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ABSTRACT

The Open Economy Phillips Curve: 'New Keynesian' Theory and Evidence*

The Paper derives an open economy New-Keynesian Phillips curve. The Phillips curve depends on growth in the domestic economy excess capacity, differential growth between foreign output and domestic output, and on the surprise depreciation of the real exchange rate. The Paper provides new evidence on the effect of globalization of the economy, in both the trade and capital transactions, in the Phillips curve. The evidence is consistent with the predictions of the theory.

JEL Classification: E12 and F41
Keywords: imperfect competition in the product market, New- Keynesian Phillips curve, Phillips curve, sacrifice ratios and strategic interactions among price setters

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1 Introduction

In this paper, we examine how open global markets interact with the degree of price rigidity in the domestic economy, to affect the output-inflation tradeoffs.

The analysis is conducted in an optimization-based "New Keynesian" framework *a la* Blanchard and Kiyotaki (1987). Our model extends, to an open-trade and open-capital economy, the succinct exposition of Woodford (2000), which is conducted in the context of a closed economy. [1] Specifically, we develop a model with imperfect competition in the product market, in which the producers mark up output prices over marginal costs, and mark down wages below the marginal productivities of labor. We thus derive a version of the Phillips curve for the product market, associating surprise inflation and excess output capacity. Markups of prices over wages in our model turn out to be counter-cyclical—a very pronounced phenomenon in the European markets, as noted by Cohen and Farhi (2001). They note that *"European firms in bad times manage to keep the prices high, while their US counterparts are pressed into cuts and discounts of various forms."* This is why the product market version of the Phillips curve (viz., the relation between inflation and the output gap), in Europe, seems to be relatively more stable empirically than the labor market version (viz., the relation between wage growth and unemployment). Our model develops the theoretical underpinning for the product market version of the Phillips curve, based on a European-type market structure.

Evidently, the equilibrium relation between inflation and excess capacity is significantly influenced by the degree of competition in the product market. A key feature of such an equilibrium is the degree of strategic interactions between firms that set their prices *ex ante* and other domestic and foreign firms that set their prices so as to clear the markets *ex post*. This market organization feature determines in turn the degree of price stickiness. The main novelty of our analysis is that we can identify the effects of openness of the economy, in both commodity trade and capital flows, on the shape of the Phillips curve, through

[1] For a useful survey of the new open economy macroeconomic approach, which we adopt here, see Lane (2001).

the change in the degree of competition in the domestic market and of price stickiness.

The theoretical linkage between sacrifice ratios and the degree of capital mobility can be established either in a Mundell-Fleming framework or in the context of an optimization-based New Keynesian framework.

In Loungani, Razin, and Yuen (2001), we use a Mundell-Fleming framework to understand how capital mobility affects the output-inflation tradeoff. We consider the two polar cases of zero mobility and perfect mobility of capital. In the zero mobility case, interest rate parity does not have to hold, and this leaves more scope for adjustment in the domestic interest rate in response to shocks. At the same time, however, closed capital accounts require that net trade be balanced, and this limits the flexibility of the real exchange rate. In the perfect mobility case, the adjustment of the domestic interest rate is limited by the interest rate parity condition, whereas the real exchange rate has greater room to adjust. Thus the degree of capital mobility influences how responsive aggregate demand is to real interest rate and real exchange rate movements; this, in turn, affects the output-inflation tradeoff.

In this paper, we derive similar results but in an optimization-based New Keynesian framework *a la* Blanchard and Kiyotaki (1987) and Woodford (2000).[2] The mechanism behind the Phillips curve is different than that in Mundell-Fleming model. For instance, while fluctuations in the real exchange rate are behind the cycles on which the Keynesian (Mundell-Fleming) Phillips curve is based, strategic interactions among price-setting firms and the effect of the globalized market on competition in the product market are the gist of the forces behind the New Keynesian Phillips curve. In the latter framework, we show that consumption smoothing, which comes together with the opening of the capital market, raises the degree of strategic complementarity among monopolistically competitive suppliers. This renders prices more sticky and magnifies the output response to nominal GDP shocks. In this framework too, therefore, a lowering of restrictions on capital mobility is associated with an increase in sacrifice ratios. We also show that if the trade account is also closed (so that the pressure of competition on domestic producers is increased further), the sacrifice

[2] See also Razin and Yuen (2001).

ratios will be even higher.

Understanding why nominal changes have real consequences (why there is a short run Phillips curve) has long been a central concern of macroeconomic research. Lucas (1973) proposes a model in which the effect arises because agents in the economy are unable to distinguish perfectly between aggregate and idiosyncratic shocks. He tests this model at the aggregate level by showing that the Phillips curve is steeper in countries with more variable aggregate maximal demand. Ball, Mankiw, and Romer (1988) show that sticky-price Keynesian models predict that the Phillips curve should be steeper in countries with higher average rates of inflation and that this prediction too receives empirical support. Given the high degree of collinearity between the variability of aggregate demand and the average inflation rate, it has proven difficult to discriminate empirically between the two theories.

A related literature owes its origins to work by Okun (1978) and Gordon (1982). The focus in this literature is on calculating "sacrifice ratios," the extent of output loss (or increase in unemployment) incurred to bring about a given reduction in inflation. Ball (1994) conducts a successful empirical exercise in explaining the determinants of the sacrifice ratios during 65 disinflation episodes in OECD countries since the 1960s. He finds that sacrifice ratios are lower when they are carried out faster and when countries have more flexible labor markets.

Focusing empirically on the determinants of a country's sacrifice ratio in an open economy, we find that the extent to which capital is internationally mobile is an important additional factor. In a an earlier paper [Loungani, Razin, and Yuen (2001)] we show that both Lucas's and Ball-Mankiw-Romer's estimates of the Phillips curve slope depend on the degree of capital account restrictions. This paper shows that sacrifice ratios also depend on the degree of the trade account restrictions. Since the methodology Ball uses to identify disinflation episodes and calculate the associated sacrifice ratios is quite different from the way Lucas and Ball, Mankiw and Romer measure the slope of the Phillips curve, the empirical results presented here represent a substantive additional test of the hypothesis put forward in our earlier paper.

The remainder of the paper is organized as follows. Section 2 lays out the New Keynesian analytical framework. Section 3 derives the open-economy Phillips curve. Section provides new evidence on the effects of globalization on the sacrifice ratio. Section 5 concludes.

2 The analytical framework

Consider a small open economy with a representative household that is endowed with a continuum of goods-specific skills—uniformly distributed on the unit interval $[0, n]$—to be supplied to a differentiated product industry. As a consumer, the representative household has access to consumption of both domestic goods (distributed on $[0, n]$) and foreign goods (distributed on $(n, 1]$). The household seeks to maximize a discounted sum of expected utilities:

$$E_0 \sum_{t=0}^{\infty} \beta^t [u(C_t, M_t/P_t; \xi_t) - \int_0^n v(h_t(j); \xi_t) dj],$$

where β is the subjective discount factor, C is the Dixit-Stiglitz (1977) index of household consumption, P the Dixit-Stiglitz price index, M/P the demand for real balances, ξ a preference shock, and $h(j)$ the supply of type-j labor to the production of good of variety j. As usual, we define the consumption index and its corresponding price index respectively as

$$C_t = \left[\int_0^n c_t(j)^{\frac{\theta-1}{\theta}} dj + \int_n^1 c_t^*(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}},$$

and

$$P_t = \left\{ \int_0^n p_t(j)^{1-\theta} dj + \int_n^1 [\varepsilon_t p_t^*(j)]^{1-\theta} dj \right\}^{\frac{1}{1-\theta}}, \tag{1}$$

where $c(j)$ represents domestic consumption of the j^{th} domestically produced good, $c^*(j)$ domestic consumption of the j^{th} foreign-produced good, $p(j)$ the domestic-currency price of $c(j)$, $p^*(j)$ the foreign-currency price of $c^*(j)$, ε the nominal exchange rate (domestic-currency price of foreign currency), $\theta > 1$ the elasticity of substitution among the different goods, and n the fraction of goods that are produced domestically.[3]

We shall focus on the relation between aggregate supply of goods and consumption smoothing made possible by international capital mobility. For this purpose, we would not be concerned about the details of aggregate demand (including the demand for money), international commodity trade, and the determination of the exchange rate, and would take them as exogenously given in what follows. For simplicity, consumer utility is assumed to be separable between consumption and real money balances.

For our purpose, the relevant utility-maximizing conditions include an intratemporal condition for the choice of labor supply of type j:

$$\frac{v_h(h_t(j);\xi_t)}{u_c(C_t;\xi_t)} = \frac{w_t(j)}{P_t} \tag{2}$$

and an intertemporal condition for the consumption-saving choice:

$$\frac{u_c(C_t;\xi_t)}{u_c(C_{t+1};\xi_{t+1})} = \beta(1+r^*), \tag{3}$$

where r^* is the world real rate of interest, assumed for simplicity to be time-invariant. This latter equality is a consequence of the covered interest parity and the Fisher equation. As

[3] In nominal terms, the budget constraint facing the household is given by:

$$\begin{aligned}
&\int_0^n p_t(j)c_t(j)dj + \varepsilon_t \int_n^1 p_t^*(j)c_t^*(j)dj + \left(\frac{i_t}{1+i_t}\right) M_t + B_t + \varepsilon_t B_t^* \\
= \quad & M_{t-1} + (1+i_{t-1})B_{t-1} + f_{t-1,t}(1+i_{t-1}^*)B_{t-1}^* + \int_0^n w_t(j)h_t(j)dj + \int_0^n \Pi_t(j)dj,
\end{aligned}$$

where B is the domestic-currency value of domestic borrowing, B^* the foreign-currency value of foreign borrowing, $f_{t-1,t}$ the forward exchange rate for foreign currencies purchased/sold at time $t-1$ for delivery at time t, i and i^* the domestic and foreign interest rates, $w(j)$ the wage rate per unit labor of type j, and $\Pi(j)$ profit income from firms of type j. With perfect capital mobility, covered interest parity prevails:

$$1 + i_t = (1+i_t^*)\left(\frac{f_{t,t+1}}{\varepsilon_t}\right).$$

[Cf. First order conditions of the household with respect to B and B^*.]

in the Dixit-Stiglitz (1977) model, demand for good j satisfies

$$c_t(j) = C_t \left(\frac{p_t(j)}{P_t} \right)^{-\theta}. \tag{4}$$

The production function assumes the form

$$y_t(j) = A_t f(h_t(j)),$$

where A is a random productivity shock. The variable cost of supplying $y_t(j)$ is $w_t(j) f^{-1}(y_t(j)/A_t)$, which implies a (real) marginal cost of

$$s_t(j) = \frac{w_t(j)}{P_t A_t f'(f^{-1}(y_t(j)/A_t))}.$$

Using (2), we can replace the real wage above by the marginal rate of substitution. Imposing symmetry across firms (so that we can drop the index j), the above equation can be rewritten as

$$s(y, C; \xi, A) = \frac{v_h(f^{-1}(y/A); \xi)}{u_c(C; \xi) A f'(f^{-1}(y/A))}. \tag{5}$$

Trade-wise, price-making firms face world demand for its products so that equation (4) implies

$$y_t(j) = Y_t^W \left(\frac{p_t(j)}{P_t} \right)^{-\theta}, \tag{4'}$$

where $y_t(j)$ is the quantity of good j supplied by the firm to meet the world demand and $Y_t^W = Y_t^H + Y_t^F$ the index for all goods produced around the world, with $P_t^H Y_t^H = \int_0^n p_t(j) y_t(j) dj$ and $P_t^F Y_t^F = \int_0^n \varepsilon_t p_t^*(j) y_t(j) dj$ as corresponding domestic-currency value indices for home goods and foreign goods.

2.1 The goods markets

Firms are monopolistically competitive in the goods markets, and monopsonistic in the labor markets (with producer j as the sole demander for labor of type-j). A fraction γ of the monopolistically competitive firms sets their prices flexibly at p_{1t}, supplying y_{1t}; whereas the remaining fraction $1-\gamma$ sets their prices one period in advance (in period $t-1$) at p_{2t}, supplying y_{2t}. In the former case, the price is marked up above the marginal cost by a factor of μ $(=\frac{\theta}{\theta-1}>1)$ so that

$$\frac{p_{1t}}{P_t}-\mu s(y_{1t},C_t;\xi_t,A_t)=0. \tag{6a}$$

In the latter case, p_{2t} will be chosen to maximize expected discounted profit

$$\begin{aligned}&E_{t-1}\left[\left(\frac{1}{1+i_{t-1}}\right)(p_{2t}y_{2t}-w_th_t)\right]\\ =\;&E_{t-1}\left\{\left(\frac{1}{1+i_{t-1}}\right)\left[Y_t^WP_t^{\theta}p_{2t}^{1-\theta}-w_tf^{-1}(Y_t^WP_t^{\theta}p_{2t}^{-\theta}/A_t)\right]\right\},\end{aligned}$$

where we have used the inverse demand function from (4) for y_{2t} and the inverse production function for h_t. One can show that p_{2t} satisfies

$$E_{t-1}\left\{\left(\frac{1}{1+i_{t-1}}\right)Y_t^WP_t^{\theta-1}\left[\frac{p_{2t}}{P_t}-\mu s(y_{2t},C_t;\xi_t,A_t)\right]\right\}=0. \tag{6b}$$

This condition has an intuitive interpretation. In the special case of perfect certainty, this is nothing but a standard equation describing price as a markup over marginal cost like (6a). With uncertainty, it can be interpreted as a weighted average of price markups over marginal cost. This expected value is equal to zero. With price-presetting, the firm is committed to supply according to the realized demand. Hence, the realization of shocks will affect actual output, with negative shocks leading to excess capacity and positive shocks to over-capacity.

Our model predicts that the markups of the producers who preset their prices will be counter-cyclical. Negative demand shocks will induce the flex-price firms to adjust their prices downward, attracting demand away from, and thus lowering the marginal costs and jacking up the price markups, of fix-price firms.

Given p_{1t} and p_{2t}, the aggregate price index (1) can be rewritten as:

$$P_t = \left\{ n[\gamma p_{1t}^{1-\theta} + (1-\gamma)p_{2t}^{1-\theta}] + (1-n)(\varepsilon_t p_t^*)^{1-\theta} \right\}^{\frac{1}{1-\theta}} . \qquad (1')$$

2.2 The labor markets

The market for each type of goods-specific skill or labor service is characterized by workers as wage-takers and producers as wage-makers as in the monopsony case. Figure 1 describes equilibrium in one such market. The downward-sloping MP_h curve is the marginal product of labor ($Af'(h)$). Supply of labor, S_h, is implicitly determined by the utility-maximizing condition for h, i.e., equation (2). The upward-sloping MC_h curve is the marginal cost of labor. It lies above S_h because, in order to hire an additional worker, the firm has to offer a higher wage not only to that (marginal) worker but also to all the (intra-marginal) existing workers. Equilibrium employment occurs at A, where $MC_h = MP_h$. Equilibrium wage is given by B, with the worker's real wage marked down below her marginal product by a distance AB.[4]

Full employment obtains because workers are offered a wage according to their supply schedule. This is why our Phillips curve will be stated in terms of excess capacity (product market version) rather than unemployment (labor market version).

In fact, the model can also accommodate unemployment by introducing a labor union, which has monopoly power to bargain on behalf of the workers with the monopsonistic firms over the equilibrium wage. In such case, the equilibrium wage will lie somewhere between S_h and MP_h, and unemployment can arise—so that the labor market version of the Phillips

[4] In the limiting case where the producers behave perfectly competitive in the labor market, the real wage becomes equal to the marginal productivity of labor and the marginal cost of labor curve is not sensitive to output changes. Thus, with a constant markup $\frac{\theta}{\theta-1}$, the Phillips curve becomes flat, i.e., no relation exists between inflation and excess capacity.

curve can be derived as well. To simplify the analysis, we assume in this paper that the workers are wage-takers.

(Figure 1 here)

2.3 Natural output and consumption

In the extreme case where all prices are fully flexible (i.e., $\gamma = 1$), output will attain its *natural* level, Y_t^n, implicitly defined by

$$\frac{p_t}{\left[np_t^{1-\theta} + (1-n)\varepsilon_t p_t^{*1-\theta}\right]^{\frac{1}{1-\theta}}} = \mu s(Y_t^n, C_t^n; \xi_t, A_t).$$

Among other things, Y_t^n depends on the level of home consumption under flexible prices (C_t^n), domestic and foreign prices (p_t and p_t^*), as well as the exchange rate (ε_t). For later purpose, we can denote $s(Y_t^n, C_t^n; \xi_t, A_t)$ as s_t^n.

In the absence of capital flows, spending equals income (i.e., $C_t^n = Y_t^n$) so that the natural output level is defined by

$$\frac{p_t}{\left[np_t^{1-\theta} + (1-n)\varepsilon_t p_t^{*1-\theta}\right]^{\frac{1}{1-\theta}}} = \mu s(Y_t^n, Y_t^n; \xi_t, A_t).$$

When the economy is completely closed in terms of both commodity trade and capital flows ($n = 1$ and $C_t^n = Y_t^n$), the equation above further simplifies to

$$1 = \mu s(Y_t^n, Y_t^n; \xi_t, A_t).$$

In this last case, equilibrium output is completely independent of monetary policy.

3 The Phillips curve

This section derives the expectations-augmented Phillips curve of the kind hypothesized by Friedman (1968) and Phelps (1970) for both closed and open economies. [Cf. Ball, Mankiw, and Romer (1988) and Roberts (1995).]

In order to obtain a tractable solution, we log-linearize the equilibrium conditions around the steady state. We assume that $\beta(1+r^*)=1$, which entails perfect consumption smoothing. We consider a *deterministic* steady state where $\xi_t = 0$ and $A_t = \overline{A}$ with $\varepsilon_t = \overline{\varepsilon}$, $p_t^* = \overline{p}^*$, and $C_t = \overline{C}$. Define $\widehat{x}_t = \log(\frac{x_t}{\overline{x}}) \simeq \frac{x_t - \overline{x}}{\overline{x}}$ as the proportional deviation of any variable x_t from its deterministic steady state value $\overline{x}$. We can then log-linearize equation (5) around the deterministic steady state equilibrium to get

$$\widehat{s}_t - \widehat{s}_t^n = \omega(\widehat{y}_t - \widehat{Y}_t^n) + \sigma^{-1}(\widehat{C}_t - \widehat{C}_t^n), \tag{5$'$}$$

where $\omega = \omega_w + \omega_p$, $\omega_w = \frac{v_{hh}\left(f^{-1}(\overline{y}/\overline{A});0\right)\cdot(\overline{y}/\overline{A})}{v_h\left(f^{-1}(\overline{y}/\overline{A});0\right)\cdot f'\left(f^{-1}(\overline{y}/\overline{A})\right)}$, $\omega_p = -\frac{f''\left(f^{-1}(\overline{y}/\overline{A})\right)\cdot(\overline{y}/\overline{A})}{\left[f'\left(f^{-1}(\overline{y}/\overline{A});0\right)\right]^2}$, and $\sigma = -\frac{u_{cc}(\overline{c};0)\cdot\overline{c}}{u_c(\overline{c};0)}$. Log-linearizing the two price-setting equations (6a) and (6b) using (5$'$), we obtain

$$\log(p_{1t}) = \log(P_t) + \omega(\widehat{y}_{1t} - \widehat{Y}_t^n) + \sigma^{-1}(\widehat{C}_t - \widehat{C}_t^n), \tag{6a$'$}$$

and

$$\log(p_{2t}) = E_{t-1}\left[\log(P_t) + \omega(\widehat{y}_{2t} - \widehat{Y}_t^n) + \sigma^{-1}(\widehat{C}_t - \widehat{C}_t^n)\right], \tag{6b$'$}$$

>From the definition of the aggregate price index (1$'$), we can derive the following approximation

$$\log(P_t) = n[\gamma\log(p_{1t}) + (1-\gamma)\log(p_{2t})] + (1-n)\log(\varepsilon_t p_t^*). \tag{1$''$}$$

Define the inflation rate $\pi_t = \ln(P_t/P_{t-1})$ so that $\pi_t - E_{t-1}(\pi_t) = \log(P_t) - E_{t-1}\log(P_t)$, and the real exchange rate as $e_t \equiv \varepsilon_t P_t^*/P_t$. We show in the Appendix how these price relations can be combined to obtain the open-economy Phillips curve as follows:

$$\begin{aligned}\pi_t - E_{t-1}(\pi_t) \;=\; & \left(\frac{\gamma}{1-\gamma}\right)\left\{\left(\frac{n\omega}{1+\theta\omega}\right)(\widehat{Y}_t^H - \widehat{Y}_t^n)\right. \\ & \left. + \left[\frac{(1-n)\omega}{1+\theta\omega}\right](\widehat{Y}_t^F - \widehat{Y}_t^n) + \left(\frac{\sigma^{-1}}{1+\theta\omega}\right)(\widehat{C}_t - \widehat{C}_t^n)\right\} \\ & + \left(\frac{1-n}{n}\right)\left\{\left(\frac{1}{1-\gamma}\right)\log(e_t) - E_{t-1}[\log(e_t)]\right\}.\end{aligned} \tag{7}$$

This Phillips curve is new in the sense that it contains variables other than the output gap—in particular, foreign output, consumption, and the real exchange rate.

3.1 Endogenizing the Real Exchange Rate

It turns out that we can relate $\log(e)$ to $\widehat{Y}^H$in equation (7). The real exchange rate is defined as the price of foreign goods in terms of domestic goods, i.e., $e = P^F/P^H$. From (4′), $P^i = P\left(Y^W/Y^i\right)^{\frac{1}{\theta}}$ $(i = H, F)$, so that $e = \left(Y^H/Y^F\right)^{\frac{1}{\theta}}$. Hence, $\log(e) = \frac{1}{\theta}\left[\log\left(Y^H\right) - \log\left(Y^F\right)\right]$, where $\log\left(Y^i\right) = \widehat{Y}^i + \log\left(\overline{y}^i\right)$. Incorporating this e-effect into the $\widehat{Y}^H$-effect in the Phillips curve, we have $\frac{\partial[\pi_t - E_{t-1}(\pi_t)]}{\partial\left(\widehat{Y}_t^H - \widehat{Y}_t^n\right)} = \left(\frac{\gamma}{1-\gamma}\right)\left(\frac{n\omega}{1+\theta\omega}\right) + \frac{1}{\theta}\left(\frac{1-n}{n}\right)\left(\frac{1}{1-\gamma}\right)$.Consequently the slope of the Phillips curve is enlarged.

3.2 Perfect capital mobility

When capital is perfectly mobile, consumption smoothing can be achieved and, given the assumption that $\beta(1+r^*) = 1$, consumption will be trendless [see equation (3)]. As a result, $\widehat{C}_t = 0 = \widehat{C}_t^n$. The Phillips curve therefore simplifies to

$$\begin{aligned}\pi_t - E_{t-1}(\pi_t) \;=\; & \left(\frac{\gamma}{1-\gamma}\right)\left\{\left(\frac{n\omega}{1+\theta\omega}\right)(\widehat{Y}_t^H - \widehat{Y}_t^n)\right. \\ & \left. + \left[\frac{(1-n)\omega}{1+\theta\omega}\right](\widehat{Y}_t^F - \widehat{Y}_t^n)\right\} \\ & + \left(\frac{1-n}{n}\right)\left\{\left(\frac{1}{1-\gamma}\right)\log(e_t) - E_{t-1}[\log(e_t)]\right\}.\end{aligned} \tag{7′}$$

3.3 Closing the capital account

In the absence of capital flows, consumption smoothing can no longer be achieved and consumption will fluctuate with domestic output (i.e., $\widehat{C}_t = \widehat{Y}_t^H$ and $\widehat{C}_t^n = \widehat{Y}_t^n$). As a result, the Phillips curve assumes the form

$$\begin{aligned}\pi_t - E_{t-1}(\pi_t) \quad = \quad & \left(\frac{\gamma}{1-\gamma}\right)\left\{\left(\frac{n\omega+\sigma^{-1}}{1+\theta\omega}\right)(\widehat{Y}_t^H - \widehat{Y}_t^n)\right. \\ & \left. + \left[\frac{(1-n)\sigma^{-1}}{1+\theta\omega}\right](\widehat{Y}_t^F - \widehat{Y}_t^n)\right\} \\ & + \left(\frac{1-n}{n}\right)\left\{\left(\frac{1}{1-\gamma}\right)\log(e_t) - E_{t-1}[\log(e_t)]\right\}.\end{aligned} \tag{7''}$$

3.4 Closed economy

If we further close the trade account, the economy will be self-sufficient and $n = 1$. In this case, the Phillips curve will take an even simpler form

$$\pi_t - E_{t-1}(\pi_t) = \left(\frac{\gamma}{1-\gamma}\right)\left(\frac{\omega+\sigma^{-1}}{1+\theta\omega}\right)(\widehat{Y}_t^H - \widehat{Y}_t^n), \tag{7'''}$$

which is exactly identical to equation (1.23) in Woodford (2000).

3.5 A comparison

The difference in the output-inflation tradeoff coefficients between (7′) and (7″) lies in $\gamma\sigma^{-1}/(1-\gamma)(1+\theta\omega)$, which captures the sensitivity of inflation to consumption spending. This term will disappear in the presence of consumption smoothing, as will be achieved under perfect capital mobility. The difference in the same coefficients between (7″) and (7‴) is $\gamma(n-1)\omega/(1-\gamma)(1+\theta\omega)$, where n represents the fraction of world consumption that is produced domestically in the case of trade openness whereas 1 stands for the same fraction (i.e., 100%) in the case of a closed economy. Therefore, successive opening of the economy will flatten the Phillips curve.[5]

4 Empirical results

4.1 Data

The data used in the regressions reported in this paper are taken from Ball (1993, 1994) and Quinn (1997).

Sacrifice ratios and their determinants: Our regressions focus on explaining the determinants of sacrifice ratios as measured by Ball. He starts out by identifying disinflations, episodes in which the trend inflation rate fell substantially. Ball identifies 65 disinflation episodes in 19 OECD countries over the period 1960 to 1987. For each of these episodes he calculates the associated sacrifice ratio. The denominator of the sacrifice ratio is the change in trend inflation over an episode. The numerator is the sum of output losses, the deviations between output and its trend ("full employment") level.

We also take from Ball the data on the determinants of the sacrifice ratios such as the initial level of inflation, the change in inflation over the course of the episode and the length of the disinflation episode.

Restrictions on trade and capital Accounts: Measuring the degree of openness of trade and capital accounts is always a heroic task. Since 1950, the IMF has issued an annual publication which tries to describe the controls that its member countries have in place on various current account capital account transactions. However, as Cooper (1999, p. 111) notes, these descriptions are very imperfect measures of the extent of restrictions, particularly in the case of the capital account:

" restrictions on international capital transactions come in infinite variety. Therefore an accurate portrayal requires knowledge not only of the laws and regulations in place, but also of how they are implemented-which often requires much official discretion-and of how

[5]Obviously, our conclusion here is valid only if the parameters involved in the various versions of the Phillips curve are stable and invariant to changes in trade and capital mobility regimes. The same condition applies to our results in the next section.

easily they are circumvented, either legally or illegally. The IMF reports the presence of restrictions, but not their intensity or their impact."

Quinn (1997) takes the basic IMF qualitative descriptions on the presence of restrictions and translates them into a quantitative measure of restrictions using certain coding rules. This translation provides a measure of the intensity of restrictions on current account transactions on a (0,8) scale and restrictions on capital account transactions on a (0,4) scale; in both cases, a higher number indicates fewer restrictions. We use the Quinn measures, labeled CURRENT and CAPITAL, respectively, as our measures of restrictions. We also use the sum of the two measures as an overall measure of the degree of openness of the economy; this measure is labeled OPEN.

For each disinflation episode identified by Ball, we use as an independent variable the current account and capital account restrictions that were in place the year before the start of the episode. This at least makes the restrictions pre-determined with respect to the sacrifice ratios, though of course not necessarily exogenous.

4.2 Regressions

The first column of Table 1 reports a regression of the sacrifice ratio on initial inflation, the length of the episode (measured in quarters) and the change in inflation over the course of the episode. Not surprisingly, as all the data were taken from Ball's study, the results are qualitatively similar and quantitatively virtually identical to regressions reported in his paper. The key finding is that sacrifice ratios are smaller the quicker is the speed with which the disinflation is undertaken. The change in inflation also enters with the predicted sign and is significant (t=1.8, p-value=.076). Initial inflation is insignificant (and has the wrong sign from the perspective of the theory).

Recall that Ball, Mankiw, and Romer (1988) show that sticky-price Keynesian models predicts that the Phillips curve should be steeper in countries with higher average rates of inflation, and this is confirmed in our regressions as well. The New Keynesian Phillips curve, described in equations (7), (7'), and (7"), offer a possible theoretical explanation for this feature. If the parameter γ, the fraction of producers who post set their prices, increases, the Phillips curve becomes steeper. Endogeneizing γ, one can postulate that plausibly it is increasing the mean rate of inflation. Hence a possible rationale behind the empirical finding that the Phillips curve should be steeper in countries with higher average rates of inflation.

Now consider the impacts of adding the measures of openness, which are shown in the next three regressions. Ball's findings continue to hold. The length of the episode and the decline in inflation become more significant, while initial inflation remain insignificant. The measures of openness enter with the positive sign predicted by the theory. The effect of openness on the sacrifice ratio is statistically significant, as reflected also in the perking up of the adjusted R-square of the three regressions when compared to the first. The restrictions on the current account appear statistically more significant than the restrictions on the capital account. When we enters both CURRENT and CAPITAL in the regression, CURRENT remained significant but CAPITAL was not. The correlation between the two variables is almost 0.5; hence, our inability to tease out separate effects is not entirely surprising.

5 Conclusion

In our earlier work we showed that restrictions of capital account transactions were significant determinants of the slope of the Phillips curve, as measured in the studies of Lucas (1973), Ball-Mankiw-Romer (1998), and others. Recall that Ball, Mankiw, and Romer (1988) show that sticky-price Keynesian Models predict that the Phillips curve should be steeper in countries with higher average rates of inflation. That received an empirical support in our paper. The New-Keynesian Phillips Curve equations (7), ($7'$) and ($7''$) offer possible explanations. If the parameter γ, the fraction of firms post-selling their prices is larger, the Phillips curve becomes steeper. One can postulate that once we are able to endogenize γ, it would be positively associated with the mean rate of inflation. Hence, a possible explanation to the empirical finding.

The findings of this paper lend support to this line of work, in particular to the open economy new Keynesian Phillips curve developed in Razin and Yuen (2001). We find that sacrifice ratios measured from disinflation episodes depend on the degree on restrictions on the current account and capital account. Of course, to be more convincing this finding will have to survive a battery of robustness checks, such as sub-sample stability, inclusion of many other possible determinants (such as central bank independence) in the regressions, and using instruments to allow for the possible endogeneity of the measures of openness.

APPENDIX I

In this appendix we derive equation (5′). Let us rewrite marginal cost functions:

$$(y, C : \zeta, A) = \frac{v_n(f^{-1}(\frac{y}{A}); \zeta)}{u_c(c; \zeta) A f'(f^{-1}(\frac{y}{A}))}$$

and

$$s^n(y^n, C^n; \zeta, A) = \frac{v_n(f^{-1}(\frac{y^n}{A}); \zeta)}{u_c(c^n; \zeta) A f' * f^{-1}(\frac{y^n}{A}))}.$$

Log-Differentiating these equations yield:

$$d \log s(y, C; \zeta, A) = \begin{array}{c} (\omega_p + \omega_w)\frac{dy}{y} + \sigma^{-1}\frac{dC}{C} \\ -(\omega_p + \omega_w)\frac{dA}{A} + (\frac{v_{h\zeta}}{v_h} - \frac{u_{c\zeta}}{u_c})d\zeta - d\log A \end{array}$$

$$d \log s(y^n, C^n; \zeta, A) = \begin{array}{c} (\omega_p + \omega_w)\frac{dy^n}{y^n} + \sigma^{-1}\frac{dC^n}{C^n} \\ -(\omega_p + \omega_w)\frac{dA}{A} + (\frac{v_{h\zeta}}{v_h} - \frac{u_{c\zeta}}{u_c})d\zeta - d\log A. \end{array}$$

Subtracting the last equation from the one above it yields equation (5′).

APPENDIX II

Let us start with the two price-setting equations:

$$\log(p_{1t}) = \log(P_t) + \omega(\widehat{y}_{1t} - \widehat{Y}_t^n) + \sigma^{-1}(\widehat{C}_t - \widehat{C}_t^n), \tag{A.1a}$$

and

$$\log(p_{2t}) = E_{t-1}\left[\log(P_t) + \omega(\widehat{y}_{2t} - \widehat{Y}_t^n) + \sigma^{-1}(\widehat{C}_t - \widehat{C}_t^n)\right]. \tag{A.1b}$$

Log-linearizing the demand functions facing the firm (4) (where we can replace c_t and C_t^W by y_t and Y_t^W respectively), we get

$$\widehat{y}_{jt} = \widehat{Y}_t^W - \theta[\log(p_{jt}) - \log(P_t)], \;\; j = 1, 2. \tag{A.2}$$

Substituting (A.2) into (A.1a) and (A.1b) and rearranging terms, we have

$$\log(p_{1t}) = \log(P_t) + \left(\frac{\omega}{1+\theta\omega}\right)(\widehat{Y}_t^W - \widehat{Y}_t^n) + \sigma^{-1}\left(\frac{1}{1+\theta\omega}\right)(\widehat{C}_t - \widehat{C}_t^n), \tag{A.1a$'$}$$

and

$$\log(p_{2t}) = E_{t-1}\left[\log(P_t) + \left(\frac{\omega}{1+\theta\omega}\right)(\widehat{Y}_t^W - \widehat{Y}_t^n) + \sigma^{-1}\left(\frac{1}{1+\theta\omega}\right)(\widehat{C}_t - \widehat{C}_t^n)\right], \tag{A.1b$'$}$$

Together, (A.1a$'$) and (A.1b$'$) imply that

$$\log(p_{2t}) = E_{t-1}[\log(p_{1t})]. \tag{A.3}$$

>From the aggregate price index equation (1$'$), we have an approximate relation of the following kind

$$\log(P_t) = n[\gamma \log(p_{1t}) + (1-\gamma)\log(p_{2t})] + (1-n)\log(\varepsilon_t p_t^*). \tag{A.4}$$

>From this and (A.3), the unanticipated rate of inflation is given by

$$\begin{aligned} \log(P_t) - E_{t-1}\left[\log(P_t)\right] &= n\gamma[\log(p_{1t}) - \log(p_{2t})] \\ &\quad + (1-n)\left\{\log(\varepsilon_t p_t^*) - E_{t-1}\left[\log(\varepsilon_t p_t^*)\right]\right\}. \end{aligned} \tag{A.4$'$}$$

(A.4) also implies that

$$\log(p_{2t}) = \left[\frac{1}{n(1-\gamma)}\right][\log(P_t) - n\gamma\log(p_{1t}) - (1-n)\log(\varepsilon_t p_t^*)].$$

Substituting this into (A.4′) and defining the real exchange rate as $e_t \equiv \varepsilon_t P_t^*/P_t$, we have

$$\begin{aligned}\log(P_t) - E_{t-1}\log(P_t) &= \left(\frac{\gamma}{1-\gamma}\right)[\log(p_{1t}) - \log(P_t)] \\ &+ \left(\frac{1-n}{n}\right)\left\{\left(\frac{1}{1-\gamma}\right)\log(e_t) - E_{t-1}[\log(e_t)]\right\}.\end{aligned}$$

Replacing $\log(p_{1t})$ in the above expression by (A.1a′) yields an open-economy Phillips curve of the form

$$\begin{aligned}\log(P_t) - E_{t-1}\log(P_t) &= \left(\frac{\gamma}{1-\gamma}\right)\left[\left(\frac{\omega}{1+\theta\omega}\right)(\widehat{Y}_t^W - \widehat{Y}_t^n) + \left(\frac{\sigma^{-1}}{1+\theta\omega}\right)(\widehat{C}_t - \widehat{C}_t^n)\right] \\ &+ \left(\frac{1-n}{n}\right)\left\{\left(\frac{1}{1-\gamma}\right)\log(e_t) - E_{t-1}[\log(e_t)]\right\}.\end{aligned}$$

Equation (7) in the text can be obtained by noting that $\widehat{Y}_t^W = n\widehat{Y}_t^H + (1-n)\widehat{Y}_t^F$.

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Table 1: Sacrifice Ratios and Restrictions on Current Account and Capital Account

Independent Variables	(1)	(2)	(3)	(4)
Constant	−0.001 (0.012)	−0.059 (0.025)	−0.033 (0.022)	−0.058 (0.026)
Initial Inflation	0.002 (0.002)	0.003 (0.002)	0.003 (0.002)	0.003 (0.002)
Length of Disinflation Episode	0.004 (0.001)	0.004 (0.001)	0.004 (0.001)	0.004 (0.001)
Change in Inflation during Episode	−0.006 (0.003)	−0.007 (0.003)	−0.006 (0.003)	−0.007 (0.003)
CURRENT Index of current account restrictions		0.008 (0.003)		
CAPITAL Index of capital account restrictions			0.010 (0.006)	
OPEN Sum of CURRENT and CAPITAL				0.006 (0.002)
Adjusted R-square	0.16	0.23	0.19	0.23
Number of Observations	65	65	65	65
Note: Numbers in parentheses are standard errors				

Figure 1: