Working Paper Series
Department of Economics
University of Verona

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WP Number: 6 April 2011

ISSN: 2036-2919 (paper), 2036-4679 (online)

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Abstract

This paper extends the efficiency wages / partially adaptive expectations Phillips curve, otherwise known as price-price Phillips curve, from a closed economy context to an open economy one with both commodity trade and capital mobility. We also consider the case of a monetary union (a country) with two member states (regions). Opening the trade account alters the slope of the Phillips curve in an ambiguous way and it makes its position a function of the change of foreign output too. Opening the capital account, after opening the trade one, does not affect the Phillips curve. Within a monetary union, the link between the size of a region and its weight in the Phillips curve has an *a priori* ambiguous sign. Once resorting to plausible numerical simulations, economic openness reduces the sacrifice ratio. Regarding a monetary union, aggregate inflation is more affected by regional unemployment dynamics the greater is the weight of the region in aggregate unemployment rate and output.

Keywords: efficiency wages, unemployment, Phillips curve, inflation, adaptive expectations

JEL classification codes: E3, E20, E40, E50.

1 Introduction

In recent years, the advance of globalization accrued economists' interest in the effect of trade openness and capital mobility on the sacrifice ratio, namely the ratio between total output losses (or increases in the unemployment rate) and the change in trend inflation over the course of a disinflation.

Daniels and Van Hoose (2009, 2010) have recently offered reviews of the relevant literature. Path-breaking papers were Romer (1993), Lane (1997) and Karras (1999). The first contribution interpreted a negative cross-country relationship between trade openness and the inflation rate as the outcome of reduced gains for inflationary policymaking resulting from negative terms-of-trade effects of domestic output expansions . The second contribution stressed that inflation surprises can have a smaller impact on potential output once allowing for trade openness, traded and non-traded goods, imperfect competition and sticky prices. Finally, according to Karras (1999), wage indexation discourages soft monetary policies once opening the trade account.

On the footsteps of Lane (1997), imperfect competition and price/wage stickiness have been key ingredients of models trying to explain how both trade and capital openness affect the Phillips curve, such as those proposed by Duca and VanHoose (2000), Daniels and VanHoose (2006, 2009, 2010), Loungani, Razin and Yuen (2001), Razin and Yuen (2002) and Razin and Loungani (2005). Often these models produced a positive connection between economic openness and the sacrifice ratio. This result is reconciled with the stylized fact that globalization reduced inflation by arguing that it also changed the behavior of central banks, by increasing the weight of inflation on policymakers' loss function. In a similar way, according to Gruben and McLeod (2002, 2004), the greater is capital mobility, the more central banks are committed to low inflation.

On the empirical side of the literature, Temple (2002) questioned the robustness of a negative correlation between openness and the sacrifice ratio.

Following this contribution, Daniels et al. (2005) and Daniels and Van Hoose (2009) found trade openness to have a positive coeffi cient in a regression explaining the sacrifice ratio in 58 disinflationary periods in various OECD countries from 1960 thorough the 1980s, once including an interaction term between it and central bank independence (CBI). However, the marginal effect of trade openness at the average value of their CBI index is very close to zero. Furthermore, when accounting not only for CBI, but also for exchange rate pass-through, greater openness has an ambiguous effect on the sacrifice ratio (Daniels and VanHoose, 2010). Studying a sample of 91 countries from 1985 to 2004, Badinger (2009) provided empirical support for the reasoning underlying Daniels and VanHoose (2006, 2010) and Razin and Loungani (2005), but not when focusing on OECD countries only.

This debate was also marked by the presence of skeptical contributions too. Terra (1998) and Bleaney (1999) suggested the trade openness-inflation relationship to be respectively illusory and unstable across time. Ball (2006) questioned at all the existence of a link between economic openness on one side and either the sacrifice ratio or inflation on the other in the US. On the theoretical side, Cavelaars (2009) challenged the tenet that central banks might be more committed to low inflation in more open economies, once dropping the small open economy assumption and defining increasing openness as either a fall of trade costs or a decrease in monopoly power. Finally, Bowdler (2009) found in a sample of 41 countries running from 1981 to 1998 a weak negative correlation of sacrifice ratios with openness, which is not affected by the kind of exchange rate regime in place.

Given this state of the art, new theoretical models can highlight further channels through which trade openness and capital mobility can affect the sacrifice ratio. This is the challenge the present paper would like to meet. Specifically, building on Campbell (2006, 2008a and 2008b), Campbell (2010a) recently proposed an alternative derivation of the Phillips curve to the New-Keynesian and sticky information ones, by adopting an effi ciency wages model with imperfect information. This Phillips curve was named price-price Phillips curve. The present paper extends the efficiency wages Phillips curve from a closed economy context to an open economy one. As a consequence, it stays to Campbell (2010a) as Razin and Yuen (2002) stays to Woodford (2003).

In order to accomplish this task we insert Campbell's model within an intertemporal optimization framework, by drawing theoretical insights also from Danthine and Kurmann (2004) and Obstfeld and Rogoff (1996). In so doing with respect to Razin and Yuen (2002), we can highlight further theoretical mechanisms that can offer an intuition for the existence of a Phillips curve and how it is affected by opening the trade and capital accounts. These mechanisms are discussed below. What is more, we consider the case of a country (or otherwise a monetary union) composed of two regions (member states) and we derive the Phillips curve for this case as well. Our purpose here is to understand whether the larger is a region, the greater is its weight in the aggregate Phillips curve. Therefore, the present contribution is also tangential to the stream of literature originated by Benigno (2004), Beetsma and Jensen (2005) and Lombardo (2006), whose main target however is not explaining the sacrifice ratio, rather studying the conduct of monetary and fiscal policies in a currency union under different assumptions regarding the economic structure of the member states. Last but not least, we propose an alternative and simpler procedure to derive the price-price Phillips curve.

The rest of this paper is structured as follows. First the model is introduced. Afterwards, the trade account of the economy is opened, followed by the capital one. We then consider the case of the monetary union and offer some numerical results. The last section summarizes our findings. The Appendix illustrates our solution procedure.

2 The model

2.1 The households'problem and the government budget constraint

We follow Danthine and Kurmann (2004), by supposing the domestic economy to be populated by a continuum of households normalized to n, each composed by a continuum of individuals normalized to 1. The number of foreign households is instead normalized to $1-n$. Households maximize their discounted utility

$$\max_{\left\{c_{t+i}(h),B_{t+i}(h),B^*_{t+i}(h),e_{t+i}(h),M_{t+i}(h)\right\}} \sum_{i=0}^{\infty} \beta^{t+i} E\left(U\left\{c_{t+i}\left(h\right), L_{t+i}\left(h\right)G\left[e_{t+i}(h)\right], \frac{M_{t+i}\left(h\right)}{P_{t+i}}\right\}\right) \tag{1}$$

subject to a series of income constraints

$$\begin{aligned} c_{t+i}\left(h\right) &= \frac{W_{t+i}\left(h\right)}{P_{t+i}}L_{t+i}(h)+\frac{T_{t+i}\left(h\right)}{P_{t+i}}-\frac{M_{t+i}\left(h\right)}{P_{t+i}}+\frac{M_{t+i-1}\left(h\right)}{P_{t+i}}+\pi_{t+i}\left(h\right)- \\ &\quad -\frac{B_{t+i}(h)}{P_{t+i}}+\frac{B_{t+i-1}(h)}{P_{t+i}}\left(1+i_{t+i-1}\right)-\frac{\epsilon_{t+i}B^*_{t+i}(h)}{P_{t+i}}+f_{t+i-1,t+i}\frac{B^*_{t+i-1}(h)}{P_{t+i}}\left(1+i^*_{t+i-1}\right) \end{aligned}$$

where β is the discount factor, E is the expectation operator, U is the utility function, $c_{t+i}\left(h\right)$ is consumption of household h at time $t+i$, $B_{t+i}(h)$ are the householdś domestic bond holdings, i_{t+i} is the nominal domestic interest rate, $L_{t+i}\left(h\right)$ is the fraction of employed individuals within the household, $G\left[e_{t+i}(h)\right]$ is the disutility of effort - $e_{t+i}(h)$ - of the typical working family member, $M_{t+i}(h)$ is nominal money balances and P_{t+i} the price level. $W_{t+i}\left(h\right)$ and $T_{t+i}\left(h\right)$ are the householdś nominal wage income and government transfers respectively. $\pi_{t+i}\left(h\right)$ is the householdś share of firm profits in real terms. ϵ_t is the spot exchange rate and $f_{t+i-1,t+i}$ is the forward exchange rate for foreign currencies purchased/sold at time $t+i-1$ and delivered at time t. Finally, asterisks denote foreign variables.

In this framework, households, and not individuals, make all the decisions regarding consumption, domestic and foreign bond holdings, real money balances and effort. Individuals are identical ex-ante, but not ex-post, given that some of them are employed - being randomly and costlessly matched with firms independently from time - and some other are unemployed. The fraction of the unemployed is the same across all the families, and so their ex-post homogeneity is preserved.

Note that, as in Danthine and Kurmann (2004), in our model no utility arises from leisure[1], therefore individual agents inelastically supply one unit of time for either work or unemployment related activities[2].

Building on Danthine and Kurmann (2004) and Campbell (2010a), we specify $G\left[e_{t+i}(h)\right]$ as follows

$$G\left[e_{t+i}(h)\right] = \left\{e_{t+i}(h) - \tilde{e}\left[\frac{W_{t+i}\left(h\right)}{P^{e}_{t+i}}, u_{t+i}(h)\right]\right\}^{2} \tag{2}$$

where P^{e}_{t+i} are price expectations, $u_{t+i}(h) = 1 - L_{t+i}(h)$ is the unemployment rate and $\tilde{e}\left[\frac{W_{t+i}(h)}{P^{e}_{t+i}}, u_{t+i}(h)\right]$ is an effi ciency function with$\tilde{e}_{W} > 0$, $\tilde{e}_{u} > 0$, $\tilde{e}_{WW} < 0, \tilde{e}_{Wu} < 0$. (2) implies that households face a trade off. A higher level of effort reduces their utility, but, as customary in many effi ciency wages model, increasing either $\frac{W_{t+i}(h)}{P^{e}_{t+i}}$ or $u_{t+i}(h)$ offers more motivation to exert it.

Under the hypothesis of an additively separable utility function, households strike a balance between these two tendencies by maximizing utility which implies

$$G'\left[e_{t+i}(h)\right] = 0 \tag{3}$$

[1] $L_{t+i}\left(h\right)$ is the fraction of employed individuals within household h and not the working time of an individual agent.

[2] This implies that, using the symbology of Campbell (2010a), $\psi = 0$, where ψ is the steady state value of the short-run elasticity of labor supply. We also assume parameters to be chosen so that excess labour supply exists.

and, therefore,

$$e_{t+i}(h) = \tilde{e}\left[\frac{W_{t+i}(h)}{P^e_{t+i}}, u_{t+i}(h)\right] \tag{4}$$

The government rebates its seigniorage proceeds to households by means of lump-sum transfers, $T_t(h)$:

$$\int_0^n \frac{T_t(h)}{P_t} dh = \int_0^n \frac{M_t(h)}{P_t} dh - \int_0^n \frac{M_{t-1}(h)}{P_t} dh$$

where $M_t(h)$ is money holdings of household h at time t.

Supposing that consumption and real money balances enter (1) in logs, utility maximization with respect to these two terms leads to a well-known money demand function (Walsh, 2003, p. 272):

$$\frac{M_{t+i}(h)}{P_{t+i}} = c_{t+i}(h)\left(\frac{1+i_{t+i}}{i_{t+i}}\right) b \tag{5}$$

where b is the weight of log real money holdings in the utility function. Note that, due to symmetry, the h index can be dropped.

2.2 The final and the intermediate product markets

As often in the New-Keynesian literature (see for instance Edge, 2002) we assume the existence of a continuum of monopolistically competitive firms hiring the homogeneous labour input to produce a horizontally differentiated output. We also assume that there exist perfectly competitive intermediaries combining the differentiated output of firms to produce a homogeneous aggregate final output for the world economy thanks to a technology with constant elasticity of substitution (CES).

Similarly to Razin and Yuen (2002), solving the profit maximization problem of the representative intermediary leads to the product demand function for the j-th domestic firm

$$y_t^H(j) = Y_t^W \left[\frac{p_t^H(j)}{P_t}\right]^{-\gamma} \tag{6}$$

where $y_t^H(j)$ and $p_t^H(j)$ are respectively the output and the price of the j-th domestic firm, Y_t^W is world output, P_t is the aggregate domestic price index and γ is the elasticity of substitution of different product varieties in the CES production function. The demand function of the j-th foreign firm mirrors (6). Also note that the number of domestic firms is normalized to n and that of foreign firms to $1-n$. We consider the small open economy case, namely $n \rightarrow 0$ (Obstfeld and Rogoff, 1996, p. 688). Finally $P_t = \left\{\int_0^n p_t^H(j)^{1-\gamma}\, dj + \int_n^1 \left[\epsilon_t p_t^F(j)\right]^{1-\gamma} dj\right\}^{\frac{1}{1-\gamma}}$ where $p_t^F(j)$ is the price of the j-th foreign firm. We hereafter drop the j index due to symmetry.

Similarly to Campbell (2010a), supposing that monopolistically competitive firms have the following production function

$$y_t^H = A_t^{\phi} L_t^{\phi} \left[\tilde{e}\left(\frac{W_t}{P_t^e}, u_t\right)\right]^{\phi} \tag{7}$$

- with A_t representing a technology shock and ϕ being a parameter-, their profit maximization problem can be expressed as

$$\max_{\{L_t, W_t\}} \left(Y_t^W\right)^{\frac{1}{\gamma}} \left\{A_t^{\phi} L_t^{\phi} \left[\tilde{e}\left(\frac{W_t}{P_t^e}, u_t\right)\right]^{\phi}\right\}^{\frac{\gamma-1}{\gamma}} P_t - W_t L_t$$

The first order condition with respect to L_t returns labour demand

$$\begin{aligned} L_t &= W_t^{\frac{\gamma}{\phi(\gamma-1)-\gamma}} \left[\frac{\phi(\gamma-1)}{\gamma}\right]^{-\frac{\gamma}{\phi(\gamma-1)-\gamma}} \left(Y_t^W\right)^{-\frac{1}{\phi(\gamma-1)-\gamma}} A_t^{-\frac{\phi(\gamma-1)}{\phi(\gamma-1)-\gamma}} \cdot \\ &\cdot \left[\tilde{e}\left(\frac{W_t}{P_t^e}, u_t\right)\right]^{-\frac{\phi(\gamma-1)}{\phi(\gamma-1)-\gamma}} P_t^{-\frac{\gamma}{\phi(\gamma-1)-\gamma}} \end{aligned} \tag{8}$$

Taking the first order condition with respect to W_t and substituting it into (8) one obtains the following condition

$$W_t \left[\tilde{e} \left(\frac{W_t}{P_t^e}, u_t \right) \right]^{-1} \tilde{e}_W \left(\frac{W_t}{P_t^e}, u_t \right) \frac{1}{P_t^e} = 1 \tag{9}$$

After Campbell (2010a), we are ready, at this stage, to linearize equations (5), (8) (9), $u_t = 1 - L_t$ and the production function of monopolistically competitive firms around the steady state so to obtain the following system of equations

$$\begin{aligned}
\left[\phi(\gamma-1)-\gamma\right]\hat{L}_t &= \gamma \hat{W}_t - \hat{Y}_t^W - \phi(\gamma-1)\hat{A}_t - \qquad (10)\\
&\quad -\phi(\gamma-1)\tilde{e}^{-1}\left[\begin{array}{c} \tilde{e}_W \frac{W_{ss}}{P_{ss}^e}\hat{W}_t \\ -\tilde{e}_W \frac{W_{ss}}{P_{ss}^e}\hat{P}_t^e + \tilde{e}_u du_t \end{array}\right] - \gamma \hat{P}_t \\
du_t &= -s_L \hat{L}_t \qquad (11)\\
\hat{W}_t &= \hat{P}_t^e + \frac{e_u - e_{Wu}\zeta}{e_{WW}\zeta^2} du_t \qquad (12)\\
\hat{P}_t &= \hat{M}_t - \hat{c}_t + \delta \hat{\imath}_t \qquad (13)\\
\hat{y}_t^H &= \phi \hat{A}_t + \phi \hat{L}_t + \phi \hat{W}_t - \phi \hat{P}_t^e - \phi e^{-1} e_u s_L \hat{L}_t \qquad (14)
\end{aligned}$$

where variables with hats denote percentage deviations from steady state values, s_L is the steady state employment rate, du_t is the absolute change of the unemployment rate, the ss subscript denotes steady state values and δ is the elasticity of money demand with respect to the nominal interest rate. Furthermore, in steady state one has $\tilde{e}\tilde{e}_W^{-1} = \frac{W_{ss}}{P_{ss}^e} = \zeta$[3]. Note that (11) is our counterpart of equation (17) in Campbell (2010a). They are different as we assume the short run elasticity of labour supply with respect to $\frac{W_t}{P_t^e}$ to be zero. Consider the case of a closed economy, where $\hat{c}_t = \hat{y}_t^H = \hat{Y}_t^W$ and call $\hat{\mathcal{M}}_t = \hat{M}_t + \delta \hat{\imath}_t$. Once imposing the short-run elasticity of labor supply to be

[3] We assume $\frac{W_s}{P_s^e} = \zeta$ as in Campbell (2011). This implies a difference between equation (12) and its counterpart in Campbell (2010a). The author thanks Carl M. Campbell for pointing this out.

zero and $\zeta = 1$, the system (10)-(14) is mathematically the same as the one used by Campbell (2010a, b). By taking similar steps to those presented in Campbell (2010b), one can derive the following equation

$$\hat{P}_t = \hat{P}_t^e - \phi \hat{A}_t - \frac{(1-\phi)\left[\tilde{e}_{WW}\zeta^2 - s_L\left(\tilde{e}_u - \tilde{e}_{Wu}\zeta\right)\right] + \phi \tilde{e}^{-1}\tilde{e}_u s_L \tilde{e}_{WW}\zeta^2}{s_L \tilde{e}_{WW}\zeta^2} du_t \tag{15}$$

We assume with Campbell (2010a, b) that P_t^e is a mixture of rational and adaptive expectations, namely that $\hat{P}_t^e = \omega \hat{P}_t + (1-\omega)\left[\hat{P}_{t-1} + \sum_{i=1}^{T} \lambda_i \left(\hat{P}_{t-i} - \hat{P}_{t-i-1}\right)\right]$ where $0 \leq \omega \leq 1$ is the degree to which expectations are rational and λ_i is the weight of i-th lag in the inflation rate in forming adaptive expectations, with $\sum_{i=1}^{T} \lambda_i = 1$. On these grounds, one can derive from (15) a price-price Phillips curve, whose slope is a multiple of the coeffi cient of absolute deviations of the unemployment rate from steady state in (15) :

$$\begin{aligned} \hat{P}_t - \hat{P}_{t-1} &= -\frac{(1-\phi)\left[\tilde{e}_{WW}\zeta^2 - s_L\left(\tilde{e}_u - \tilde{e}_{Wu}\zeta\right)\right] + \phi \tilde{e}^{-1}\tilde{e}_u s_L \tilde{e}_{WW}\zeta^2}{(1-\omega) s_L \tilde{e}_{WW}\zeta^2} du_t + \\ &\quad + \sum_{i=1}^{T} \frac{\lambda_i}{(1-\omega)} \left(\hat{P}_{t-i} - \hat{P}_{t-i-1}\right) - \frac{\phi}{(1-\omega)} \hat{A}_t \end{aligned}$$

We now move to open first the trade account of the economy and then the capital one.

3 Opening the trade account

Once opening the trade account only, $\hat{c}_t = (1-n)\left(\hat{p}_t^H - \hat{\epsilon}_t - \hat{p}_t^F\right) + \hat{y}_t^H$, due to the aggregate resource constraint and to $\hat{P}_t = n\left(\hat{p}_t^H\right) + (1-n)\left(\hat{\epsilon}_t + \hat{p}_t^F\right)$. Furthermore, as in Razin and Yuen (2002), $\hat{Y}_t^W = n\hat{y}_t^H + (1-n)\hat{y}_t^F$. On these grounds, the Appendix shows that one can follow a similar, but less complicate, procedure to Campbell (2010b) to obtain the equation below

$$\begin{aligned}\hat{P}_t &= \hat{P}_t^e - \left(\frac{1-n}{\gamma}\right)\left(\hat{y}_t^F - \hat{y}_t^H\right) - \phi\hat{A}_t - \\ &\quad - \frac{(1-\phi)\left[\tilde{e}_{WW}\zeta^2 - s_L\left(\tilde{e}_u - \tilde{e}_{Wu}\zeta\right)\right] + \phi\tilde{e}^{-1}\tilde{e}_u s_L \tilde{e}_{WW}\zeta^2}{s_L\tilde{e}_{WW}\zeta^2}du_t\end{aligned} \tag{16}$$

Note that $-\left(\frac{1-n}{\gamma}\right)\left(\hat{y}_t^F - \hat{y}_t^H\right)$ can be rewritten as $(1-n)\left(\hat{p}_t^F + \hat{\epsilon}_t\right) - (1-n)\left(\hat{p}_t^H\right)$ by taking the difference between the linearized version of (6) and its counterpart for $\hat{y}_t^F$. So this term accounts for changes in the terms of trade. Though we consider a small open economy, terms of trade are not exogenous in our setting. Firms in the domestic country are a small proportion of the worldwide number of firms, however they retain monopoly power on their products. So, with difference to Razin and Yuen (2002), where in their Phillips curve there appears a term accounting for the relative price of domestic and foreign goods, it is useful to make explicit the connection between terms of trade and the domestic absolute change in the unemployment rate. In order to do so, one can, further, substitute equations (11) and (12) into (14) to obtain

$$\hat{y}_t^H = \phi\hat{A}_t + \phi\left[\frac{e_u - e_{Wu}\zeta}{e_{WW}\zeta^2} - \frac{(1-e^{-1}e_u s_L)}{s_L}\right]du_t \tag{17}$$

which in its turn can be substituted into (16) to obtain a new version of equation (15)

$$\begin{aligned}\hat{P}_t &= \hat{P}_t^e - \left(\frac{1-n}{\gamma}\right)\hat{y}_t^F + \phi\left(\frac{1-n}{\gamma} - 1\right)\hat{A}_t - \\ &\quad - \frac{\left[1-\left(1-\frac{1-n}{\gamma}\right)\phi\right]\left[e_{WW}\zeta^2 - s_L\left(e_u - e_{Wu}\zeta\right)\right] + \phi\left[1-\left(\frac{1-n}{\gamma}\right)\right]e^{-1}e_u s_L e_{WW}\zeta^2}{s_L e_{WW}\zeta^2}du_t\end{aligned} \tag{18}$$

Note that for $n = 1$, (16) and (18) coincide with (15). The difference between (18) and (15) is both in the unemployment multiplier and in the presence of an additional shifter, namely the variation in foreign output. (18) implies that the Phillips curve changes to

$$\hat{P}_t - \hat{P}_{t-1} = \sum_{i=1}^{T} \lambda_i \left(\hat{P}_{t-i} - \hat{P}_{t-i-1}\right) - \frac{1-n}{\gamma\left(1-\omega\right)} \hat{y}_t^F + \frac{\phi}{\left(1-\omega\right)} \left(\frac{1-n}{\gamma} - 1\right) \hat{A}_t - \tag{19}$$

$$- \frac{\left[1 - \left(1 - \frac{1-n}{\gamma}\right)\phi\right]\left[e_{WW}\zeta^2 - s_L\left(e_u - e_{Wu}\zeta\right)\right] + \phi\left[1 - \left(\frac{1-n}{\gamma}\right)\right] e^{-1} e_u s_L e_{WW}\zeta^2}{\left(1-\omega\right) s_L e_{WW}\zeta^2} du_t$$

An increase in foreign output moves the Phillips curve downward because it produces an increase in labour demand via (10) and therefore a decline in unemployment through (11).

To understand the change in the slope of the Phillips curve consider, for illustrative purposes only, an increase in the price level in a closed economy. This generates a fall in the real wage and an increase in the employment and unemployment rates via (10) and (11) respectively. After Campbell (2006, 2010) $\tilde{e}_W > 0$, $\tilde{e}_u > 0$, $\tilde{e}_{WW} < 0$, $\tilde{e}_{Wu} < 0$ and so $\frac{\tilde{e}_{WW}\zeta^2 - s_L(\tilde{e}_u - \tilde{e}_{Wu}\zeta)}{s_L \tilde{e}_{WW\zeta^2}} - \tilde{e}^{-1}\tilde{e}_u \gtreqless 0$. This implies that the unemployment multiplier in (17) can be either positive or negative, as a lower unemployment means a greater labour input but also less effort. So a decrease in unemployment can be associated to either an increase or a decrease in output, which then can either reinforce or dampen the initial change in the price level. So to summarize

$$P_t \uparrow \rightarrow \frac{W_t}{P_t} \downarrow \rightarrow L_t \uparrow \rightarrow u_t \downarrow \rightarrow y_t \updownarrow \rightarrow P_t \updownarrow$$

However, as showed by Campbell (2010a), the slope of the Phillips curve is, in the end, *a priori* negative, given the sign restrictions above. So the effort effect of unemployment on output and, therefore, on prices, even if present, will not be of such a magnitude to completely offset the labour input effect.

Upon opening the trade account, one further transmission channel appears through the terms of trade. An increase in $\hat{p}_t^H$ does not generate only a fall in the real wage, it also affect the demand for domestic output as implied by (6), given that perfectly competitive intermediaries on the final product market can substitute it with foreign output. This is a negative terms of trade effect à la Romer (1993). Once again, given that $\frac{\tilde{e}_{WW}\zeta^2 - s_L(\tilde{e}_u - \tilde{e}_{Wu}\zeta)}{s_L\tilde{e}_{WW\zeta^2}} - \tilde{e}^{-1}\tilde{e}_u \gtreqless 0$, this can either reinforce or dampen the effect of the fall in the real wage on the unemployment rate. As a matter of consequence, opening the trade account has an *a priori* ambiguous effect on the slope of the Phillips curve. To see this, it is necessary to verify whether the following inequality between the slopes of (18) and (15) holds

$$\frac{[1-\Gamma\phi]\left[e_{WW}\zeta^2 - s_L\left(e_u - e_{Wu}\zeta\right)\right] + \phi\,[\Gamma]\,e^{-1}e_u s_L e_{WW}\zeta^2}{s_L e_{WW}\zeta^2} > \\ > \frac{(1-\phi)\left[e_{WW}\zeta^2 - s_L\left(e_u - e_{Wu}\zeta\right)\right] + \phi e^{-1}e_u s_L e_{WW}\zeta^2}{s_L e_{WW}\zeta^2} \tag{20}$$

where

$$\Gamma \equiv \left(1 - \frac{1-n}{\gamma}\right) < 1 \tag{21}$$

For (20) to hold, it should be that

$$e^{-1}e_u s_L e_{WW}\zeta^2 - \left[e_{WW}\zeta^2 - s_L\left(e_u - e_{Wu}\zeta\right)\right]\Gamma < e^{-1}e_u s_L e_{WW}\zeta^2 - \left[e_{WW}\zeta^2 - s_L\left(e_u - e_{Wu}\zeta\right)\right] \tag{22}$$

however the sign of $e^{-1}e_u s_L e_{WW}\zeta^2 - \left[e_{WW}\zeta^2 - s_L\left(e_u - e_{Wu}\zeta\right)\right]$ is ambiguous and so (21) and (22) can *a priori* be in conflict.

Proposition 1 *Opening the trade account has an ambiguous effect on the sacrifice ratio implied by the price-price Phillips curve.*

4 Opening the capital account

Upon opening the capital account, we follow Razin and Yuen (2002, p. 6) by assuming that the product of the discount rate times 1 plus the real interest rate is equal to one. As a result, consumption smoothing can be achieved and $\hat{c}_t = 0$. Therefore, (13) turns out to be $\hat{P}_t = \hat{M}_t + \delta i_t$. Under these assumptions, by following a very similar procedure to that set out in the Appendix, it is possible to show that (16) does not change.

Proposition 2 *Perfect capital mobility in a small open-to-trade economy does not alter the sacrifice ratio implied by the price-price Phillips curve.*

This is because perfect capital mobility does not change neither labour demand nor the substitutability of domestic and foreign output. In order to see the former point consider the linearized labour demand with trade openness

$$\gamma \hat{L}_t = \left(\hat{y}_t^F - \hat{y}_t^H\right)(1-n) + \gamma \left[\hat{M}_t + \delta \hat{\imath}_t - (1-n)\left(\hat{p}_t^H - \hat{\epsilon}_t - \hat{p}_t^F\right)\right] - \gamma \hat{W}_t$$

Substitute in it $\left(\hat{y}_t^F - \hat{y}_t^H\right) = -\gamma\left(\hat{p}_t^F + \hat{\epsilon}_t - \hat{p}_t^H\right)$ and simplify to obtain

$$\gamma \hat{L}_t = \gamma \left[\hat{M}_t + \delta \hat{\imath}_t\right] - \gamma \hat{W}_t$$

Recall that due to the money demand function $\hat{P}_t + (1-n)\left(\hat{p}_t^H - \hat{\epsilon}_t - \hat{p}_t^F\right) + \hat{Y}_t^H = \hat{M}_t + \delta \hat{\imath}_t$ and so

$$\gamma \hat{L}_t = \gamma \left[\hat{P}_t + (1-n)\left(\hat{p}_t^H - \hat{\epsilon}_t - \hat{p}_t^F\right) + \hat{Y}_t^H\right] - \gamma \hat{W}_t \tag{23}$$

Consider now the case of perfect capital mobility. Labour demand is

$$[-\gamma]\left(\hat{L}_t + \hat{W}_t\right) = -\gamma \hat{y}_t^H + (1-n)\left(\hat{y}_t^H - \hat{y}_t^F\right) - \gamma \hat{P}_t$$

Using the equality $\left(\hat{y}_t^F - \hat{y}_t^H\right) = -\gamma\left(\hat{p}_t^F + \hat{\epsilon}_t - \hat{p}_t^H\right)$ and simplifying, one obtains again (23).

5 A monetary union

We now consider the case of two regions (member states) within a country (monetary union), having two segmented labour markets with different effort functions, leading to different unemployment rates and real wages. We further suppose that the markets for the final product, bonds and money are perfectly integrated. No migration is possible. The total number of households is normalized to 1. A fraction n of each household is located in region A and the other fraction in region B. Intra-households transfers, playing a similar role to intra-national remittances, make sure that consumption is the same in both regions, notwithstanding the heterogeneity characterizing the labour market.

Similarly to above, firms located in the two regions are symmetric within the region and they are specialized in goods that are imperfectly substitutes. The total number of firms is normalized to 1, with n firms being located in region A and $1-n$ in region B. Their output is then assembled by perfectly competitive intermediaries, producing a final homogeneous product.

Under these assumptions, linearized labour demands for the fractions of households located in the two regions will be

$$\begin{aligned}\hat{L}_t^A &= \frac{(\gamma-1)y_t^A + s^A\hat{y}_t^A + s^B\hat{y}_t^B}{\gamma} + \hat{P}_t - \hat{W}_t^A \\ \hat{L}_t^B &= \frac{(\gamma-1)y_t^B + s^A\hat{y}_t^A + s^B\hat{y}_t^B}{\gamma} + \hat{P}_t - \hat{W}_t^B\end{aligned}$$

where $s^A = \frac{n\left(Y_{ss}^A\right)^\gamma}{n(Y_{ss}^A)^\gamma + (1-n)(Y_{ss}^B)^\gamma}$, $s^B = \frac{(1-n)\left(Y_{ss}^B\right)^\gamma}{n(Y_{ss}^A)^\gamma + (1-n)(Y_{ss}^B)^\gamma}$, where the ss subscript denotes steady state values. We aggregate the two labour demand above by using as weights $l^A = \frac{nL_{ss}^A}{nL_{ss}^A + (1-n)L_{ss}^B}$, $l^B = \frac{(1-n)L_{ss}^B}{nL_{ss}^A + (1-n)L_{ss}^B}$ and we follow a similar procedure to that set out in the Appendix. In this way we obtain the following aggregate Phillips curve

$$\begin{aligned}\hat{P}_t - \hat{P}_{t-1} &= \sum_{i=1}^{T} \lambda_i \left(\hat{P}_{t-i} - \hat{P}_{t-i-1}\right) - \left[\frac{l^A(\gamma-1)+s^A}{(1-\omega)\,\gamma}\right]\phi \hat{A}_t^A + \\ &+ \left[\frac{(1-n)\,l^B(\gamma-1)+s^B}{(1-\omega)\,\gamma}\right]\phi \hat{A}_t^B + \\ &+ \frac{1}{(1-\omega)}\left[l^A\left(\eta^A - e^{A^{-1}} e_u^A - \frac{[(\gamma-1)]\,\phi\eta^A}{\gamma}\right) - \frac{s^A\phi\eta^A}{\gamma}\right] du_t^A + \\ &+ \frac{1}{(1-\omega)}\left[l^B\left(\eta^B - e^{B^{-1}} e_u^B - \frac{[(\gamma-1)]\,\phi\eta^B}{\gamma}\right) - \frac{s^B\phi\eta^B}{\gamma}\right] du_t^B\end{aligned}$$

with $\eta^j = \frac{e_u^j - e_{Wu}^j \zeta^j}{e_{WW}^j \left(\zeta^j\right)^2} - \frac{1-\left(e^j\right)^{-1} e_u^j s_L^j}{s_L^j}$, with $j = A, B$. On these grounds, by considering the first order derivative of unemployment multipliers with respect to l^j and s^j with $j = A, B$, it is easy to show that the weights of the absolute deviations of regional unemployment rates from their steady state levels might either decrease or increase with the size of the regions themselves, measured by either their share in the steady state aggregate employment rate or by the share of their output in the CES aggregator leading to the final good.

Proposition 3 *In a monetary union/country with perfectly integrated asset and product markets, segmented national/regional labour markets and international/inter-regional private transfers, the link between the size of a region and its weight in the price-price Phillips curve has an a priori ambiguous sign.*

6 Numerical examples

In the present section, we give some numerical examples, adopting the four calibrations for the effort function proposed by Campbell (2006). γ was, instead, set equal to 10 following for instance Chari, Kehoe and McGrattan

(2000), implying an 11% markup in steady state. Finally, the value of ω was taken from Campbell (2008).

Table 1 sets out the values we attached to the parameters and our results. In all our simulations, economic openness increases the reactiveness of inflation to unemployment, reducing the sacrifice ratio. This is so for two reasons, which can be explained resorting again to the example of an exogenous increase in the price level, even though for illustrative purposes only.

First, all the above calibrations imply a negative link between output and unemployment, as the labour input effect prevails over the effort one. So output changes would tend to offset price changes. However, trade openness weakens such countervailing effect, as the smaller is n the smaller are the fractions of $\hat{p}_t^H$ and y_t^H in the price index and in aggregate output respectively.

Table 1 also shows that calibration remain a major issue for the present model. Under the present approach, the effort function is theoretically flexible, but highly parametrized. Little changes in the parameter constellation can produce sizeable changes in the sacrifice ratio, more sizeable than economic openness itself. This highlights the need for the literature of reference to find new strategies to calibrate the effort function.

Regarding the monetary union model sketched above, let us stick with the assumption of a negative link between unemployment and output, such that $\eta^j < 0$ with $j = A, B$. Under this hypothesis, the derivatives of the unemployment multiplier with respect to l^j and s^j are $\left\{ \left[1 - \frac{(\gamma-1)\phi}{\gamma} \right] \eta^j - \left(e^j\right)^{-1} e_u^j \right\}$ and $-\frac{\phi\eta^j}{\gamma}$ respectively. This entails that the weight of the sacrifice ratio in the Phillips curve decreases the higher is its weight in the steady state employment rate and the smaller is its weight in terms of output. In other words, unemployment dynamics within a region will exert a larger effect on aggregate inflation dynamics the higher is its relative steady state unemployment rate and the more it accounts for aggregate steady state output.

Table 1 - Numerical examples of the effect of openness on the sacrifice ratio

	Calibration 1	Calibration 2	Calibration 3	Calibration 4
e	0.8	0.7	0.85	0.8
$e_u \frac{u}{e}$	0.0638	0.055	0.0672	0.0516
e_{WW}	-0.227	-0.0116	-0.0342	-0.00568
e_{Wu}	-0.395	-0.174	-0.626	-0.160
ω	0.5	0.5	0.5	0.5
ϕ	0.67	0.67	0.67	0.67
n	0.01	0.01	0.01	0.01
γ	10	10	10	10
u	0.05	0.05	0.05	0.05

		Sacrifice ratio		
closed economy	-0.77	-0.47	-1.03	-0.26
open economy	-0.64	-0.40	-0.86	-0.22

% output change after 1 point increase in u	-1.30	-2.11	-0.96	-3.85

7 Conclusions

The present paper extends the effi ciency wages Phillips curve proposed by Campbell (2010a) from a closed economy setting to both a small open economy and a monetary union ones, building on Obstfeld and Rogoff (1996), Razin and Yuen (2002) and Danthine and Kurmann (2004).

In Razin and Yuen (2002) openness to trade and capital flows affect the Phillips curve by changing the structure of the product market in presence of price stickiness. We have showed here that such changes can affect the Phillips curve also when it originates from the labour market due to the existence of efficiency wages and partially adaptive expectations though in absence of price stickiness.

In particular, we showed that opening the trade account of the economy exposes the Phillips curve to changes in foreign output, while also affecting its slope in an *a priori* ambiguous way. Opening the capital account after opening the trade one has no further effect on the sacrifice ratio. Once exploring a monetary union or otherwise a country with two regions, the link between the size of a region and its weight in the Phillips curve is *a priori* ambiguous.

Upon calibrating our model on the footsteps of Campbell (2006), we found that in our setting economic openness decreases the sacrifice ratio. Finally, supposing that output and unemployment have a negative link, unemployment dynamics within a region of a country will have a greater effect on aggregate inflation the higher is its relative steady state unemployment rate and the higher is its weight in total output.

We also found that numerical results can be very sensitive to the underlying calibration of the effort function. Either a firmer knowledge of its or alternative calibration strategies are, therefore, preconditions to study, for instance, the determinacy properties of the model under different monetary policy rules or to provide simulations after hitting the model with various kinds of shocks.

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8 Appendix: Deriving the effi ciency wages Phillips curve upon opening the trade account of the economy

The present appendix focuses on an economy with a closed capital account and an open trade one, given that a completely open economy is a special case of what follows. The procedure below is a generalization and a simplification of the one proposed by Campbell (2010b).

Consider equation (10) and substitute inside it (11) , (14) and the condition $\tilde{e}\tilde{e}_W^{-1} = \frac{W_{ss}}{P_{ss}^e}$ to obtain

$$\gamma \hat{L}_t = -\gamma \hat{W}_t + (1-n)\hat{y}_t^F + n\hat{y}_t^H + (\gamma - 1)\hat{y}_t^H + \gamma \hat{P}_t \tag{24}$$

Further make explicit $\hat{L}_t + \hat{W}_t$ in (24) and substitute it with $\frac{\hat{y}_t^H}{\phi} - \hat{A}_t + \hat{P}_t^e - e^{-1}e_u du_t$ from (14) to obtain

$$\hat{P}_t = \hat{P}_t^e - \hat{A}_t - e^{-1}e_u du_t - \frac{(1-n)}{\gamma}\hat{y}_t^F - \frac{n}{\gamma}\hat{y}_t^H - \frac{(\gamma-1)}{\gamma}\hat{y}_t^H + \frac{\hat{y}_t^H}{\phi} \tag{25}$$

Combine equations (11) , (12)and (14) to obtain

$$\hat{y}_t^H = \phi \hat{A}_t + \phi \left[\frac{e_u - e_{Wu}\zeta}{e_{WW}\zeta^2} - \frac{(1 - e^{-1}e_u s_L)}{s_L} \right] du_t \tag{26}$$

Substitute (26) into (25) to obtain (18).