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Advanced economy inflation: the role of global factors

Task force on low inflation (LIFT)

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This paper presents research conducted within the Task Force on Low Inflation (LIFT). The task force is composed of economists from the European System of Central Banks (ESCB) - i.e. the 29 national central banks of the European Union (EU) and the European Central Bank. The objective of the expert team is to study issues raised by persistently low inflation from both empirical and theoretical modelling perspectives.

The research is carried out in three workstreams:

1) Drivers of Low Inflation;

2) Inflation Expectations;

3) Macroeconomic Effects of Low Inflation.

LIFT is chaired by Matteo Ciccarelli and Chiara Osbat (ECB). Workstream 1 is headed by Elena Bobeica and Marek Jarocinski (ECB) ; workstream 2 by Catherine Jardet (Banque de France) and Arnoud Stevens (National Bank of Belgium); workstream 3 by Caterina Mendicino (ECB), Sergio Santoro (Banca d'Italia) and Alessandro Notarpietro (Banca d'Italia).

The selection and refereeing process for this paper was carried out by the Chairs of the Task Force. Papers were selected based on their quality and on the relevance of the research subject to the aim of the Task Force. The authors of the selected papers were invited to revise their paper to take into consideration feedback received during the preparatory work and the referee's and Editors' comments.

The paper is released to make the research of LIFT generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the ones of the author(s) and do not necessarily reflect those of the ECB, the ESCB, or any of the ESCB National Central Banks.

Abstract

A number of studies document the prominent role of global factors in domestic inflation developments (e.g. Borio and Filardo, 2007; Ciccarelli and Mojon, 2010). In this paper we investigate global dimensions of advanced economy inflation. We estimate open-economy Phillips curves for 19 advanced economies. We include backward- and forward-looking survey measures of inflation expectations and augment Phillips curves with global factors including global economic slack, global inflation and commodity prices. Our results provide little support for the existence of direct effects of global economic slack on domestic inflation. Moreover, the results suggest that the importance of global inflation in forecasting domestic inflation has its roots solely in its ability to capture slow-moving trends in inflation rates. In the Phillips curve context much the same role is performed by domestic forward-looking inflation expectations. With the exception of commodity prices therefore our results reveal little reason to include global factors into traditional reduced form Phillips curves.

JEL Classification: E31, E32, E37

Keywords: inflation, Phillips curve, global economic slack, global inflation, forecasting, advanced economies

Non-technical summary

A number of studies document the prominent role of global factors in domestic inflation dynamics. One strand of the literature has emphasised the importance of the global output gap as a determinant of national inflation processes. Borio and Filardo (2007), for example, found that proxies for global economic slack added considerable explanatory power to traditional inflation equations and that the role of global factors had grown over time. A second strand, such as Ciccarelli and Mojon (2010), focused on the common component in national inflation rates and finds that models including a measure of global inflation consistently improve benchmark national inflation forecasts. They conclude that inflation should be modelled as a global rather than a national phenomenon.

This paper investigates the global dimensions of advanced economy inflation. We estimate open-economy Phillips curves for 19 advanced economies to understand the extent to which global factors contribute to inflation developments. We include backward- and forward-looking measures of inflation expectations and augment Phillips curves with global factors including commodity prices, global economic slack and global inflation.

With the exception of the well-documented role for commodity prices, our results provide little support for the increased role of global factors in driving national inflation dynamics. First, we find that measures of global economic slack are rarely significant in standard Phillips curve estimates.

Second, we find that measures of global inflation were helpful for forecasting national inflation rates in the 1970s and 80s when there was significant variation in inflation trends but they have been much less useful since the mid-1990s when inflation has been more stable. We confirm the Ciccarelli and Mojon (2010) result that models that include a measure of global inflation improve benchmark national inflation forecasts. However, this is only the case for models estimated since 1970. For the estimation period since the 1990s, when inflation trends have been more stable, we find the case for including global inflation in forecasting models to be much less compelling. Moreover, we also find that measures of global inflation are typically insignificant once specifications include (survey) measures of forward-looking inflation expectations (using Consensus Economics) and that forecast models augmented with long-term inflation expectations outperform those augmented with global inflation. These findings suggest that global inflation helps in explaining domestic inflation dynamics, possibly, because it acts as a proxy for (national) inflation expectations by capturing slow-moving trends in inflation rates.

Overall, our findings suggest that, with the exception of commodity prices, there is little reason to include global factors into traditional reduced-form Phillips curves.

1 Introduction

Recent studies document the increased role of global factors in driving domestic inflation developments, suggesting that it could be important to augment standard inflation models with global variables.

One strand of the literature has emphasised the importance of global output gap as a determinant of domestic inflation processes. Borio and Filardo (2007), for example, found that proxies for global economic slack added considerable explanatory power to traditional benchmark inflation equations in advanced economies and that the role of global factors had grown over time. The relevance of the global output gap was also supported by Milani (2009) for the US after 1985.[1] Other studies (Ihrig *et al.*, 2010; Calza, 2008; Gerlach *et al.*, 2008), however, find conflicting evidence and suggest that Borio and Filardo (2007) results are likely to be specific to the estimation sample or particular measurement of the global output gap. No significant global output gap effects were also detected by Eickmeier and Pijnenburg (2013). The authors, however, identify that common changes in unit labour costs are important in determining domestic inflation and conclude that, together with import prices, foreign competition and global interest rates, their developments should be carefully observed by policy makers.

A second strand of the literature has focused on the common component in national inflation rates. Ciccarelli and Mojon (2010) note significant co-movement in advanced economy inflation rates and find that models which include a measure of global inflation consistently improve benchmark national inflation forecasts.[2] Neely and Rapach (2011) support their view. By analysing a larger group of countries in a dynamic factor model setting they find that on average over half of variation in domestic inflation is explained by an "international" (world or regional) component.[3] Mumtaz and Surico (2012) follow a similar approach but focus only on industrialised economies. They confirm that both the level and persistence of domestic inflation are reasonably well tracked by a single global factor. Taken together these strands of the literature suggest that inflation should be modelled as a global rather than a national phenomenon.

There are a number of reasons why global factors may be playing a more prominent role in shaping domestic inflation dynamics. One argument is that globalisation has rendered national inflation less responsive to domestic capacity constraints, either because a sudden expansion in demand for goods would translate into higher imports rather than into higher prices or because foreign competition constrains wage or price increases in industries open to global competition, and lowers the sensitivity of wages to productivity increases (e.g.

[1] Importance of global output gap is also established in all New Keynesian open economy models (see, e.g. Clarida *et al.*, 2002, Galí and Monacelli, 2005).

[2] Ferroni and Mojon (2014) perform a similar analysis but use a wider range of forecasting models and include the 2008/2009 recession in the forecasting sample. The authors draw similar conclusions - global inflation augmented model performs better than other inflation forecasting models.

[3] Instead of aggregate inflation rates Monacelli and Sala (2009) use sectoral CPI data in four advanced economies and find that one international common factor explains 15-30% of variation in inflation. They consider it to be a lower bound of common variation in domestic inflation.

Guerrieri *et al.*, 2010). Another argument emphasises the role of credible monetary policies that stabilised inflation expectations and trend inflation (e.g. Mishkin, 2009). With domestic price expectations well anchored proportionally more of the variation in national inflation rates would be explained by exogenous global price shocks such as commodity price changes.

Understanding the role of global factors may also contribute towards explaining some recent inflation puzzles. Output fell sharply after the 2008/2009 recession. However, inflation in advanced economies remained more resilient, which raised questions about the apparent decline in the sensitivity of inflation to economic slack (e.g. IMF, 2013). From mid-2011, however, simultaneous declines in inflation across many advanced economies raised further questions about the "commonality" of inflation trends and whether this reflected well-defined shocks from global economic slack on domestic inflation or other common factors. Yet, more recent heterogeneous inflation developments – with euro area inflation declining further than in other advanced economies – may have shifted the focus again towards domestic factors influencing inflation trends.

In this paper, we assess the role of global factors in a traditional Phillips curve framework. We first augment advanced economy Phillips curves with measures of global economic slack, test their significance and assess whether their role has changed over time. We then assess the role of global inflation in helping to forecast domestic inflation rates. Section 2 outlines the method and approach. Section 3 discusses the results and robustness. Section 4 concludes. The Appendix contains a detailed data description and additional results from model estimations.

2 Phillips Curve Estimates: Methods and Approach

We investigate the role of global factors in domestic inflation processes by augmenting standard Phillips curve specifications with a series of global variables. We estimate separate equations for each advanced economy in the sample, using quarterly data over the period 1970q1-2014q3.[4] The model is of the following general form:

$$\pi_{it} = \alpha_i + \beta_i \pi^e_{it} + \gamma_i y_{it} + \sum_{k=1}^{K} \theta_{k,i} z_{k,it} + \delta_i f_t + \epsilon_{it}, \qquad (1)$$

where the dependent variable π_{it} is headline inflation rate in country i at time t, computed using year-on-year changes in CPI[5] and f_t is a global factor.

The π^e_{it} term denotes expected inflation. According to the expectations formation process we distinguish three Phillips curve specifications. Namely, *(i)* a traditional backward-looking specification as in Friedman (1968) and Phelps (1968) with adaptive expectations

[4] The sample includes 19 advanced OECD economies: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, UK and US. Starting date varies per country.

[5] This definition of inflation has no seasonal pattern by construction.

given by (2) *(ii)* a micro-founded New-Keynesian specification with forward-looking expectations (3) which open up a channel for a credible monetary authority to affect inflation (e.g., Woodford, 2003) and *(iii)* a hybrid Phillips curve as in Galí and Gertler (1999) with the expectations term (4) that combines the first two.[6]

$$\beta_i \pi^e_{it} = \beta_i E_{t-1}\pi_{it} = \sum_{l=1}^{L} \beta_{l,i}\pi_{i,t-l} \tag{2}$$

$$\beta_i \pi^e_{it} = \beta_i E_t \pi_{i,t+h} \tag{3}$$

$$\beta_i \pi^e_{it} = \sum_{l=1}^{L} \beta_{l,i}\pi_{i,t-l} + \beta_i E_t \pi_{i,t+h} \tag{4}$$

In (2)-(4) L denotes the number of included inflation lags and h is the forward-looking horizon for inflation expectations. The most general, hybrid, Phillips curve includes both lagged inflation terms and a term that captures forward-looking inflation expectations. Because rational expectations are not entirely observable in agents' behaviour we use a survey based measure of long-term inflation expectations taken from Consensus Economics.[7] Other Phillips curve specifications include one of the two components. Data availability means that the estimation samples differ: backward-looking Phillips curves are estimated from 1970s onwards; forward-looking and hybrid curves from early 1990s. In the specifications that include lags of inflation the lag order is selected separately for each country on the basis of the four standard information criteria,[8] limiting the maximum number of lags to four. Our preferred lag order is the order selected by most of the criteria.

The next term in the Phillips curve (1) is domestic slack y_{it} measured with an unemployment and output gap available in OECD Economic Outlook and IMF World Economic Outlook databases. For the countries with unavailable quarterly data on the output gap and the non-accelerating rate of unemployment (NAIRU), used to compute the unemployment gap, we use cubic splines to interpolate annual data to quarterly.

The variables $z_{k,it}$ are K additional exogenous factors commonly found to affect inflation rate. We tested a range of various explanatory variables such as the year-on-year percentage changes in the price of oil, natural gas, all commodities excluding energy, money supply (M3),[9] real and nominal effective exchange rates. Our final models included only the

[6] Despite having no clear microfoundations and being subject to the Lucas critique, backward-looking Phillips curve is common in empirical literature due to its ability to fit actual inflation data reasonably well (O'Reilly and Whelan, 2005; Estrella and Fuhrer, 2003; Paloviita, 2008; Stock and Watson, 2007). The micro-founded New-Keynesian Phillips curve, instead, avoids the Lucas critique, appears in a substantial number of theoretical papers, but shows rather inconclusive empirical support (Rudd and Whelan, 2007, Mavroeidis *et al.*, 2014).

[7] We use 6 to 10 years ahead inflation forecasts from Consensus Economics. The data are available on a biannual basis since 1990. We interpolate the data using cubic splines to obtain quarterly series.

[8] Akaike's information criterion, Schwarz's Bayesian information criterion, the final prediction error and the Hannan and Quinn information criterion.

[9] The link between inflation and low-frequency movements in money growth is studied, for example, in

variables that were typically significant in country estimations, i.e. change in oil price, change in non-energy prices, and change in nominal effective exchange rate.[10]

The global factor f_t includes estimates of global economic slack and global inflation. For a measure of global economic slack we considered both aggregate OECD estimates of the unemployment gap and output gap. The estimates are based on the 34 member countries of the OECD and as such are not limited only to advanced economies.[11] To investigate the role of global inflation, we considered: *(i)* a simple average of inflation rates in the 19 economies under analysis and *(ii)* the aggregate OECD inflation rate based on all the 34 member countries. We have also considered the first principal component estimated on the full sample of 19 inflation rates. Because it appeared to essentially proxy average inflation, we excluded it from further analysis.

We estimate (1) by the two-step generalized method of moments (GMM; Hansen, 1982) to address the risk of endogeneity of some explanatory variables. Survey-based measure of (unobservable) inflation expectations may contain measurement errors that could lead to endogeneity bias. Likewise, the bias may arise due to simultaneity between actual inflation and some of the right-hand-side variables such as the global factor. While endogeneity of the global factor may not be a serious concern for smaller economies, it may well be so for larger countries that mainly determine its value. As instruments in the GMM estimation we consider two lags of inflation expectations and two lags of global factor.[12] To address slight serial correlation in the residuals we use Heteroskedasticity and Autocorrelation Consistent (HAC) estimates of the covariance matrix (Newey and West, 1987) with a Bartlett kernel and an automatic Newey-West bandwidth selection (Newey and West, 1994).

3 Results: the Role of Global Factors in Standard Phillips Curve Estimates

In this section we focus principally on the role of global factors in our Phillips curve estimates, assessing first the role of global slack and second the importance of measures of global inflation. The Appendix provides more detail on other aspects of the Phillips curve estimates (see Table A.1).

Overall, those estimates are consistent with the existing literature. Inflation is highly

Gerlach (2004) and Assenmacher-Wesche and Gerlach (2008). Unlike the authors we do not extract the low-frequency component from the year-on-year M3 growth as long-term inflation expectations and global inflation in our models already capture this trend. Instead, we include the unfiltered year-on-year growth in M3. We detect no significant contribution of money growth that would go beyond what is already embedded in our measures of inflation expectations.

[10] Exchange rate in our data set is expressed in units of foreign currency per unit of domestic so that an increase in exchange rate corresponds to domestic currency appreciation.

[11] In addition to the 19 countries we consider, global OECD measures include Chile, Czech Republic, Estonia, Greece, Hungary, Iceland, Ireland, Israel, South Korea, Mexico, Poland, Portugal, Slovak Republic, Slovenia and Turkey.

[12] Adding other instruments does not bring significant changes to the estimates nor improves the outcome of model diagnostic tests. With a very few exceptions the J-test does not reject the overidentifying restrictions (see Table A.1 in the Appendix).

persistent across most countries with lagged inflation terms highly significant regardless of whether we control for forward-looking inflation expectations. Moreover, the Phillips curves that contain lagged inflation terms fit actual inflation data considerably better than the pure forward-looking Phillips curve. The fit of the forward-looking Phillips curve is nevertheless moderate rather than weak favouring in general the use of survey-based inflation expectations in empirical New Keynesian Phillips Curve research (see Table A.2 in the Appendix). Our results also confirm a prominent role for commodity price developments, which account for an important part of headline inflation dynamics, and a modest role for domestic slack variables, with coefficients on the unemployment and output gaps typically significant but small for the majority of countries (see Figure 1 and Appendix).

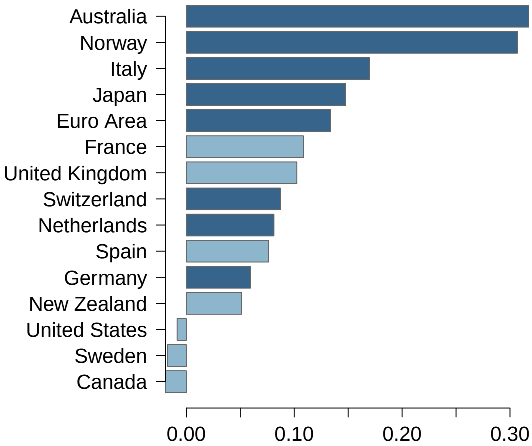
3.1 The Role of Global Economic Slack

We find little evidence for the role of global economic slack in driving national inflation developments. In hybrid Phillips curves, estimated from the 1990s onwards, the coefficients on global output gaps are small and insignificant for most of the countries in our sample. Moreover, significant coefficients are typically negatively signed (Figure 2). Although a negative sign may arise in some cases because of, for example, the amount of relative price adjustment in tradables, most of the literature looks for a positive relationship (see, e.g. Borio and Filardo, 2007, Milani, 2009). Identical conclusions can be drawn by replacing global output gaps with global unemployment gaps (Figure A.2 in the Appendix). Global output gaps remain insignificant also in backward-looking Phillips curves estimated since 1970.

Furthermore, we find little evidence that the role of global economic slack in driving national inflation dynamics is increasing. Rolling regressions suggest that the flattening of the Phillips curve was a common phenomenon across advanced economies, particularly during the 1980s and 1990s (Figure 3).[13] Although, after the 2008/2009 recession there is some evidence of the steepening, particularly notable for the major euro area economies. These results are in line with a number of recent empirical studies. Oinonen and Paloviita (2014), for example, document the recent steepening of the euro area Phillips curve while IMF (2013) provides evidence of the flattening of the Phillips curves for a sample of 21 advanced economies. However, despite the decreased role of domestic slack we do not find evidence of a simultaneously increasing role of global slack (Figure 4). Rolling estimates of coefficients on the global unemployment gap are typically insignificant and have been fairly stable over time. We find similar evidence when we use output gaps rather than unemployment gaps (Figures A.3 and A.4).

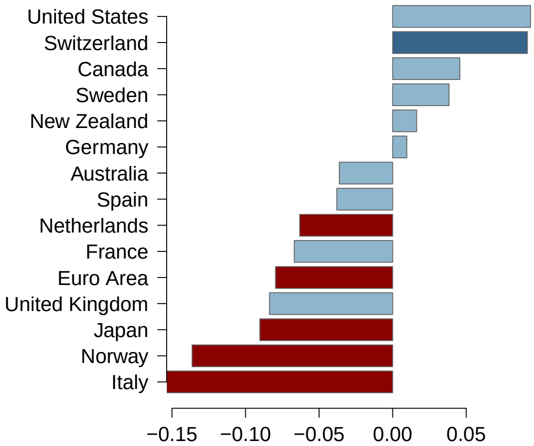
[13] Notably we find no support for the flattening of the Phillips curve for the major euro area economies. Although coefficients on the domestic unemployment gap have varied over time they do not display a trend decline.

Figure 1: Estimated coefficient of domestic output gap γ_i in a hybrid Phillips curve.



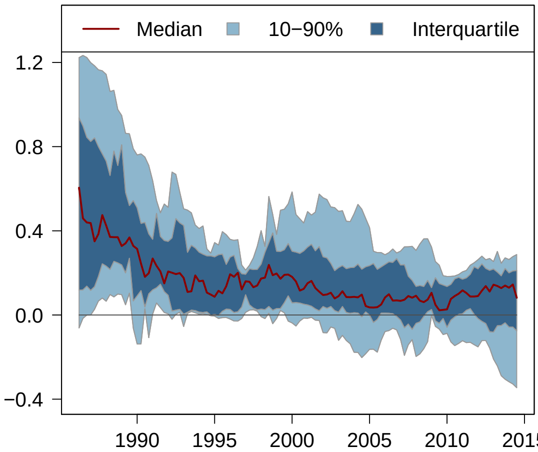
Source: Own calculations.
Notes: (i) Dark blue bars denote statistically significant (10% significance level) positively signed estimates; (ii) Estimated by GMM.

Figure 2: Estimated coefficient of global output gap δ_i in a hybrid Phillips curve.



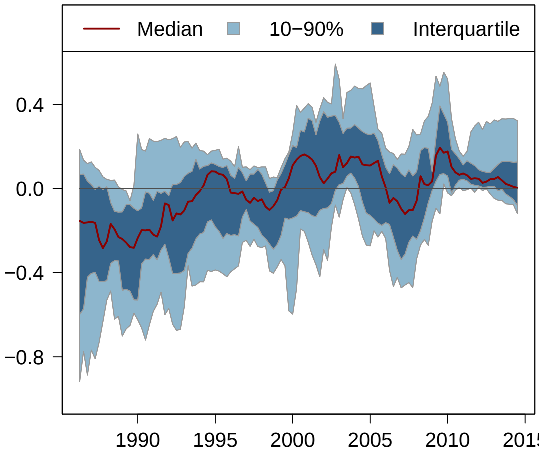
Source: Own calculations.
Notes: (i) Dark blue bars denote statistically significant positively signed estimates (10% significance level). Red bars denote statistically significant negatively signed estimates; (ii) Global output gap is measured by OECD output gap.

Figure 3: Rolling coefficient of domestic unemployment gap γ_i in a backward-looking Phillips curve.
(range of estimates of coefficients across countries)



Source: Own calculations.
Notes: (i) The initial estimation sample covers 1971q1-1985q4 (60 quarters). Rolled forward by one quarter at a time; (ii) The coefficient is displayed with a negative sign; (iii) Eq.(1)-(2) are estimated by OLS with $L = 2$ and f_t measured by GDP weighted unemployment gap of 12 advanced economies; (iv) The chart is based on estimation results for 19 economies.

Figure 4: Rolling coefficient of global unemployment gap δ_i in a backward-looking Phillips curve.
(range of estimates of coefficients across countries)

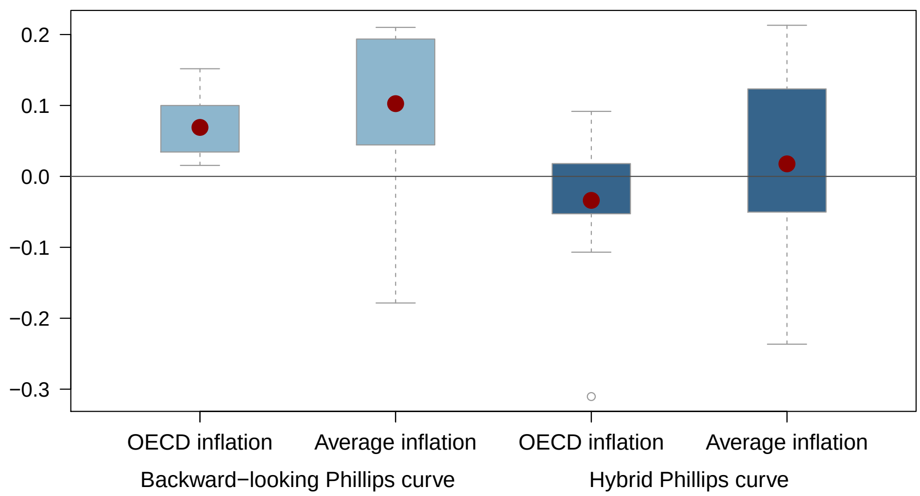


Source: Own calculations.
Notes: (i) The initial estimation sample covers 1971q1-1985q4 (60 quarters). Rolled forward by one quarter at a time; (ii) The coefficient is displayed with a negative sign; (iii) Eq.(1)-(2) are estimated by OLS with $L = 2$ and f_t measured by GDP weighted unemployment gap of 12 advanced economies; (iv) The chart is based on estimation results for 19 economies.

3.2 The Role of Global Inflation Measures in Standard Phillips Curve Estimates

We find that global inflation is a significant explanatory factor in inflation models estimated since 1970s. In backward-looking Phillips curves augmented with measures of global inflation and estimated from 1970s onwards the coefficient on global inflation is statistically significant for more than half of the countries in our sample.[14] However, for a shorter sample, from 1990s onwards, and in a hybrid Phillips curve, which includes long-term inflation expectations, the coefficients on global inflation are smaller and typically insignificant (Figure 5). Backward-looking Phillips curves estimated using a decreasing sample size also suggest that the importance of OECD inflation has declined. Figures A.5 and A.6 show estimates of the backward-looking Phillips curves with a decreasing window. It is evident that when the 1970s and early 1980s are included in the estimation sample, OECD inflation is significant in most countries. Once the 1970s-80s are excluded from the sample, OECD inflation plays a less important role.

Figure 5: Sensitivity to global inflation δ_i across different Phillips curve specifications.



Source: Own calculations.
Notes: (*i*) The chart displays the minimum, quartiles and the maximum of GMM estimates of sensitivity to global inflation δ_i. Points mark the average; (*ii*) The sample includes 14 countries and euro area aggregate for which inflation expectations data is available; (*iii*) Domestic slack in the Phillips curves is measured by unemployment gap.

How might we interpret these results? Why is global inflation a significant explanatory variable in the backward-looking Phillips curve estimated from 1970s but not in a hybrid curve estimated from 1990s onwards? Ciccarelli and Mojon (2010) offered two explanations for the prominent role for global inflation in forecasting national inflation - a structural and

[14] The OECD inflation variable is statistically significant for 11 out of 19 advanced economies we consider. This result does not change with the measure of domestic economic slack (unemployment or output gap).

a statistical interpretation. The first explanation is that the global inflation component captures structural factors - i.e. the influence of global developments on national inflation processes (e.g. through the impact of commodity prices developments) or commonalities in the business cycles. The second explanation is more statistical and suggests that incorporating a global inflation measure is helpful because it identifies slow-moving trends in national inflation processes. Faust and Wright (2013), for example, argue that inflation forecasts at horizons beyond a couple of quarters should have mechanisms to capture low-frequency local mean dynamics. The second view therefore emphasises the role of global inflation in helping to identify these slow-moving trends in national inflation rates. Our findings would tend to point towards this second, statistical explanation. We find that global inflation is highly significant for equations estimated during periods of significant changes in inflation trends (i.e. the 1970-80s). But from the mid-1990s onwards, when inflation trends converged to more stable rates, global inflation becomes considerably less helpful in explaining domestic inflation dynamics. We also find that once survey inflation expectations are included in the model, global inflation ceases to play an important role. Moreover, global inflation and (long-term) inflation expectations measures have shown a high correlation over time (see Table A.3 and Figure A.7). These findings suggest, to us, that global inflation helps in explaining domestic inflation dynamics within the reduced-form Phillips curve, possibly, because it acts as a proxy for (domestic) inflation expectations by capturing slow-moving trends in inflation rates.

To further understand the role of global inflation in explaining inflation dynamics we compare standard inflation forecasting equations with those augmented with global inflation. Following Ciccarelli and Mojon (2010) we estimate pairs of alternative inflation forecasting models for each country. We run out-of-sample forecasts and compare root mean squared errors (RMSE) for the competing models over one- and two-year-ahead forecast horizons. To replicate the exercise as closely as possible, the benchmark forecasting model we consider is the global inflation augmented autoregression:

$$\pi_{it} = \alpha_{i0} + \alpha_{i1}(L)\pi_{it} + \alpha_{i2}(L)f_t + u_{it},$$

where f_t is global inflation. We contrast this model, first, with the standard autoregression, that links current inflation to its lagged values, and, second, with the inflation expectations augmented autoregression, that links current inflation to its lagged values and domestic inflation expectations:

$$\pi_{it} = \beta_{i0} + \beta_{i1}(L)\pi_{it} + \beta_{i2}(L)\pi_{it}^{e,LT} + u_{it},$$

where $\pi_{it}^{e,LT}$ are long-term inflation expectations. As in Ciccarelli and Mojon (2010) in all the forecasting models we fix the order of lag polynomials $\alpha_{i2}(L)$ and $\beta_{i2}(L)$ to four and we let the order of $\alpha_{i1}(L)$ and $\beta_{i1}(L)$ to be determined by the standard Bayesian information criterion at every forecast generating stage. We start with the estimation sample of ten years and we subsequently increase it with one observation at a time. At every stage we re-select the optimal number of lags, re-run the estimation and compute the h-step ahead inflation forecast $\pi_{i,t+h|t}$ given inflation data up to point t.

Individual country forecast results are provided in the Appendix. Table 1 summarises the results across countries, showing the percentage of countries for which each model statistically outperformed the rival model.[15]

Table 1: Forecasting performance of global inflation augmented model relative to standard autoregression.
(percent of country models in which particular model is significantly better than competitor)

Model that produces significantly lower forecast RMSEs	One-year-ahead	Two-years-ahead
Forecasting sample: 1981q4-2014q3		
Global inflation augmented autoregression	77.8%	83.3%
Standard autoregression	5.6%	5.6%
Forecasting sample: 2002q1-2014q3		
Global inflation augmented autoregression	5.6%	0.0%
Standard autoregression	16.7%	27.8%

Source: Own calculations.
Notes: (*i*) The table summarises forecasting performance results of 18 economies (individual country results are provided in Table A.4 in the Appendix); (*ii*) Initial estimation sample covers 10 years of data (1971q1 - 1980q4 and 1991q2 - 2001q1 respectively). The sample is subsequently augmented with one observation at a time to produce the next h-step-ahead forecast; (*iii*) Estimated by OLS.

Forecast comparisons show that global inflation only improves inflation forecasts in models estimated since 1970s, but not in those estimated since 1990s. We confirm the result of Ciccarelli and Mojon (2010) that, indeed, the model augmented with global inflation significantly outperforms the standard autoregression for the majority of countries (upper panel of Table 1). However, this is only the case when the models are estimated on a sample that includes the 1970-80s, a period of high and volatile inflation rates. When the models are estimated from 1991 and used to forecast inflation from 2002 onwards, the measure of global inflation does not provide significant improvement to the forecasting ability of a simple autoregression (lower panel of Table 1). Indeed, at one- and two-year-ahead horizons it is a statistically better performer only in 5.6% and 0.0% of cases, respectively.

As a further test to enhance our understanding of the role of global inflation, we also compared two further models: one which augments an autoregressive model with global inflation and another which augments it with long-term inflation expectations. The period for comparison is somewhat shorter as availability of long-term inflation expectations lim-

[15]Since there are some countries for which the forecast performance of the two models is statistically indistinguishable the figures in Table 1 and 2 do not sum to 100%. We test statistical distinguishability using the Diebold-Mariano test statistic (Diebold and Mariano, 1995) with bootstrapped critical values.

its the forecasting sample to 2002 onwards. Nevertheless, the results point to a broadly similar forecasting performance of models augmented with global inflation and inflation expectations. Indeed, if anything, the models with inflation expectations augmented model performed slightly better (Table 2).

Table 2: Forecasting performance of inflation expectations augmented model relative to global inflation augmented model.
(percent of country models in which particular model is significantly better than competitor)

Model that produces significantly lower forecast RMSEs	One-year-ahead	Two-years-ahead
Forecasting sample: 2002q1-2014q3		
Global inflation augmented autoregression	0.0%	0.0%
Inflation expectations augmented autoregression	23.1%	15.4%

Source: Own calculations.
Notes: (*i*) The table summarises forecasting performance results of 13 economies (individual country results are provided in Table A.5 in the Appendix); (*ii*) Initial estimation sample covers 1991q2 - 2001q1 (10 years). The sample is subsequently augmented with one observation at a time; (*iii*) Estimated by OLS.

We are able to perform this exercise over a longer horizon for the US. Using combined Livingston and Blue Chip long-term inflation forecasts since 1979 we find that our conclusions remain valid. The RMSE of the model augmented with inflation expectations relative to the global inflation augmented model is insignificantly different from one.[16]

3.3 Robustness Analysis

We perform several robustness checks to confirm the validity of our findings. We start by showing that our results are robust to using core rather than headline inflation data as a dependent variable. Estimation results with core inflation in (1) are broadly similar to those with headline the only difference being considerably reduced, often insignificant, effects of commodity prices. We conclude that commodity prices, included as exogenous factors, reasonably well capture temporary fluctuations of food and energy components in headline inflation and do not drive our main results. Considering that overall price stability is the policy goal of the central bank we keep the focus on headline inflation in the main text.

Furthermore, we find that our results do not change when we replace year-on-year headline inflation with annualised seasonally adjusted quarter-on-quarter headline inflation rates. Annual inflation measured by year-on-year rates is approximately the sum of quarterly (*log*) CPI differences. Thus, using year-on-year rates may introduce a moving average component to inflation data, which can complicate econometric inference. Annu-

[16]RMSE is 0.99 for one-year- and 0.95 for two-year-ahead forecasts.

alised quarter-on-quarter inflation based on seasonally adjusted CPI data circumvents this drawback. By replacing year-on-year inflation with quarter-on-quarter we find that our results on the significance of global slack and global inflation measures remain unchanged. Estimates based on quarter-on-quarter inflation rates, however, deliver larger in magnitude sensitivities.

Finally, our results are robust to using lagged rather than contemporaneous measures of global economic slack. It might be that foreign or domestic measures of real activity affect inflation with some delay either directly or via other factors, which a single-equation model with contemporaneous explanatory variables is unable to capture. Bianchi and Civelli (2013), for example, while not finding significant direct effects of global slack on domestic inflation, provide evidence that might suggest the presence of indirect channels. A study by Milani (2010), based on Bayesian estimation of a structural model for a sample of G-7 economies, also presents evidence suggesting that global slack affects inflation via its influence on domestic output. It may therefore be that there is a lag until global slack has its impact on domestic inflation. We tried including up to four periods lagged GDP weighted unemployment gaps and OECD output gaps in the hybrid Phillips curve equation. This did not alter our conclusions. Regardless of its measure and with a very few exceptions (Table 3) global slack continues to be statistically insignificant. Results are similar when lagged domestic slack is used instead.

Table 3: Percent of countries for which a significant positively (resp. negatively) signed global output (resp. unemployment) gap is found.

Domestic slack	Global slack	Percent of countries
Output gap	OECD output gap	6.67
Output gap	1-quarter lagged OECD output gap	6.67
Output gap	2-quarters lagged OECD output gap	6.67
Output gap	3-quarters lagged OECD output gap	6.67
Output gap	4-quarters lagged OECD output gap	6.67
Unemployment gap	GDP weighted unemployment gap	13.33
Unemployment gap	1-quarter lagged GDP weighted unemployment gap	13.33
Unemployment gap	2-quarters lagged GDP weighted unemployment gap	6.67
Unemployment gap	3-quarters lagged GDP weighted unemployment gap	6.67
Unemployment gap	4-quarters lagged GDP weighted unemployment gap	6.67

Notes: (*i*) Hybrid Philllips curve results; (*ii*) Total number of countries is 15 (14 countries and euro area aggregate); (*iii*) The calculation of the GDP weighted unemployment gap is based on unemployment gap data for 12 major advanced economies; (*iv*) 5% significance level.

4 Conclusion

In this paper we have examined the extent to which advanced economy inflation can be considered to be a global phenomenon. While we confirm that commodity prices have a strong effect on headline inflation, our results provide little support for other global factors as prominent drivers of domestic inflation dynamics.

First, we detect no direct effects of global economic slack on domestic inflation for the majority of advanced economies. Second, we find that measures of global inflation are helpful for forecasting domestic inflation rates during periods of significant variation in global inflation trends, particularly in the 1970s and 1980s, but have been much less useful since the mid-1990s when inflation has been more stable. From the mid-1990s onwards, as inflation trends have converged and become more stable, measures of global inflation have considerably less power for forecasting inflation dynamics. Moreover, survey measures of (national) long-term inflation expectations appear to perform much the same task as global inflation in explaining domestic inflation developments. These findings suggest that global inflation matters possibly because it acts as a proxy for (national) inflation expectations by capturing slow-moving trends in inflation rates.

Our analysis though is limited to reduced-form Phillips curves and univariate inflation forecasting models. It might be possible that global slack influences inflation through indirect channels that are not modelled in this framework. Nonetheless, our results strongly exclude the existence of large direct effects of global factors on domestic inflation and overall suggest that, with the exception of commodity prices, there is little reason to include global factors into traditional reduced-form Phillips curves.

A Appendix

Table A.1: GMM estimates of the backward-looking and hybrid Phillips curves for G-7 economies.

	Canada		France		Germany		Italy		Japan		UK		US	
Backward-looking Phillips curve														
Intercept	0.19	0.08	0.12	-0.02	0.05	0.04	0.01	-0.10	0.29***	0.15	-0.01	0.01	0.20	0.11
1-quarter lagged inflation	0.89***	1.11***	0.89***	1.15***	0.94***	0.91***	1.23***	0.99***	0.78***	1.10***	0.97***	1.07***	0.74***	0.89***
2-quarters lagged inflation		-0.22***		-0.29**			-0.29***	-0.08	0.05	-0.13		-0.16**	-0.07	
3-quarters lagged inflation				0.04					0.25**	0.12			0.11	
4-quarters lagged inflation				0.06					-0.27***	-0.15*			0.14*	
Output gap	0.05	0.08***	0.03	0.02	-0.03	0.07**	0.11**	0.01	0.14***	0.08	0.07	0.03	0.09	0.05**
Change in oil price	0.01***	0.00**	0.01***	0.00***	0.00***	0.00*	0.00***	0.01***	0.01***	0.00**	0.00*	0.00	0.02***	0.01***
Change in non-energy prices	0.01	0.00	0.00	0.00	0.00	0.00	0.00*	0.00	0.00	0.01*	0.01*	0.01	0.01	0.01**
OECD output gap	-0.01		-0.03		0.03		-0.10*		-0.09***		-0.04		-0.13	
OECD inflation		0.06**		0.01		0.05***		0.07**		0.00		0.04		0.05
Change in NEER	-0.02	-0.02*	0.00	-0.03**	-0.02**	-0.04***	-0.02***	-0.02***	-0.01	-0.01	-0.01	-0.02***	-0.01	-0.01
P-value of the J-test	0.52	0.26	0.93	0.01	0.68	0.01	0.65	0.68	0.75	0.35	0.78	0.22	0.74	0.22
Number of obs	116	175	115	135	115	135	115	135	115	174	116	136	116	175
Hybrid Phillips curve														
Intercept	-0.19	-0.72	-0.40**	-0.26	-0.58*	-0.73	-0.11	-0.08	0.35	0.34	-0.39	-0.36	-0.45*	-0.63**
1-quarter lagged inflation	0.86***	0.92***	0.74***	0.76***	0.81***	0.78***	1.19***	1.30***	0.87***	0.82***	0.90***	0.92***	0.55***	0.63***
2-quarters lagged inflation	-0.22*	-0.22*					-0.44***	-0.47***						
Inflation expectations	0.35	0.61**	0.35***	0.28**	0.45**	0.70*	0.29***	0.21***	-0.06	-0.08	0.20	0.18	0.54***	0.62***
Output gap	-0.02	0.01	0.11	0.05	0.06*	0.11***	0.17***	0.03**	0.15**	0.15**	0.10	0.03	-0.01	0.03
Change in oil price	0.01***	0.01***	0.01***	0.01***	0.00***	0.01**	0.00***	0.00**	0.00	0.00	0.00	0.00	0.01***	0.01***
Change in non-energy prices	0.00	0.00	0.01*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01**	0.01**	0.00	0.00
OECD output gap	0.05		-0.07		0.01		-0.15***		-0.09***		-0.08		0.09	
OECD inflation		-0.03		0.00		-0.08		0.00		0.02		-0.01		-0.04
Change in NEER	-0.01	0.00	0.01	0.00	-0.02*	-0.03*	-0.02***	-0.02***	-0.01	0.00	-0.01	-0.01	-0.02	-0.04**
P-value of the J-test	0.14	0.03	0.49	0.58	0.59	0.06	0.82	0.47	0.58	0.24	0.84	0.79	0.09	0.76
R-squared	0.79	0.78	0.86	0.86	0.86	0.86	0.98	0.98	0.84	0.83	0.92	0.92	0.86	0.86
Number of obs	98	98	97	97	97	97	97	97	97	97	98	98	98	98

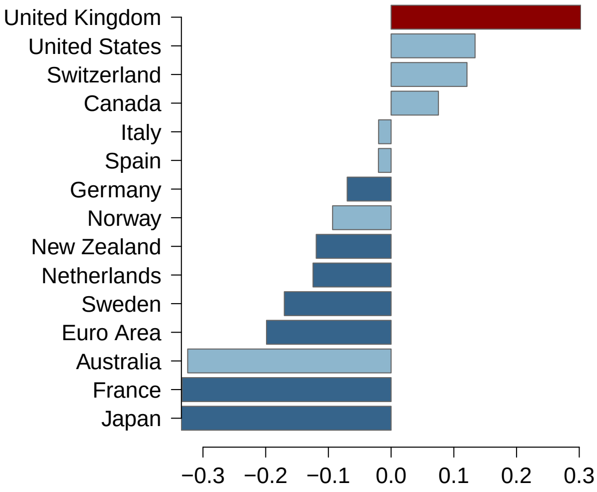
Notes: (*i*) Dependent variable is headline CPI inflation; (*ii*) Estimated by GMM; (*iii*) Instruments include two lags of OECD output gap/OECD inflation and, in the hybrid Phillips curve, include additionally two lags of inflation expectations; (*iv*) Significance stars *, ** and *** denote statistical significance at 10%, 5% and 1% levels respectively.

Table A.2: GMM estimates of the forward-looking Phillips curves for G-7 economies.

	Canada		France		Germany		Italy		Japan		UK		US	
	Forward-looking Phillips curve													
Intercept	0.37	-0.23	-0.75	-0.48	-2.10***	-3.60***	-0.46**	-0.66**	0.50	0.25	0.22	0.49	-0.46	1.53**
Inflation expectations	0.66	0.83**	1.14***	0.96***	2.10***	3.12***	1.30***	0.88***	0.39	0.08	0.82	0.47	0.95***	-0.49
Output gap	-0.01	0.15	0.24**	0.20***	0.17*	0.41***	0.57***	0.08	0.43***	0.39***	-0.17	-0.01	-0.18***	0.02
Change in oil price	0.02***	0.01***	0.00	0.01	0.00	0.01	0.01***	0.00	0.00	-0.01**	0.01	0.00	0.02***	0.01**
Change in non-energy prices	-0.01	-0.01	0.01	0.01	0.01	0.02*	-0.01***	0.00	-0.01**	0.00	0.01	0.00	0.00	0.00
OECD output gap	0.15**		-0.05		0.11*		-0.50***		-0.08		0.13		0.40***	
OECD inflation		0.11		0.04		-0.14		0.42***		0.16		0.19		0.68***
Change in NEER	0.01	0.02	0.00	0.01	0.00	-0.04	-0.03***	-0.02*	0.03**	0.03***	-0.05*	-0.04	0.00	-0.07***
P-value of the J-test	0.13	0.19	0.79	0.07	0.13	0.91	0.23	0.23	0.81	0.32	0.36	0.29	0.19	0.22
R-squared	0.40	0.38	0.56	0.56	0.59	0.64	0.87	0.85	0.65	0.62	0.35	0.36	0.67	0.74
Number of obs	98	98	97	97	97	97	97	97	97	97	98	98	98	98

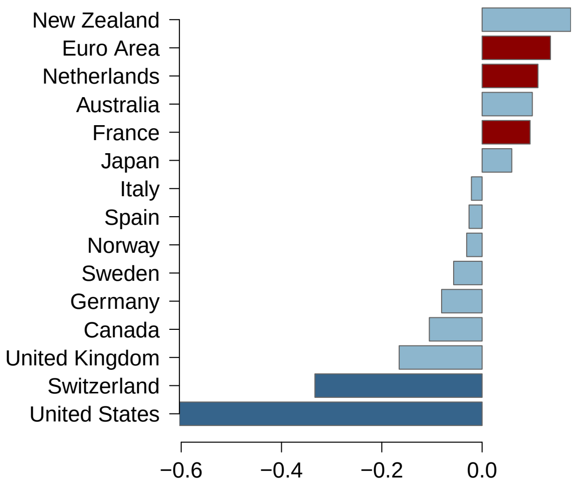
Notes: (*i*) Dependent variable is headline CPI inflation; (*ii*) Estimated by GMM; (*iii*) Instruments include two lags of OECD output gap/OECD inflation and two lags of inflation expectations; (*iv*) Significance stars *, ** and *** denote statistical significance at 10%, 5% and 1% levels respectively.

Figure A.1: Estimated coefficient of domestic unemployment gap γ_i in a hybrid Phillips curve.



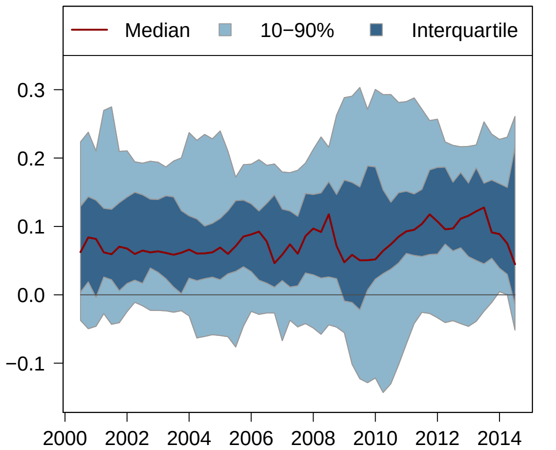
Source: Own calculations.
Notes: (i) Dark blue bars denote statistically significant negatively signed estimates (10% significance level). Red bars denote statistically significant positively signed estimates; (ii) Estimated by GMM.

Figure A.2: Estimated coefficient of global (OECD) unemployment gap δ_i in a hybrid Phillips curve.



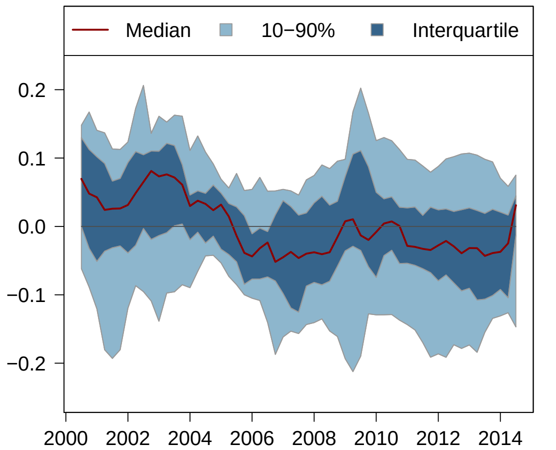
Source: Own calculations.
Notes: (i) Dark blue bars denote statistically significant negatively signed estimates (10% significance level). Red bars denote statistically significant positively signed estimates; (ii) Global unemployment gap is measured by OECD unemployment gap.

Figure A.3: Rolling coefficient of domestic output gap γ_i in a backward-looking Phillips curve.
(range of estimates of coefficients across countries)



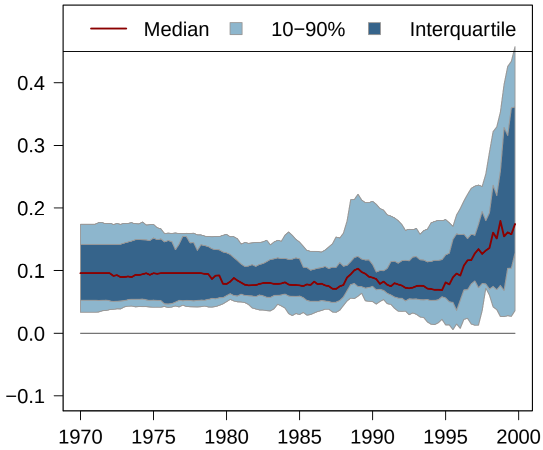
Source: Own calculations.
Notes: (i) The initial estimation sample covers 1985q4-2000q3 (60 quarters). Rolled forward by one quarter at a time; (ii) Eq.(1)-(2) are estimated by OLS with $L = 2$ and f_t measured by OECD output gap; (iii) The chart is based on estimation results for 19 economies.

Figure A.4: Rolling coefficient of global output gap δ_i in a backward-looking Phillips curve.
(range of estimates of coefficients across countries)



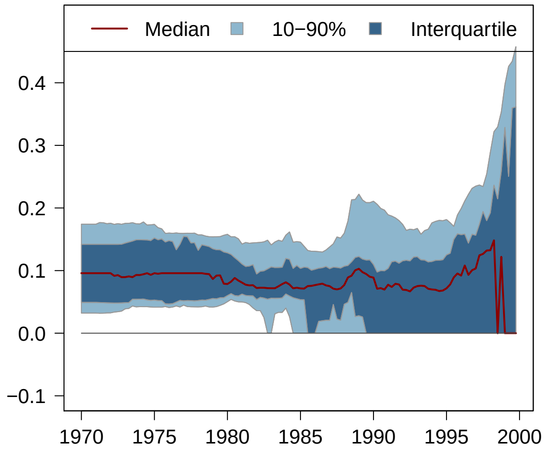
Source: Own calculations.
Notes: (i) The initial estimation sample covers 1985q4-2000q3 (60 quarters). Rolled forward by one quarter at a time; (ii) Eq.(1)-(2) are estimated by OLS with $L = 2$ and f_t measured by OECD output gap; (iii) The chart is based on estimation results for 19 economies.

Figure A.5: Coefficient of OECD inflation in a backward-looking Phillips curve (decreasing window).
(range of estimates of coefficients across countries)



Source: Own calculations.
Notes: (*i*) The initial estimation sample covers 1970q1-2014q3. Then the estimation window is decreased by one quarter each time, i.e. the second estimation sample is 1970q2-2014q3, then 1970q3-2014q3, etc.; (*ii*) The chart ignores significance of the coefficient of OECD inflation in country-by-country regressions; (*iii*) Eq. (1)-(2) are estimated by OLS with $L = 2$ and f_t measured by OECD inflation; (*iv*) The charts are based on estimation results for 19 economies.

Figure A.6: Coefficient of OECD inflation in a backward-looking Phillips curve (decreasing window).
(range of estimates of coefficients across countries)



Source: Own calculations.
Notes: (*i*) The initial estimation sample covers 1970q1-2014q3. Then the estimation window is decreased by one quarter each time, i.e. the second estimation sample is 1970q2-2014q3, then 1970q3-2014q3, etc.; (*ii*) Before plotting the chart insignificant coefficient values are set to zero in country-by-country Phillips curves; (*iii*) Eq. (1)-(2) are estimated by OLS with $L = 2$ and f_t measured by OECD inflation; (*iv*) The charts are based on estimation results for 19 economies.

Figure A.7: Comovement of global (OECD) inflation and Consensus long-term inflation expectations.

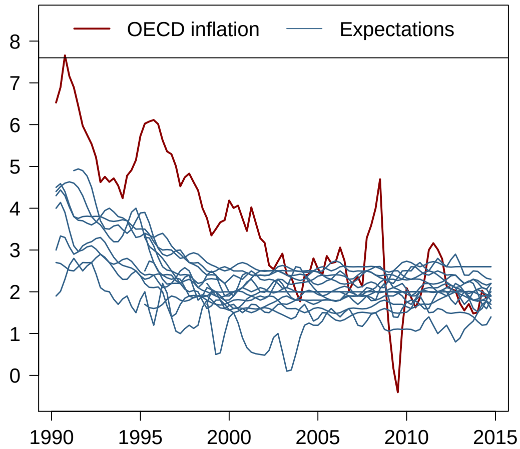


Table A.3: Correlations between global (OECD) inflation and Consensus long-term inflation expectations.

Country	Correlation coefficient
Australia	0.70
Canada	0.58
France	0.69
Germany	0.75
Italy	0.76
Japan	0.61
Netherlands	0.72
New Zealand	-0.69
Norway	0.03
Spain	0.51
Sweden	0.67
Switzerland	0.24
United Kingdom	0.75
United States	0.83

Table A.4: RMSE of global inflation augmented model relative to RMSE of standard autoregression.

Country	One-year-ahead	Two-years-ahead
Forecasting sample: 1981q4-2014q3		
Australia	**0.82**	**0.66**
Austria	**0.85**	**0.82**
Belgium	**0.67**	**0.51**
Canada	**0.76**	**0.65**
Denmark	**0.73**	**0.58**
Finland	**0.70**	**0.55**
France	**0.81**	**0.66**
Germany	**1.11**	**1.15**
Italy	**0.43**	**0.27**
Japan	0.98	1.02
Luxembourg	**0.85**	**0.73**
Netherlands	**0.80**	**0.76**
New Zealand	0.93	**0.81**
Norway	**0.83**	**0.73**
Spain	**0.66**	**0.44**
Sweden	**0.75**	**0.59**
United Kingdom	**0.82**	**0.45**
United States	0.94	0.98
Forecasting sample: 2002q1-2014q3		
Australia	0.90	1.11
Austria	**0.94**	0.96
Belgium	0.90	**1.22**
Canada	0.97	0.87
Denmark	**1.14**	**1.19**
Finland	**1.16**	**1.21**
France	1.09	**1.16**
Germany	**1.22**	1.06
Italy	1.03	1.04
Japan	0.94	1.05
Luxembourg	1.07	**1.23**
Netherlands	0.94	0.88
New Zealand	1.07	1.07
Norway	1.01	1.13
Spain	0.98	1.02
Sweden	0.92	1.10
United Kingdom	1.03	1.08
United States	1.04	1.07

Source: Own calculations.
Notes: (*i*) Bold entries denote ratios statistically significant at a 5% level; (*ii*) Initial estimation sample covers 10 years of data (1971q1 - 1980q4 and 1991q2 - 2001q1 respectively). The sample is subsequently augmented with one observation at a time; (*iii*) Estimated by OLS.

Table A.5: RMSE of inflation expectations augmented model relative to RMSE of global inflation augmented model.

Country	One-year-ahead	Two-years-ahead
Forecasting sample: 2002q1-2014q3		
Australia	1.03	0.81
Canada	1.09	1.12
France	1.06	1.06
Germany	**0.87**	1.03
Italy	**0.80**	**0.72**
Japan	1.06	0.99
Netherlands	**0.84**	0.83
New Zealand	0.85	**0.62**
Norway	0.79	0.88
Spain	1.01	0.90
Sweden	0.97	0.94
United Kingdom	1.11	1.15
United States	1.03	1.05

Source: Own calculations.

Notes: (*i*) Bold entries denote ratios statistically significant at a 5% level; (*ii*) Initial estimation sample covers 1991q2 - 2001q1 (10 years). The sample is subsequently augmented with one observation at a time; (*iii*) Estimated by OLS.

Table A.6: Data definitions and sources.

Variable	Transformation	Source	Frequency	Notes
Dependent variables				
Headline inflation	Year-on-year growth rate	Haver Analytics	Quarterly	Computed using Consumer Price Index (2010=100) .
Core inflation	Year-on-year growth rate	Haver Analytics	Quarterly	Computed using CPI of all items excl. food and energy (2010=100) .
Domestic variables				
Unemployment rate		Haver Analytics	Quarterly	1970q1 - 1992q1 data for Germany is taken from FAME (West Germany).
Real effective exchange rate		Haver Analytics	Quarterly	
Nominal effective exchange rate		Haver Analytics	Quarterly	
Real GDP		Haver Analytics	Quarterly	
Output gap		Haver Analytics	Annual	Percentage deviation of actual real GDP from its potential counterpart as estimated by IMF. Data was interpolated to quarterly frequency using cubic splines. For Canada, Japan and US national quarterly output gap estimates were used. As an alternative to IMF estimates we also consider output gap measured as a cyclical component of the Hodrick-Prescott filter applied to quarterly real GDP data in logarithms. For the Hodrick-Prescott filter we use the typical for quarterly data smoothing parameter $\lambda = 1600$.
Non-accelerating inflation rate of unemployment (NAIRU)		Haver Analytics	Annual	For US national quarterly estimates of long-term natural rate of unemployment equivalent to NAIRU were used. For other countries annual OECD estimates were taken. Data was interpolated to quarterly frequency using cubic splines.
Broad money	Year-on-year growth rate	Haver Analytics	Quarterly	M3 data in local currency units or in index terms. For Austria, Germany, Italy, Japan, Netherlands, Spain and UK growth rates of FAME data were used to extend Haver data.

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Table A.6 – *Continued from previous page*

Variable	Transformation	Source	Frequency	Notes
Long-term inflation expectations		Consensus Economics	Biannual	Average expected consumer price inflation 6 to 10 years ahead. Data was interpolated to quarterly frequency using cubic splines.
Industrial production index	Year-on-year growth rate	Haver Analytics	Quarterly	
Standard VAT rate	Year-on-year difference	OECD Consumption Tax Trends 2014; European Commission "VAT rates applied in the member states of the European Community"; *www.vatlive.com*; *www.tradingeconomics.com*	Quarterly	Standard non-reduced value-added/goods and services tax rate applicable in the entire or the largest part of the country. May be particularly important to control for in countries like Japan, where all the three VAT increases since 1989 were nearly fully passed through to consumer prices.
		Global variables		
OECD unemployment rate		Haver Analytics	Annual	OECD estimate of global unemployment rate.
OECD NAIRU		OECD Economic Outlook 2014	Annual	OECD estimate based on the 34 member countries of the OECD. Data was interpolated to quarterly frequency using cubic splines.
OECD unemployment gap		Own calculations	Quarterly	Computed as a difference between OECD unemployment rate and OECD NAIRU.
OECD output gap		Haver Analytics	Annual	OECD estimate of the global output gap based on the 34 member countries of the OECD. Data was interpolated to quarterly frequency using cubic splines.
OECD inflation		Haver Analytics	Annual	OECD estimate based on the 34 member countries of the OECD.
Average oil price	Year-on-year growth rate	Haver Analytics	Quarterly	Price index representing average spot price of UK Brent (light)/Dubai (medium)/Alaska (heavy) crude oils
Natural gas price index	Year-on-year growth rate	Haver Analytics	Quarterly	Natural gas price index

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Table A.6: Data definitions and sources.

Variable	Transformation	Source	Frequency	Notes
Dependent variables				
Headline inflation	Year-on-year growth rate	Haver Analytics	Quarterly	Computed using Consumer Price Index (2010=100) .
Core inflation	Year-on-year growth rate	Haver Analytics	Quarterly	Computed using CPI of all items excl. food and energy (2010=100) .
Domestic variables				
Unemployment rate		Haver Analytics	Quarterly	1970q1 - 1992q1 data for Germany is taken from FAME (West Germany).
Real effective exchange rate		Haver Analytics	Quarterly	
Nominal effective exchange rate		Haver Analytics	Quarterly	
Real GDP		Haver Analytics	Quarterly	
Output gap		Haver Analytics	Annual	Percentage deviation of actual real GDP from its potential counterpart as estimated by IMF. Data was interpolated to quarterly frequency using cubic splines. For Canada, Japan and US national quarterly output gap estimates were used. As an alternative to IMF estimates we also consider output gap measured as a cyclical component of the Hodrick-Prescott filter applied to quarterly real GDP data in logarithms. For the Hodrick-Prescott filter we use the typical for quarterly data smoothing parameter $\lambda = 1600$.
Non-accelerating inflation rate of unemployment (NAIRU)		Haver Analytics	Annual	For US national quarterly estimates of long-term natural rate of unemployment equivalent to NAIRU were used. For other countries annual OECD estimates were taken. Data was interpolated to quarterly frequency using cubic splines.
Broad money	Year-on-year growth rate	Haver Analytics	Quarterly	M3 data in local currency units or in index terms. For Austria, Germany, Italy, Japan, Netherlands, Spain and UK growth rates of FAME data were used to extend Haver data.

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Table A.6 – *Continued from previous page*

Variable	Transformation	Source	Frequency	Notes
HWWI price index (all commodities)	Year-on-year growth rate	Haver Analytics	Quarterly	HWWI commodity price index (all commodities) in USD constructed by Hamburg Institute of International Economics.
HWWI price index (all commodities excl. energy)	Year-on-year growth rate	Haver Analytics	Quarterly	Commodity price index (all commodities excl. energy) in USD constructed by Hamburg Institute of International Economics.

Table A.6 – *Continued from previous page*

Variable	Transformation	Source	Frequency	Notes
HWWI price index (all commodities)	Year-on-year growth rate	Haver Analytics	Quarterly	HWWI commodity price index (all commodities) in USD constructed by Hamburg Institute of International Economics.
HWWI price index (all commodities excl. energy)	Year-on-year growth rate	Haver Analytics	Quarterly	Commodity price index (all commodities excl. energy) in USD constructed by Hamburg Institute of International Economics.

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