Does Global Slack Matter More than Domestic Slack in Determining U.S. Inflation?*

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Abstract

This paper employs a structural model to estimate whether global output gap has become an important determinant of U.S. inflation dynamics.

The results provide support for the relevance of global slack as a determinant of U.S. inflation after 1985. The role of domestic output gap, instead, seems to have diminished over time.

Keywords: Globalization; Global Slack; Inflation Dynamics; Phillips Curve; Bayesian Estimation.

JEL classification: E31, E50, E52, E58, F41.

1 Introduction

Closed-economy New Keynesian models typically describe the domestic inflation rate as being determined by future inflation expectations and by a measure of the domestic output gap.

Recent research, however, has argued that globalization, intended here generally as the increased integration of national economies in a global market, may have crucially affected inflation dynamics in most countries. First, globalization may affect the trade-off between inflation and domestic output gap (e.g.

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Rogoff, 2003, 2006, Razin and Yuen, 2002, Razin and Loungani, 2005, Razin and Binyamini, 2007). But, as it has been argued, globalization may have a deeper effect: the increased international trade may make domestic inflation depend not only on domestic measures of slack, but also, or even mostly, on a measure of "global slack", i.e. the relation between worldwide demand and global productive capacity.

Borio and Filardo (2007) test this idea on a sample of different countries and find that for most of them global slack has become a significant determinant of inflation in reduced-form regressions over the 1985-2005 sample. They also find that the relation between inflation and measures of domestic slack has, instead, considerably weakened over time for most countries. Ihrig et al. (2007) perform a similar exercise and find results that are less supportive of the importance of measures of global slack. Earlier papers had already analyzed the issue, also finding contrasting evidence: Gamber and Hung (2001), for example, find evidence that global measures of resource utilization have significant effects on U.S. inflation, while Tootell (1998) finds almost no evidence in support.

This paper aims to contribute to this literature by estimating the importance of global slack for U.S. inflation dynamics, but by using a different approach. The paper, in fact, estimates the role of global output in a structural model, as the one sketched in Woodford (2007), rather than in a reduced-form single-equation framework. The model is estimated using a full-information likelihood-based approach.

Measures of foreign output enter the Phillips curve and the aggregate demand equation. Foreign output appears in the domestic aggregate demand equation since each household is assumed to consume a basket of domestically and foreign-produced goods. Foreign output, therefore, affects inflation through two channels: indirectly, through its described effect on aggregate demand and through a direct effect on aggregate supply. In fact, as discussed in Woodford

(2007), in a globalized economy, the incentive that domestic firms have to change their prices do not depend only on the domestic output gap, but also on foreign output terms.

As a measure of foreign slack, I use the weighted average of the output gaps of a large set of U.S. trading partners, where the weights are given by the magnitude of trade with each partner as a fraction of total trade.

The model is estimated over two different sub-samples: 1960-1979 and 1985-2007. The first sample is characterized by a smaller degree of global integration, which has, instead, rapidly increased starting from around 1985 (the 1985 starting date is also chosen to be consistent with Borio and Filardo, 2007, and Ihrig et al., 2007). Moreover, a large literature has documented a regime switch in monetary policy around 1979: the first sample is usually characterized by a monetary policy rule that is less aggressive toward inflation than the one in the second sample.

The results indicate that global slack was not an important determinant of U.S. inflation in the 1960s and 1970s (it enters the Phillips curve with a negative coefficient, estimated with large uncertainty), while domestic slack had a positive effect on inflation. In the post-1985 sample, instead, inflation depends positively on the global slack measure: its posterior distribution falls almost entirely above 0 and the model's fit improves by adding global slack. The posterior mean for the sensitivity of inflation to domestic gap, instead, declines from its pre-1979 value.

2 The Model

I assume that the economy can be summarized by the following New Keynesian model, whose microfoundations are provided in Woodford (2007), who builds on Clarida, Galí, and Gertler (2002)'s open economy framework. A measure of foreign, or 'global', output enters the aggregate demand and supply equations:

$$
\begin{aligned}
\pi_t &= \beta E_t \pi_{t+1} + \kappa^H x_t + \kappa^F x_t^* + u_t & (1)\\
x_t &= E_t x_{t+1} + \frac{\theta}{1+\theta} x_t^* - \frac{\theta}{1+\theta} E_t x_{t+1}^* - \frac{\sigma}{1+\theta} E_t \left(i_t - \pi_{t+1} - r_t^n\right) & (2)\\
i_t &= \rho i_{t-1} + (1-\rho)[\chi_\pi \pi_{t-1} + \chi_x x_{t-1}] + \varepsilon_t, & (3)
\end{aligned}
$$

where β denotes the households' discount factor, σ denotes the elasticity of intertemporal substitution, ρ, χ_π, and χ_x denote monetary policy feedback coefficients, and θ, κ^H, and κ^F are convolutions of various structural parameters: θ, κ^H, and κ^F all depend on the expenditure share of foreign country goods in the households' consumption basket, and κ^H and κ^F are also a negative function of the degree of price stickiness. The coefficients θ and κ^F affect the extent of foreign output's influence on domestic aggregate demand and supply.

Equation (1) is a New Keynesian Phillips curve, in which *domestic* inflation π_t depends on expected inflation and on both domestic and foreign output gaps (denoted by x_t and x_t^*). Foreign output enters the aggregate supply relation because in the model marginal costs do not depend exclusively on domestic production, but also on foreign production, since the latter affects the marginal utility of income, which affects the wage demanded by domestic workers. Equation (2) is the log-linearized Euler equation, which is derived assuming that households consume a basket of domestically-produced and foreign-produced goods. Equation (3) is a Taylor rule, which describes monetary policy (i_t is the policy instrument). The natural rate and cost-push shocks follow AR(1) processes $r_t^n = \rho_r r_{t-1}^n + \nu_t^r$ and $u_t = \rho_u u_{t-1} + \nu_t^u$, while the policy shock ε_t is assumed to be *i.i.d.* Those shocks are treated as unobservable in the estimation.

As the U.S. economy is usually considered a driver of global economic growth, foreign output is unlikely to be exogenous. The paper, therefore, assumes that it depends on past U.S. output and real interest rates (the assumption, which is confirmed by looking at the cross-correlations, is that U.S. variables affect the rest of the world with a one quarter lag).[1] Foreign output x_t^*, therefore, evolves as:

$$x_t^* = \rho_{x*} x_{t-1}^* + \delta_x x_{t-1} + \delta_r (i_{t-1} - \pi_{t-1}) + \upsilon_t \tag{4}$$

Economic agents are assumed to form rational expectations. Following Sims (2002), equations (1) to (4), together with the AR(1) expressions for r_t^n and u_t, can be written in state-space form as

$$\Gamma_0 \xi_t = \Gamma_1 \xi_{t-1} + \Psi w_t + \Pi \eta_t \tag{5}$$

where $\xi_t = [\pi_t, x_t, i_t, x_t^*, u_t, r_t^n, E_t \pi_{t+1}, E_t x_{t+1}]'$, $w_t = [\varepsilon_t, \nu_t^r, \nu_t^u, \upsilon_t]'$, and the vector of expectational errors $\eta_t = z_t - E_{t-1} z_t$ is introduced for $z_t = \pi_t, x_t$. The model has solution (obtained using Sims' gensys routine)

$$\xi_t = F \xi_{t-1} + G w_t. \tag{6}$$

3 Empirical Results

3.1 Data

I use quarterly U.S. data on the domestic inflation rate, real GDP, the federal funds rate, and 'global' output gap, which are the observable variables in the estimation. Inflation is calculated as the annualized log change in the GDP Implicit Price Deflator, the output gap as the log Real GDP (SA), detrended using the Hodrick-Prescott filter,[2] and the federal funds rate represents the monetary policy instrument. All variables are demeaned before the estimation.

To compute a measure of global slack, instead, I identify the largest 50 trading partners of the U.S. in 2005 and I consider quarterly data on their

[1] The foreign economy in not modeled as structural. In that case, the foreign economy would be described by a set of equations similar to (1) to (3). This would require specifying a global Taylor rule and a global Phillips curve with common coefficients across countries. I prefer here to avoid those assumptions and use, instead, a backward-looking equation that still allows me to control for foreign output's dependence on U.S. output.

[2] I have also repeated the estimation with output gap calculated as the log deviation of Real GDP from CBO's Potential GDP, obtaining almost identical results.

GDP as well as their exports and imports with the U.S. over the sample (I use seasonally-adjusted variables and, when not available, I seasonally-adjust them using the Census-X12 method).[3]

For each country, I compute the output gap using the HP filter. The global output gap series is then obtained as the weighted average of the countries' output gaps, where the weights w^i are given by the sum of U.S. imports and exports with country i in each period t as a fraction of total U.S. imports and exports in period t:

$$x_t^* = \sum_{i=1}^{N} w_t^i x_t^i \tag{7}$$

where $i = 1, ..., N$ is an index for the different countries and

$$w_t^i = \frac{(Imports_t^i + Exports_t^i)}{(Imports_t^{TOT} + Exports_t^{TOT})}. \tag{8}$$

Similar global output measures have been adopted by Borio and Filardo (2007), although they use a changing weighted average of the top 10 trading partners, and by Ihrig et al. (2007), who consider the top 35 partners.[4] Figure 1 displays the derived global slack series together with U.S. output gap.[5]

3.2 Structural Estimation

I estimate the model parameters using likelihood-based Bayesian methods. The priors are shown in Table 1. I assume a Gamma distribution for κ^H and a

[3]Not all data are available for every country. Only annual GDP data were available for some countries, which were, therefore, dropped from the analysis. These typically occupied positions between 35 and 50 in the trading partners' rankings and, therefore, their omission should not have a sizeable effect on the results. At the end, global slack is constructed using data on about 40 countries: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Costa Rica, Denmark, Ecuador, Finland, France, Germany, Hong Kong, India, Indonesia, Ireland, Israel, Italy, Japan, South Korea, Malaysia, Mexico, Netherland, Norway, New Zealand, Philippines, Russia, South Africa, Singapore, Spain, Sweden, Switzerland, Thailand, Turkey, UK, Venezuela.

[4]Borio and Filardo (2007) considered four alternative measures of global slack, but their results did not seem sensitive to these choices.

[5]Although the two series often move together, their correlation coefficient is 0.66. Therefore, the estimation does not suffer from problems that would exist under almost-perfect collinearity. The respective parameters κ_H and κ_F seem well-identified, particularly considering that a non-informative Uniform distribution is used as prior for κ_F.

Uniform distribution for κ^F to minimize the influence of the prior on the main coefficient of interest.

I use the Metropolis-Hastings algorithm to generate draws from the posterior distribution. I run 5 separate chains composed of 1,000,000 draws each, discarding the first 200,000 as initial burn-in and starting from different initial values each time.[6]

I split the sample in two subperiods: 1960-1979 and 1985-2007. The middle years of non-borrowed reserves targeting are excluded as customary, and the second sample starts from 1985 to be consistent with Borio and Filardo (2007) and Ihrig et al. (2007).

3.3 Results: 1960-1979 Sample

Table 2 reports the results. In the pre-1979 sub-sample, the posterior estimates indicate that inflation is affected by the domestic measure of slack ($\kappa^H = 0.076$). Global slack enters with a negative sign (the posterior mean for κ^F equals -0.19), but it is estimated with a large degree of uncertainty.[7]

3.4 Results: 1985-2007 Sample

In the post-1985 sample, the measure of global slack enters the Phillips curve with a positive coefficient: the posterior mean for κ^F now equals 0.0615 and the 95% highest posterior density interval falls between -0.018 and 0.143 (with $Pr\left(\kappa^F > 0|Data\right) = 92\%$). It should be noticed that the model that allows domestic U.S. inflation to depend on the foreign output gap fits the data better than the alternative without foreign terms (the log marginal likelihood increases from -285.03 to -282.931).

[6] I have also estimated the model under different priors: the results are robust. Trace plots of the draws and CUSUM plots show that convergence is achieved relatively quickly.

[7] Notice that the monetary policy feedback coefficient to inflation is well below 1 in the pre-1979 sample. The Taylor principle is, however, satisfied given the large estimated reaction to the output gap.

Figure 2 overlaps the posterior distributions of the coefficients on domestic and global slack in the Phillips curve equation across the two samples. The posterior distribution for the coefficient on domestic output gap shifts toward zero in the second sub-sample (the posterior mean for κ^H falls from 0.076 to 0.0375 after 1985). The posterior distribution for the sensitivity of U.S. inflation to global slack shifts, instead, from one that favors negative values to one characterized by a positive effect of global slack on domestic inflation. [8]

The posterior mean for θ increases from a posterior mean equal to 0.363 to 0.416, suggesting a slightly larger effect through aggregate demand.[9] Turning to the other estimates, the data clearly indicate a switch in the monetary policy rule (which becomes more inertial and more aggressive toward inflation after 1979) and in the standard deviations of the shocks. The dependence of global output on U.S. output was substantially stronger in the first sample than in the second.

4 Conclusions

The paper has provided evidence that global slack has become a positive determinant of U.S. inflation in the post-1985 sample. After accounting for the role of global slack, the data are also suggestive of a reduction in the slope coefficient of the Phillips curve across samples. Both findings confirm in a structural model the results that are obtained by Borio and Filardo (2007) in their reduced-form regressions.

[8] Although globalization represents one crucial difference across sub-samples, it should be noticed that κ^H and κ^F may also be affected by other factors, as the degrees of price rigidity and strategic complementarity. A flattening of the Phillips curve, for example, may alternatively reflect longer intervals between price changes and greater strategic complementarity in price-setting in the most recent sample. Those factors, however, may themselves be affected by globalization (e.g., Sbordone, 2007).

[9] The estimation has considered a Phillips curve without lagged inflation. I have re-estimated the model allowing for lagged inflation (through indexation) and the results remain absolutely similar.

References

[1] Borio, C., and A. Filardo, (2007). "Globalisation and Inflation: New Cross-Country Evidence on the Global Determinants of Domestic Inflation," Working Paper # 227, BIS.

[2] Clarida, R., J. Galí, and M. Gertler, (2002). "A Simple Framework for International Monetary Policy Analysis", *Journal of Monetary Economics*, 49: 879-904.

[3] Gamber, E.N., and J.H. Hung, (2001). "Has the Rise in Globalization Reduced U.S. Inflation in the 1990s?", *Economic Inquiry*, Volume 39, Issue 1, Page 58-73.

[4] Ihrig, J., S.B. Kamin, D. Lindner, and J. Marquez, (2007). "Some Simple Tests of the Globalization and Inflation Hypothesis," Federal Reserve IF Discussion Paper No. 891.

[5] Razin, A., and C.-W. Yuen, (2002). "The 'New Keynesian' Phillips Curve: Closed Economy versus Open Economy," *Economics Letters* 75, 1-9.

[6] Razin A. and P. Loungani, (2005). "Globalization and Inflation-Output Tradeoffs," NBER Working Paper 11641.

[7] Razin A. and A. Binyamini, (2007). "Flattened Inflation-Output Tradeoff and Enhanced Anti-Inflation Policy: Outcome of Globalization?" NBER Working Paper 13280.

[8] Rogoff, K.S., (2003). "Globalization and Global Disinflation" in *Monetary Policy and Uncertainty: Adapting to a Changing Economy*, Federal Reserve Bank of Kansas City.

[9] Rogoff, K.S., (2006). "Impact of Globalization on Monetary Policy," in *The New Economic Geography: Effects and Policy Implications*, Federal Reserve Bank of Kansas City.

[10] Sbordone, A., (2007). "Globalization and Inflation Dynamics: The Impact of Increased Competition," NBER Working Paper 13556.

[11] Tootell, G., (1998). "Globalization and U.S. Inflation", Federal Reserve Bank of Boston, *New England Economic Review*, pp. 21-33.

[12] Woodford, M. (2007). "Globalization and Monetary Control," NBER Working Paper 13329.

		Prior Distribution			
Description	Parameter	Distr.	Support	Prior Mean	95% Prior Prob. Interval
Discount Factor	β	-	-	0.99	-
Sensit. Infl. to Domestic Slack	κ^H	Γ	$\mathbb{R}^+$	0.25	[0.03,0.69]
Sensit. Infl. to Global Slack	κ^F	U	[-0.5,0.5]	0	[-0.475,0.475]
Sensit. Gap to Foreign Gap	θ	N	$\mathbb{R}$	0	[-0.49,0.49]
IES Cons.	σ	Γ	$\mathbb{R}^+$	1	[0.12,2.78]
MP Inertia	ρ	B	[0,1]	0.8	[0.46,0.985]
MP Inflation feedback	χ_π	N	$\mathbb{R}$	1.5	[1.01,1.99]
MP Output Gap feedback	χ_x	N	$\mathbb{R}$	0.5	[0.01,0.99]
Std. Demand Shock	σ_r	Γ^{-1}	$\mathbb{R}^+$	0.25	[0.045,1.035]
Std. Supply Shock	σ_u	Γ^{-1}	$\mathbb{R}^+$	0.25	[0.045,1.035]
Std. MP Shock	σ_ε	Γ^{-1}	$\mathbb{R}^+$	0.25	[0.045,1.035]
Std. Foreign Gap Shock	σ_{x^*}	Γ^{-1}	$\mathbb{R}^+$	0.25	[0.045,1.035]
Autoregr. coeff. r_t^N	ρ_r	B	[0,1]	0.7	[0.15,0.996]
Autoregr. coeff. u_t	ρ_u	B	[0,1]	0.7	[0.15,0.996]
Autoregr. coeff. x_t^*	ρ_{x*}	B	[0,1]	0.7	[0.15,0.996]
Effect of US Gap on Global Gap	δ_x	N	$\mathbb{R}$	0	[-0.49,0.49]
Effect of US Real Rate on Global Gap	δ_r	N	$\mathbb{R}$	0	[-0.49,0.49]

Table 1 - Prior Distributions
(N = Normal, U = Uniform, Γ, B = Beta, Γ^{-1} = Inverse Gamma).

		Posterior Distribution			
		1960-1979 Sample		1985-2007 Sample	
Description	Parameter	Posterior Mean	95% HPD	Posterior Mean	95% HPD
Discount Factor	β	0.99	-	0.99	-
Sensit. Infl. to Domestic Slack	κ^H	0.076	[0.006,0.14]	0.0375	[0.002,0.073]
Sensit. Infl. to Global Slack	κ^F	-0.19	[-0.34,-0.03]	0.0615	[-0.018,0.143]
Sensit. Gap to Foreign Gap	θ	0.363	[0.08,0.63]	0.416	[0.14,0.69]
IES Cons.	σ	0.065	[0.024,0.11]	0.014	[0.0003,0.021]
MP Inertia	ρ	0.731	[0.66,0.81]	0.89	[0.85,0.921]
MP Inflation feedback	χ_π	0.884	[0.7,1.06]	1.45	[1.09,1.83]
MP Output Gap feedback	χ_x	0.931	[0.65,1.20]	1.02	[0.64,1.41]
Std. Demand Shock	σ_r	0.21	[0.12,0.31]	0.107	[0.076,0.14]
Std. Supply Shock	σ_u	0.19	[0.10,0.28]	0.338	[0.20,0.47]
Std. MP Shock	σ_ε	0.734	[0.64,0.83]	0.436	[0.38,0.49]
Std. Foreign Gap Shock	σ_{x^*}	0.557	[0.48,0.63]	0.34	[0.30,0.38]
Autoregr. coeff. r_t^N	ρ_r	0.835	[0.75,0.92]	0.781	[0.72,0.85]
Autoregr. coeff. u_t	ρ_u	0.87	[0.81,0.93]	0.605	[0.43,0.754]
Autoregr. coeff. x_t^*	ρ_{x*}	0.372	[0.23,0.51]	0.797	[0.71,0.89]
Effect of US Gap on Global Gap	δ_x	0.313	[0.23,0.39]	0.129	[0.04,0.21]
Effect of US Real Rate on Global Gap	δ_r	-0.0003	[-0.08,0.08]	-0.013	[-0.045,0.016]

Table 2 - Posterior Estimates: Pre-1979 versus Post-1985 Sample.

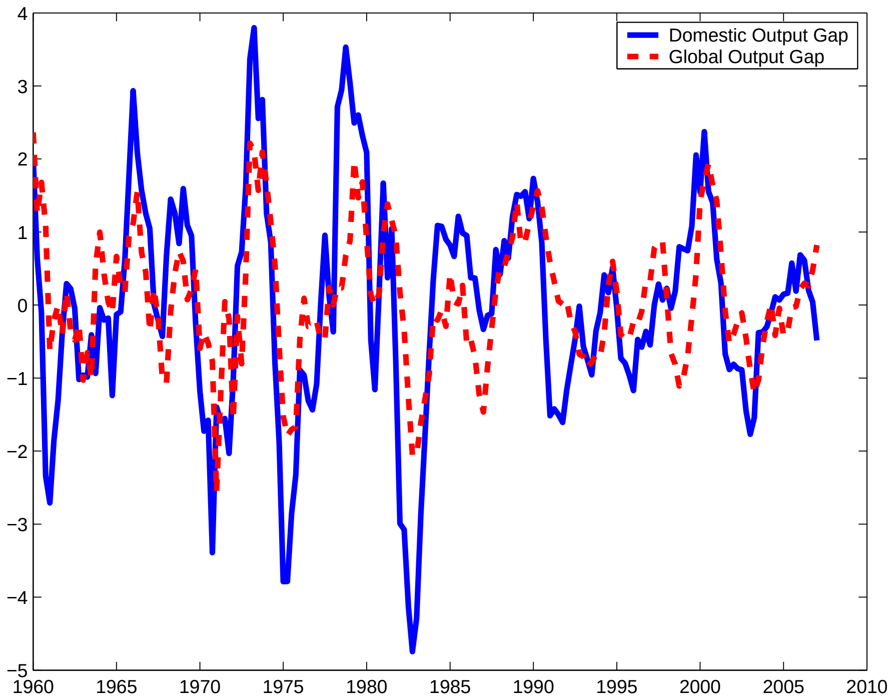

Figure 1: Domestic and 'Global' Output Gap Series.

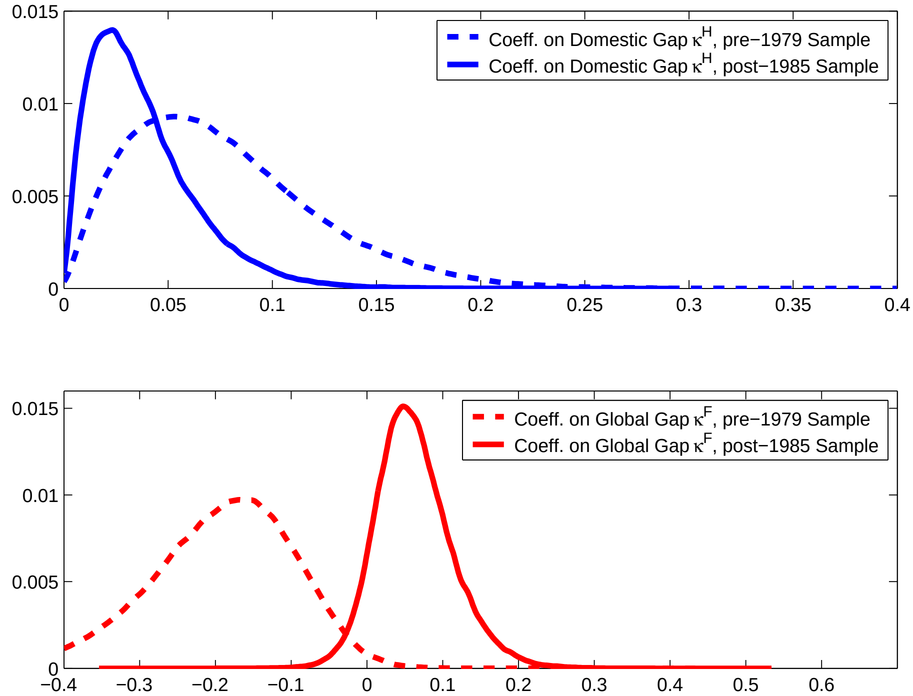

Figure 2: Posterior Distributions across Sub-Samples: NK Phillips Curve Coefficients on Domestic and 'Global' Slack.