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No. 1904 | January 2014

Web: www.ifw-kiel.de

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Abstract:
This paper extends the efficiency wages/partially adaptive expectations Phillips curve, otherwise known as the 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). The theoretical results are a priori ambiguous. However, in the first place, on resorting to plausible numerical simulations, economic openness increases the reactiveness of inflation to the unemployment rate. In regard to a monetary union, the national unemployment multiplier in the aggregate Phillips curve decreases with the weight of the member state in aggregate employment and increases with that in output. Secondly, we show in two empirical applications that our calibration can provide informative priors for models to be estimated thanks to the Kalman filter.

Keywords: efficiency wages, unemployment, Phillips curve, inflation, adaptive expectations, Kalman filter.

JEL classification: E3, E20, E40, E50, F15, F41, C22, C26.

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1 Introduction

In recent years, the advance of globalization has heightened economists' interest in the effect of trade openness and capital mobility on the slope of the Phillips curve.

Our aim is to shed further light on this issue. Building on Campbell (2006, 2008a and 2008b), Campbell (2010a) has recently proposed a derivation of the Phillips curve alternative to the New-Keynesian and sticky information ones by adopting an efficiency wages model with imperfect information. This Phillips curve was named the price-price Phillips curve.[1] Our first purpose is to extend this model from a closed economy context to an open economy one with both commodity trade and capital mobility. Therefore, this paper relates to Campbell (2010a) as Razin and Yuen (2002) relates to Woodford (2003), which focused on the New-Keynesian Phillips curve.

In order to accomplish this task we insert Campbell's model into 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 explanation for the existence of a Phillips curve and how it is affected by opening the trade and capital accounts. These mechanisms are discussed below. Part of the originality of our analysis, therefore, consists in bringing together research streams that have to date proceeded separately.

Moreover, we consider the case of a country (or otherwise a monetary union) composed of two regions (member states) and we derive the Phillips curve under these assumptions as well. Considering a monetary union is interesting because it can be regarded as a limit case of economic integration of different open economies, as also argued by Guiso et al. (2004) in a different

[1] Also to distinguish it from the wage-wage Phillips curve proposed by Campbell (2010a) as well. In this further model, it is wage and not price inflation that is connected to unemployment within an efficiency wages/imperfect information framework.

context. Our purpose here is to understand whether the larger a region is, the greater its weight in the aggregate Phillips curve.

In general we find that the theoretical results are *a priori* ambiguous. However, on adopting parameter values that can be plausible for different countries, we always find that the reactiveness of inflation to unemployment increases with openness. Furthermore, in a monetary union, the Phillips curve unemployment multiplier of a country increases with its share in aggregate long-run output and decreases with its long-run employment share.[2] Last but not least, we propose an alternative and simpler procedure with which to derive the price-price Phillips curve, and we offer a new calibration strategy based on empirical estimates of Okun's Law. Finally, we show that our calibration can furnish guidance for empirical model building and economic policy-making, as testified by two empirical applications making use of the Kalman filter at the end of this work.

In general, our paper is part of a broad research effort aiming to gain better understanding of the connection between unemployment and the business cycle, an unexplored issue in standard New-Keynesian sticky prices/wages models (Blanchard and Galì, 2010). In particular, we contribute to a substream of literature nesting efficiency wages within New-Keynesian models, as in Danthine and Kurmann (2004, 2010), Alexopoulos (2004, 2006, 2007) and Vaona (2013a, b).

The present work - as far as our monetary union model is concerned - is tangential to the stream of literature originated by Benigno (2004), Beetsma and Jensen (2005) and Lombardo (2006), whose main purpose, however, is not to explain the slope of the Phillips curve, bur rather to study the conduct of monetary and fiscal policies in a currency union under different assumptions regarding the economic structure of the member states.

In regard to small open economy issues, our research is motivated by past

[2] We identify the long-run structural values with steady state ones as done for instance by Aghion and Howitt (1998, p. 9).

mixed results at both the theoretical and empirical levels. Daniels and VanHoose (2009, 2013) 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 policy-making resulting from negative terms-of-trade effects of domestic output expansions. The second contribution stressed that inflation surprises can produce smaller output gains when 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 on opening the trade account.

Since Lane (1997), imperfect competition and price/wage stickiness have been key ingredients of models intended 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, 2013), Loungani, Razin and Yuen (2001), Razin and Yuen (2002) and Razin and Loungani (2005). These models have often produced a negative connection between economic openness and the slope of the Phillips curve. This result is reconciled with the stylized fact that globalization has reduced inflation by arguing that it has also changed the behavior of central banks by increasing the weight of inflation on policy-makers' loss function. In a similar way, according to Gruben and McLeod (2002, 2004), the greater capital mobility is, 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 slope of the Phillips curve. Following this contribution, Daniels et al. (2005) and Daniels and VanHoose (2009) found that trade openness has a positive coefficient in a regression explaining the sacrifice ratio in 58 dis-inflationary periods in various OECD countries from 1960 through the 1980s, on including an interaction term between it and central bank independence (CBI). Note that these authors use the term "sacrifice ratio" as a synonym for the inverse of the slope of the Phillips curve.[3] In what follows, we too will employ this expression. Studying a sample of 91 countries from 1985 to 2004, Badinger (2009) provided empirical support for the reasoning underlying Daniels and VanHoose (2006) and Razin and Loungani (2005), but not when focusing on OECD countries only.

This debate has been marked by the presence of skeptical contributions as well. Terra (1998) and Bleaney (1999) suggested that the trade openness-inflation relationship is respectively illusory and unstable across time. Ball (2006) questioned the existence of any link at all between economic openness, on the one hand, 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 are more committed to low inflation in more open economies, on dropping the small economy assumption and defining increasing openness as either a fall of trade costs or a decrease in monopoly power.

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 taken up by the present paper.

The rest of this paper is structured as follows. First, the model is intro-

[3] From an empirical point of view, the sacrifice ratio is defined, after Ball (1994), as the ratio of the sum of the differences between trend output and actual output in logs, at the numerator, and the change in trend inflation during a disinflationary period, at the denominator. This variable - considering the differential between actual and potential output - is also interesting for short-run analyses. This is not so for the variable adopted in Bowdler (2009) and Daniels and Van Hoose (2013) where reductions in trend output are considered. The former study 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. In the latter study 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. However, these results, given their long-run nature, cannot be considered as directly relevant to our analysis, which is concerned with the short-run.

duced. Thereafter, the trade account of the economy is opened, followed by the capital one. We then consider a monetary union and offer some numerical results. We next show that our calibrated models can offer informative priors when analyzing the cases of Denmark and the Eurozone thanks to the Kalman filter, which is able to keep track of changes in the slope of the Phillips curve. The last section summarizes our findings and reflects on the research and policy implications of our work. 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 that the domestic economy is populated by a continuum of households normalized to n, each composed of 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

$$\begin{aligned} c_{t+i}\left(h\right) &= \frac{W_{t+i}\left(h\right)}{P_{t+i}} L_{t+i}(h) + \frac{T_{t+i}\left(h\right)}{P_{t+i}} - \frac{M_{t+i}\left(h\right)}{P_{t+i}} + \frac{M_{t+i-1}\left(h\right)}{P_{t+i}} + \pi_{t+i}\left(h\right) - \\ &\quad - \frac{B_{t+i}(h)}{P_{t+i}} + \frac{B_{t+i-1}(h)}{P_{t+i}}\left(1+i_{t+i-1}\right) - \frac{\epsilon_{t+i} B^*_{t+i}(h)}{P_{t+i}} + f_{t+i-1,t+i} \frac{B^*_{t+i-1}(h)}{P_{t+i}}\left(1+i^*_{t+i-1}\right) \end{aligned} \tag{2}$$

where β is the discount factor, E is the expectation operator, U is the utility function, $c_{t+i}(h)$ is consumption by household h at time $t+i$, $B_{t+i}(h)$ are the household's domestic bond holdings, i_{t+i} is the nominal domestic interest rate, $L_{t+i}(h)$ is the fraction of employed individuals within the household, $G[e_{t+i}(h)]$ is the dis-utility 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. $W_{t+i}(h)$ and $T_{t+i}(h)$ are the household's nominal wage income and government transfers respectively. $\pi_{t+i}(h)$ is the household's 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 $t+i$. 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 of time - and some others are unemployed. The fraction of the unemployed is the same across all the families, so that their ex-post homogeneity is preserved.

Note that, as in Danthine and Kurmann (2004), in our model no utility arises from leisure.[4] Therefore individual agents inelastically supply one unit of time for either work- or unemployment-related activities.[5]

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

$$G[e_{t+i}(h)] = \left\{ e_{t+i}(h) - \tilde{e}\left[\frac{W_{t+i}(h)}{P^e_{t+i}}, u_{t+i}(h) \right] \right\}^2 \tag{3}$$

[4] $L_{t+i}(h)$ is the fraction of employed individuals within household h, not the working time of an individual agent.

[5] 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.

where P^e_{t+i} are price expectations, $u_{t+i}(h) = 1 - L_{t+i}(h)$ is the unemployment rate within household h and $\tilde{e}\left[\frac{W_{t+i}(h)}{P^e_{t+i}}, u_{t+i}(h)\right]$ is an efficiency function with $\tilde{e}_W > 0$, $\tilde{e}_u > 0$, $\tilde{e}_{WW} < 0, \tilde{e}_{Wu} < 0$. (3) implies that households face a trade off. A higher level of effort reduces their utility, but, as customary in many efficiency wages model, increasing either $\frac{W_{t+i}(h)}{P^e_{t+i}}$ or $u_{t+i}(h)$ offers more motivation to exert effort.

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

$$G'\left[e_{t+i}(h)\right] = 0 \tag{4}$$

and, therefore,

$$e_{t+i}(h) = \tilde{e}\left[\frac{W_{t+i}(h)}{P^e_{t+i}}, u_{t+i}(h)\right] \tag{5}$$

As argued by Campbell (2010a), the reason for inserting price expectations in the effort function is that workers - primarily concerned with outside options for their jobs - can use price inflation as a proxy to predict wage changes at other firms, given that wage inflation and price inflation tend to be connected and price inflation data are more publicized than wage inflation data.

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 the 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):

$$\frac{M_{t+i}(h)}{P_{t+i}} = c_{t+i}(h)\left(\frac{1+i_{t+i}}{i_{t+i}}\right)b \tag{6}$$

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.[6]

2.2 The final and the intermediate product markets

As is customary in the New-Keynesian literature (see for instance Edge, 2002, p. 571-72; Walsh, 2003, p. 217-218) 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).

As in 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

$$y_t^H(j) = Y_t^W\left[\frac{p_t^H(j)}{P_t}\right]^{-\gamma} \tag{7}$$

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 (7). 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

[6] Equation (6) does not imply rational expectations. To obtain this equation, one only has to leave unspecified the expectation operator in the first order conditions for bond and money holdings.

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

$$y_t^H = A_t^\phi L_t^\phi \left[\tilde{e}\left(\frac{W_t}{P_t^e}, u_t\right)\right]^\phi \tag{8}$$

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

$$\max_{\{L_t, W_t\}} \left(Y_t^W\right)^{\frac{1}{\gamma}} \left\{A_t^\phi L_t^\phi \left[\tilde{e}\left(\frac{W_t}{P_t^e}, u_t\right)\right]^\phi\right\}^{\frac{\gamma-1}{\gamma}} P_t - W_t L_t \tag{9}$$

The first order condition with respect to L_t yields labour demand

$$\begin{aligned} L_t &= W_t^{\frac{\gamma}{\phi(\gamma-1)-\gamma}} \left[\frac{\phi(\gamma-1)}{\gamma}\right]^{-\frac{\gamma}{\phi(\gamma-1)-\gamma}} \left(Y_t^W\right)^{-\frac{1}{\phi(\gamma-1)-\gamma}} A_t^{-\frac{\phi(\gamma-1)}{\phi(\gamma-1)-\gamma}} \cdot \\ &\cdot \left[\tilde{e}\left(\frac{W_t}{P_t^e}, u_t\right)\right]^{-\frac{\phi(\gamma-1)}{\phi(\gamma-1)-\gamma}} P_t^{-\frac{\gamma}{\phi(\gamma-1)-\gamma}} \end{aligned} \tag{10}$$

Taking the first order condition with respect to W_t and substituting it into (10), one obtains the following condition

$$W_t \left[\tilde{e}\left(\frac{W_t}{P_t^e}, u_t\right)\right]^{-1} \tilde{e}_W\left(\frac{W_t}{P_t^e}, u_t\right) \frac{1}{P_t^e} = 1 \tag{11}$$

At this stage, we are ready to linearize equations (6), (10) (11), $u_t = 1 - L_t$ and the production function of monopolistically competitive firms around the steady state so as to obtain the following system of equations

$$
\begin{aligned}
\left[\phi(\gamma-1)-\gamma\right]\hat{L}_t &= \gamma\hat{W}_t-\hat{Y}_t^W-\phi(\gamma-1)\hat{A}_t- \\
&\quad -\phi(\gamma-1)\tilde{e}^{-1}\begin{bmatrix} \tilde{e}_W\frac{W_{ss}}{P_{ss}^e}\hat{W}_t \\ -\tilde{e}_W\frac{W_{ss}}{P_{ss}^e}\hat{P}_t^e+\tilde{e}_u du_t \end{bmatrix}-\gamma\hat{P}_t && (12)\\
du_t &= -s_L\hat{L}_t && (13)\\
\hat{W}_t &= \hat{P}_t^e+\frac{e_u-e_{Wu}\zeta}{e_{WW}\zeta^2}du_t && (14)\\
\hat{P}_t &= \hat{M}_t-\hat{c}_t+\delta\hat{\imath}_t && (15)\\
\hat{y}_t^H &= \phi\hat{A}_t+\phi\hat{L}_t+\phi\hat{W}_t-\phi\hat{P}_t^e-\phi e^{-1}e_u s_L\hat{L}_t && (16)
\end{aligned}
$$

where variables with hats denote percentage deviations from steady state values, s_L is the steady state employment rate, du_t is the absolute deviation of the unemployment rate from steady state at time t, 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 $\tilde{e}\tilde{e}_W^{-1}=\frac{W_{ss}}{P_{ss}^e}=\zeta$.[7] Note that (13) is our counterpart of equation (17) in Campbell (2010a). They are different given that - as explained above - 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 $\hat{\mathcal{M}}_t=\hat{M}_t+\delta\hat{\imath}_t$. On setting the short-run elasticity of labor supply to zero and imposing $\zeta=1$, the system (12)-(16) 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

$$
\hat{P}_t=\hat{P}_t^e-\phi\hat{A}_t-\frac{(1-\phi)\left[\tilde{e}_{WW}\zeta^2-s_L\left(\tilde{e}_u-\tilde{e}_{Wu}\zeta\right)\right]+\phi\tilde{e}^{-1}\tilde{e}_u s_L\tilde{e}_{WW}\zeta^2}{s_L\tilde{e}_{WW}\zeta^2}du_t \tag{17}
$$

[7] We assume $\frac{W_s}{P_s^e}=\zeta$ as in Campbell (2011a). This implies a difference between equation (14) and its counterpart in Campbell (2010a). We thank Carl M. Campbell for pointing this out.

We assume with Campbell (2010a, b) that P_t^e is a mixture of rational and adaptive expectations[8], 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 this basis, one can derive from (17) a price-price Phillips curve whose slope is a multiple of the coefficient of absolute deviations of the unemployment rate from steady state in (17) :

$$\begin{aligned} \hat{P}_t - \hat{P}_{t-1} &= -\frac{(1-\phi)\left[\tilde{e}_{WW}\zeta^2 - s_L\left(\tilde{e}_u - \tilde{e}_{Wu}\zeta\right)\right] + \phi\tilde{e}^{-1}\tilde{e}_u s_L \tilde{e}_{WW}\zeta^2}{(1-\omega)\, s_L \tilde{e}_{WW}\zeta^2} du_t + \\ &+ \sum_{i=1}^{T} \frac{\lambda_i}{(1-\omega)} \left(\hat{P}_{t-i} - \hat{P}_{t-i-1} \right) - \frac{\phi}{(1-\omega)} \hat{A}_t \end{aligned} \tag{18}$$

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

3 Opening the trade account

On 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 this basis, the Appendix shows that one can follow a procedure similar to but less

[8] The reasons for not simply assuming either rational or adaptive expectations are reviewed in Campbell (2011b). Many studies have found that expectations are neither completely rational (Evans and Gulamani, 1984; Batchelor and Dua, 1989; Roberts, 1997; Thomas, 1999; Mankiw, Reis and Wolfers, 2003) nor purely adapative (Mullineaux, 1980; Gramlich, 1983; Baghestani and Noori, 1988). The results obtained by Fuhrer (1997) and Roberts (1998) support a mixture of rational and adaptive expectations.

complicated than Campbell (2010b) to obtain the equation below

$$\begin{aligned} \hat{P}_t &= \hat{P}_t^e - \left(\frac{1-n}{\gamma}\right)\left(\hat{y}_t^F - \hat{y}_t^H\right) - \phi\hat{A}_t - \\ &- \frac{(1-\phi)\left[\tilde{e}_{WW}\zeta^2 - s_L\left(\tilde{e}_u - \tilde{e}_{Wu}\zeta\right)\right] + \phi\tilde{e}^{-1}\tilde{e}_u s_L \tilde{e}_{WW}\zeta^2}{s_L\tilde{e}_{WW}\zeta^2} du_t \end{aligned} \tag{19}$$

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 (7) and its counterpart for $\hat{y}_t^F$. Hence this term accounts for changes in the terms of trade. Although 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. Hence, differently to Razin and Yuen (2002), in whose 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 (13) and (14) into (16) to obtain

$$\hat{y}_t^H = \phi\hat{A}_t + \phi\left[\frac{e_u - e_{Wu}\zeta}{e_{WW}\zeta^2} - \frac{\left(1 - e^{-1}e_u s_L\right)}{s_L}\right] du_t \tag{20}$$

which in its turn can be substituted into (19) to obtain a new version of equation (17)

$$\begin{aligned} \hat{P}_t &= \hat{P}_t^e - \left(\frac{1-n}{\gamma}\right)\hat{y}_t^F + \phi\left(\frac{1-n}{\gamma} - 1\right)\hat{A}_t - \\ &- \frac{\left[1 - \left(1 - \frac{1-n}{\gamma}\right)\phi\right]\left[e_{WW}\zeta^2 - s_L\left(e_u - e_{Wu}\zeta\right)\right] + \phi\left[1 - \left(\frac{1-n}{\gamma}\right)\right]e^{-1}e_u s_L e_{WW}\zeta^2}{s_L e_{WW}\zeta^2} du_t \end{aligned} \tag{21}$$

Note that for $n = 1$, (19) and (21) coincide with (17). The difference between (21) and (17) consists in both the unemployment rate multiplier and the presence of an additional shifter, namely the deviation of foreign output from steady state. (21) implies that the Phillips curve changes to

$$\hat{P}_t - \hat{P}_{t-1} = \sum_{i=1}^{T} \frac{\lambda_i}{(1-\omega)} \left(\hat{P}_{t-i} - \hat{P}_{t-i-1}\right) - \frac{1-n}{\gamma(1-\omega)} \hat{y}_t^F + \frac{\phi}{(1-\omega)} \left(\frac{1-n}{\gamma} - 1\right) \hat{A}_t - \tag{22}$$

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

An increase in foreign output moves the Phillips curve downwards because it produces an increase in labour demand via (12) and therefore a decline in unemployment through (13).

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 followed by an increase in the employment rate and a decrease in the unemployment rate via (12) and (13) 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 (20) can be either positive or negative, because a lower unemployment rate means a greater labour input but also less effort. Hence a decrease in the unemployment rate can be associated with either an increase or a decrease in output, which then can either reinforce or dampen the initial change in the price level. To summarize

$$P_t \uparrow \rightarrow \frac{W_t}{P_t} \downarrow \rightarrow L_t \uparrow \rightarrow u_t \downarrow \rightarrow \begin{cases} y_t \uparrow \rightarrow P_t \downarrow : \text{input effect} \\ y_t \downarrow \rightarrow P_t \uparrow : \text{effort effect} \end{cases}$$

However, as shown by Campbell (2010a), the slope of the Phillips curve is, in the end, *a priori* negative, given the above sign restrictions. Hence the effort effect of unemployment on output and, therefore, on prices, even if present, will not be of such a magnitude as 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 affects the demand for domestic output as implied by (7), 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 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 (21) and (17) holds

$$\frac{[1-\Gamma\phi]\left[e_{WW}\zeta^2 - s_L\left(e_u - e_{Wu}\zeta\right)\right] + \phi\left[\Gamma\right]e^{-1}e_u s_L e_{WW}\zeta^2}{s_L e_{WW}\zeta^2} > \\ > \frac{(1-\phi)\left[e_{WW}\zeta^2 - s_L\left(e_u - e_{Wu}\zeta\right)\right] + \phi e^{-1}e_u s_L e_{WW}\zeta^2}{s_L e_{WW}\zeta^2} \tag{23}$$

where

$$\Gamma \equiv \left(1 - \frac{1-n}{\gamma}\right) < 1 \tag{24}$$

For (23) to hold, it should be that

$$e^{-1}e_u s_L e_{WW}\zeta^2 - \left[e_{WW}\zeta^2 - s_L\left(e_u - e_{Wu}\zeta\right)\right]\Gamma < e^{-1}e_u s_L e_{WW}\zeta^2 - \left[e_{WW}\zeta^2 - s_L\left(e_u - e_{Wu}\zeta\right)\right] \tag{25}$$

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 (24) and (25) 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.[9] As a result, consumption smoothing can be achieved and $\hat{c}_t = 0$. Therefore, (15) turns out to be $\hat{P}_t = \hat{M}_t + \delta\hat{\imath}_t$. Under these assumptions, by following a very similar procedure to that set out in the Appendix, it is possible to show that (19) 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 either labour demand or the substitutability of domestic and foreign output. In order to see the former point, consider the linearized labour demand with trade openness

$$\gamma\hat{L}_t = \left(\hat{y}_t^F - \hat{y}_t^H\right)(1-n) + \gamma\left[\hat{M}_t + \delta\hat{\imath}_t - (1-n)\left(\hat{p}_t^H - \hat{\epsilon}_t - \hat{p}_t^F\right)\right] - \gamma\hat{W}_t \tag{26}$$

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

$$\gamma\hat{L}_t = \gamma\left[\hat{P}_t + (1-n)\left(\hat{p}_t^H - \hat{\epsilon}_t - \hat{p}_t^F\right) + \hat{Y}_t^H\right] - \gamma\hat{W}_t \tag{27}$$

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

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

[9] This is also consistent with Obstfeld and Rogoff (1996, Chapter 1).

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 again obtains (27).[10]

5 A monetary union

We now consider the case of two regions (member states) within a country (monetary union), which have two segmented labour markets with different effort functions, leading to different unemployment rates and real wages. We further suppose that markets for the final product, bonds and money are perfectly integrated. No migration is possible - a sensible assumption in the short run. 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-household transfers, playing a similar role to intra-national remittances, ensure that consumption is the same in both regions, notwithstanding the heterogeneity characterizing the labour market. Note that $\epsilon_t = 1$.

This assumption is not so implausible for the following reasons. If one focuses on OECD countries and considers the standard deviation of logged households' final consumption expenditure per head in PPP adjusted constant 2005 international dollars, one finds that in 2011 it was equal to 0.14 for EMU member states and to 0.35 for the other countries. Therefore, per capita consumption displays much less variation in the former group of countries than in the latter one. Furthermore, intra-household transfers play the role of a risk-sharing mechanism, one of the features of an optimal currency area, and they allow us to focus on the labour market structure, which is the main focus of our paper.

As above, firms located in the two regions are symmetric within the region and they are specialized in goods that are imperfect substitutes. The total

[10] This result of ours is broadly consistent with empircal findings by Çenesiz and Pierdzioch (2010), who showed that capital mobility has small effects on labour market magnitudes.

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

$$\hat{L}_t^A = \frac{(\gamma-1)\hat{y}_t^A + s^A\hat{y}_t^A + s^B\hat{y}_t^B}{\gamma} + \hat{P}_t - \hat{W}_t^A \tag{28}$$

$$\hat{L}_t^B = \frac{(\gamma-1)\hat{y}_t^B + s^A\hat{y}_t^A + s^B\hat{y}_t^B}{\gamma} + \hat{P}_t - \hat{W}_t^B \tag{29}$$

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 above labour demands 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

$$\begin{aligned}\hat{P}_t - \hat{P}_{t-1} = {} & \sum_{i=1}^{T} \frac{\lambda_i}{(1-\omega)}\left(\hat{P}_{t-i} - \hat{P}_{t-i-1}\right) - \left[\frac{l^A(\gamma-1) + s^A}{(1-\omega)\,\gamma}\right]\phi\hat{A}_t^A + \\ & + \left[\frac{(1-n)\,l^B(\gamma-1) + s^B}{(1-\omega)\,\gamma}\right]\phi\hat{A}_t^B + \\ & + \frac{1}{(1-\omega)}\left[l^A\left(\eta^A - e^{A^{-1}}e_u^A - \frac{[(\gamma-1)]\,\phi\eta^A}{\gamma}\right) - \frac{s^A\phi\eta^A}{\gamma}\right]du_t^A + \\ & + \frac{1}{(1-\omega)}\left[l^B\left(\eta^B - e^{B^{-1}}e_u^B - \frac{[(\gamma-1)]\,\phi\eta^B}{\gamma}\right) - \frac{s^B\phi\eta^B}{\gamma}\right]du_t^B\end{aligned} \tag{30}$$

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 this basis, 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 may 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 obtained by adopting the four calibrations for the effort function proposed by Campbell (2006). γ was, instead, set equal to 10 following e.g. 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 that we attached to the parameters and our results. We only consider the parameters that are relevant to computing the sacrifice ratio and the connection between output and unemployment deviations from steady state. In all our simulations, economic openness increased the reactiveness of inflation to unemployment, reducing the sacrifice ratio. This can be explained by resorting again to the example of an exogenous increase in the price level, though for illustrative purposes only.

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

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

Table 1 also shows that calibration is very important for the present model. Under the present approach, the effort function is theoretically flexible, but highly parametrized. Small changes in the parameter constellation can produce sizeable changes in the sacrifice ratio, more sizeable than economic openness itself. However, this can hardly be considered a shortcoming of the model as it can be well adapted to different countries. One strategy for doing so is to consider the connection between output and unemployment changes - such as in (20) - which is empirically captured by Okun's Law. According to Sögner and Stiassny (2010), the coefficient in Okun's Law can differ across countries. Thus, for instance, Calibration 4 could well suit Norway and Sweden, Calibration 2 Denmark, and Calibration 3 the Netherlands.

Proposition 4 *For plausible parameter values, openness increases the reactiveness of inflation to unemployment in the price-price Phillips curve.*

In regard to the monetary union model sketched above, let us maintain the assumption of a negative link between unemployment and output, as in Okun's Law, 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 $\frac{1}{(1-\omega)}\left\{\left[1-\frac{(\gamma-1)\phi}{\gamma}\right]\eta^j - \left(e^j\right)^{-1} e_u^j\right\}$ and $-\frac{\phi\eta^j}{\gamma}\frac{1}{(1-\omega)}$ respectively. This entails that the unemployment multiplier of a region/member state will increase with its steady state share of output and decrease with its steady state share of employment.

Proposition 5 *For plausible parameter values, in a monetary union (a country) the unemployment multiplier of a country (region) decreases with its steady state share of employment and increases with its steady state share of output.*

7 Empirical applications

In this section, we describe two applications that show the empirical relevance of our theoretical analysis above. This is particularly important because, for sake of simplicity, the above models do not consider certain phenomena that could in fact contribute to shaping the observed Phillips curve: such as, for instance, structural change, possible reactions of the central bank, or the fact that globalization has most often affected economies that were already open. In other words, progressively moving from a fully closed economy, opening first the trade account and, finally, the capital account is a useful theoretical research strategy but something that seldom happens in reality. Furthermore, as discussed in the Introduction, a part of the relevant literature has found that economic openness reduces the unemployment multiplier in the Phillips curve, while we find the opposite. For all the above reasons, we show that our results and calibrations can stand the test of the data.

We used the Kalman filter and we focused on exploiting time variation in the data. The Kalman filter is a well-known econometric technique able to update priors on parameter values when analyzing a data set (Hamilton, 1994, p. 372-408). We analyzed two cases, a small open economy - Denmark - and the Euro area - partitioning it into a Northern and a Southern part as is often done in the contemporary macroeconomic debate (De Grauwe, 2011; Honkapohja, 2013; Gibson et al., 2013).

7.1 The case of Denmark

For Denmark we considered quarterly data from 1983Q2 to 2013Q2. We focused on equation (22). We measured $\hat{P}_t$ as the percentage deviation of the CPI index from its long-run value, as computed by either the Hodrick-Prescott or the Band-Pass filter in its Baxter-King fixed length symmetric version. In the latter case, we used 12 lags and leads to compute the implied weighted moving average. We tried different filtering techniques because it is well known that results can be sensitive to them (Canova, 1998). Regarding $\hat{y}_t^F$, we first took the sum of the real GDP in millions of US dollars of the OECD reference year of all OECD countries but Denmark and, then, we proceeded in a similar way to $\hat{P}_t$ in order to obtain percentage deviations from long-run values. du_t was measured by using a first difference filter on the unemployment rate at time t. $\hat{A}_t$ was treated as an exogenous shock. According to our previous analysis, the unemployment multiplier was taken to be a function of trade openness (TO_t) - measured by the ratio of the sum of imports and exports over GDP, all in current prices - and openness of the capital account (KO_t). In order to measure this latter variable, we built a dummy on the basis of the the updated version of the Chinn and Ito (2008) index, which measures the extensiveness of capital controls based on IMF information. The dummy variable assumed a value equal to 1 when the Chinn and Ito index for Denmark reached a value equal to the US one and zero otherwise. We used OECD data for all our variables except the Chinn and

Ito index, which can be downloaded from http://web.pdx.edu/~ito/Chinn-Ito_website.htm. We show our variables in Figure 1, with the exception of KO_t which assumes a value of 1 for $t \geq 1992Q1$ and 0 otherwise.

(Insert Figure 1 about here)

In brief our empirical model was

$$\hat{P}_t - \hat{P}_{t-1} = c_1 \left(\hat{P}_{t-1} - \hat{P}_{t-2} \right) + c_2 \hat{y}_t^F + \xi_t du_t + v_{1,t} \tag{31}$$

$$\xi_t = c_4 TO_t + c_5 KO_t + c_6 + v_{2,t} \tag{32}$$

where $v_{1,t}$ and $v_{2,t}$ are zero means stochastic errors with variances $\exp(c_3)$ and $\exp(c_7)$ respectively, c_i for $i = 1, ..., 7$ are parameters to be estimated and ξ_t is a time varying parameter (our state variable). On the basis of our theoretical analysis and of the parameter values set out in Table 1, we could use some priors regarding c_2, c_4, c_5, c_6. In particular, on the basis of the empirical evidence available in the literature, we noticed that Calibration 2 could well suit Denmark. So, given also (22), we set our priors for c_2 and c_6 respectively equal to -0.18 and -2.5 (in the latter case the inverse of the sacrifice ratio of an already open economy). Regarding c_4, we started with a value equal to -0.33, which is the difference between the unemployment multiplier of a closed and an open economy in Calibration 2 of Table 1. In other words, we made the preliminary assumption that passing from a closed to an open economy has an effect similar to an increase in trade openness in an already open economy. Finally we set $c_5 = 0$, on the basis our Proposition 2. Note that we did not test for the order of integration of the variables under study, because the Kalman filter is a technique suitable for both stationary and non-stationary data (Pedregal and Young, 2002).

The Marquardt optimization algorithm converged after one iteration yielding the parameter values set out in Table 2.

Table 2 - Kalman filter estimates of equations (31)-(32)

Coefficient	Point estimates	P-values
c_1	0.794	0.0000
c_2	-0.179	0.0000
c_3	-14.272	0.0000
c_4	-0.330	0.0000
c_5	-0.000	0.8539
c_6	-2.499	0.0000
c_7	-13.130	0.0000

	Final state	P-value
ξ_t	-2.842	0.0000

Note: parameter estimates are based on variables obtained by the band-pass filter. Using the HP filter would produce almost identical results. Further details are available from the author upon request.

We project the one-step ahead prediction of ξ_t in Figure 2. As can be seen, as the Danish economy progressively opened up to trade, the predicted unemployment multiplier became more negative; that is, it increased in absolute value.

(Figure 2 about here)

7.2 The case of the Euro area

In this subsection we deal with the case of the dichotomy between Northern and Southern countries in the Euro area. Though both the journalistic and academic debates often make reference to this distinction, most studies do not offer a complete partition of the monetary union. The cases of a selected number of countries are instead considered. There is no shared view about exactly which countries should be the "North" and which ones the "South".

In order to split the Euro area into two parts, we considered the S&P credit ratings in November 2013. We included in the North countries with at least A- and in the South countries with lower grades. Therefore, we defined the "Northern" Euro area as composed of Austria, Finland, Germany, the Netherlands, Belgium, Estonia, Luxembourg, Slovakia, Slovenia and France. Greece, Ireland, Portugal, Spain, Italy, Cyprus and Malta were the "South" (though, *per se*, Ireland is of course not a Mediterranean country).

Our aim was to bring to the data equation (30). Therefore, our starting empirical model, on considering $\hat{A}_t$ as an exogenous shock, was

$$\hat{P}_t - \hat{P}_{t-1} = c_1 \left(\hat{P}_{t-1} - \hat{P}_{t-2}\right) + \xi_{N,t} du_t^N + \xi_{S,t} du_t^S + v_{1,t} \tag{33}$$

$$\xi_{N,t} = c_3 l_t^N + c_4 s_t^N + v_{N,t} \tag{34}$$

$$\xi_{S,t} = c_6 l_t^S + c_7 s_t^S + v_{S,t} \tag{35}$$

where $v_{1,t}$, $v_{N,t}$ and $v_{S,t}$ are zero mean stochastic errors with variances $\exp(c_2)$, $\exp(c_5)$ and $\exp(c_8)$ respectively and c_i for $i = 1, ..., 8$ are parameters to be estimated. $\xi_{N,t}$ and $\xi_{S,t}$ are our state variables. N and S stand for "North" and "South" respectively.

In this case, for $\hat{P}_t$, we considered quarterly data on the HCPI for the Euro area, the source being the European Central Bank. From the same source, we collected data for the unemployment rates and levels of the country members of the monetary union. From these data, it was possible to derive information about the labour force and employment and then carry out calculations to obtain du_t^j, l_t^j and s_t^j for $j = N, S$. Our period of observation was from 2000Q1 to 2013Q2. For the rest, regarding $\hat{P}_t$ and du_t^j with $j = N, S$ we proceeded as in the Danish case.

Recall that $s^j = \frac{n\left(Y_{ss}^j\right)^\gamma}{n\left(Y_{ss}^j\right)^\gamma + (1-n)(Y_{ss}^i)^\gamma}$, $l^j = \frac{nL_{ss}^j}{nL_{ss}^j + (1-n)L_{ss}^i}$ with $j = N, S$, $i = N, S$ and $i \neq j$. We proxied n, the number of firms, as follows. First we computed the average number of self-employed over the period of observation for each member of the Euro area, and we then took the share of Northern countries in the total average number of the self-employed - the source being Eurostat. Unfortunately, data on business demography are still too sparse to be helpful for our estimates. To obtain the long-run values of the variables involved in s^j and l^j for $j = N, S$ we adopted both the HP and the Band Pass filters, as in the Danish case. γ was taken from Table 1.

Note that s_t^N turned out to have an average of 0.998, a maximum value of 0.999 and a minimum value of 0.997. This is because its underlying transformation boosts the weight of Northern countries. The other variables are shown in Figures 3 and 4. As will be seen, while $\Delta\hat{P}_t$ - where Δ is the first difference operator - did not exhibit any particular trend over the period of observation, the share in total employment of Northern Euro countries first shrank and than inflated, the turning point being in 2006Q1. This is mirrored by the series of the changes in the unemployment rate in the North and in the South, which experienced a clear cross-over around the same period.

(Insert Figures 3 and 4 about here)

In order to have priors for c_i for $i = 3, 4, 6, 7$ in equations (33)-(35), we first needed to estimate (20) for both the Northern and Southern Eurozone, so as to be able to initialize η^N and η^S. As a consequence, we also needed data about $\hat{y}_t^N$ and $\hat{y}_t^S$. Our starting point here was the real GDP of the two areas under analysis, obtained as the sum of those of the constituent countries as listed above. Our computing procedure was the same as the one used for OECD data in the case of Denmark. $\hat{y}_t^N$ and $\hat{y}_t^S$ tended to overlap for a good portion of our data set, with the exceptions of the earlier and the more recent quarters. In the former ones, the Southern Eurozone tended to experience larger positive deviations from trend output than the North, while in the latter period they tended to experience larger negative deviations.

(Insert Figure 5 about here)

To estimate (20) , we resorted to the two stage least squares approach, in order to take account of the possible endogeneity of du_t^j for $j = N, S$. We treated $\hat{A}_t$ as a stochastic error. For the North we had a coefficient of -7.09 with a p-value of 0.00. Given the calibration for ϕ in Table 1, this implied $\eta^N = -10.58$. The Durbin-Watson statistic was 1.89, signalling that residual autocorrelation hardly affected our estimate and inference. Instruments, including $\hat{y}_{t-1}^N$, du_{t-1}^N and du_{t-2}^N were supported by the J-statistic which returned a p-value of 0.34 and by a Cragg and Donald (1993) F-statistic of 18.47, well above the relevant 5% Stock and Yogo (2005) critical value for relative bias of 13.91. A Durbin-Wu-Hausman test for exogeneity rejected the null reporting a p-value of 0.01.[11]

For the South, we obtained a coefficient estimate of -2.65 with a p-value of 0.00, implying $\eta^S = -3.95$. The Durbin-Watson statistic was 2. A J-statistic of 0.01 with a p-value of 0.91 supported our instruments - du_{t-3}^S and du_{t-4}^S. Exogeneity was rejected by the Durbin-Wu-Hausman test, which returned a p-value of 0.01. The Cragg and Donald (1993) F-statistic was 13.29, above the rule of thumb value of 10 proposed by Staiger and Stock (1997). With two instruments, the Stock and Yogo (2005) critical values for relative bias are not available.

With the above values for η^N and η^S at hand, considering equation (30) and Table 1, we formulated priors for our Kalman filter estimates as follows: $c_3 = -2.47, c_4 = 0.35, c_6 = -0.82$ and $c_7 = 0.13$. Before moving to estimation, however, to be noted is that s_t^N and s_t^S vary little through time. Therefore, there was little chance of identifying c_4 and c_7. As a consequence, in our estimates we imposed the above relevant equalities as restrictions and we multiplied them by the average values of s_t^N and s_t^S. Consider also that c_6 is

[11] To facilitate the economic interpretation of our results, consider that unemployment rates were not multiplied by 100. Therefore, in the North a one point increase in the unemployment rate translates into a -0.07% deviation of output from its long-run value. In the South, this deviation is about -0.02%.

small. It therefore appeared sensible to multiply its value for the average of l_t^S and build a prior for a fixed coefficient for du_t^S, because the data features did not make it possible to track the evolution over time of the state variable $\xi_{S,t}$.

Table 3 - Kalman filter estimates of equations (36)-(37)

Coefficient	Point estimates	P-values
c_1	0.35	0.0000
c_2	-0.33	0.0000
c_3	-17.07	0.0000
c_4	-2.47	0.0000

	Final state
$\xi_{N,t}$	-1.147

Note: parameter estimates are based on variables obtained by the HP filter. We imposed the restriction $v_{N,t} = 0$. Using the Band-pass filter would have produced almost identical results. Further details are available from the author upon request.

After these considerations our new empirical model was

$$\hat{P}_t - \hat{P}_{t-1} = c_1 \left(\hat{P}_{t-1} - \hat{P}_{t-2} \right) + \xi_{N,t} du_t^N + c_2 du_t^S + v_{1,t} \quad (36)$$

$$\xi_{N,t} = c_4 l_t^N + 0.35 + v_{N,t} \quad (37)$$

with two priors $c_2 = -0.33$ and $c_4 = -2.47$. The Kalman filter yielded a point estimate of c_5 - the coefficient of the variance of $v_{N,t}$ - equal to -0.28 with a p-value of 0.30. Therefore we imposed the restriction $v_{N,t} = 0$. Our new estimates, obtained thanks to the Berndt-Hall-Hall-Hausman algorithm, converged in 1 iteration, and they are set out in Table 3.

Figure 6 shows one-step ahead estimates of $\xi_{N,t}$. The unemployment multiplier of the Northern Eurozone is greater than that of its Southern counterpart. Furthermore, although it decreased in the first half of our sample, it returned back close to its initial value in the second half of our period of observation. This entails that aggregate inflation in the Euro area is driven to a great extent by labour market conditions in Northern countries. As a consequence, Southern countries may experience large increases in their unemployment rates (and large welfare losses), before this has an impact on the aggregate inflation rate. This highlights the need either to consider further indicators when devising the Union's monetary policies - such as country level inflation and unemployment rates - or to strengthen policies of other kinds - such as regional, fiscal or industrial ones - able to offset welfare losses arising in the Southern Eurozone from tight control of the aggregate inflation rate.

(Insert Figure 6 about here)

8 Conclusions

The paper has extended the efficiency wages Phillips curve proposed by Campbell (2010a) from a closed economy setting to both a small open economy and a monetary union one, 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 the presence of price stickiness. We have shown 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 the absence of price stickiness. This is important because - as urged by important recent contributions mentioned in the Introduction - our model, differently to that of Razin and Yuen (2002), stressed in the Phillips curve the unemployment rate more than output deviations from its natural level.

In particular, we have shown 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. On 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 building on Campbell (2006), economic openness increased the magnitude of the unemployment coefficient in the price-price Phillips curve. However, the extent to which this happened depends on deep parameters. The ambiguity mentioned above and the variability of calibration outcomes should not be discarded as useless results. On the contrary, they may well be at the root of the contrasting results obtained by the empirical literature. In our view, we have offered theoretical arguments to maintain that the effect of globalization on the various countries and time periods may well depend on labour market features, which notoriously change over time and across countries. In fact, building on empirical results concerning Okun's Law, the model can be calibrated to better suit specific countries. Moreover, our calibrations have proved to be able to furnish informative priors to be used in empirical applications on using the Kalman filter.

One further implication of the above discussion is that empirical researchers in the field should control for the underlying diversity of countries. Pooling various countries within a panel model may not be the specification most suitable for investigating the issues at stake. Poolability tests are highly recommended (Baltagi, 2005, p. 57-62; for an application see Vaona, 2007).

Contrary to the available literature, our result that economic openness increases the unemployment coefficient prevents us from making any further assumptions regarding the reasons why inflation decreased as globalization deepened: for instance, arguing that the weight of inflation in central bankers' loss function increased, as mentioned in the Introduction. We have also offered further theoretical grounds for considering changes in the unemployment rate when modelling inflation dynamics (as in Stock and Watson, 1999). According to our results, this recommendation of ours applies especially to small open economies.

Upon considering a monetary union (a country) - on the basis of a negative link between output and unemployment, as in Okun's Law - the unemployment Phillips curve multiplier of a country (region) will decrease with its relative steady state weight in aggregate employment and increase with the one in output. This implies that when monetary authorities in currency unions focus only on aggregate inflation, they run the risk of imposing significant welfare losses on countries with relative fewer employees. This can offer guidance to central bankers. For instance, as far as the Euro zone is concerned, it is well known that, in several respects, the members' business cycles have not yet synchronized (Gouveia and Correia, 2013; Caraballo and Efthimiadis, 2012; Koronowski, 2009; Hughes Hallett and Richter, 2008). In these circumstances, our model implies that the ECB executive board should not focus only on Northern countries; it should also carefully consider unemployment developments in Southern ones, as also testified by our empirical results. In principle, similar research and police advice could be given to the Bank of England regarding Northern and Southern UK.

9 Acknowledgements

We wish to thank Carl M. Campbell and three anonymous referees for insightful comments. The usual disclaimer applies.

References

[1] Aghion P, Howitt P (1998) Endogenous growth theory. MIT Press, Cambridge (MA)

[2] Alexopoulos M (2004) Unemployment and the business cycle. J Monetary Econ 51: 277-298.

[3] Alexopoulos, M (2006) Shirking in a monetary business cycle model. Canadian J Econ 39: 689-718.

[4] Alexopoulos, M (2007) A monetary business cycle model with unemployment. J Econ Dynamics Control 31: 3904-3940.

[5] Badinger, H (2009) Globalization, the output-inflation trade-off and inflation. Eur Econ Rev 53: 888-907.

[6] Baghestani H, Noori E (1988) On the rationality of the Michigan monthly survey of inflationary expectations. Econ Let 27: 333-35.

[7] Ball L (1994) What Determines the Sacrifice Ratio? In: Mankiw G (ed) Monetary Policy. NBER, Cambridge (MA), pp 155-193

[8] Ball L (2006) Has globalization changed inflation? Working Paper 12687 NBER, Cambridge MA.

[9] Baltagi B H (2005) Econometric Analysis of Panel Data, 8th edn. Wiley, Chichester.

[10] Batchelor R A, Dua P (1989) Household versus Economist Forecasts of Inflation: A Reassessment. J Money, Credit, and Bank 21: 252-57.

[11] Beetsma R M W J, Jensen H (2005) Monetary and fiscal policy interactions in a micro-founded model of a monetary union. J Intern Econ 67: 320-352.

[12] Benigno P (2004) Optimal monetary policy in a currency area. J Int Econ 63: 293-320.

[13] Blanchard O, Galì J (2010) Labor Markets and Monetary Policy: A New Keynesian Model with Unemployment. Am Econ J Macroecon 2: 1-30.

[14] Bleaney M (1999) The disappearing openness-inflation relationship: a cross-country analysis of inflation rates. Working Paper WP/99/161, International Monetary Fund, Washington, DC.

[15] Bowdler C (2009) Openness, exchange rate regimes and the Phillips curve. J Int Money Finance 28: 148–160.

[16] Campbell C M (2006) A model of the determinants of effort. Economic Modelling 23: 215-237.

[17] Campbell C M (2008a) An efficiency wage approach to reconciling the wage curve and the Phillips curve. Labour Econ, 15: 1388-1415.

[18] Campbell C M (2008b) An efficiency wage - imperfect information model of the Phillips curve. Working Paper 2008-1. Northern Illinois University, Dekalb. http://nzae.org.nz/wp-content/uploads/2011/08/nr1215477105.pdf

[19] Campbell C M (2010a) Deriving the wage-wage and price-price Phillips curves from a model with efficiency wages and imperfect information. Econ Lett 107: 242-245.

[20] Campbell C M (2010b), Appendix to "Deriving the wage-wage and price-price Phillips curves from a model with efficiency wages and imperfect information". http://www.niu.edu/econ/Directory/Campbell/PhillipsPaperELAppendix.pdf. Accessed on the 8th March 2011.

[21] Campbell C M (2011a) Efficiency wage setting, labour demand, and Phillips curve microfoundations. http://mpra.ub.uni-muenchen.de/49196/.

[22] Campbell C M (2011b) The formation of wage expectations in the effort and quit decisions of workers. http://mpra.ub.uni-muenchen.de/31590/.

[23] Canova, F (1998), Detrending and business cycle facts, Journal of Monetary Economics 41, 475-512.

[24] Caraballo M Á, Efthimiadis T (2012) Is 2 % the optimal inflation rate for the Euro Area? Int Econ Econ Policy 9: 235-243

[25] Cavelaars P (2009) Does globalization discipline monetary policymakers? J Int Money Finance 28: 392–405.

[26] Çenesiz M A, Pierdzioch C (2010) Capital mobility and labor market volatility, Int Econ and Econ Policy 7: 391-409.

[27] Chinn M D, Ito H (2008) A new measure of financial openness, J Comparative Policy Analysis 10: 309 – 322 (September).

[28] Chari V V, Kehoe P J, McGrattan E R (2000) Sticky price models of the business cycle: can the contract multiplier solve the persistence problem? Econometrica 68: 1151–11 80.

[29] Cragg J G, Donald S G (1993) Testing identifiability and specification in instrumental variable models. Econometric Theory 9: 222-240.

[30] Daniels J P, Nouzard F, VanHoose D D (2005) Openness, central bank independence, and the sacrifice ratio. J Money Credit Bank 37: 371-379.

[31] Daniels J, VanHoose D (2006) Openness, the sacrifice ratio, and inflation: is there a puzzle? J Int Money Finance 25:1336–1347.

[32] Daniels J P, VanHoose D D (2009) Trade openness, capital mobility and the sacrifice ratio. Open Econ Rev 20: 473-487.

[33] Daniels J P, VanHoose D D (2013) Exchange rate pass through, openness, and the sacrifice ratio. J Int Money Finance 36: 131-150.

[34] Danthine J P, Kurmann, A (2004) Fair wages in a new Keynesian model of the business cycle, Rev Econ Dynamics 7: 107-142.

[35] Danthine, J P, Kurmann, A (2010) The business cycle implications of reciprocity in labor relations. J Monetary Econ 57: 837-850.

[36] De Grauwe, P (2011) The Eurozone as a morality play, Interecon 46: 230-231.

[37] Duca J, VanHoose D (2000) Has greater competition restrained inflation? South Econ J 66:479–491.

[38] Edge R M (2002) The equivalence of wage and price staggering in monetary business cycle models, Rev Econ Dynamics 5: 559–585.

[39] Evans G, Gulamani R (1984) Tests for Rationality of the Carlson-Parkin Inflation Expectations Data. Oxf Bull Econ Stat: 46, 1-19.

[40] Fuhrer J C (1997) The (Un)Importance of forward-looking behavior in price specifications. J Money Credit Bank August 29: 338-50.

[41] Gibson H D, Palivos T, Tavlas G S (2013) The crisis in the Euro area: An analytic overview, J Macroecon, forthcoming, http://dx.doi.org/10.1016/j.jmacro.2013.09.014.

[42] Gouveia S, Correia L (2013) Labour costs dynamics in the Euro area: some empirical evidence, Int Econ and Econ Policy 10: 323-347.

[43] Gramlich, E M (1983) Models of inflation expectations formation. J Money Credit Bank 15: 155-73.

[44] Gruben W, McLeod D (2002) Capital account liberalization and inflation. Econ Lett 77:221–225.

[45] Gruben W, McLeod D (2004) Capital market liberalization, disinflation, and commitment. Federal Reserve Bank of Dallas, Dallas.

[46] Guiso L, Sapienza P, Zingales L (2004) Does Local Financial Development Matter? Q J Econ 119: 929—969.

[47] Hamilton J (1994) Time series analysis. Princeton University Press, Princeton.

[48] Honkapohja S (2013) The euro area crisis: A view from the North, J Macroecon, forthcoming, http://dx.doi.org/10.1016/j.jmacro.2013.08.004.

[49] Hughes Hallett A, Richter C (2008) Have the Eurozone economies converged on a common European cycle? Int Econ Econ Policy 5: 71-101

[50] Karras G (1999) Openness and the effects of monetary policy. J Int Money Finance 19: 13-26.

[51] Koronowski A (2009) Divergent business cycles as an effect of a monetary union. Int Econ Econ Policy 6: 103-13

[52] Lane P (1997) Inflation in open economies. J Int Econ 42: 327-247.

[53] Lombardo G (2006) Inflation targeting rules and welfare in an asymmetric currency area. J Int Econ 68: 424-442.

[54] Loungani P, Razin A, Yuen C W (2001) Capital mobility and the output-inflation trade-off. J Development Econ 64: 255-274.

[55] Mankiw N G, Reis R, Wolfers J (2003) Disagreement about Inflation Expectations. NBER Macroecon Annu, 18: 209-48.

[56] Mullineaux D J (1980) Inflation expectations and money growth in the United States. Am Econ Rev 70: 149-161.

[57] Obstfeld M, Rogoff K (1996) Foundations of International Macroeconomics. MIT Press, Cambridge, MA.

[58] Pedregal D J, Young P C (2002) Statistical approaches to modelling and forecasting time series. In: Clements M P, Hendry D A (eds) A companion to economic forecasting. Blackwell, Oxford, pp 69-104.

[59] Razin A, Loungani P (2005) Globalization and inflation-output tradeoffs. Working Paper 11641. NBER, Cambridge MA-

[60] Razin A, Yuen C (2002) The 'New Keynesian' Phillips curve: closed economy versus open economy. Econ Lett 75: 1–9.

[61] Roberts J M (1997) Is Inflation Sticky. J Monetary Econ 39: 173-196.

[62] Roberts J M (1998) Inflation Expectations and the Transmission of Monetary Policy. Board of Governors of the Federal Reserve System, Finance and Economics Discussion, Washington D. C.

[63] Romer D (1993) Openness and inflation: theory and evidence. Q J Econ 108: 869-903.

[64] Sögner L, Stiassny A (2010) An analysis on the structural stability of Okun's law–a cross-country study. Applied Econ 34: 1775-1787.

[65] Staiger D, Stock J H (1997) Instrumental variables regression with weak instruments. Econometrica 65: 557-586.

[66] Stock J H, Yogo M (2005). Testing for weak instruments in linear IV regression. In: Andrews D W K, Stock J H (eds) Identification and inference for econometric models: essays in honor of Thomas Rothenberg. Cambridge University Press, Cambridge, pp 80–108.

[67] Stock J, Watson M W (1999) Forecasting inflation. J Monetary Econ 44: 293-335.

[68] Temple J (2002) Openness, inflation, and the Phillips curve: a puzzle. J Money Credit Bank 34: 450–468

[69] Terra C (1998) Openness and inflation: a new assessment. Q J Econ 113:641–648

[70] Thomas L B (1999) Survey measures of expected U.S. inflation. J Econ Perspect 13: 125-44.

[71] Vaona A (2007) Merging the purchasing power parity and the Phillips curve literatures: regional panel data evidence from Italy. Int Reg Sci Rev 30: 152-172.

[72] Vaona A (2013a), The most beautiful variations on fair wages and the Phillips curve. J Money, Credit Bank, 45: 1069–84.

[73] Vaona A (2013b) Inflation gifts and endogenous growth through learning-by-doing. Working Papers 09/2013, University of Verona, Department of Economics, Verona.

[74] Walsh C (2003) Monetary Theory and Policy. The MIT Press, Cambridge, MA.

[75] Woodford M (2003) Interest and Prices: Foundations of a Theory of Monetary Policy. Princeton University Press, Princeton, US.

10 Appendix: Deriving the efficiency 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 (12) and substitute into it (13) , (16) and the condition $\tilde{e}\tilde{e}_W^{-1} = \frac{W_{ss}}{P_{ss}^e}$ to obtain

$$\gamma\hat{L}_t = -\gamma\hat{W}_t + (1-n)\hat{y}_t^F + n\hat{y}_t^H + (\gamma-1)\hat{y}_t^H + \gamma\hat{P}_t \tag{38}$$

Further make explicit $\hat{L}_t + \hat{W}_t$ in (38) and substitute it with $\frac{\hat{y}_t^H}{\phi} - \hat{A}_t + \hat{P}_t^e - e^{-1}e_u du_t$ from (16) to obtain

$$\hat{P}_t = \hat{P}_t^e - \hat{A}_t - e^{-1}e_u du_t - \frac{(1-n)}{\gamma}\hat{y}_t^F - \frac{n}{\gamma}\hat{y}_t^H - \frac{(\gamma-1)}{\gamma}\hat{y}_t^H + \frac{\hat{y}_t^H}{\phi} \tag{39}$$

Combine equations (13) , (14) and (16) to obtain

$$\hat{y}_t^H = \phi\hat{A}_t + \phi\left[\frac{e_u - e_{Wu}\zeta}{e_{WW}\zeta^2} - \frac{(1-e^{-1}e_u s_L)}{s_L}\right]du_t \tag{40}$$

Substitute (40) into (39) to obtain (21).

Figure 1 - Summary of Danish data (1983Q2-2013Q2)

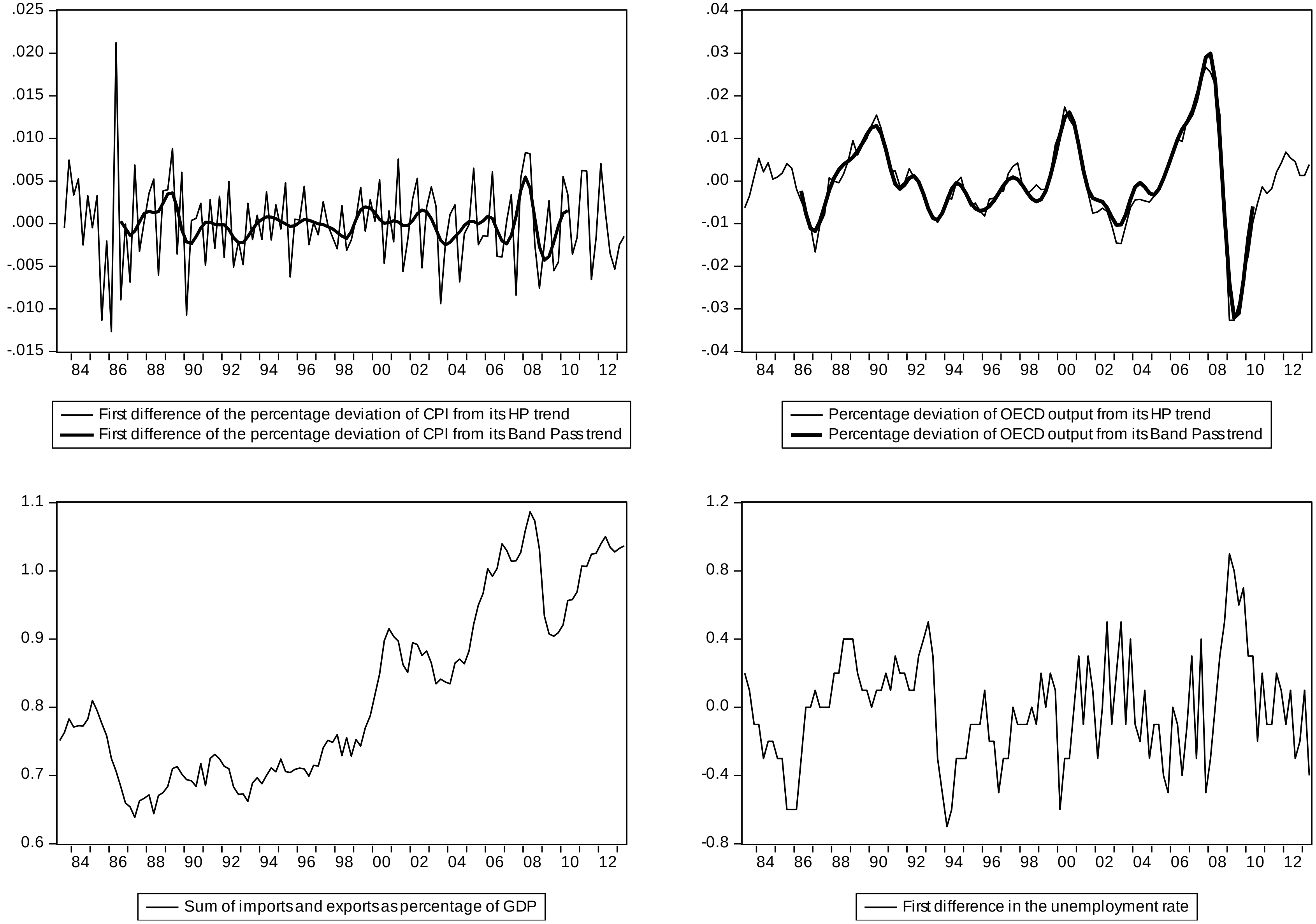
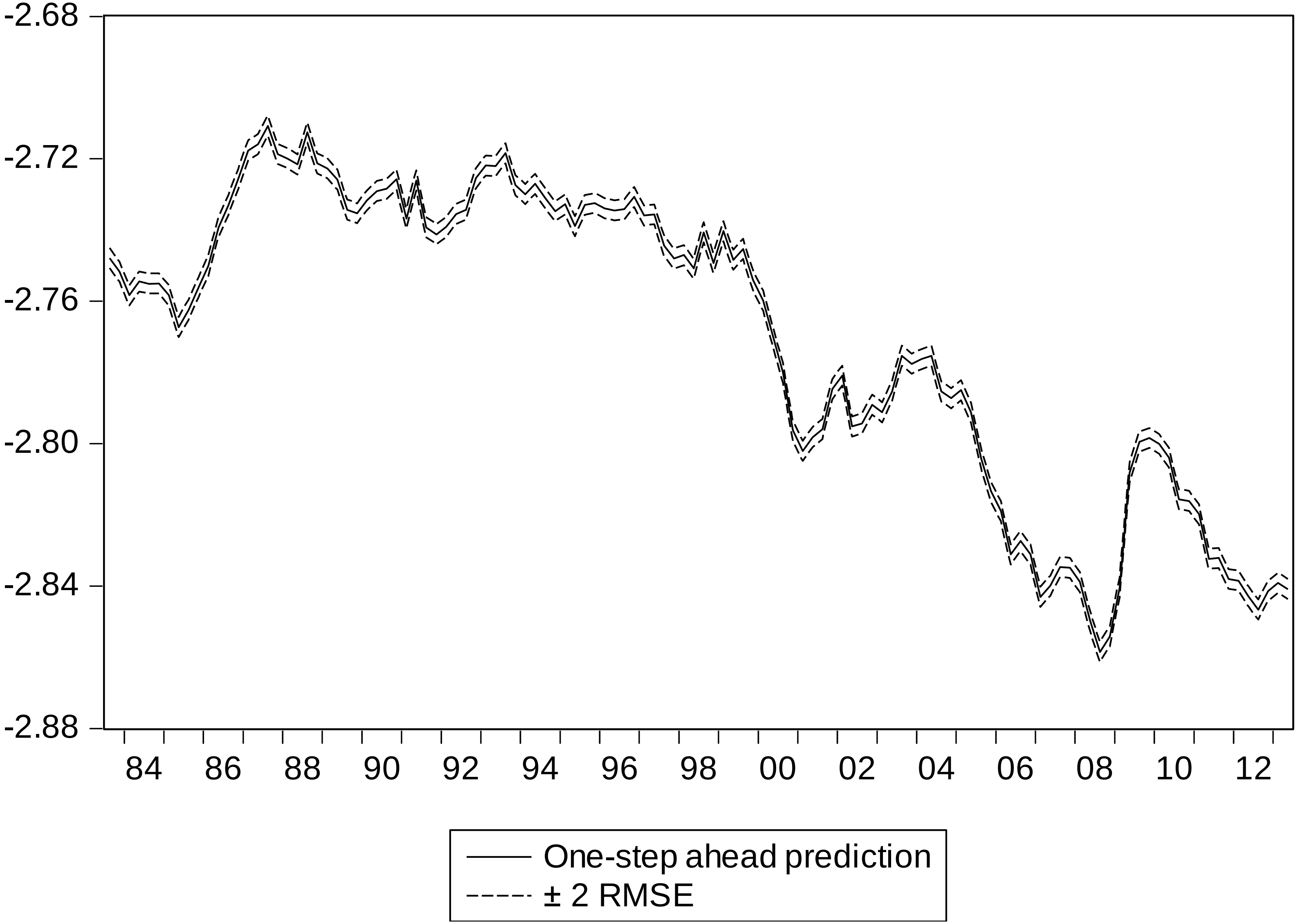
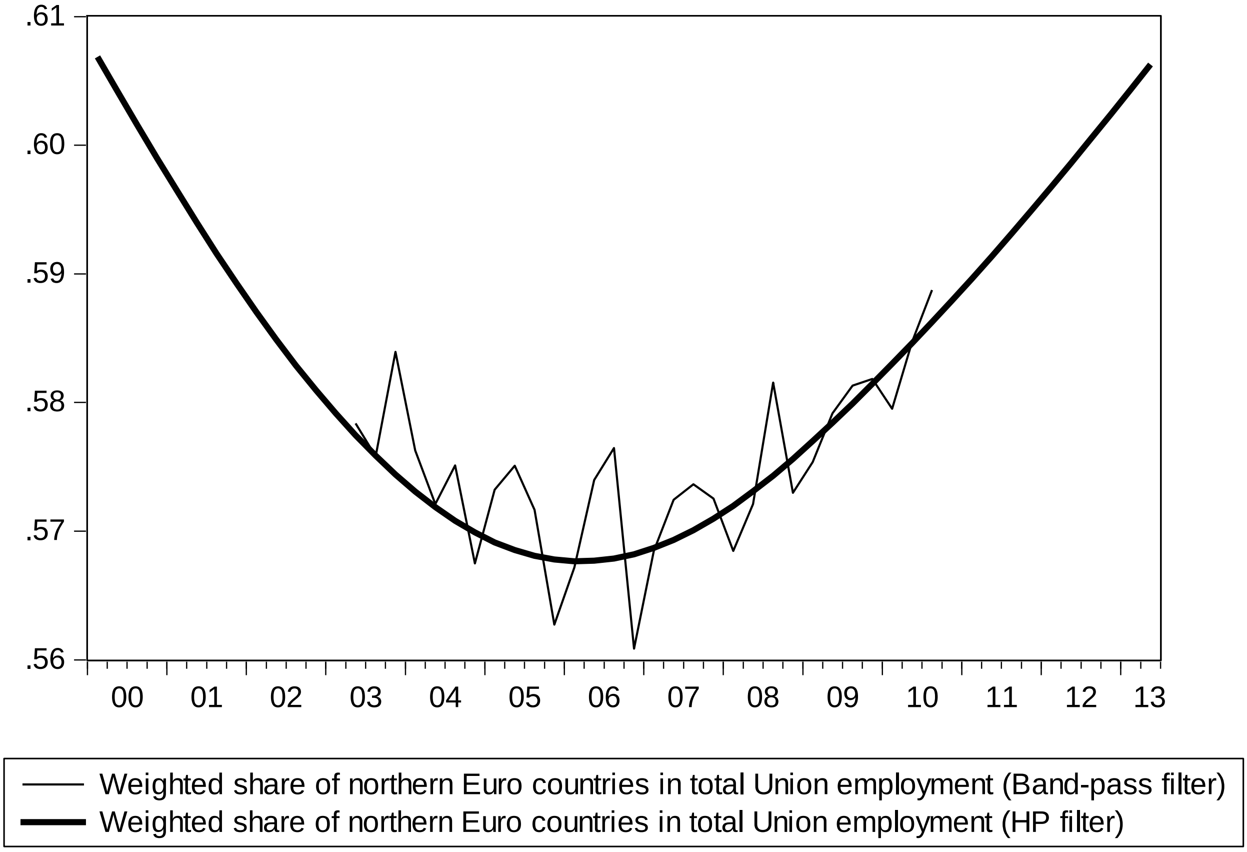


Figure 2 - One-step ahead prediction of ξ_t for Denmark



Note. ξ_t is the unemployment multiplier in the price-price Phillips curve

Figure 3 - Summary of Euro area data (2000Q1-2013Q2)



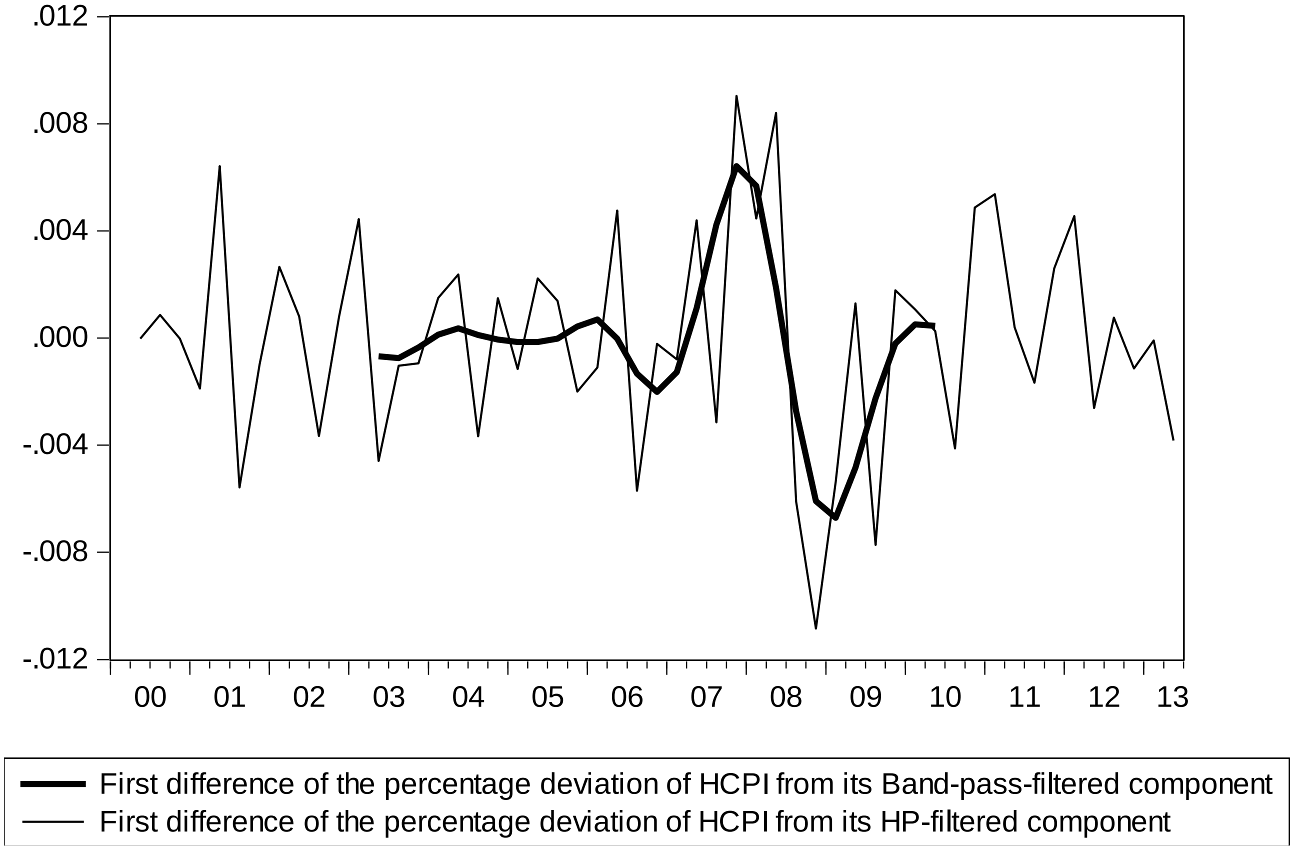


Figure 4 - Change in the unemployment rate in northern and southern Euro areas (2000Q1-2013Q2)

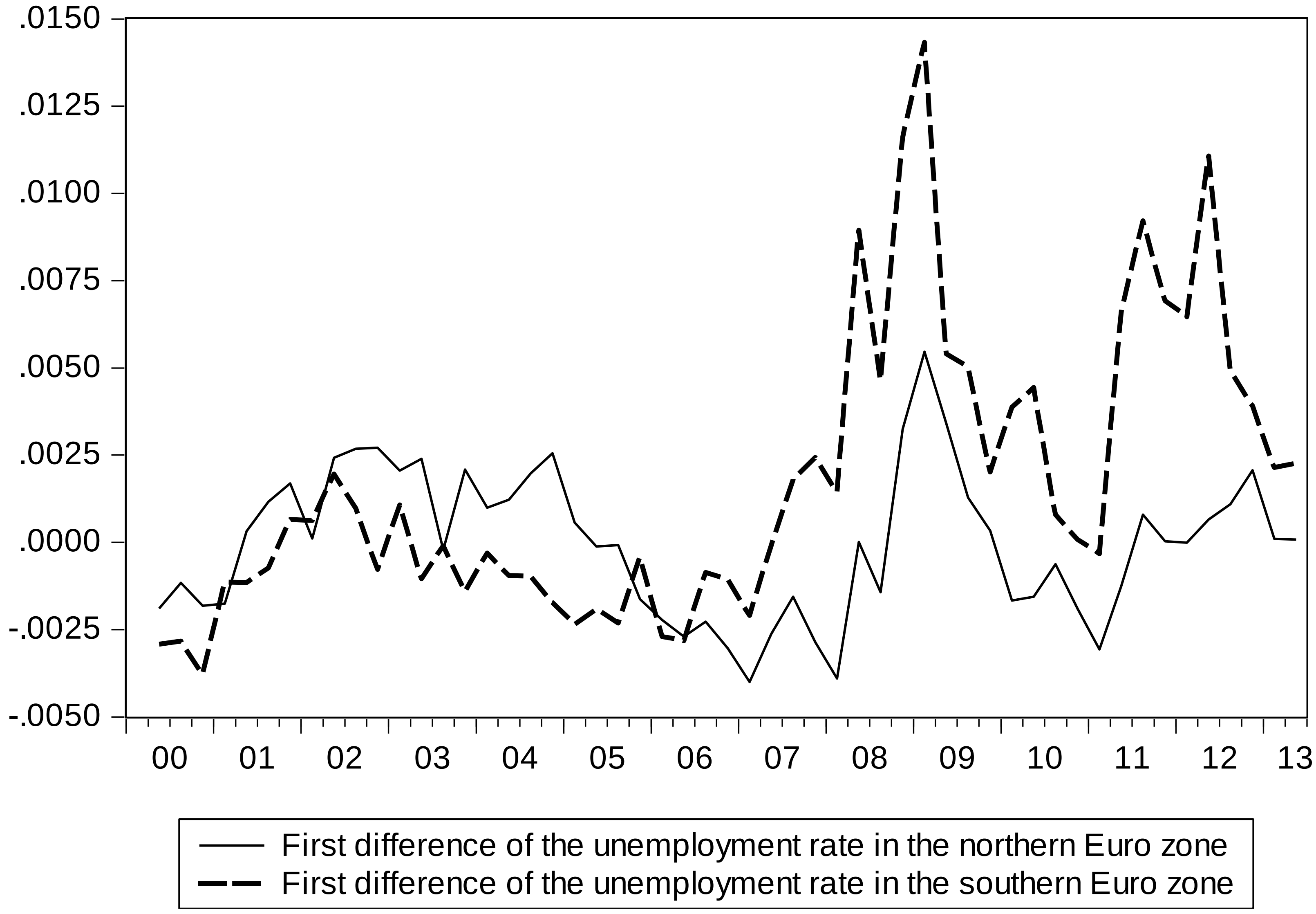


Figure 5 - Percentage deviations of real GDP from its trend in northern and southern Euro areas (2000Q1-2013Q2)

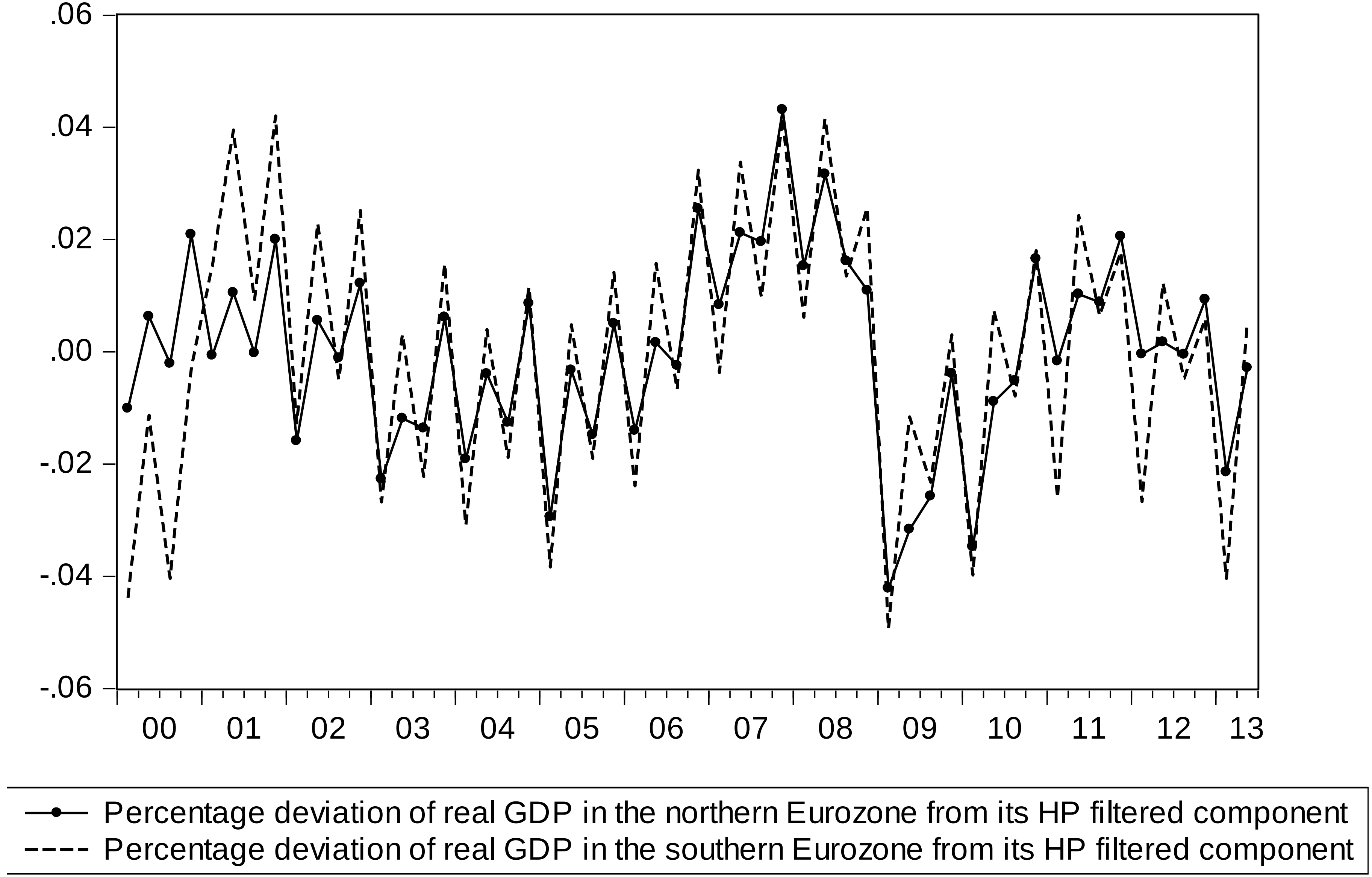
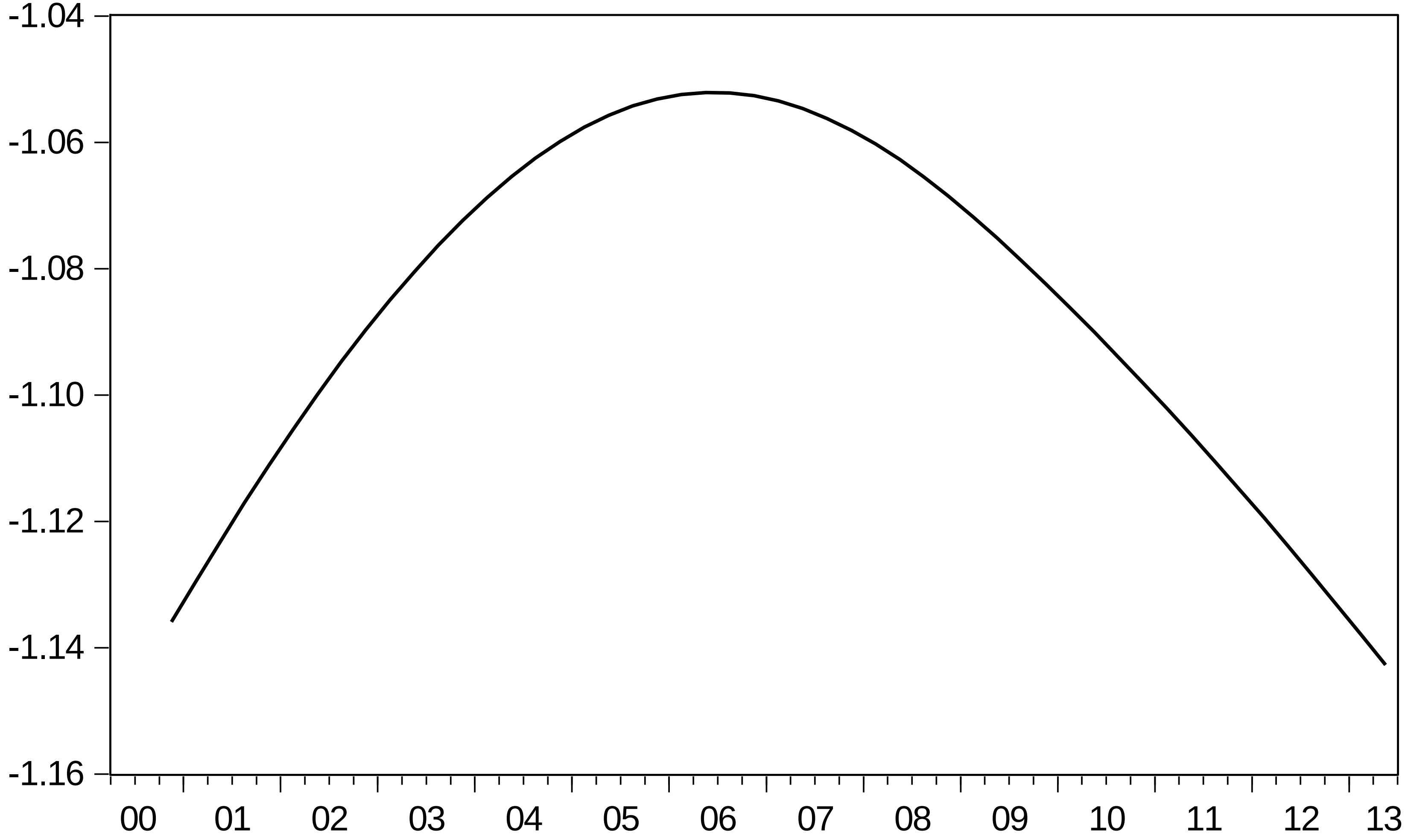


Figure 6 - One step ahead estimates of $\xi_{N,t}$ (2000Q3-2013Q2)



Note: of $\xi_{N,t}$ is the unemployment multiplier of Northern Euro countries in the aggregate Eurozone price-price Phillips curve.