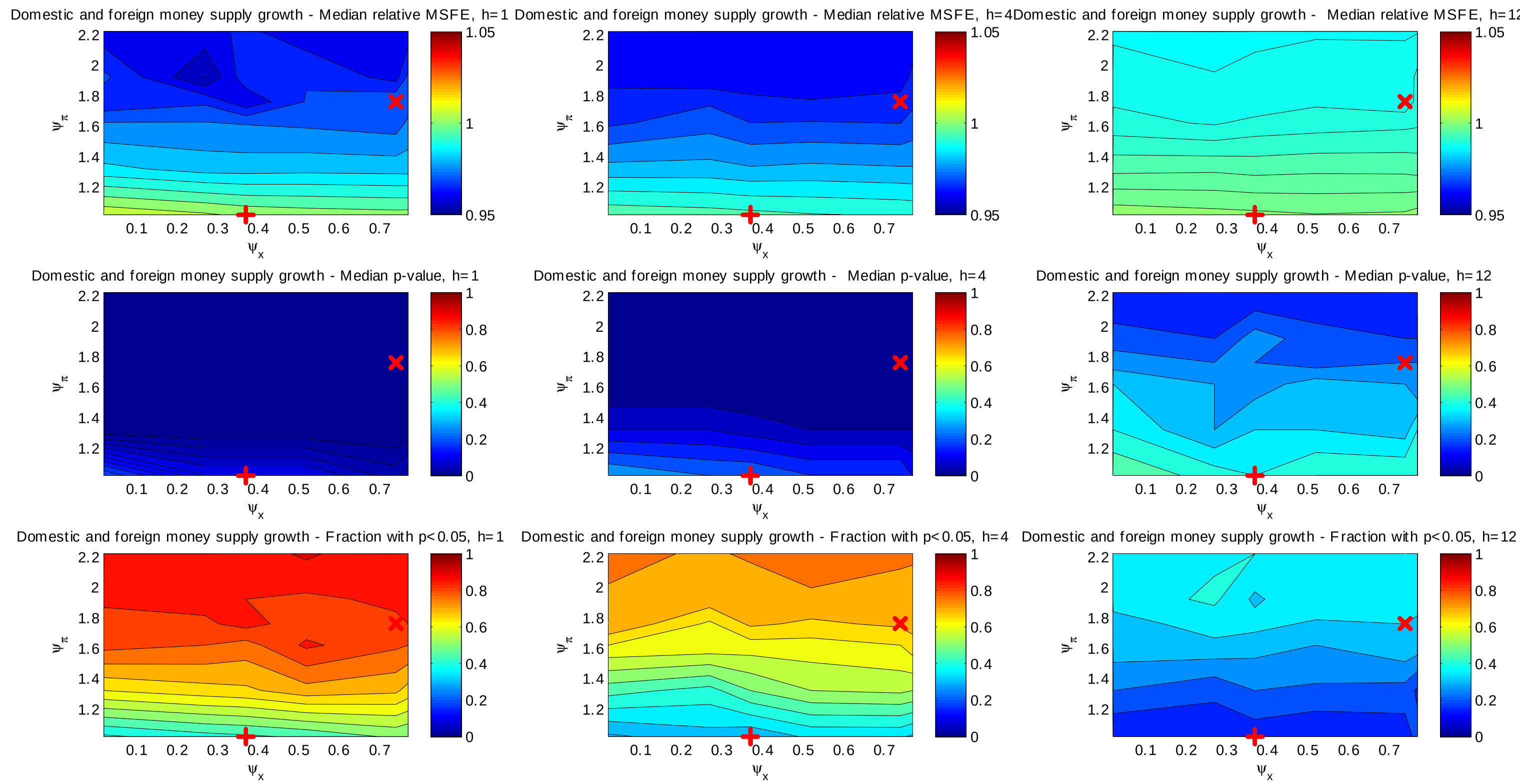

FIGURE 8E. Model's prediction of the relative MSFEs of forecasts with domestic and foreign money supply growth as a function of the parameters of *monetary policy*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).

Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

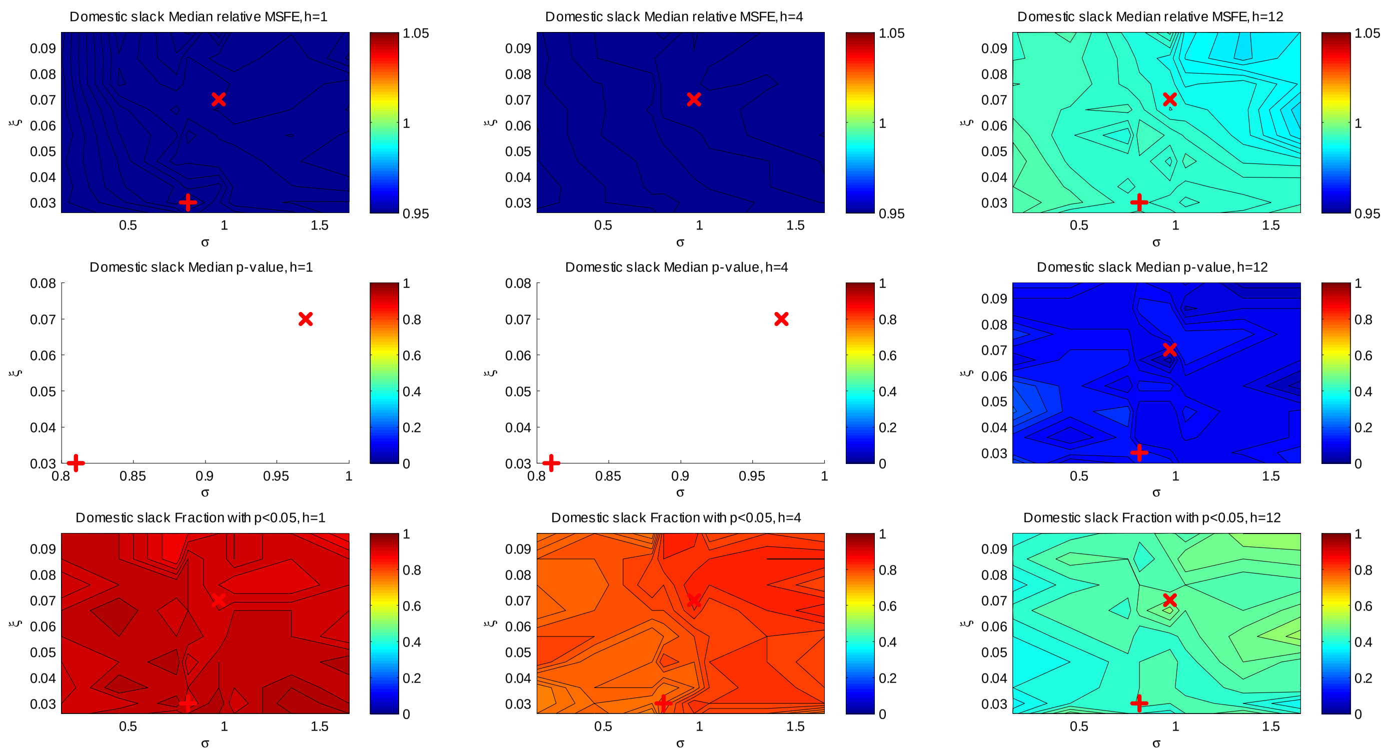

FIGURE 9A. Model's prediction of the relative MSFEs of forecasts with domestic slack as a function of the parameters of *openness*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).
Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.
Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

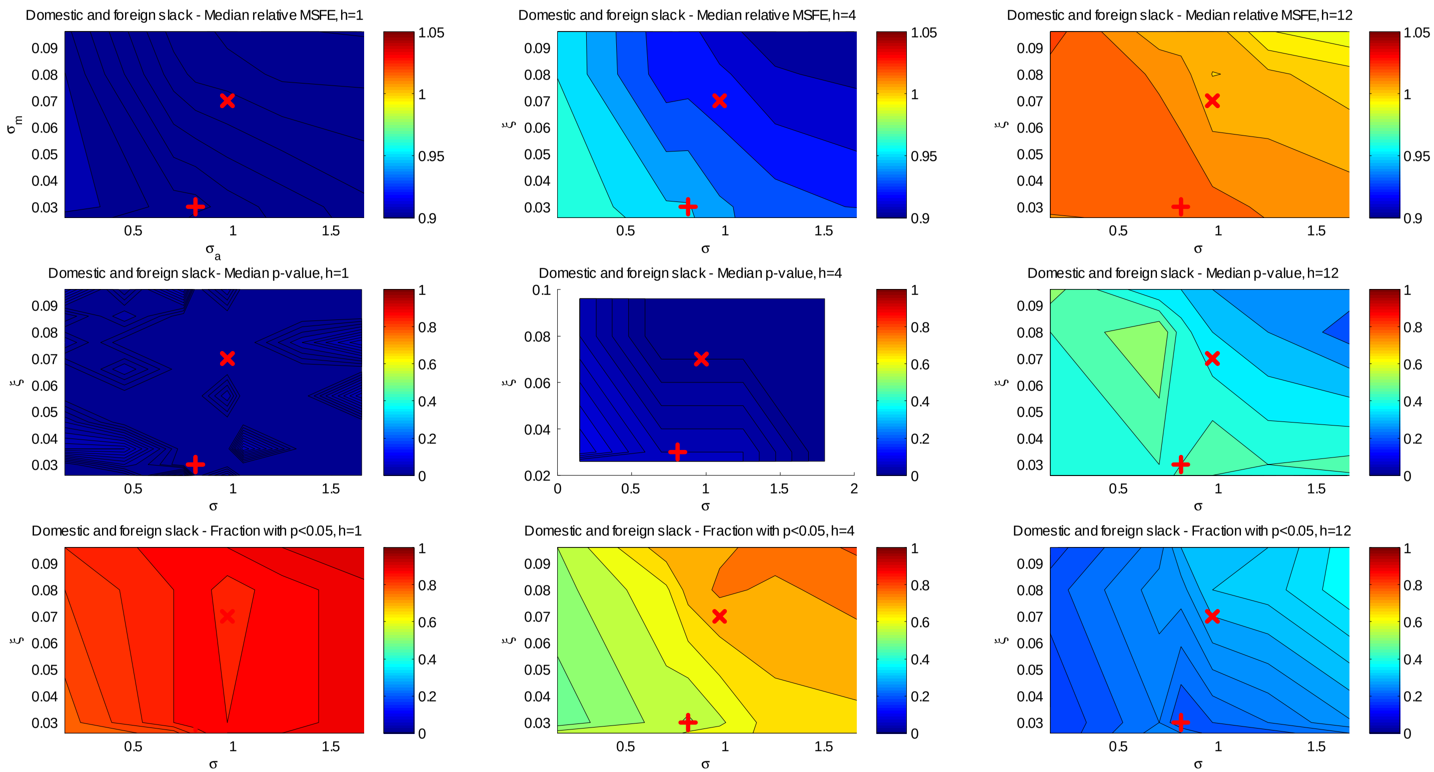

FIGURE 9B. Model's prediction of the relative MSFEs of forecasts with domestic and foreign output gap as a function of the parameters of *openness*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).

Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

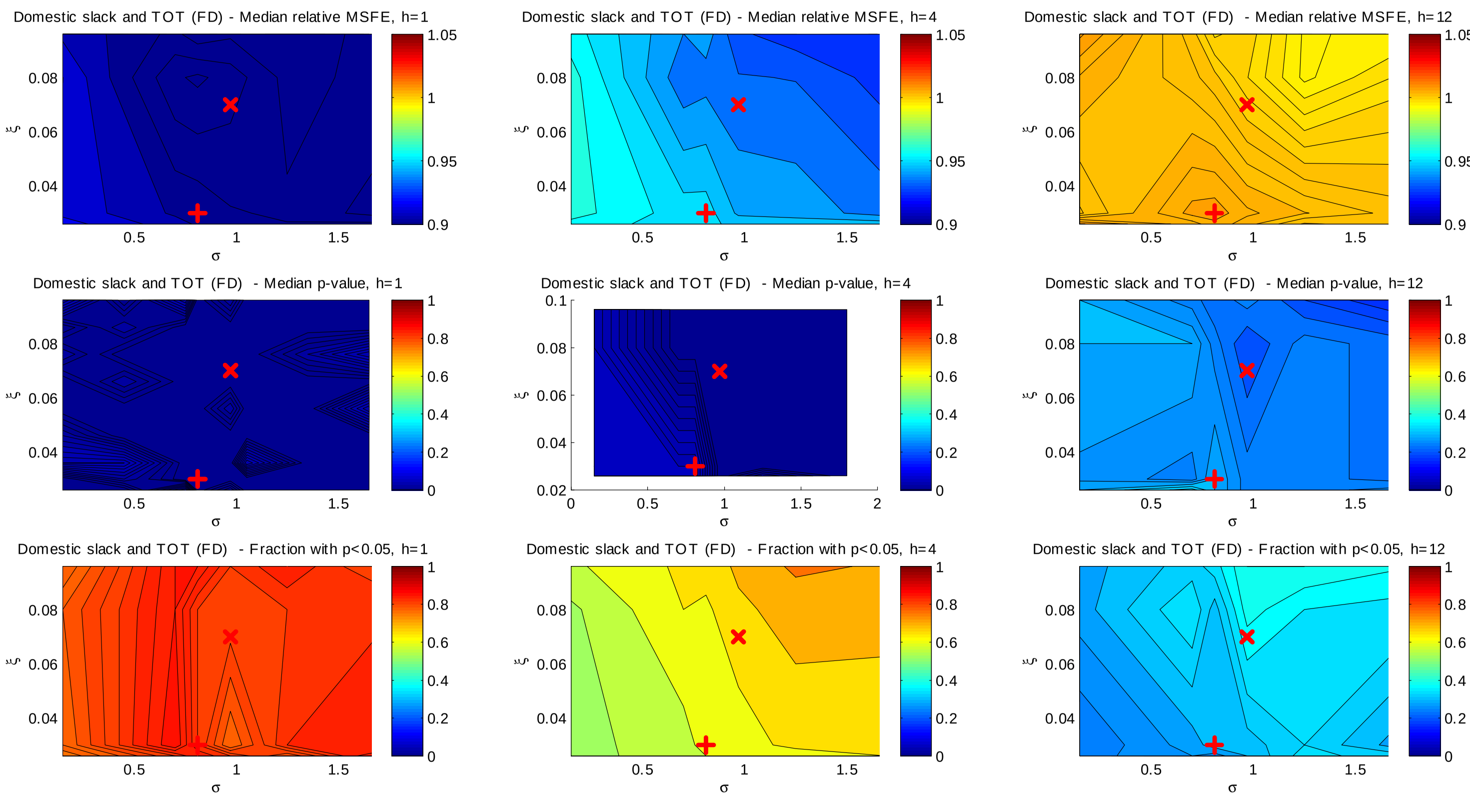

FIGURE 9C. Model's prediction of the relative MSFEs of forecasts with domestic slack and TOT (FD) as a function of the parameters of *openness*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).

Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

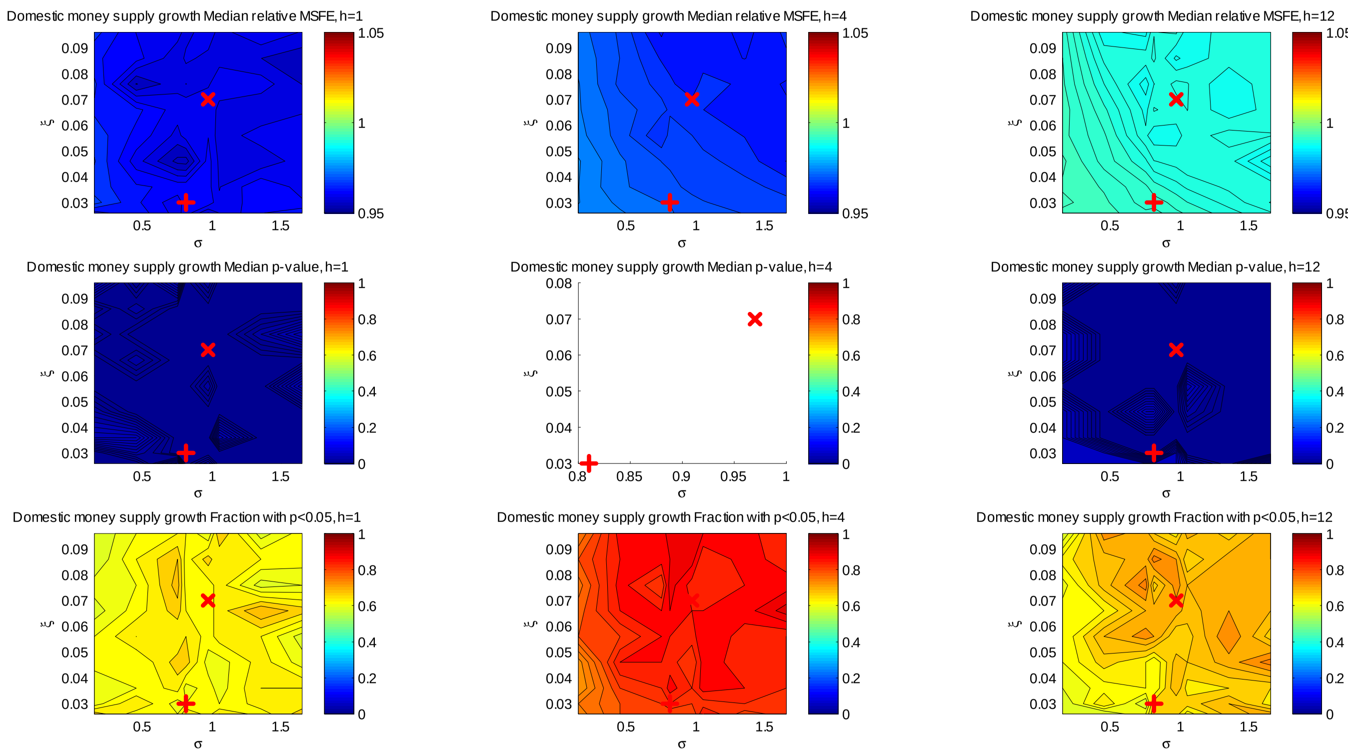

FIGURE 9D. Model's prediction of the relative MSFEs of forecasts with domestic money supply growth as a function of the parameters of *openness*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).

Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

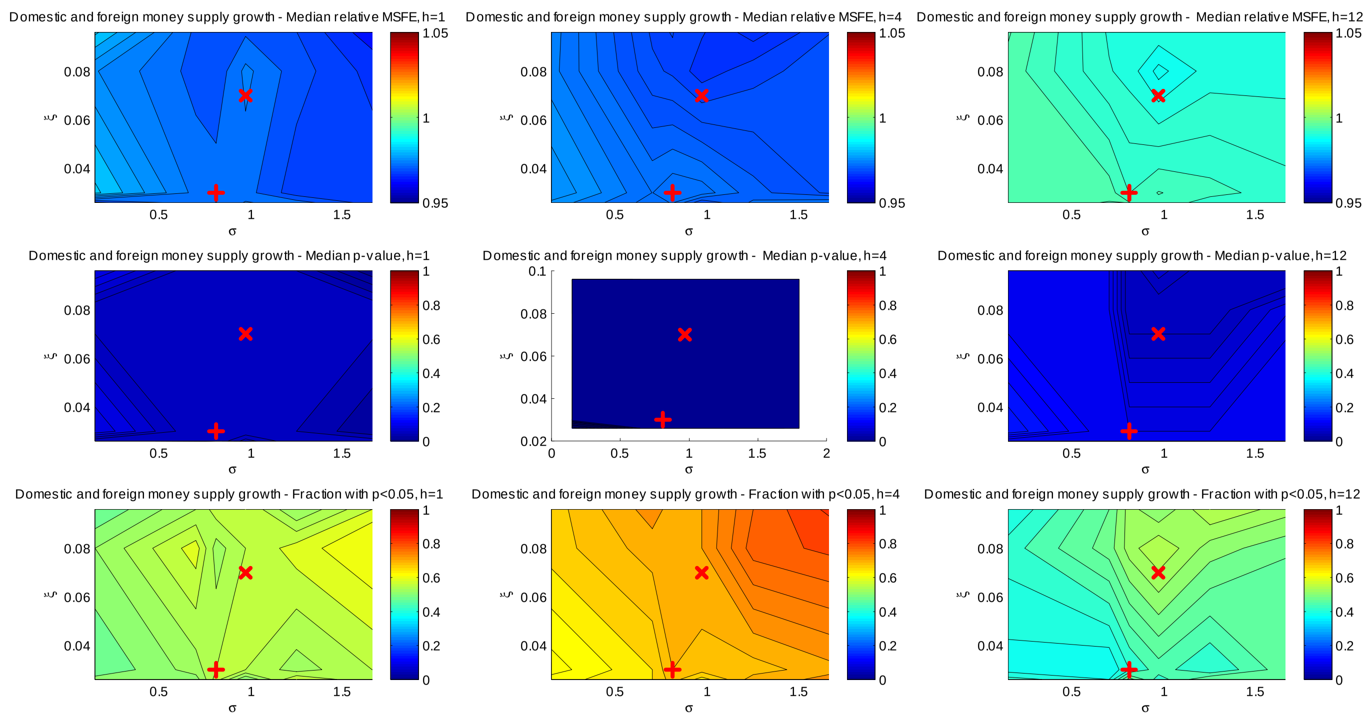

FIGURE 9E. Model's prediction of the relative MSFEs of forecasts with domestic and foreign money supply growth as a function of the parameters of *openness*

Note: MSFEs are relative to the MSFEs of the univariate AR process of inflation (restricted model).

Median MSFEs, median p-values and fraction of statistically significant MSFEs in 100 simulations are reported.

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

F.2 Correlations

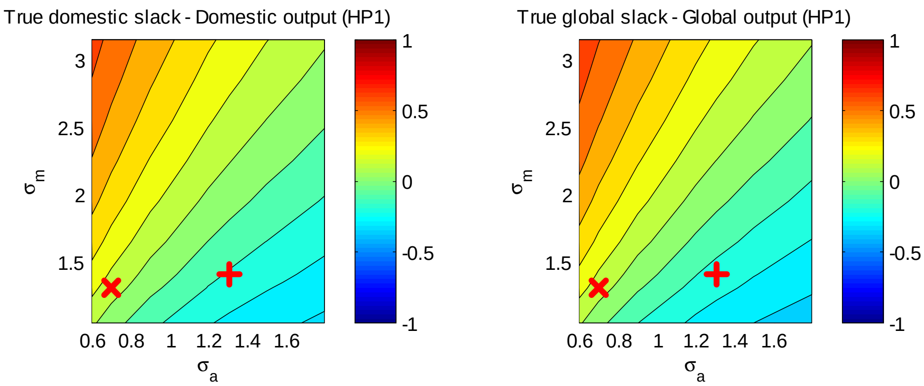

FIGURE 10A. Correlations of variables as a function of the parameters of *good luck*

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

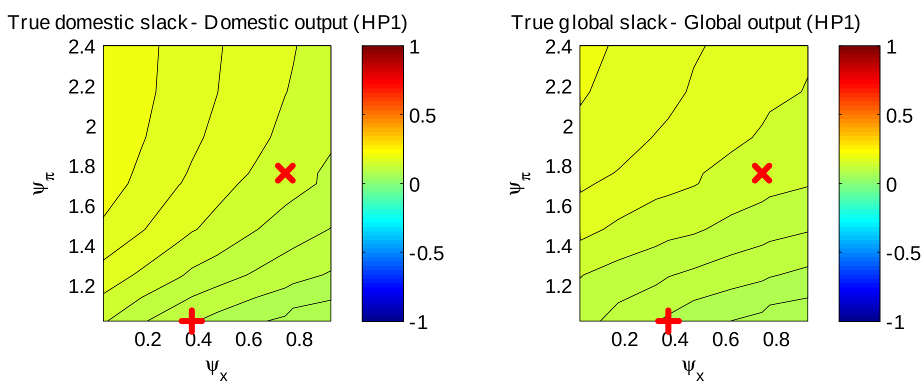

FIGURE 10B. Correlations of variables as a function of the parameters of *monetary policy*

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

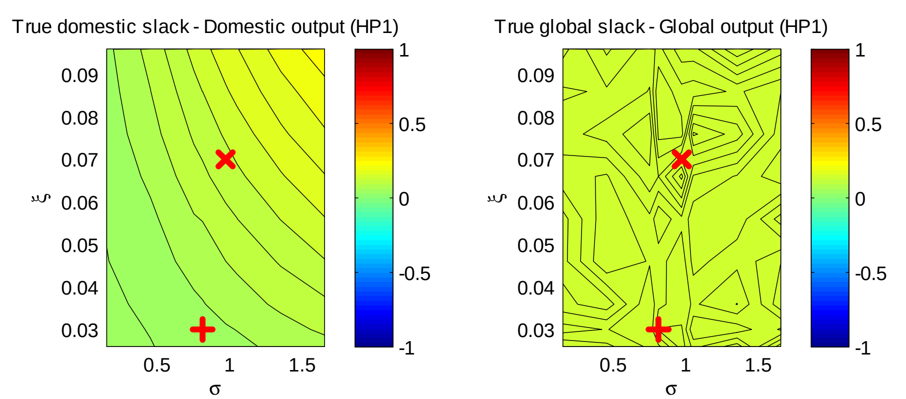

FIGURE 10C. Correlations of variables as a function of the parameters of *openness*

Period 1 and Period 2 (benchmark) parameters are denoted by '+' and 'x', respectively.

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