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Globalization and International Inflation Dynamics: The Role of the Global Output Gap

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Abstract: Globalization has been suggested to increase the sensitivity of domestic inflation to global economic conditions. This paper develops an unobserved components model that is consistent with an open economy New Keynesian Phillips curve (NKPC), and finds that a global output gap has replaced the domestic output gap as the key driving variable for inflation in 17 advanced and emerging countries, particularly since the year 2000. The cross-country analysis also suggests that the influence of the global output gap for national price movements is positively correlated to a country's degree of openness in trade. Upon the inclusion of import and oil prices to the NKPC specification, the global output gap remains a significant driving variable for inflation, suggesting that the global output gap matters for inflation beyond the traditional import price channel.

Keywords: Inflation; Globalization; New Keynesian Phillips Curve; Output Gap; Unobserved Components Model.

JEL Classifications: E3, E5, F4.

1 Introduction

International inflation dynamics has undergone fundamental changes during recent decades. Since the 1990s, there has been a marked decline in the level as well as the variability of inflation in a number of advanced and emerging economies. During the recent global financial crises, despite persistently weak growth and extraordinarily accommodative monetary policy on the one hand, and volatile global commodity prices on the other, worldwide inflation rates have remained remarkably stable. Accompanying low and subdued inflation, there has also been an observed increase in the degree of inflation rate comovements worldwide.

The underlying forces responsible for such changes in international inflation rates have been subject to much debate. Some attribute low and stable inflation to improved monetary policy, particularly the widespread adoption of inflation targeting in the 1990s that has helped to anchor long-run inflation expectations. However, given that such effects are likely to work primarily through lowering long-run inflation trends, it cannot explain the rise in the synchronicity of inflation rates over the short to medium term.

Another view that has gained prominence is based on the 'good-luck' hypothesis, which attributes globalization with helping to mute inflationary pressures around the world through a series of favorable external shocks. For example, the rapid integration of lower cost economies into the global trading system is seen to have depressed international goods prices. This acts to moderate inflation directly by lowering import prices, as well as indirectly through enhanced price competition that restrain markups and producer prices in relevant industries. To the extent that greater integration of markets increases cross-border spillovers, it may also help account for observed co-movements of inflation rates across countries.

Consistent with the 'good-luck' notion is the globalization hypothesis (GH), which originated from the concerns of some policymakers (Fisher, 2006; Kohn, 2006; Yellen, 2006; Bernanke, 2007). According to the GH, the internationalization of goods and financial markets should have altered the sensitivity of inflation to its key driving variables. In the

widely studied Phillips curve relation, short-run inflation dynamics is primarily driven by the domestic output gap, which measures the degree of economic slack or resource utilization pressures at the country level. The GH applied to the Phillips curve thus implies that as markets become increasingly integrated, inflation dynamics should have become more sensitive to global rather than domestic measures of slack. Should this occurrence take place, the observed synchronicity of inflation rates across countries may be attributed to the influence of the global output gap acting as a common driving variable for inflation.

According to estimates of closed economy Phillips curves, a number of studies have reported a decline in the link between inflation and domestic measures of slack during recent decades (Roberts, 2006; IMF, 2006; Pain et al. 2008). However, whether the role of domestic slack in the Phillips curve relation is supplanted by a global output gap remains a topic that is still subject to considerable debate. On the one hand, a widely cited study by Borio and Filardo (2007) shows that measures of the global output gap can add considerable explanatory power to reduced form Phillip curve equations for 17 OECD countries. They also show that the influence of the global output gap for national inflation rates have been increasing over time. However, Ihrig et al. (2010), among others, argue that these results are not robust to alternative specifications of the Phillips curve. In particular, they show that the positive results of Borio and Filardo can be overturned once a more plausible specification for inflation expectations is taken into account.

This paper joins the existing literature and examines the GH for 17 advanced and emerging market countries. As a preliminary study, a principal component analysis (PCA) is employed to first examine whether globalization matters for inflation, by investigating whether there exists a common component responsible for the overall movements in international inflation rates. Then, the influence of the global output gap for domestic inflation is investigated within a New Keynesian Phillips curve (NKPC) framework. The response of inflation to the global output gap is studied over different time dimensions and is also investigated in relation to a country's degree of openness in trade. Finally, the external influences of import

and oil prices are allowed to enter the NKPC specification to explore whether the global output gap is still relevant for inflation beyond the traditional import price channel.

The main contributions of this paper are along at least two dimensions. First, a main shortcoming of past work is their limited focus on advanced countries. This paper extends the analysis to cover a broader number of countries, including emerging Asia Pacific economies. In doing so, it reduces potential misspecification problems in previous work where the measure of the global slack used in the Phillips curve estimation may be too narrow because it does not account for resource utilization pressures from emerging market countries. Second, this paper proposes a new way to explore the GH by extending the unobserved components (UC) modeling approach for the NKPC as outlined in Kim et al. (2014) to an open economy framework. In the UC model, long-horizon inflation expectations as well as the output gap can be treated as unobserved state variables, which are estimated from the observed data. Therefore, compared to existing methods that are used to explore the GH, less restrictive assumptions are needed in the UC approach as the empirical model 'allows the data to speak' as much as possible.

As a preview of the empirical results, this paper finds strong evidence in support of the GH. Based on the PCA results, a sizable common component drives worldwide inflation rates, and accounts for over half of the variation in its movements. The importance of this common factor increases over time, reaching a level of over 90% after the year 2000. The NKPC estimations for each country suggest that this common driving factor is most likely explained by the global output gap, as it enters the NKPC specification as a statistically significant explanatory variable for all countries. Furthermore, the link between inflation and the global output gap becomes more prominent since the year 2000, and is positively related to a country's degree of openness in trade. Finally, import and oil prices generally do not help account for the impact of global influences onto domestic inflation rates, suggesting that the global output gap is capturing the effects of global supply and demand pressures for inflation beyond the traditional import price channel.

This paper is organized as follows. Section 2 discusses the channels through which globalization may have altered the behavior of inflation and explores whether there is a common factor driving international inflation rates via a PCA method. Section 3 outlines the empirical UC model based on the open economy NKPC which is used to investigate the GH. Section 4 presents the empirical findings and Section 5 discusses the implications of the estimation results for monetary policy. Section 6 concludes.

2 The Global Dimension of Inflation

International inflation dynamics have moderated considerably over the past 25 years, starting first with the set of advanced economies in the early 1990s, followed by emerging market economies later in the decade (see Figure 1). By the early 2000s, inflation in most countries had fallen well below double digit levels. An exception is the Middle East, where inflation has accelerated during recent years.

Accompanying this remarkable decline in average inflation rates has been a marked fall in inflation variability. Prior to the early 2000s, the standard deviation of annual world consumer price inflation averaged around 4 percent. In recent years, it has dropped to approximately 1 percent (see Figure 2). With inflation rates around the world becoming more stable, the degree of co-movement across countries has also increased significantly.

Many have invoked globalization as an explanation for these changes in global inflation dynamics. Globalization - defined as the international integration of goods, factor and financial markets - has indeed been increasing significantly over recent decades. In terms of trade integration, world trade as a share of GDP climbed from 20 percent to 50 percent during the 1970-2014 period. Globalization accelerated particularly in the early 2000s, as emerging market economies such as China and India became more integrated into the global trading system.

Globalization has been suggested to affect inflation through three main channels. First,

the entrance of lower cost producers into world trade systems may exert downward pressure on global prices both directly - through lower import prices on final and intermediated goods - and indirectly - by intensifying competition in domestic markets that serve to restrain producer prices and markups. In addition, as China and other emerging markets become more integrated into global production networks, the effective increase in world labor supply, as well as the threat of relocation or off-shoring, may reduce workers' bargaining power and limit wage inflation.

Second, globalization can spur productivity growth. Increased competition puts an onus on efficiency, creating incentives for firms to innovate as well as invest in new technologies and production processes. It also encourages productivity gains by enabling economies to specialize in sectors where they have a comparative advantage. The resulting improvements in productivity lower the prices of goods relative to the cost of production, thereby helping to keep inflation low.

Finally, world commodity price cycles may be strengthened by globalization, resulting in a greater influence of external shocks on domestic inflation. Rising commodity prices during 2008 and 2011, for example, was in large part driven by the strong demand from emerging market economies such as China and India. More recently, some have argued that recent increases in commodity prices have helped to stabilize inflation by counterbalancing the downward price pressures induced by the global slowdown. In addition, as global commodity price shocks affect several countries at the same time, their movements can also help to explain the synchronization of inflation rates across countries.

One way to investigate whether globalization may have accounted for the recent reduction in the levels and volatility of worldwide inflation rates is to examine whether there is a common or global factor that can help explain international inflation rate movements. The principal component analysis (PCA), which is a widely used statistical procedure to extract out the underlying components of the data based on its covariance structure, is used for this purpose. The results presented here are based on the first principal component, which by

construction explains the largest proportion of variance in the data.

The PCA is performed separately on world, advanced and East Asia Pacific country groups using consumer price inflation (CPI) data between 1971Q1-2013Q4[1]. For the full 1971Q1-2013Q4 sample period, the percentage of variance explained by an estimated common component is 50 percent for the world as a whole, which suggests that international inflation rates have become more global in nature. Conducting the analysis for just the set of advanced economies, the importance of the common factor increases to 84 percent, while in the case of East Asia Pacific countries, the percentage of variance explained by the common component is 50 percent. Note that these results are roughly in line with previous studies. For a group of advanced economies, Ciccarelli and Mojon (2010) find that on average, a single common factor can explain nearly 70 percent of the variance in national inflation rates. Including emerging market economies into the analysis, Neely and Rapach (2011) show that the importance of a world and regional factor together is smaller at 50 percent, but is nonetheless significant.

To investigate whether the importance of globalization for inflation has changed over time, the PCA is repeated using a 15-year rolling estimation window. The results shown in Figure 3 reveal a number of interesting observations. For advanced economies, even though the full sample results indicate a very high percentage of variance explained by the common component, the rolling analysis suggests that the importance of this common factor has declined since the mid 1990s. Given the growing importance of emerging market economies in global trade, the diminished importance of the common factor in advanced economies' inflation rates may simply reflect the fact that price developments in these countries are now becoming more dependent on global factors that extend beyond simply those captured by

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[1]The set of countries in each group are selected based on data availability and are obtained from the IMF International Financial Statistics database. Advanced countries include Austria, Belgium, Canada, Denmark, Finland, France, Italy, Japan, the Netherlands, Norway, Sweden, Switzerland, and the United States. East Asia Pacific countries include Australia, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, and Thailand. The world country group contains both the advanced and East Asia Pacific country groups, and also includes Egypt, Greece, India, Ireland, Luxembourg, Mexico, South Africa, Spain, and Turkey.

other advanced economies.

By contrast, the importance of the common component for world and East Asia Pacific inflation has increased from around 50 percent to as much as 90 percent in recent years. While this increase has been relatively gradual for the group of East Asia Pacific countries, the world component experienced a sharp increase around the year 2000. The increased co-movement of inflation rates for the world as a whole possibly reflects greater real integration of the global economy and the associated increase in cross-border spillovers[2]. According to Figure 3, this process accelerated around the year 2000, and has been particularly strong among the East Asia Pacific countries. As shown by Auer and Mehrotra (2014), intense integration of the manufacturing supply chain among Asian countries seems to have led to more synchronized price movements.

3   Model Specification

The analysis from the previous section suggests that there is a sizeable common component driving world inflation rates. What forces are behind the significance of this global factor? This section employs the Phillips curve to formally explore the underlying driving factors that may help explain the growing influence of the common component in worldwide inflation rates.

According to the Phillips curve relation, an important driver of inflation in the short-run is the amount of economic 'slack' in the country, as proxied by the domestic output gap. From this perspective, a common component in national inflation rates may reflect greater co-movement in domestic output gaps driven by fluctuations in global output and exchange rates.

However, this does not seem to be supported by the data. A number of studies indicate

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[2]However, it is evident from Figure 3 that that the degree of co-movement in inflation rates decline during major economic downturns. When data from the global financial crisis is included, for example, the percentage of variance explained by the common component for advanced economies' inflation rates dip below 40%. Similarly, the importance of the common component in East Asia Pacific economies falls sharply during the 1997 Asian financial crisis.

that the link between inflation and the domestic output gap since the 1990s has generally weakened, and disappeared altogether in some cases (IMF, 2006; Pain et al., 2008; IMF, 2013). This finding is relatively robust, and has been widely referred to as the 'flattening' of the Phillips curve[3]. To explain this phenomenon, Razin and Yuen (2002), Razin and Loungani (2005), and Razin and Binyamini (2007) cite the effects of globalization whereby both the opening of the capital account and trade balance flattened the Phillips curve through channels such as enhanced consumption smoothing and greater consumption diversification.

In light of these evidences, a common view is that the process of globalization may have supplanted the role of the domestic output gap in Phillip curve models with global economic measures of slack - defined as the difference between world demand and estimated world potential supply. In other words, as internationalization of goods and factor markets have gathered momentum, it has been suggested that national inflation rates may have become more sensitive to resource utilization at the global, rather than domestic, level. For instance, Bullard (2012) argues that the reason why US inflation has not fallen more in the aftermath of the 2007 crisis despite large negative domestic output gaps is because they have become more dependent on the state of global capacity, which is substantially tighter (Figure 4). A number of policymakers have taken interest in this so-called globalization hypothesis (GH), as whether domestic inflation has become more sensitive to foreign cyclical conditions has important implications for the formulation of monetary policy.

Despite the intuitive appeal of the GH, the issue as to whether the global slack can empirically explain the movements in inflation data is still subject to considerable debate. On the one hand, a widely cited study by Borio and Filardo (2007) provides strong evidence that the foreign output gap helps explain inflation dynamics in 17 OECD economies during the 1985-2005 period. Gamber and Hung (2001) and Wynne and Kersting (2007) also confirm the importance of the global output gap for the US. However, the robustness of

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[3]Consistent with this finding is the recent evidence that domestic output gaps in standard Phillips curve models have not been able to offer any additional predictive content beyond lags of inflation when forecasting US inflation (Atkeson and Ohanian, 2001; Stock and Watson, 2007).

Borio and Filardo's results have been challenged by Ihrig et al. (2010), where they show that the importance of the global output gap for inflation disappears with plausible alternative specifications of the reduced form Phillips curve. These results are confirmed by Pain et al. (2008) based on a system of error correction models as well as by Ball (2006) using panel regression analyses for a number of OECD countries. Milani (2010) reaches the same conclusion by estimating a structural model for a sample of G7 economies over the 1985-2007 time period. Conflicting evidence is also present in earlier work (Garner, 1994; Orr, 1994; and Tootell, 1998).

This paper joins the existing literature in investigating the GH, but takes upon a different econometric approach by building upon the UC empirical model of Kim et al. (2014), henceforth referred to as KMN. The UC modeling approach of KMN is based on the following baseline specification of the New Keynesian Phillips (NKPC) curve:

$$\pi_t - \bar{\pi}_t = \beta E_t(\pi_{t+1} - \bar{\pi}_{t+1}) + kx_t + \epsilon_t, \tag{1}$$

$$\bar{\pi}_t = \lim_{j \to \infty} E_t(\pi_{t+j}), \tag{2}$$

where π_t is the inflation rate; $\bar{\pi}_t$ is the trend rate of inflation; β is the subjective discount factor, $E_t(.)$ denotes expectations formed conditional on information up to time t; x_t is the domestic output gap; k is the slope of the Phillips curve; and ϵ_t are shocks to inflation that are not explained by the NKPC. The ϵ_t term may capture, for example, the effects of external supply side shocks or backward-looking dynamics in the NKPC, and thus may exhibit serial correlation.

By forward iteration, Eq. (1) can be written as:

$$\pi_t - \bar{\pi}_t = \lim_{j \to \infty} \beta^j E_t(\pi_{t+j} - \bar{\pi}_{t+j}) + k \sum_{j=0}^{\infty} \beta^j E_t(x_{t+j}) + \tilde{z}_t, \tag{3}$$

where $\tilde{z}_t = \sum_{j=0}^{\infty} E_t(\epsilon_{t+j})$ and the first term on the right hand side of the above equation is zero. However, note that in the above specification, the infinite sum term $\sum_{j=0}^{\infty} \beta^j E_t(x_{t+j})$

is a function of the current output gap x_t, which may be correlated with the $\tilde{z}_t$ component. To avoid this challenge in estimation, the expectation element $E_t(x_{t+j})$ is replaced with $E_{t-1}(x_{t+j})$, resulting in:

$$\pi_t = \bar{\pi}_t + k \sum_{j=0}^{\infty} E_{t-1}(x_{t+j}) + z_t, \tag{4}$$

where $z_t = k(\sum_{j=0}^{\infty} E_t(x_{t+j}) - \sum_{j=0}^{\infty} E_{t-1}(x_{t+j})) + \tilde{z}_t$ and the discount factor has been calibrated to one[4].

To explore the importance of foreign slack pressures for domestic inflation rates, a measure of foreign slack pressures is added to Eq. (4) as an additional explanatory variable for inflation. This results in the model as shown below which can be viewed as a reduced form specification of the open economy New Keynesian Phillips curve (see Clarida et al. 2002).

$$\pi_t = \bar{\pi}_t + k \sum_{j=0}^{\infty} E_{t-1}(x_{t+j}) + \gamma x_{t-1}^* + \eta_t. \tag{5}$$

In the equation above, x_{t-1}^* captures the strength of foreign excess demand pressures from the country's rest-of-the-world trading partners in period $t-1$. Note that η_t may be serially correlated as it is a function of z_t which captures the influence of shocks to inflation beyond the global output gap effect that is not explained by the NKPC.

Following KMN, the NKPC model in Eq. (5) can be written as the following unobserved components (UC) model for inflation:

$$\pi_t = \bar{\pi}_t + k \sum_{j=0}^{\infty} E_{t-1}(x_{t+j}) + \gamma x_{t-1}^* + \eta_t, \tag{6}$$

$$\bar{\pi}_t = \bar{\pi}_{t-1} + v_t, \tag{7}$$

$$\eta_t = \psi \eta_{t-1} + \epsilon_t, \tag{8}$$

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[4]The discount factor is typically set to 0.99 in NKPC specifications. Calibration of the discount factor to 0.99 did not change the quantitative results from the model.

$$y_t = \tau_t + x_t, \tag{9}$$

$$\tau_t = \mu + \tau_{t-1} + e_t, \tag{10}$$

$$x_t = \phi_1 x_{t-1} + \phi_2 x_{t-2} + u_t, \tag{11}$$

where $\bar{\pi}_t$ is the Beveridge-Nelson stochastic trend which follows a driftless random walk (Beveridge and Nelson, 1981). Allowing for a stochastic trend in inflation dynamics is in the spirit of recent studies that emphasize the importance of accounting for time-variation in long-horizon forecasts of inflation (see Ireland, 2007; Cogley and Sbordone, 2008; Cogley et al., 2010; Kim et al., 2014)[5].

To capture possible serial correlation in η_t, η_t is assumed to follow an autoregressive process (AR) of order one[6]. In dealing with the output gap term x_t, this paper departs from the KMN approach by allowing x_t to enter the NKPC as a latent state variable. In the KMN model which is estimated with US data, the output gap x_t is treated as an observed variable and is proxied by the Congressional Budget Office's (CBO) measure of the output gap. However, for the majority of countries in this study, reliable or official measures of the domestic output gap is lacking. To address this shortcoming, this paper uses the UC framework to an advantage. More specifically, the UC model for inflation is augmented with a UC model for output as shown by Eqs. (9)-(11), where real output y_t is decomposed into a stochastic trend component τ_t and a cyclical component x_t that corresponds to the domestic output gap which enters the NKPC relation. In this way, the dynamics of x_t can be inferred from the observed movements in inflation and real output data, in such a way

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[5]A stochastic trend rate of inflation implies that inflation has a unit root. Some may argue for stationarity in the inflation rate given the relatively stable dynamics of inflation rates worldwide as well as the widespread adoption of inflation targeting regimes. However, the random walk specification for trend inflation in Eq. (7) does allow for stationarity as a special case. In such a scenario, trend inflation will be constant, and the variance of v_t will be estimated to be zero.

[6]The role of η_t is to capture the effects of other external influences onto inflation beyond global output gap effects. Apart from supply shocks, it may also account for the intertia in inflation arising from backward-looking price setting dynamics (see Fuhrer and Moore, 1995; Christiano et al., 2005; Fuhrer, 1997). Or, as shown by Cogley and Sbordone (2008), it may capture the effects of additional forward-looking elements that enter the NKPC in the presence of stochastic trend inflation.

that is consistent with the NKPC.

Finally, to keep the model as generalized as possible, all shocks to the UC model are allowed to be correlated. The UC model in Eqs. (6)-(11) can then be put into state-space form, and estimated with the Kalman filter using maximum-likelihood techniques. Readers are referred to Appendix A for details on the state-space representation of the model.

4 Empirical Relevance of the Global Output Gap

The empirical UC model is estimated over two samples spanning 1990Q1-2013Q4 and 2000Q1-2013Q4. The purpose of conducting the analysis over two sample periods is to examine whether the relation between inflation and foreign slack may have changed as a result of globalization. Rapid integration of emerging market economies onto the world trading system occured around the year 2000 (Miotti and Sachwald, 2006), thus the latter subsample corresponds to the period of enhanced globalization. The choice to split the sample in year 2000 is also motivated by the PCA results as discussed in Section 2. More specifically, it is clear from Figure 3 that the importance of the common factor for world inflation rates is higher in the post 2000 period.

Estimation of the model is performed with quarterly data, obtained from the IMF International Financial Statistics database. Seventeen countries are selected for the analysis which includes the United States, Japan, Australia, Italy, France, United Kingdom, New Zealeand, Indonesia, China, Canada, Korea, Germany, Thailand, Malaysia, Hong Kong, Singapore, and the Philippines. Domestic inflation π_t is calculated from the Consumer Price Index (CPI) and real output y_t is the PPP-adjusted GDP series using PPP numbers from the 2005 Penn World Table.

The foreign output gap series x_t^* is extracted from foreign output y_t^*, which is constructed from the trade-weighted aggregate of the PPP-adjusted GDP series of 30 foreign countries[7].

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[7]The countries included are United States, Brazil, Japan, Australia, Peru, Turkey, Italy, France, South Africa, Mexico, the United Kingdom, Spain, New Zealand, China, Canada, Poland, Korea, Germany, Fin-

The foreign output series for country i is computed as $y_t^* = \sum_{k=1}^{29} \gamma_k y_{k,t}$ where $i \neq k$ and $k = 1, ..., 29$ denotes country $i's$ foreign trading partner. The trade weights are computed as $\gamma_k = (imports_{i,k} + exports_{i,k})/total\ imports\ and\ exports_i$ where trade numbers are specific to the year 2005 in order to be consistent with the PPP numbers from the 2005 Penn World Table[8].

4.1 Estimation Results

The estimation results from the UC model confirm the findings in the existing literature that the link between inflation and the domestic output gap is weak. As shown in Table 1, the coefficients on domestic output gaps are statistically significant for only a few countries for both the full and shorter recent subsample. On the other hand, the coefficient on the foreign output gap is large and statistically significant for all countries during the full sample, with the exception of Indonesia, the UK, and Korea. The importance of the global output gap for national inflation rates also appears to have risen since 2000 as the coefficient on the foreign output gap is larger in magnitude in the more recent sub-sample for most countries.

The importance of global output gaps for domestic inflation goes some way to shed light on possible determinants of the common factor that was discussed above. Inflation co-movement appears to be related to global capacity constraints. That said, questions remain about the exact channels through which global output gaps exert influence on national inflation rates, as well as the factors that determine the relative importance of global output gaps across countries. Previous studies have argued that the significance of global output gaps may depend on certain country-specific characteristics such as the degree of trade openness, monetary policy credibility, or the strength of wage bargaining power. So far however, no clear conclusion has been reached (IMF, 2006; Borio and Filardo, 2007; Bianchi

land, Sweden, Switzerland, Denmark, Austria, Taiwan, Netherlands, Hungary, Thailand, Belgium, Malaysia, Hong Kong and Singapore.

[8]Robustness checks are performed with other aggregation methods based on time-varying trade weighted shares and GDP-weighted shares. See Borio and Filardo (2007) for a detailed explanation of other aggregation methods. The qualitative results are not sensitive to alternate aggregation methods for the foreign output series.

and Civelli, 2013). To provide some suggestive evidence, the role of trade-openness and variations in import prices is investigated below.

Global Slack and Trade Openness

The importance of global influences on inflation should depend on the degree of trade openness. To see whether this carries through to global output gaps, Figure 5 plots the estimated coefficient on the foreign slack variable for each country over the full sample against the country's ratio of trade to GDP. As shown, there is a strong positive relationship between the country's measure of trade openness and the sensitivity of inflation to foreign slack conditions. This positive correlation becomes stronger in the more recent 2000Q1-2013Q4 period (Figure 6), as reflected in the steeper slope of the best-fitting trend line as well as the tighter fit of country data points around it (R-squared rises from 0.47 to 0.75). As a country's degree of trade openness rises, as has been the case for most countries in the Asia Pacific region, the influence of global output gaps on inflation increases.

The findings here are similar to existing work that have found some evidence that the sensitivity of inflation to output depends on the country's degree of openness in trade. For example, IMF (2006) allows the slope of the Phillips curve in eight advanced economies to depend on changes of openness, monetary policy credibility, average inflation, and a wage-bargaining index through multiplicative terms. The study finds that trade openness is the key factor behind the reduced sensitivity of prices to domestic output. Using a panel analysis where the degree of openness is regressed on impulse response functions of inflation to a unit shock in the domestic and foreign output gaps, Bianchi and Civelli (2013) also find that the impact of global slack on inflation is increasing in a country's degree of openness for a large set of countries.

Global Slack and the Import Price Channel

The relevance of global output gaps for inflation may be due to the effects of import prices

on inflation dynamics. For example, a tighter global output gap reflecting rapid growth in emerging market economies may be associated with higher commodity prices that, in turn, feed into domestic prices.

To investigate this possibility, import price inflation and oil prices are added, one at a time, to the NKPC specification. More specifically, Eq. (6) in the UC model becomes:

$$\pi_t = \bar{\pi}_t + k \sum_{j=0}^{\infty} E_{t-1}(x_{t+j}) + \gamma x_{t-1}^* + \alpha z_{t-1} + \eta_t, \tag{6'}$$

where z_{t-1} denotes import or oil prices in the time period $t-1$. Import prices are measured as the year-on-year change in the natural logarithm of the import price index for each country with data obtained from IMF International Financial Statistics and CEIC databases. Oil prices is expressed as the year-on-year change in the natural logarithm of the simple average of the spot prices of the Brent, Dubai, and West Texas Intermediate crude oil varieties obtained from the IMF Commodity Price System database.

The results in Tables 2 and 3 do not lend much support for the import price channel. The estimated coefficients on the additional variables are generally small and statistically significant in only a few countries. Moreover, the inclusion of import price inflation and oil prices to the Phillips curve does not reduce the size of the coefficient on the foreign slack measure, nor remove their statistical significance. This finding echoes Borio and Filardo's (2007) argument that import prices are not a 'sufficient statistic' for the influence of foreign markets on domestic prices. In other words, import prices can only capture the cost of goods and services that are actually imported. A seperate foreign slack variable is therefore still needed in the NKPC relation to capture the threat of foreign competition, or the effect from the cost of other products that could potentially be imported, which helps keep prices and wages in check. Additionally, the effect of foreign resource utilization on domestic inflation could operate through factor markets rather than through import prices alone. For example, if foreign labor markets are loose, wage pressures in domestic markets may not necessarily translate to higher prices due to the possibility of job offshoring.

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The limited direct influence of import price on domestic inflation also suggests the importance of local currency pricing, whereby prices of imported goods are set in the local currency rather than (external) producer currency. This tends to stabilize the local price of imported goods even if the underlying cost changes. This is in line with numerous studies that document a decline in the degree of exchange rate pass-through to consumer prices in many countries, both advanced and emerging markets, during the recent decade (Takhtamanova, 2010). The decline in pass-through likely also reflects increased foreign competition, which makes it more difficult for firms to adjust prices in response to higher costs of imported goods.

5   Implications for Monetary Policy

The empirical results from the previous sections suggest that globalization may have altered the inflation process in fundamental ways, contributing to the excellent peformance of inflation during recent decades. These findings indeed have important implications for monetary policy. Most directly, central banks must now pay more attention to external developments and respond to a wider range of shocks. More fundamentally, greater sensitivity of inflation to global factors has implications for i) monetary control; and ii) policy incentives and frameworks. These are discussed in turn.

The increased global nature of inflation has created growing unease about whether central banks' ability to control inflation within national borders has diminished. Fisher (2006) voiced the concern that "the old models simply no longer apply in our globalized, interconnected and expanded economy", and calls for a reassessment of the traditional frameworks being used for monetary policy analysis.

A key question is whether changes in the underlying inflation process have weakened the ability of monetary policy to achieve desired economic outcomes. For example, a flatter Phillips curve documented in the previous section implies that a larger interest rate change

is required to achieve a given effect on prices (ie. a larger "sacrifice ratio"). Moreover, a decline in exchange rate pass-through suggests that the exchange rate channel of monetary transmission is weaker. For countries where this channel is important, more forceful policy moves may be needed to achieve the same impact. At the same time, a smaller degree of exchange rate pass-through also reduces the need to undertake foreign exchange interventions, as the gains from doing so are smaller. This may be particularly relevant for emerging market economies in the Asia Pacific region given that foreign exchange interventions have been quite common in the region and that exchange rate pass-through seems to have fallen significantly for these countries (Devereux and Yetman, 2014).

On the other hand, while globalization implies that international influences play an important role in shaping the price process, it need not compromise the ability of central banks to control domestic inflation. Woodford (2007) provides theoretical support for this argument by showing that the high degree of integration of goods, financial or factor markets is unlikely to diminish the control of monetary policy over inflation. In fact, monetary policy may be more potent due to more forceful exchange rate and terms of trade effects. Drawing on available empirical evidence, Kohn (2006) and Yellen (2006) also argued that central bank's ability to control inflation remains unabated despite greater globalization.

Greater market integration also has implications for policy incentives and appropriate frameworks. One possibility is that globalization has improved inflation outcomes by its 'disciplining' effect on monetary policy. Rogoff (2003), for example, argued that increased competition makes prices and wages more flexible, increasing the cost of surprise inflation. This reduces the incentives for central banks to exploit the inflation-output tradeoff and pursue overly expansionary monetary policies. Similarly, Romer (1993) rationalizes his findings of a negative correlation between openness and the level of inflation by arguing that policymakers' incentive to inflate is weaker in more open economies because unanticipated policy easing leads to depreciation which, in turn, raises inflation through higher import prices. More broadly, "sound macro policy" has become a prerequisite for maintaining good

standing with international investors and credit rating agencies. On the other hand, to the extent that inflation is determined more by global factors, policymakers may discount the inflationary risks of expansionary monetary policy. This may create a global inflation bias as countries pursue easier policy at the margin and fail to internalize aggregate inflationary consequences of those policies at the global level. This raises the question of whether some form of policy coordination might be beneficial as inflation becomes more of a global phenomenon. Thus far, the case for global policy rules have not received much support, as various theoretical frameworks show that the resulting gains are small and the practical challenges of policy coordination are formidable (Coenen et al. 2007; Taylor, 2008 and 2013). Nevertheless, the fact that policymakers now pay a great deal of attention to external developments, including policy moves in other countries, implies that a degree of tacit coordination is already taking place.

Finally, much caution is warranted in drawing policy recommendations from existing empirical evidence on globalization and inflation. The changing behavior of the inflation process may be an endogenous outcome of monetary policy that has become more vigilant towards inflation (Roberts, 2006; Mishkin, 2007). If so, the correlation between globalization and changes in the inflation process may be spurious, and adjustments to policy on the presumption that these changes in the inflation process are structural may lead to unexpected outcomes. The Lucas critique applies fully here. Greater understanding of the underlying drivers of the changing inflation process, and in particular how they relate to globalization and monetary policy conduct, should be a priority research focus going forward.

6   Conclusion

This paper investigates whether the process of globalization has increased the role of international factors in the inflation process for a sample of 17 advanced and emerging economies. Toward this end, an initial examination for the role of a global factor in international infla-

tion rates is conducted with a PCA. Then, a NKPC in the form of an UC model is estimated for each of the 17 countries to examine the forces behind the significance of the global factor.

Overall, the empirical findings strongly suggest that over time, national inflation rates have indeed become more global in nature. This conclusion is drawn from the following results. First, the PCA findings show that in the 1990s, a sizeable common component drives worldwide inflation rates, and accounts for approximately 50% of its variation. The role of the common component becomes more pronounced over time, particularly in the post 2000 period, where the percentage of variation explained climbs to over 90%. Second, the NKPC estimations suggest that the significance of this common component may be attributed to the growing influence of the global output gap for international inflation rates. While the response of inflation to domestic slack pressures have become muted, the link between inflation and the global output gap is statistically significant for all countries. Furthermore, the role of the global gap for inflation has been growing steadily over time, and appears to be an increasing function of a country's degree of openness in trade. Adding traditional external influences such as import and oil prices to the NKPC specification does not diminish the importance of the global output gap for inflation, suggesting that the global output gap is capturing additional information regarding global influences beyond the import price channel.

The bottom line of this study suggests that much of the co-movement in national inflation rates may be related to cyclical fluctuations in the world economy as captured in measures of global slack. Further research is needed to disentangle the underlying demand and supply influences working through the global output gap. This will lead to a greater understanding of the transmission mechanism from external shocks onto domestic prices that is crucial for policy formulation. Furthermore, it is also of key importance to understand how globalization may have altered the deep structural parameters of the macroeconomy. For example, increased international competition may effect the frequency of price adjustment, which may have been responsible for the altered sensitivity of inflation to economic slack conditions.

Sbordone (2007) and Guerrieri et al. (2008) are some early works that investigate such issues by estimating small-scale New Keynesian structural models. Future research in this direction will serve fruitful, and provide us with a broader understanding of the empirical consequences of globalization on inflation dynamics.

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Table 1: **Estimation results for the NKPC with a foreign output gap**

| | 1990Q1-2013Q4 | | 2000Q1-2013Q4 | |
Countries	Domestic Gap	Foreign Gap	Domestic Gap	Foreign Gap
US	0.039	0.301**	0.018	0.562***
	(0.044)	(0.115)	(0.023)	(0.107)
Japan	0.298	0.221*	0.228	0.413**
	(0.617)	(0.126)	(0.189)	(0.157)
Australia	0.079	0.345**	-0.075	0.409***
	(0.049)	(0.129)	(0.075)	(0.094)
Italy	0.105	0.525***	-0.048	0.616***
	(0.089)	(0.104)	(0.117)	(0.127)
France	0.678	0.377***	0.143	0.421***
	(0.654)	(0.090)	(0.141)	(0.101)
UK	0.012	0.123	-0.097	0.323***
	(0.026)	(0.126)	(0.113)	(0.144)
New Zealand	0.084**	0.396***	-0.297	0.223*
	(0.042)	(0.144)	(0.356)	(0.129)
Indonesia	-2.577**	0.612*	0.035*	0.430
	(1.210)	(0.317)	(0.019)	(0.282)
China	0.209**	0.278*	0.063	0.254**
	(0.077)	(0.158)	(0.076)	(0.128)
Canada	0.273	0.785***	0.659	0.752***
	(0.233)	(0.211)	(0.879)	(0.128)
Korea	0.034	0.145	-2.836	0.600***
	(0.084)	(0.188)	(2.939)	(0.208)
Germany	-0.071	0.424***	-0.041	0.417***
	(0.069)	(0.126)	(0.035)	(0.090)
Thailand	-0.026	0.687*	0.007	0.535**
	(0.067)	(0.401)	(0.047)	(0.259)
Malaysia	0.078	0.629***	0.813	1.068***
	(0.122)	(0.217)	(1.074)	(0.239)
Hong Kong	0.457*	0.568**	0.225	0.849***
	(0.278)	(0.219)	(0.268)	(0.268)
Singapore	0.480	0.986***	0.216	1.466***
	(0.302)	(0.267)	(0.136)	(0.356)
Philippines	-6.937	0.742***	8.295	0.744***
	(11.207)	(0.157)	(6.207)	(0.159)

Note: Standard errors are in parentheses.

***,**,* denotes significance at the 1, 5 and 10 percent levels respectively. The foreign output gap is calculated by detrending the trade-weighted aggregate of each country's trading partners' PPP-adjusted output with the Hodrick-Prescott filter.

Table 2: **Estimation results for the NKPC with a foreign output gap and import price inflation**

Countries	1990Q1-2013Q4			2000Q1-2013Q4		
	Domestic Gap	Foreign Gap	Import prices	Domestic Gap	Foreign Gap	Import prices
US	0.040	0.288**	0.006	-0.228**	0.528***	-0.015
	(0.044)	(0.115)	(0.016)	(0.093)	(0.118)	(0.015)
Japan	0.390	0.141	0.027**	0.239	0.343**	0.019
	(0.359)	(0.159)	(0.013)	(0.201)	(0.165)	(0.017)
Australia	0.079*	0.345***	0.004	-0.078	0.412***	-0.011
	(0.048)	(0.130)	(0.014)	(0.076)	(0.094)	(0.014)
Italy	-	-	-	-	-	-
France	-	-	-	0.205	0.455***	-0.010
				(0.241)	(0.170)	(0.028)
UK	0.015	0.100	0.014	-0.061	0.240	0.033
	(0.031)	(0.138)	(0.022)	(0.095)	(0.197)	(0.046)
New Zealand	0.080*	0.471***	-0.059***	-6.803	0.312**	-0.056***
	(0.043)	(0.152)	(0.019)	(18.404)	(0.134)	(0.016)
Indonesia	-	-	-	-	-	-
China	-	-	-	-	-	-
Canada	-	-	-	0.738	0.767***	0.013
				(0.997)	(0.128)	(0.017)
Korea	0.005	0.146	-0.017	-1.036	0.796***	-0.051**
	(0.035)	(0.197)	(0.016)	(0.306)	(0.231)	(0.023)
Germany	-0.093	0.177	0.043	-0.042	0.397***	0.010
	(0.174)	(0.138)	(0.030)	(0.035)	(0.111)	(0.032)
Thailand	-	-	-	0.287*	0.706*	-0.072
				(0.162)	(0.367)	(0.061)
Malaysia	-	-	-	0.946**	0.943***	0.134*
				(0.483)	(0.196)	(0.081)
Hong Kong	0.460*	0.572**	0.008	0.601	0.878***	-0.128
	(0.278)	(0.219)	(0.049)	(1.263)	(0.296)	(0.154)
Singapore	0.477	1.008***	-0.012	0.220	1.527***	-0.023
	(0.296)	(0.325)	(0.094)	(0.137)	(0.410)	(0.076)
Philippines	-	-	-	-	-	-

Note: Standard errors are in parentheses.
***,**,* denotes significance at the 1, 5 and 10 percent levels respectively. Import prices are measured as the year-on-year change in the natural logarithm of the import price index for each country obtained from IMF International Financial Statistics and CEIC databases. Missing entries are due to data unavailability.

Table 3: **Estimation results for the NKPC with a foreign output gap and oil prices**

Countries	1990Q1-2013Q4			2000Q1-2013Q4		
	Domestic Gap	Foreign Gap	Oil prices	Domestic Gap	Foreign Gap	Oil prices
US	0.039	0.304***	-0.001	0.020	0.588***	-0.002
	(0.043)	(0.115)	(0.002)	(0.027)	(0.121)	(0.003)
Japan	0.372	0.188	0.008*	0.223	0.360**	0.007
	(0.378)	(0.158)	(0.004)	(0.167)	(0.164)	(0.006)
Australia	0.079	0.319**	0.002	-0.076	0.388***	0.002
	(0.048)	(0.141)	(0.003)	(0.070)	(0.101)	(0.003)
Italy	0.713	0.435***	0.004	1.027	0.605***	0.002
	(0.484)	(0.121)	(0.003)	(0.939)	(0.175)	(0.004)
France	0.023	0.241**	0.002	0.076	0.304**	0.003
	(0.030)	(0.090)	(0.002)	(0.127)	(0.141)	(0.003)
UK	0.013	0.073	0.003	-0.088	0.279	0.003
	(0.036)	(0.155)	(0.003)	(0.135)	(0.180)	(0.004)
New Zealand	0.084*	0.389**	0.000	0.037	0.201	0.003
	(0.048)	(0.162)	(0.004)	(1.346)	(0.149)	(0.004)
Indonesia	-2.477	0.710**	-0.006	0.034*	0.530*	-0.005
	(1.168)	(0.348)	(0.009)	(0.019)	(0.313)	(0.008)
China	0.210***	0.302*	-0.001	0.059	0.320**	-0.004
	(0.078)	(0.174)	(0.004)	(0.076)	(0.142)	(0.004)
Canada	0.045	0.765***	0.004	-0.144	0.524***	0.008**
	(0.273)	(0.111)	(0.003)	(0.876)	(0.120)	(0.003)
Korea	0.044	0.191	-0.036	0.132	0.370*	0.004
	(0.111)	(0.208)	(0.006)	(0.648)	(0.224)	(0.007)
Germany	-0.115	0.317***	0.008**	0.102	0.297***	0.004
	(0.095)	(0.117)	(0.003)	(0.136)	(0.103)	(0.003)
Thailand	0.579	0.156	0.020**	0.024	0.261	0.023*
	(0.518)	(0.313)	(0.009)	(0.064)	(0.364)	(0.013)
Malaysia	-6.146	0.547**	0.011*	-2.377	0.868***	0.020***
	(3.987)	(0.219)	(0.006)	(2.320)	(0.208)	(0.006)
Hong Kong	0.438	0.486**	0.007	0.222	0.787**	0.004
	(0.281)	(0.233)	(0.006)	(0.373)	(0.343)	(0.008)
Singapore	0.486	0.946***	0.003	0.212	1.422***	0.003
	(0.314)	(0.283)	(0.009)	(0.134)	(0.404)	(0.013)
Philippines	-23.06	0.647***	0.003	-4.077	0.681***	0.003
	(16.28)	(0.192)	(0.005)	(4.284)	(0.177)	(0.004)

Note: Standard errors are in parentheses.
***,**,* denotes significance at the 1, 5 and 10 percent levels respectively. Oil price is expressed as the year-on-year change in the natural logarithm of the simple average of the spot prices of the Brent, Dubai, and West Texas Intermediate crude oil varieties obtained from the IMF Commodity Price System database.

Figure 1: Consumer Price Inflation
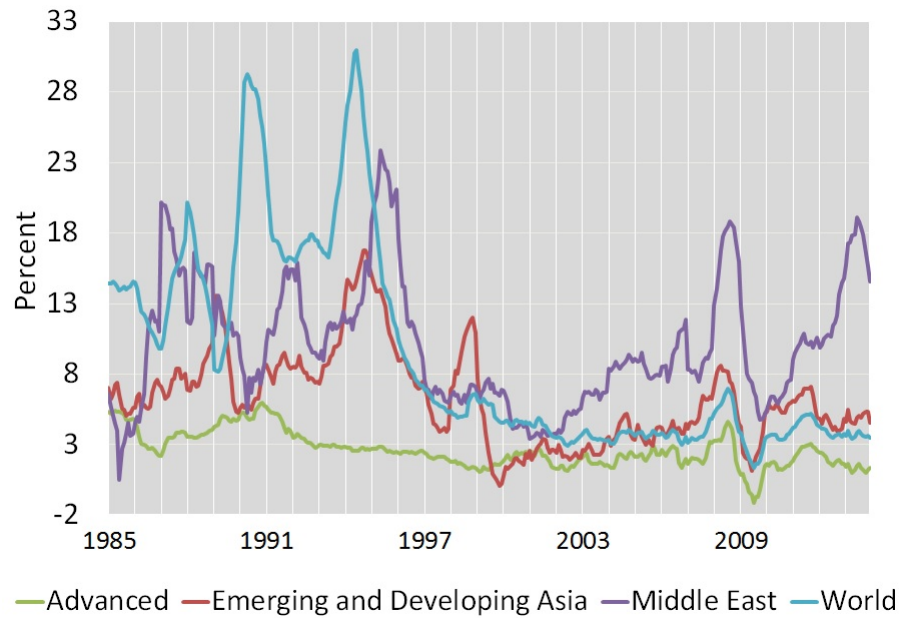
Source: IMF International Financial Statistics.

Figure 2: Standard Deviations of Consumer Price Inflation
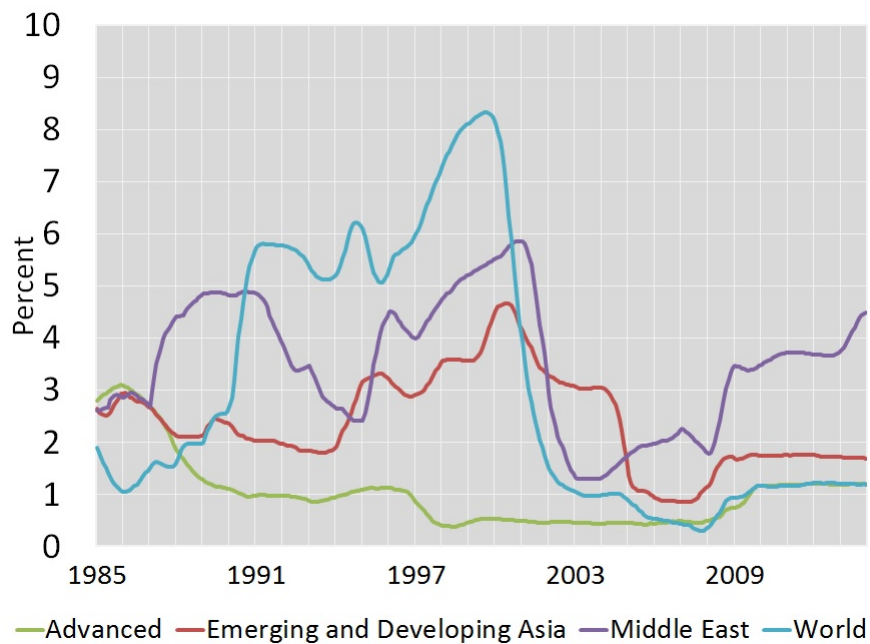
Note: Standard deviations in the right-hand panel are computed using a five-year rolling window.
Sources: IMF International Financial Statistics; Author's calculations.

Figure 3: Percentage of Variance Explained by the Common Component
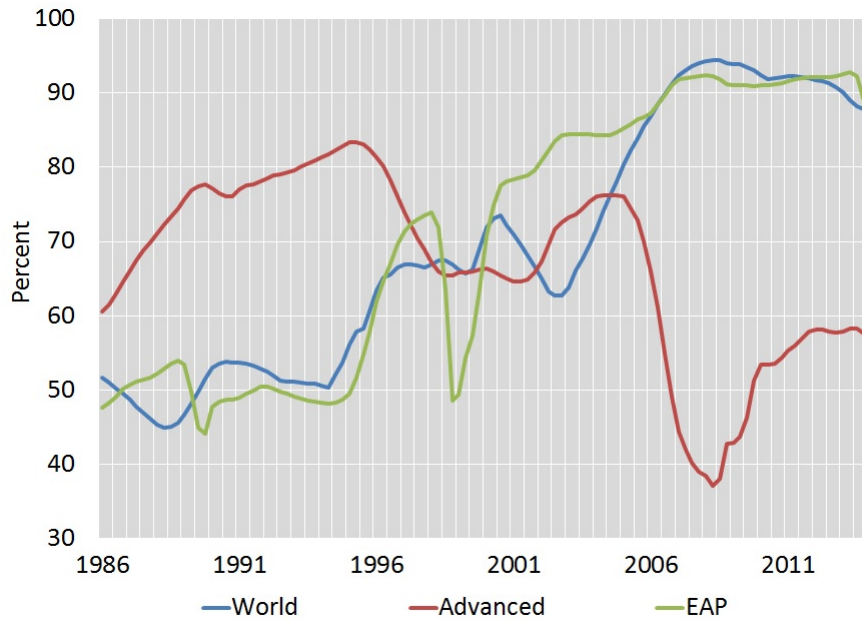
Note: The common component is the first principal component of the inflation rates in the region, extracted by principal components analysis (PCA) for the 1971Q1-2013Q4 sample using a 15-year rolling window. The set of countries that are chosen for each group are based on data availability. Advanced economies include Austria, Belgium, Canada, Denmark, Finland, France, Italy, Japan, the Netherlands, Norway, Sweden, Switzerland, and the United States. East Asia Pacific (EAP) countries include Australia, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, and Thailand. The world group comprises of advanced and EAP countries, as well as Egypt, Greece, India, Ireland, Luxembourg, Mexico, South Africa, Spain, and Turkey.
Sources: IMF International Financial Statistics; Author's calculations.

Figure 4: US Domestic Output Gap and Global Output Gap
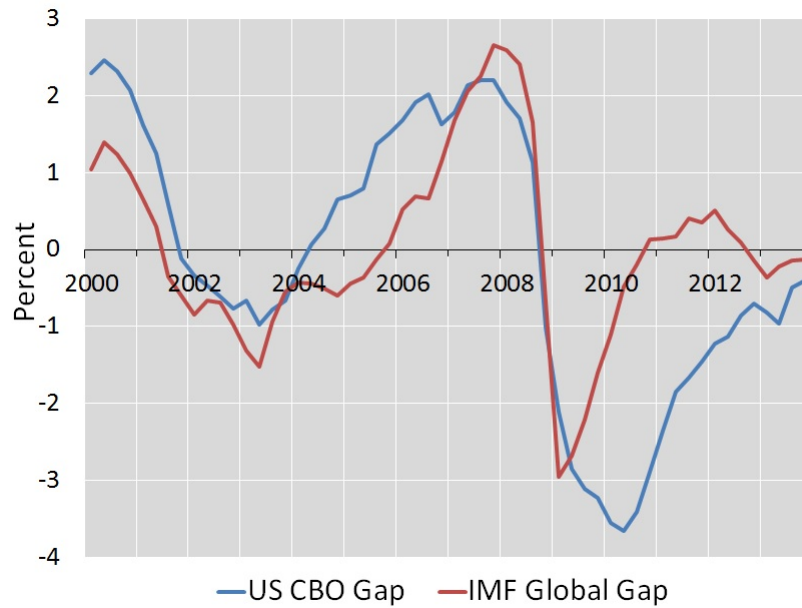
Note: The Congressional Budget Office's estimate of potential output is based on a multi-sector growth model while the IMF's estimate is a smoothed series obtained from the Hodrick-Prescott filter.

Sources: Federal Reserve Economic Data (FRED); IMF Global Projection Model estimates.

Figure 5: The foreign slack coefficient and trade openness, 1990Q1-2013Q4
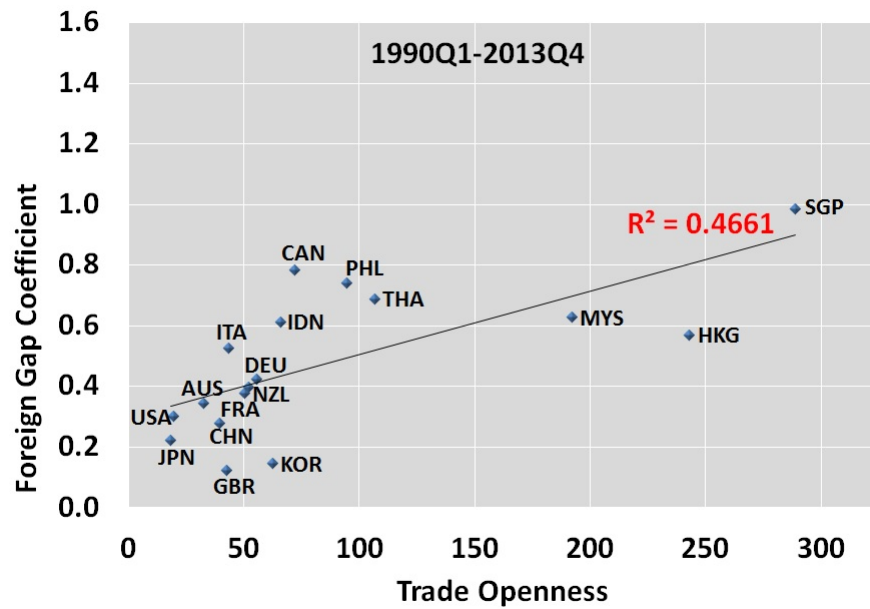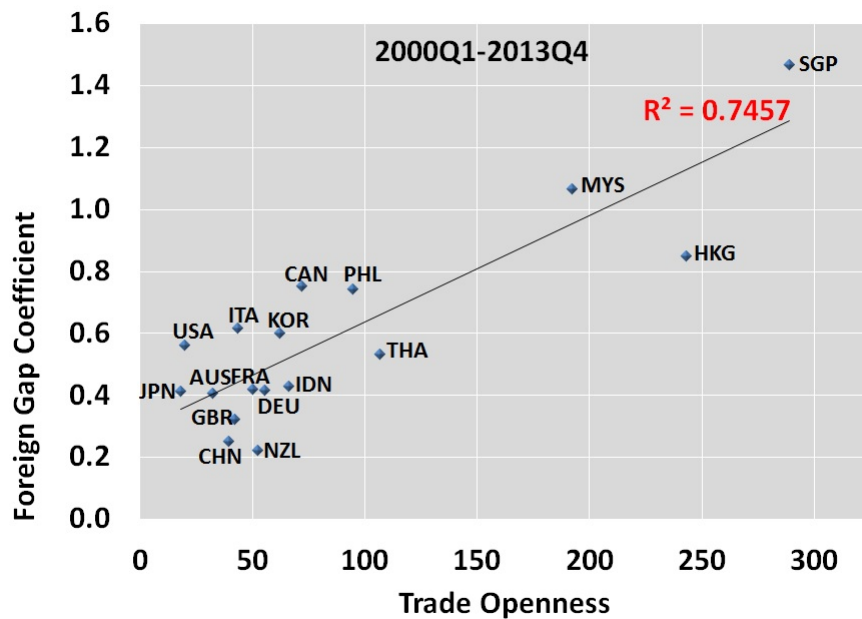

Figure 6: The foreign slack coefficient and trade openness, 2000Q1-2013Q4

Note: Trade openness is measured by the ratio of trade to GDP in year 2000. The R-squared statistic measures how close the data points are to the best-fitting trend line.
Sources: World Bank World Development Indicators; Author's calculations.

Appendix: State-Space Representation of the UC model

Below is the state-space representation of the UC model corresponding to Eqs. (6)-(11):

Measurement equation

$$
\begin{bmatrix} \pi_t \\ y_t \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} \bar{\pi}_t \\ \eta_t \\ x_t \\ x_{t-1} \\ \tau_t \end{bmatrix} + \begin{bmatrix} k \sum_{j=0}^{\infty} E_{t-1}(x_{t+j}) + \gamma x_{t-1}^* \\ 0 \end{bmatrix}
$$

Transition equation

$$
\begin{bmatrix} \bar{\pi}_t \\ \eta_t \\ x_t \\ x_{t-1} \\ \tau_t \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ \mu \end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & \psi & 0 & 0 & 0 \\ 0 & 0 & \phi_1 & \phi_2 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \bar{\pi}_{t-1} \\ \eta_{t-1} \\ x_{t-1} \\ x_{t-2} \\ \tau_{t-1} \end{bmatrix}
$$

$$
+ \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} v_t \\ \epsilon_t \\ u_t \\ e_t \end{bmatrix}
$$

$$
\begin{bmatrix} v_t \\ \epsilon_t \\ u_t \\ e_t \end{bmatrix} \sim i.i.d.N \left(\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_v^2 & \sigma_{v,\epsilon} & \sigma_{v,u} & \sigma_{v,e} \\ \sigma_{v,\epsilon} & \sigma_\epsilon^2 & \sigma_{\epsilon,u} & \sigma_{\epsilon,e} \\ \sigma_{v,u} & \sigma_{\epsilon,u} & \sigma_u^2 & \sigma_{e,u} \\ \sigma_{v,e} & \sigma_{\epsilon,e} & \sigma_{e,u} & \sigma_e^2 \end{bmatrix} \right)
$$

Note that the infinite sum term $\sum_{j=0}^{\infty} E_{t-1}(x_{t+j})$ in the inflation equation can be computed as:

$$
\sum_{j=0}^{\infty} E_{t-1}(x_{t+j}) = e_1' F (I_2 - F)^{-1} \tilde{X}_{t-1}
$$

where $e_1 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, $F = \begin{bmatrix} \phi_1 & \phi_2 \\ 1 & 0 \end{bmatrix}$ and $\tilde{X}_{t-1} = \begin{bmatrix} x_{t-1} \\ x_{t-2} \end{bmatrix}$.

Once put into state-space form, the UC model can be estimated with the Kalman filter.