Department of Economics
Johannes Kepler University of Linz

The Small Open Economy New Keynesian Phillips Curve: Empirical Evidence and Implied Inlfation Dynamics

by

Alexander Mihailov, Fabio Rumler, Johann Scharler*)

Working Paper No. 0817
September 2008

Johannes Kepler University of Linz
Department of Economics
Altenberger Strasse 69
A-4040 Linz - Auhof, Austria
www.econ.jku.at

johann.scharler@jku.at
phone +43 (0)70 2468 -8360, -9679 (fax)

The Small Open-Economy New Keynesian Phillips Curve: Empirical Evidence and Implied Inflation Dynamics

Alexander Mihailov* Fabio Rumler† Johann Scharler‡

September 2008§

Abstract

This paper applies GMM estimation to assess empirically the small open-economy New Keynesian Phillips Curve derived in Galí and Monacelli (2005). We obtain a testable specification where fluctuations in the terms of trade enter explicitly, thus allowing a comparison of the relevance of domestic versus external determinants of CPI inflation dynamics. For most countries in our sample the expected relative change in the terms of trade emerges as a more relevant inflation driver than the contemporaneous domestic output gap. Overall, our results indicate some, albeit moderate, support for the tested relationship based on data from ten OECD countries typically classified as open economies.

Key words: New Keynesian Phillips Curve, small open economies, terms of trade fluctuations, inflation dynamics, GMM estimation.

JEL classification codes: C32, C52, E31, F41.

*University of Reading, Henley Business School, School of Economics, Whiteknights, Reading RG6 6AA, United Kingdom; a.mihailov@henley.reading.ac.uk.

†Oesterreichische Nationalbank, Economic Analysis Division, Otto Wagner Platz 3, A-1090 Vienna, Austria; Fabio.Rumler@oenb.at.

‡University of Linz, Department of Economics, Altenbergerstrasse 69, A-4040 Linz, Austria; Johann.Scharler@jku.at.

§First version: June 2008 (available at http://www.soegw.org/files/program/63-Rumler.pdf). Comments welcome. For useful feedback on earlier versions, we thank Kerry Patterson and the audience at the 2nd International Conference on *Small Open Economies in a Globalized World*, Wilfrid Laurier University, Waterloo, Ontario, Canada (June 2008). The usual disclaimer applies.

Contents

List of Tables

1 Introduction

The New Keynesian Phillips Curve (NKPC) is a key ingredient in what currently appears to be the workhorse model for business cycle analysis and evaluation of monetary policy. In fact, the NKPC is one of the structural-form equations in the so-called New Keynesian (NK) model. Starting with Galí and Gertler (1999), many authors have estimated various specifications of the NKPC – see, e.g., Galí, Gertler and López-Salido (2001, 2003, 2005), Rudd and Whelan (2005, 2006) and Sbordone (2002, 2005, 2007).[1] However, most available estimates are inferred from a *closed-economy* context, usually employing the generalized method of moments (GMM) to handle expectational terms. The purpose of this paper is, therefore, to evaluate empirically the *small open-economy* (SOE) version of the NKPC derived in Galí and Monacelli (2005), henceforth the SOE NKPC. Notably, the SOE NKPC links inflation dynamics to external-sector macro-variables, such as the terms of trade (ToT), in addition to domestic ones.

Our analysis is partly related to Leith and Malley (2007) and Rumler (2007), who also estimate open-economy versions of the NKPC although in a less explicit way. In contrast to our paper, these authors focus on parameters such as the degree of backward- and forward-lookingness, the Calvo probability of a price change, and the degree of imperfect substitutability between domestic and foreign intermediate inputs, without examining in more detail the role of external-sector inflation drivers.[2] The novel aspect in this paper is that we transform the open-economy NKPC of Galí and Monacelli (2005) into an expression that figures fluctuations in the ToT as an additional inflation driver and, consequently, allows a comparison of the role of domestic versus external factors in determining CPI inflation dynamics. Furthermore, it also allows estimation of the degree of openness in consumption of the respective economies.

We apply GMM to quarterly data from ten OECD countries typically classified as SOEs and covering the period since the early 1970s. Our results indicate some, albeit moderate, empirical support for the SOE specification of the NKPC implied by the Galí-Monacelli (2005) model. In particular, for most countries in our sample, the expected relative change in the terms of trade emerges as a more relevant driver of CPI inflation than the contemporaneous domestic output gap.

The paper is structured as follows. The next section outlines our empirical strategy and derives the main testable equation. Section 3 introduces our data and estimation method. Section 4 summarizes our econometric results, and the last section concludes the paper.

[1] Rudd and Whelan (2007) is a critical review of this literature.

[2] Razin and Yuen (2002) highlight the theoretical similarities and differences of closed- versus open-economy NKPC formulations. Razin and Binyamini (2007) investigate empirical issues related to the flattening of the inflation-output tradeoff and whether this could be assigned to monetary policy or globalization.

2 Empirical Strategy

Our analysis is based on the model described in Galí and Monacelli (2005). They show that in a small open economy consumer-price inflation, $\pi_t \equiv p_t - p_{t-1}$, with $p_t \equiv \ln P_t$, is determined by domestic-price inflation, $\pi_{H,t} \equiv p_{H,t} - p_{H,t-1}$, and the change in the terms of trade, $\Delta s_t \equiv s_t - s_{t-1}$, with $s_t \approx p_{F,t} - p_{H,t}$, where s_t is the (natural) log of the effective ToT of the SOE *vis-à-vis* the rest of the world and $p_{H,t}$ and $p_{F,t}$ are the (natural) logs of its domestic price index and import price index, respectively.

In particular, the following equation holds as a log-linear approximation around the steady state:[3]

$$\pi_t = \pi_{H,t} + \alpha \Delta s_t, \tag{1}$$

where $\alpha \in [0,1]$ is inversely related to the degree of home bias in consumption preferences. The equation states that the gap between consumer- and domestic-price inflation is proportional to the per cent change of the terms of trade, with the coefficient of proportionality given by the index of openness. In other words, CPI inflation can be viewed as determined by two major factors, domestic-price inflation, a domestic cause, and changes in the terms of trade, an external cause, which matter more the more open the economy is.

As Galí and Monacelli (2005) point out, equation (1) holds in approximation since the *effective* (i.e., multilateral) terms of trade of the SOE are, more precisely, defined by

$$S_t \equiv \frac{P_{F,t}}{P_{H,t}} = \left(\int_0^1 S_{i,t}^{1-\gamma} di \right)^{\frac{1}{1-\gamma}},$$

where $\gamma > 0$ measures the substitutability between goods produced in different countries other than the SOE indexed by i (and, thus, entering its import-price index), which can be approximated (up to first order) by the log-linear expression

$$s_t = \int_0^1 s_{i,t} di.$$

Moreover, *log-linearization* of the CPI Dixit–Stiglitz (1977) constant elasticity of substitution aggregator common to such frameworks,

$$P_t \equiv \left[(1-\alpha) P_{H,t}^{1-\eta} + \alpha P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}},$$

where $\eta > 0$ is the substitutability between the SOE's domestically-produced and imported goods (i.e., those produced in the rest of the world), around a *symmetric* steady state satisfying the purchasing power parity condition, $P_{H,t} = P_{F,t}$ under assumed full

[3]For a detailed derivation see Galí and Monacelli (2005).

producer currency pricing and $\overline{S} = 1$, implies

$$\begin{aligned} p_t &\equiv (1-\alpha) p_{H,t} + \alpha p_{F,t} \\ &= p_{H,t} - \alpha p_{H,t} + \alpha p_{F,t} \\ &= p_{H,t} + \alpha (p_{F,t} - p_{H,t}) \\ &= p_{H,t} + \alpha s_{t.} \end{aligned}$$

The last expression above, taken in differences, in fact leads to (1).

A further implication of the Galí–Monacelli (2005) model is the following variant of the NKPC:

$$\pi_t = \beta E_t \pi_{H,t+1} + \lambda \widehat{mc}_t + \alpha \Delta s_t. \tag{2}$$

This equation follows directly from (14) and (32) in Galí and Monacelli (2005). Their (14) is (1) above, and their (32) is (3) below, an equation analogous to the one typically derived and estimated for a closed economy,

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \lambda \widehat{mc}_t, \tag{3}$$

where $\widehat{mc}_t$ is the SOE's real marginal cost in per cent deviation from its steady state value. In such frameworks $\widehat{mc}_t$ can be shown to be *proportional* to the SOE's output gap, x_t, so that a version of the NKPC for the SOE can also be expressed in terms of the output gap,[4] similarly to its closed-economy parallels:

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa_\alpha x_t, \tag{4}$$

with the critical slope coefficient $\kappa_\alpha \equiv \lambda (\sigma_\alpha + \varphi)$, where $\lambda \equiv \frac{(1-\beta\theta)(1-\theta)}{\theta}$, $\sigma_\alpha \equiv \frac{\sigma}{(1-\alpha)+\alpha\omega}$, and $\omega \equiv \sigma\gamma + (1-\alpha)(\sigma\eta - 1)$; furthermore, σ is the inverse of the *inter*temporal elasticity of substitution in consumption and φ is an analogous parameter characterizing the *inter*temporal labor/leisure choice, θ is related to the degree of price stickiness (as $1-\theta$ is the probability of setting optimally in a Calvo (1983) fashion, i.e., in each period and independently of past history, a firm's price under monopolistic competition), $0 < \beta \equiv \frac{1}{1+\rho} < 1$ is the standard (subjective) time discount *factor*, with ρ being the (subjective) time discount *rate*, and $\eta > 0$ (as already mentioned) is the *intra*temporal substitutability in consumption between the SOE's domestically-produced and imported goods.

Equation (2), therefore, states that overall (or CPI) inflation is theoretically deter-

[4] Theoretically defined as the deviation of the sticky-price output level from the output level when all prices are perfectly flexible; empirically measured most frequently as the deviation of actual output from 'potential' output proxied by trend output, as we do and explain further down.

mined in the context of the SOE NK model of Galí and Monacelli (2005) by expected domestic inflation, $E_t\pi_{H,t+1}$, domestic real marginal cost, $\widehat{mc}_t$, and the change in the SOE's ToT, Δs_t. Because of the proportionality between the real marginal cost (in deviation from its steady state value) and the output gap in this model – formally, $\widehat{mc}_t = (\sigma_\alpha + \varphi)\, x_t$ as on p. 718 in Galí and Monacelli (2005) – (2) can alternatively be written as[5]

$$\pi_t = \beta E_t\pi_{H,t+1} + \kappa_\alpha x_t + \alpha\Delta s_t. \tag{5}$$

Further algebraic substitutions, starting from (1), lead to a third version, as follows:

$$\begin{aligned} \pi_t &= \pi_{H,t} + \alpha\Delta s_t \Leftrightarrow \\ \pi_{H,t} &= \pi_t - \alpha\Delta s_t \\ \text{therefore, } E_t\pi_{H,t+1} &= E_t\pi_{t+1} - \alpha E_t\Delta s_{t+1}, \end{aligned}$$

and substituting out $E_t\pi_{H,t+1}$ in (2),

$$\begin{aligned} \pi_t &= \beta E_t\pi_{H,t+1} + \lambda\widehat{mc}_t + \alpha\Delta s_t \\ &= \beta\left(E_t\pi_{t+1} - \alpha E_t\Delta s_{t+1}\right) + \lambda\widehat{mc}_t + \alpha\Delta s_t \\ &= \beta E_t\pi_{t+1} - \alpha\beta E_t\Delta s_{t+1} + \lambda\widehat{mc}_t + \alpha\Delta s_t \\ &= \beta E_t\pi_{t+1} + \lambda\widehat{mc}_t - \alpha\left(\beta E_t\Delta s_{t+1} - \Delta s_t\right) \\ &= \beta E_t\pi_{t+1} + \lambda\widehat{mc}_t + \alpha\left(\Delta s_t - \beta E_t\Delta s_{t+1}\right). \end{aligned}$$

Sticking to the last specification above, as being the most intuitive and, perhaps, straightforward to estimate, we arrive at

$$\pi_t = \beta E_t\pi_{t+1} + \lambda\widehat{mc}_t + \alpha\left(\Delta s_t - \beta E_t\Delta s_{t+1}\right). \tag{6}$$

Finally, replacing the marginal cost term with the proportional output gap term, we end up with a fourth SOE NKPC version, (7), which is employed in our estimations reported further down together with (6):

$$\pi_t = \beta E_t\pi_{t+1} + \kappa_\alpha x_t + \alpha\left(\Delta s_t - \beta E_t\Delta s_{t+1}\right). \tag{7}$$

Equation (7) resembles its closed-economy counterpart. However, (7) also shows that CPI inflation, a much more relevant measure of the growth of the overall price level for small open economies than domestic-price inflation, is not just driven by the

[5] Similar CPI inflation dynamics arises also in two-country (large) open-economy models, e.g., in Benigno and Benigno (forthcoming) and McKnight and Mihailov (2007).

current-period domestic output gap in addition to expected next-period CPI inflation, as in closed economies. In SOEs CPI inflation is also theoretically determined by the expected current-to-next-period (discounted) change in the terms of trade *relative to* the observed past-to-current period ToT change. More precisely, an expected relative improvement in the ToT ($\Delta s_t > \beta E_t \Delta s_{t+1}$) would stimulate expenditure switching to foreign goods, so that CPI inflation would be under upward pressure arising from the demand for imports. This pressure is stronger the higher is the degree of openness to trade, α. Inversely, an expected relative deterioration of the ToT ($\Delta s_t < \beta E_t \Delta s_{t+1}$) would stimulate expenditure switching to domestically-produced goods, so that CPI inflation would be under *downward* pressure arising from the demand for imports. This pressure is stronger the higher is the degree of openness to trade.

Our main contribution here is to test up against the data the relationship captured theoretically by equation (7) and to also provide, in consequence, empirical estimates for α. We do so by estimating via GMM, as is standard in the NKPC context, the orthogonality conditions implied by our main test equation, (7). To check for robustness, we also estimate (6), as well as 'pure', 'hybrid' and 'empirically motivated' closed- and open-economy variations of the NKPC for the whole sample and by two subperiods. Our data, econometric specifications and instruments are discussed next.

3 Data Description

We estimate equations (7) and (6) for ten advanced OECD countries, most of which are typically classified as small open economies (and also selected according to data availability and to maximize comparability): Austria, Canada, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom. We include France, Germany and the UK even if they are not small countries since they are fairly open and interdependent in terms of consumption habits, whereas we do not consider the US and Japan which have a much lower import share in consumption.

All data (for the CPI, GDP and the import and export prices for the construction of the terms of trade as well as compensation to employees) stem from the Economic Outlook (ECO) database of the OECD. In estimating specification (7), we employ two different proxies for the output gap, namely the deviation of real GDP from a Hodrick-Prescott (H-P) trend, and its deviation from a quadratic-polynomial (Q-P) trend.[6] To solve the well-known endpoint problem of any one-sided filtering method, the H-P and Q-P trend have been calculated including forecast values up to 2009:4 available at the ECO database. The H-P output gap has additionally been normalized by its standard

[6] These commonly applied empirical measures of the output gap are, certainly, only imperfect proxies to the theoretically relevant output gap. The underlying detrending procedures, which postulate a specific functional form to separate the trend (or potential) real GDP from the cyclical component, are sometimes referred to as 'naive' in the literature. The alternatives in applied work, though, are not obvious.

deviation to ensure comparable magnitudes across countries.

In line with the approaches implemented with respect to the closed-economy NKPC, notably following Galí and Gertler (1999) and Sbordone (2002), we also estimate specification (6) using average real unit labor costs as a proxy for real marginal costs instead of the output gap. Empirically, average real unit labor cost is proxied by the labor share in income, $\frac{Wl}{Py}$, where W is hourly compensation, l total hours worked, y real output and P a measure of the (relevant) price level.[7] We construct this variable by dividing total nominal compensation to employees by nominal GDP. As detrending method we use the Q-P trend in this case.

To construct the effective ToT, s_t, which in our model corresponds to $p_{F,t} - p_{H,t}$, we calculate - assuming producer's currency pricing as said before - the log difference of the import prices (given by the import deflator) and the export prices (given by the export deflator) for each country. Implicitly, this ratio gives the effective ToT because the importance of the trading partners is automatically reflected in the deflators.

Our data covers the period from the first quarter of 1970 to the last quarter of 2007, where the samples vary somewhat due to limited data availability for some countries. All estimations are from 1970:1 to 2007:4, with the following exceptions. For Austria, all data are available only from 1980 on. Specification (6) is estimated from 1975 for Italy and from 1980 for Spain because compensation of employees is available only from these respective years on. For Switzerland, specification (6) could not be estimated due to the lack of quarterly data on compensation.

The instruments used in the GMM estimation have been chosen for each country individually. They mainly consist of various lags of the right-hand-side variables in each regression, which are selected according to experimentation with different lag combinations. In addition to lagged regressors, we used commodity prices and the bilateral USD/EUR exchange rate as instruments for some countries. The instruments are the same in the estimations of the two subsamples. The complete set of instrumental variables by country and econometric specification is provided in Appendix A.

The dependent variable in each regression is (seasonally unadjusted) quarter-on-quarter CPI inflation.

4 Estimation Results

In this section we first assess the empirical fit of the SOE NKPC derived by Galí and Monacelli (2005). We then attempt to summarize the implications of our estimation results as far as the role of external versus domestic factors as inflation drivers is concerned.

[7] Most empirical studies have found a negative correlation between the labor share in income and the traditional, 'naive' measures of the output gap. For that reason, the notorious problem with wrongly signed (i.e., statistically significant and negative) output gaps found in the data has been often avoided by employing the labor share as a proxy for real marginal costs. See Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001).

We do so in the hope of adding to the current debate on the inflation-globalization nexus, whose more profound study remains outside the scope of our paper.

Table 1 shows the results from the estimation of our main specification, (7), where we proxy the output gap, x_t, by the deviation of real GDP from its H-P trend. The p-value associated with the J-test statistic reported in the last column implies that the null of the validity of the overidentifying restrictions imposed by the instruments cannot be rejected at standard levels of significance.

[Table 1 about here]

The table shows that the time discount factor β is statistically significant in all countries and the point estimate is slightly below unity, except for Italy and France. For these two countries we estimate β to be only marginally above unity.[8]

Turning to κ_α, the parameter that measures the impact of the output gap on inflation, we see that this parameter is significantly greater than zero only in France and the UK. For Sweden, the point estimate for κ_α is significantly negative. Intuitively, higher output gaps are associated with an increase in marginal costs, which translate into price pressure. Therefore, one would expect κ_α to be generally positive. However, as we demonstrate in Appendix B, this need not be theoretically true in all possible cases in the context of the model of Galí and Monacelli (2005). Moreover, several authors argue that a shortcoming of the standard New Keynesian framework is that it does not allow for a trade-off between inflation and output stabilization.[9] Thus, it might be the case that despite the fact that our estimated equation is based on a model which does not generally allow for this type of trade-off, our estimate for κ_α actually picks up the effect of real rigidities insofar these are present in the data. In any case, in the majority of the countries in our sample the output gap turns out to be insignificant, which casts some doubt on the importance of domestic factors on inflation dynamics in small open economies relative to external factors, as we claim below. Yet, 'wrongly' (i.e., negatively) signed or insignificant output gaps are known to have plagued the closed-economy empirical NKPC literature too (see Rudd and Whelan, 2007).

Our estimates for α, the parameter we are mostly interested in, are positive and significant at standard levels for half of the countries in our sample: namely, at 1% level for Germany, the Netherlands, the UK and Switzerland, and at 10% level for Canada. Thus, external factors appear to be more relevant than the domestic output gap as inflation divers in the small open economies in our sample. Recall that in Galí and Monacelli (2005) α corresponds to the share of domestic consumption allocated to

[8] This is not uncommon in the empirical NKPC literature employing GMM: e.g., Rudd and Whelan (2007), Table 1, p. 159, similarly report discount factors slightly higher than unity for quarterly US estimates over 1960:1–2004:3.

[9] Blanchard and Galí (2007) dub this property the 'divine coincidence': stabilizing the welfare-relevant output gap at the same time stabilizes inflation. They explain it with the absence of real imperfections in the NK framework and show that once real wage rigidity is introduced the property holds no longer.

imported goods in the steady state. Clearly, a negative estimate for α is inconsistent with this interpretation. Thus, it appears that the model in Galí and Monacelli (2005) does not fully capture all factors influencing the impact of terms of trade fluctuations on inflation dynamics. A particularly relevant such factor seems the pricing behavior of exporting firms. As mentioned, the Galí-Monacelli (2005) model is based on full producer currency pricing. However, if prices are actually set according to local currency pricing in some proportion, then our estimates of α may be affected by this feature, itself likely to be highly country-specific. Note also that the degree of trade openness we estimate ranges from 14% (Canada, which is, inversely, a home bias of 86%) to 48% (UK, i.e., a home bias of 52%).

In short, we conclude that expected *relative* variations in the terms of trade appear to be an important driver of CPI inflation in the majority of countries under consideration. Moreover, the impact of domestic factors on inflation dynamics, summarized by the output gap, come out to be of less importance. To be more precise, the output gap is statistically significant at the 5% level for three economies in our sample out of ten, namely, France, the UK and Sweden. Only in the UK both the expected relative ToT change and the current output gap are simultaneously significant, together with expected next-period CPI inflation as the third factor in our main test equation (7). Nevertheless, for three SOEs, Austria, Italy and Spain, we find that neither the output gap, nor the terms of trade change turn out to be significant. Thus, our results are largely, although not entirely, in line with the model in Galí and Monacelli (2005).

[Table 2 about here]

As a next step in our analysis, we re-estimate (7) but this time with the output gap calculated as deviation of real GDP from a quadratic-polynomial (Q-P) trend. Table 2 demonstrates a slight improvement of our results in terms of our estimates for α. In addition to being rather robust to this modification, the outcome from this latter estimation also yields a sixth country, Italy, where the expected relative ToT change now becomes statistically significant at the 10% level and acquires a plausible positive magnitude of 0.31. However, the above improvement comes at some cost: when estimating (7) with Q-P instead of H-P filtering, the output gap coefficient, κ_α, turns out to be insignificant in all countries in the sample except France. As before, the estimated β's are all significant at the 1% level and show plausible values.

It is well known that the output gap and marginal costs do not need to be proportional, whereas our estimated equation (7) relies on assumption that they are indeed. Galí and Gertler (1999) and Sbordone (2002) were among the first to argue that a more general approach would be to use average real unit labor costs to proxy marginal costs.

[Table 3 about here]

Thus, we proceed by estimating equation (6) directly, where we proxy $\widehat{mc}_t$ by the average real unit labor costs. We see from Table 3 that this modification leads to rather similar outcomes. Now λ is still insignificant (in nine out of the ten economies in our sample) or wrongly signed (for the UK, the only country where it comes out significant, at the 1% level). On the other hand, we get estimates for α that are statistically significant at the 1% level and plausible in four cases (Germany, Italy, the Netherlands and the UK). Overall, for the remaining six countries in the sample we find that neither the current-period labor share in income, nor the expected next-period change in the terms of trade relative to that observed since the past period matter for the dynamics of the CPI inflation rate. Thus, this specification performs relatively worse, which is in line with the criticism in Rudd and Whelan (2007).

[Table 4 about here]

Note that specification (7) imposes rather strong theoretical restrictions on how the terms of trade enter and influence inflation dynamics. Since β is close to unity in most cases, the last term in (7) closely resembles the second difference of the terms of trade. Empirically, the second difference of the ToT behaves very much like white noise in most countries. This could be one reason why the estimates of α turn out to be insignificant or negatively signed in some of the countries. Thus, regardless the theoretical justification in Galí and Monacelli (2005), as an additional robustness analysis we estimate an alternative specification motivated on empirical grounds (only) which replaces $(\Delta s_t - \beta E_t \Delta s_{t+1})$ simply by Δs_t. Of course, this additional specification does not allow to interpret the coefficients on the output gap and on the terms of trade in a structural way. Table 4 shows the results. We see that this slightly less restrictive specification delivers broadly similar results. In particular, now the first difference of the terms of trade comes out significant in six countries, whereas the output gap is significantly different from zero in three countries.

[Tables 5 and 6 about here]

To further cross-check our findings, we compare our open-economy results to what we obtain based on closed-economy specifications. More specifically, we estimate a purely forward-looking and a hybrid version of the closed-economy NKPC. For the hybrid specification we add the lagged inflation rate as an additional explanatory variable.

The results based on the purely forward-looking closed-economy NKPC in Table 5 show a positive and significant coefficient on the output gap for four out of ten countries, which is a marginally better performance than in our baseline specification in Table 1. From this finding we may conclude that the inclusion of expected relative ToT fluctuations in the SOE specification of the NKPC may slightly contribute to the loss of significance of the output gap. For the hybrid model, in contrast, the results for the output gap – shown in Table 6 – do not improve compared to the SOE NKPC estimation in Table 1. Thus, in our sample, including lagged inflation in the NKPC does not solve the problem of insignificant or wrongly signed output gap coefficients often found in the literature.[10]

Overall, these cross-checks reassure us that the empirical fit of the SOE NKPC we found was reasonable. We therefore interpret our results as providing evidence in favor of a moderate support of the underlying theory.

As an additional dimension of our analysis, we estimate (7) over subsamples. This dimension is motivated by a number of recent studies which discuss the potential implications of the ongoing process of globalization for inflation dynamics (see, e.g., Rogoff, 2003 and 2006, among others). Borio and Filardo (2007) and White (2008) argue that due to increased openness and the resulting increase in trade and financial flows, traditional domestic factors have become less important in determining inflation. The opposite strand of the literature – e.g., Ball (2006), Woodford (2007), Mishkin (2007, 2008) – concludes that there is no evidence for a strong effect of globalization in determining domestic inflation.

We use two subsamples, 1970:1–1986:4 and 1987:1–2007:4. We choose this particular approach since it splits our sample in equal halves and also because the late 1980s saw substantial financial liberalizations and increases in international trade. For Germany we choose the sample split date to be 1991, i.e., the two subsamples are 1970:1–1990:4 and 1991:1–2007:4, because of the break induced by the German re-unification. Since data for Austria start in 1980 and due to its close economic links with Germany, we chose the break date for Austria to be 1991 as well.

Tables 7 and 8 show the results across subperiods. We report only the estimates for the specification with H-P detrended real GDP as a proxy for the output gap. Results obtained for the other specifications are qualitatively similar.[11] Comparing the estimates for κ_α across subsamples shows that the output gap becomes somewhat less important as a driving force behind inflation over time. In the first subsample κ_α is significantly different from zero at the 5% level in five countries. In the second subsample, we find only three countries where the output gap enters significantly at the 5%, while the latter has lost significance in all five countries of the first subsample. In Switzerland the output gap is only significant at the 10% level, coming out as positive at 0.10, whereas being negative at -0.14 in the earlier subperiod. Thus, if at all our results capture a pattern, we find some indications for a slightly reduced sensitivity of CPI inflation dynamics to domestic output gaps overall in our sample, which is roughly in line with Borio and

[10] Additionally estimating the SOE NKPC in an empirically motivated hybrid form, i.e. adding a lagged inflation term in equation (7), does not deliver a better fit than the original SOE NKPC. In particular, our main conclusion that the external inflation driver is more relevant for explaining inflation than the domestic output gap survives also in this estimation. The results are available upon request.

[11] We also estimated specifications where GDP is detrended using a Q-P trend and where unit labor costs replace the output gap. These results are available upon request.

Filardo (2007) and White (2008).

[Tables 7 and 8 about here]

For α, however, we find a similarly inconclusive pattern. In the later subsample α is significantly different form zero in three countries, compared to five countries in the earlier sample. Note as well that, numerically, we obtain *larger* point estimates in the second subsample for *all* three economies where α is significantly greater than zero. More precisely, α has risen across the subperiods studied from 0.07 in the 1970s and the 1980s to 0.14 in the 1990s and the 2000s in Italy, from 0.47 to 0.84 in the UK and from 0.21 to 0.27 in the Netherlands. With no overwhelming evidence of globalization effects along these estimates in our sample, the latter trends are perhaps indicative for a potential role of country-specific features at the level of production and trade structures as well as of policy and institutional mechanisms in explaining the divergence of the mentioned three countries from the other countries in our sample. In two countries, Austria and Germany, α actually decreased in the later subperiod relative to the earlier one, in Sweden it increased but lost its significance, and in the other four countries it remained insignificant.

Thus, although the economies in our sample may have increasingly become more open over time, we do not find that changes in the expected relative ToT have become a more important determinant of inflation dynamics in the majority of countries. Yet, whereas the number of countries for which the terms of trade are a key determinant of inflation dynamics has decreased, its relative importance in the economies of our sample where it remains relevant (three cases) has considerably increased.

5 Concluding Remarks

In this paper we subject the small open-economy version of the New Keynesian Phillips Curve derived in Galí and Monacelli (2005) to empirical assessment. To implement it, we first transform the SOE NKPC equation of their model into a testable econometric specification. Notably, the latter contains an additional explicit term capturing ToT fluctuations, and hence allows a comparison of the relevance of domestic versus external factors as driving forces in CPI inflation dynamics.

We do not find overwhelming support for the Galí and Monacelli (2005) SOE NKPC, yet we document some moderate evidence in its favor. Thus, for most economies in the sample we considered, expected relative changes in the ToT turned out to be a more important consumer-price inflation driver than the contemporaneous domestic output gap. Such weakly supportive evidence covers, depending on specification, about one-third to two-thirds of the countries in the sample.

Our estimates are not conclusive either concerning the potential effects of globalization on inflation dynamics, although we find that for about one-third of the countries in our sample the role of external factors does seem to have increased substantively in quantitative terms over time. Needless to say, globalization may not be the only factor contributing to this outcome. Factors such as the specific size, production structure and/or trade patterns of a particular country may have contributed, in addition to global trends, to a stronger or weaker influence of external versus domestic factors. Separating out and quantifying the effects along these dimensions, as well as other refinements of our initial broad estimates reported here, constitute interesting avenues for further theoretical and empirical research. More disaggregated data and alternative modeling of the pricing behavior of firms or of real rigidities are also among the areas for future exploration.

References

[1] Ball, Lawrence (2006), "Has Globalization Changed Inflation?", NBER Working Paper No. 12687 (October).

[2] Benigno, Gianluca and Pierpaolo Benigno (2008), "Exchange Rate Determination under Interest Rate Rules", *Journal of Money, Credit and Banking*, forthcoming.

[3] Blanchard, Olivier and Jordi Galí (2007), "Real Wage Rigidities and the New Keynesian Model", *Journal of Money, Credit and Banking* 39 (S1, February), 35–65.

[4] Borio, Claudio and Andrew Filardo (2007), "Globalisation and Inflation: New Cross-Country Evidence on the Global Determinants of Domestic Inflation," Bank for International Settlements Working Paper 227 (May), Basle.

[5] Calvo, Guillermo (1983), "Staggered Prices in a Utility-Maximizing Framework", *Journal of Monetary Economics* 12, 383–398.

[6] Dixit, Avinash and Joseph Stiglitz (1977), "Monopolistic Competition and Optimum Product Diversity," *American Economic Review* 67 (3, June), 297–308.

[7] Galí, Jordi and Mark Gertler (1999), "Inflation Dynamics: A Structural Econometric Approach," *Journal of Monetary Economics* 44 (2), 195–222.

[8] Galí, Jordi and Mark Gertler and David López-Salido (2001), "European Inflation Dynamics," *European Economic Review* 45 (7), 1237–1270.

[9] Galí, Jordi and Mark Gertler and David López-Salido (2003), "Erratum to European Inflation Dynamics," *European Economic Review* 47 (4), 759–760.

[10] Galí, Jordi and Mark Gertler and David López-Salido (2005), "Robustness of Estimates of the Hybrid New Keynesian Phillips Curve," *Journal of Monetary Economics* 52, 1107–1118.

[11] Galí, Jordi and Tommaso Monacelli (2005), "Monetary Policy and Exchange Rate Volatility in a Small Open Economy," *Review of Economic Studies* 72, 707–734.

[12] Leith, Campbell and Jim Malley (2007), "Estimated Open Economy New Keynesian Phillips Curves for the G7," *Open Economy Review* 18, 405–426.

[13] McKnight, Stephen and Alexander Mihailov (2007), "Re-examining the Importance of Trade Openness for Aggregate Instability", Economic Analysis Research Group Working Paper 12 (October), University of Reading.

[14] Mishkin, Frederic (2007), "Inflation Dynamics," *International Finance* 10 (3), 317–334.

[15] Mishkin, Frederic (2008), "Globalization, Macroeconomic Performance, and Monetary Policy", NBER Working Paper No. 13948 (April).

[16] Razin, Assaf and Chi-Wa Yuen (2002), "The 'New Keynesian' Phillips Curve: Closed Economy versus Open Economy," *Economics Letters* 75, 1–9.

[17] Razin, Assaf and Alon Binyamini (2007), "Flattened Inflation-Output Trade-off and Enhanced Anti-Inflation Policy: Outcome of Globalization?", NBER Working Paper No. 13280 (July).

[18] Rogoff, Kenneth (2003), "Globalization and Global Disinflation," in *Monetary Policy and Uncertainty: Adapting to a Changing Economy* , a symposium sponsored by the Federal Reserve Bank of Kansas City, Jackson Hole, Wyoming (August).

[19] Rogoff, Kenneth (2006), "Impact of Globalization on Monetary Policy," in *The New Economic Geography: Effects and Policy Implications*, a symposium sponsored by the Federal Reserve Bank of Kansas City, Jackson Hole, Wyoming (August).

[20] Rudd, Jeremy and Karl Whelan (2005), "New Tests of the New-Keynesian Phillips Curve", *Journal of Monetary Economics*, 52 (6, September), 1167–1181.

[21] Rudd, Jeremy and Karl Whelan (2006), "Can Rational Expectations Sticky-Price Models Explain Inflation Dynamics?", *American Economic Review* 96, 303–320.

[22] Rudd, Jeremy and Karl Whelan (2007), "Modeling Inflation Dynamics: A Critical Review of Recent Research", *Journal of Money Credit and Banking* 39 (1, February), 155–170.

[23] Rumler, Fabio (2007), "Estimates of the Open Economy New Keynesian Phillips Curve for Euro Area Countries", *Open Economy Review* 18, 427–451.

[24] Sbordone, Argia (2002), "Prices and Unit Labor Costs: A New Test of Price Stickiness," *Journal of Monetary Economics* 49 (2), 235–456.

[25] Sbordone, Argia (2005), "Do Expected Future Marginal Costs Drive Inflation Dynamics?," *Journal of Monetary Economics* 52, 1183–1197.

[26] Sbordone, Argia (2007), "Globalization and Inflation Dynamics: The Impact of Increased Competition,", NBER Working Paper No. 13556 (October).

[27] White, William (2008), "Globalisation and the Determinants of Domestic Inflation," Bank for International Settlements Working Paper 250 (March), Basle.

[28] Woodford, Michael (2007), "Globalization and Monetary Control", prepared for the NBER conference on *International Dimensions of Monetary Policy*, Girona, Spain, June 11-13, 2007, forthcoming in the NBER volume with the same title at the University of Chicago Press.

A Instrumental Variables Used in the Estimations

In addition to the instruments below, each instrument set includes also a constant.

In Table 1:

Austria: CPI inflation lags 1 to 4, H-P filtered output gap lags 1 to 4, change in terms of trade lags 1 to 6;
Germany: CPI inflation lags 1 to 6, H-P filtered output gap lags 1 to 4, change in terms of trade lags 1 to 4;
Italy: CPI inflation lags 1 to 4, H-P filtered output gap lags 1 to 4, change in terms of trade lags 1 to 4;
France: CPI inflation lags 1 to 4, real unit labor costs lags 1 to 6, change in terms of trade lags 1 to 4;
Spain: CPI inflation lags 1 to 4, H-P filtered output gap lags 1 to 6, change in terms of trade lags 1 to 4;
Netherlands: CPI inflation lags 1 to 4, H-P filtered output gap lags 1 to 4, change in terms of trade lags 1 to 6;
UK: CPI inflation lags 1 to 6, H-P filtered output gap lags 1 to 6, change in terms of trade lags 1 to 4;
Canada: CPI inflation lags 1 to 4, H-P filtered output gap lags 1 to 6, change in terms of trade lags 1 to 6;
Sweden: CPI inflation lags 1 to 6, H-P filtered output gap lags 1 to 4, change in terms of trade lags 1 to 4;
Switzerland: CPI inflation lags 1 to 6, H-P filtered output gap lags 1 to 4, change in terms of trade lags 1 to 4.

In Table 2:

As in Table 1, except with Q-P filtered output gap instead of H-P filtered output gap.

In Table 3:

As in Table 1, except with real unit labor costs instead of H-P filtered output gap.

In Table 4:

As in Table 1.

In Table 5:

Austria: CPI inflation lags 1 to 6, H-P filtered output gap lags 1 to 6, change in the bilateral USD/EUR (national currency before 1999) exchange rate lags 1 to 4;
Germany: CPI inflation lags 1 to 6, H-P filtered output gap lags 1 to 4, change in the HWWA commodity price index lags 1 to 4;
Italy: CPI inflation lags 1 to 4, H-P filtered output gap lags 1 to 4, terms of trade lags 1 to 4;
France: CPI inflation lags 1 to 4, real unit labor costs lags 1 to 6, change in terms of trade lags 1 to 4;
Spain: CPI inflation lags 1 to 4, real unit labor costs lags 1 to 6, change in the HWWA commodity price index lags 1 to 4;
Netherlands: CPI inflation lags 1 to 6, H-P filtered output gap lags 1 to 4, change in the bilateral USD/EUR (national currency before 1999) exchange rate lags 1 to 4;
UK: CPI inflation lags 1 to 6, H-P filtered output gap lags 1 to 6, change in terms of trade lags 1 to 4;
Canada: CPI inflation lags 1 to 6, H-P filtered output gap lags 1 to 6, change in import prices lags 1 to 6;
Sweden: CPI inflation lags 1 to 6, real unit labor costs lags 1 to 6, change in the bilateral USD/SEK exchange rate lags 1 to 6;
Switzerland: CPI inflation lags 1 to 6, H-P filtered output gap lags 1 to 4, change in the bilateral USD/CHF exchange rate lags 1 to 4.

In Table 6:

As in Table 5, except that CPI inflation starts at lag 2 instead of 1.

In Table 7:

As in Table 1.

In Table 8:

As in Table 1.

B Theoretically Expected Sign of κ_α

Note that in Galí–Monacelli's (2005) SOE version of the NK model, which we subject to empirical testing here, $\kappa_\alpha \equiv \lambda(\sigma_\alpha + \varphi)$, where $\lambda \equiv \frac{(1-\beta\theta)(1-\theta)}{\theta} > 0$, $\varphi > 0$, $\sigma_\alpha \equiv \frac{\sigma}{(1-\alpha)+\alpha\omega} \gtrless 0$, and $\omega \equiv \sigma\gamma + (1-\alpha)(\sigma\eta - 1) \gtreqless 0$. From the signs of the enumerated components in the definition of κ_α *two general cases* and *one special case* stand out.

The *first general case* is where $\sigma\eta > 1$, i.e., the *product* of the *inverse* of the intERtemporal substitutability in consumption of the aggregate SOE's consumption index, $\sigma > 0$, and the intRAtemporal substitutability in consumption between domestically-produced and imported goods entering that index, $\eta > 0$, is *larger than unity.* In this case,

$$\omega \equiv \sigma\gamma + (1-\alpha)\underbrace{(\sigma\eta - 1)}_{>1} > 0$$

so that

$$\sigma_\alpha \equiv \frac{\sigma}{(1-\alpha) + \alpha\underbrace{\omega}_{>0}} > 0$$

and clearly then

$$\kappa_\alpha \equiv \lambda\left(\underbrace{\sigma_\alpha}_{>0} + \quad \varphi\right) > 0.$$

The *special case* is where $\sigma\eta = 1$, implying $\omega \equiv \sigma\gamma > 0$ too and, hence, again $\sigma_\alpha > 0$ and finally $\kappa_\alpha > 0$. These two cases, the general and the special ones, both implying $\kappa_\alpha > 0$. In the context of such parameter values, namely, $\sigma\eta \geq 1$ leading to $\kappa_\alpha > 0$, therefore, the theoretically expected sign of the output gap is *unambiguously positive.*

However, the *second general case* arises where $\sigma\eta < 1$, i.e., the *product* of the *inverse* of the *inter*temporal substitutability in consumption of the aggregate SOE's consumption index, $\sigma > 0$, and the *intra*temporal substitutability in consumption between domestically-produced and imported goods entering that index, $\eta > 0$, is *smaller than unity.* In this case,

$$\omega \equiv \underbrace{\sigma\gamma}_{+} + \underbrace{(1-\alpha)}_{+}\underbrace{(\sigma\eta - 1)}_{-}$$

so that if

$$\underbrace{\sigma\gamma}_{+} > \underbrace{(1-\alpha)}_{+}\underbrace{(1-\sigma\eta)}_{+}$$

$$\Leftrightarrow \frac{\gamma}{1-\alpha} + \eta > \sigma^{-1}$$

then $\kappa_\alpha > 0$, as before, but if the opposite is true, i.e.,

$$\frac{\gamma}{1-\alpha} + \eta < \sigma^{-1}$$

then $\omega < 0$, so that

$$\sigma_\alpha \equiv \frac{\overbrace{\sigma}^{+}}{\underbrace{(1-\alpha)}_{+} + \underbrace{\alpha\omega}_{-}}$$

and if, further,

$$\underbrace{\alpha - 1}_{-} < \underbrace{\alpha\omega}_{-}$$

then $\sigma_\alpha > 0$ and so $\kappa_\alpha > 0$, as before, but if the opposite is true, i.e.,

$$\underbrace{\alpha - 1}_{-} > \underbrace{\alpha\omega}_{-}$$

then $\sigma_\alpha < 0$ and

$$\kappa_\alpha \equiv \underbrace{\lambda}_{+} \left(\underbrace{\sigma_\alpha}_{-} + \underbrace{\varphi}_{+} \right)$$

so that if

$$|\sigma_\alpha| < |\varphi|$$

then $\kappa_\alpha > 0$, as before, but if the opposite is true, i.e.,

$$|\sigma_\alpha| > |\varphi|$$

then $\kappa_\alpha < 0$ we obtain the standard NK model. As we can verify from the long chain of ‘ifs’ that need to be true in order to finally arrive at $\kappa_\alpha < 0$ in the Galí–Monacelli (2005) SOE version of the usual NK framework, the case of $\kappa_\alpha < 0$ would be theoretically (much) less probable – or may be even not plausible for appropriately chosen parameter values – than the case of $\kappa_\alpha > 0$.

Table 1: GMM Estimates of the SOE NKPC with H-P Filtered Output Gap

	β		p-value	κ_α		p-value	α		p-value	p(J-stat)
Austria	0.87	***	0.00	0.00		1.00	-0.27		0.10	0.43
Germany	0.97	***	0.00	0.02		0.53	0.17	***	0.00	0.51
Italy	1.01	***	0.00	0.06		0.26	0.06		0.10	0.53
France	1.05	***	0.00	0.19	**	0.02	-0.08		0.31	0.42
Spain	0.99	***	0.00	0.01		0.70	-0.01		0.54	0.77
Netherlands	0.94	***	0.00	0.01		0.79	0.28	***	0.00	0.30
UK	0.87	***	0.00	0.18	**	0.02	0.48	***	0.00	0.46
Canada	0.99	***	0.00	0.04		0.28	0.14	*	0.07	0.72
Sweden	0.93	***	0.00	-0.14	**	0.03	0.01		0.60	0.54
Switzerland	0.93	***	0.00	0.02		0.67	0.24	***	0.03	0.35

Notes: Coefficients are estimated according to equation (7). The estimation period is 1970:1–2007:4 (except for Austria: 1980:1–2007:4). The stars attached to the coefficients estimates show significance levels, where * denotes significance at the 10%, ** at the 5% and *** at the 1% level. The Hansen's J-test tests the validity of the overidentifying restrictions imposed by the instruments with the null hypothesis that the overidentifying restrictions are satisfied (the instruments are valid). Standard errors are robust with respect to heteroskedasticity and autocorrelation.

Table 2: GMM Estimates of the SOE NKPC with Q-P Filtered Output Gap

	β		p-value	κ_α		p-value	α		p-value	p(J-stat)
Austria	0.89	***	0.00	0.02		0.52	-0.26		0.12	0.44
Germany	0.98	***	0.00	0.00		0.94	0.18	***	0.00	0.54
Italy	1.01	***	0.00	0.02		0.31	0.06	*	0.08	0.60
France	1.01	***	0.00	0.12	*	0.01	-0.06		0.40	0.42
Spain	0.99	***	0.00	0.00		0.83	0.00		0.70	0.76
Netherlands	0.94	***	0.00	0.01		0.36	0.29	***	0.00	0.32
UK	0.86	***	0.00	0.04		0.23	0.47	***	0.00	0.36
Canada	0.99	***	0.00	0.01		0.44	0.15	*	0.07	0.72
Sweden	0.95	***	0.00	-0.02		0.20	0.01		0.62	0.52
Switzerland	0.91	***	0.00	0.01		0.47	0.25	***	0.02	0.36

Notes: Coefficients are estimated according to equation (7). The estimation period is 1970:1–2007:4 (except for Austria: 1980:1–2007:4). The stars attached to the coefficients estimates show significance levels, where * denotes significance at the 10%, ** at the 5% and *** at the 1% level.

Table 3: GMM Estimates of the SOE NKPC with Labor Income Share (as RMC Proxy)

	β		p-value	λ		p-value	α		p-value	p(J-stat)	
Austria	0.89	***	0.00	-0.02		0.72	-0.02		0.91	0.40	
Germany	0.97	***	0.00	0.00		0.91	0.17	***	0.00	0.54	
Italy	1.02	***	0.00	0.00		0.76	0.23	***	0.02	0.73	
France	0.98	***	0.00	0.01		0.27	-0.04		0.52	0.20	*
Spain	1.00	***	0.00	0.00		0.33	0.01		0.38	0.95	
Netherlands	0.96	***	0.00	0.01		0.54	0.28	***	0.00	0.20	*
UK	0.81	***	0.00	-0.10	***	0.00	0.53	***	0.00	0.27	
Canada	0.99	***	0.00	0.00		0.81	0.00		0.98	0.72	
Sweden	0.93	***	0.00	-0.02		0.24	0.01		0.61	0.46	

Notes: Coefficients are estimated according to equation (6). The estimation period is 1970:1–2007:4 (except for Austria: 1980:1–2007:4; Italy: 1975:1–2007:4; Spain: 1980:1–2007:4). The stars attached to the coefficients estimates show significance levels, where * denotes significance at the 10%, ** at the 5% and *** at the 1% level.

Table 4: GMM Estimates of the SOE NKPC with H-P Filtered Output Gap but Differenced ToT

	β_Δ		p-value	$\kappa_{\alpha\Delta}$		p-value	α_Δ		p-value	p(J-stat)	
Austria	0.89	***	0.00	0.02		0.65	0.35	**	0.02	0.45	
Germany	0.95	***	0.00	0.03		0.29	0.18	***	0.00	0.33	
Italy	1.01	***	0.00	0.08		0.10	0.05		0.29	0.41	
France	1.06	***	0.00	0.15	**	0.02	0.09	**	0.02	0.67	
Spain	0.99	***	0.00	0.01		0.60	0.01		0.54	0.76	
Netherlands	0.96	***	0.00	-0.01		0.84	0.31	***	0.00	0.19	*
UK	0.83	***	0.00	0.30	***	0.00	0.55	***	0.00	0.32	
Canada	1.00	***	0.00	0.03		0.34	0.04		0.42	0.64	
Sweden	0.92	***	0.00	-0.14	**	0.03	0.02		0.61	0.55	
Switzerland	0.81	***	0.00	-0.04		0.43	0.16	**	0.03	0.25	

Notes: Coefficients are estimated from $\pi_t = \beta_\Delta E_t \pi_{t+1} + \kappa_{\alpha\Delta} x_t + \alpha_\Delta \Delta s_t$. The estimation period is 1970:1–2007:4 (except for Austria: 1980:1–2007:4). The stars attached to the coefficients estimates show significance levels, where * denotes significance at the 10%, ** at the 5% and *** at the 1% level.

Table 5: GMM Estimates of the Pure Closed Economy NKPC with H-P Filtered Output Gap

	β		p-value	κ		p-value	p(J-stat)
Austria	0.91	***	0.00	0.04		0.28	0.53
Germany	0.99	***	0.00	0.05	*	0.08	0.47
Italy	1.00	***	0.00	0.12	**	0.02	0.42
France	1.03	***	0.00	0.13	**	0.02	0.30
Spain	1.02	***	0.00	0.05		0.22	0.84
Netherlands	0.97	***	0.00	0.01		0.66	0.26
UK	0.81	***	0.00	0.48	***	0.00	0.21
Canada	1.00	***	0.00	0.05		0.10	0.80
Sweden	1.00	***	0.00	0.11		0.42	0.51
Switzerland	0.95	***	0.00	-0.01		0.74	0.23

Notes: Coefficients are estimated from $\pi_t = \beta E_t \pi_{t+1} + \kappa x_t$. The estimation period is 1970:1–2007:4 (except for Austria: 1980:1–2007:4). The stars attached to the coefficients estimates show significance levels, where * denotes significance at the 10%, ** at the 5% and *** at the 1% level.

Table 6: GMM Estimates of the Hybrid Closed Economy NKPC with H-P Filtered Output Gap

	γ_f		p-value	γ_b		p-value	κ		p-value	p(J-stat)	
Austria	0.71	***	0.00	0.29	***	0.00	0.01		0.66	0.47	
Germany	0.55	***	0.00	0.44	***	0.00	0.02		0.19	0.25	*
Italy	0.62	***	0.00	0.38	***	0.00	0.07	**	0.04	0.29	*
France	0.40	***	0.00	0.60	***	0.00	-0.01		0.75	0.24	*
Spain	0.79	***	0.00	0.23		0.32	0.06		0.10	0.74	
Netherlands	0.54	***	0.00	0.46	***	0.00	0.01		0.75	0.19	*
UK	0.58	***	0.00	0.23	***	0.01	0.32	***	0.00	0.13	**
Canada	0.67	***	0.00	0.33	***	0.00	0.04	*	0.07	0.66	
Sweden	0.69	***	0.00	0.33	***	0.00	0.14		0.32	0.40	
Switzerland	0.34	***	0.00	0.62	***	0.00	0.00		0.92	0.14	**

Notes: Coefficients are estimated from $\pi_t = \gamma_f E_t \pi_{t+1} + \gamma_b \pi_{t-1} + \kappa x_t$. The estimation period is 1970:1–2007:4 (except for Austria: 1980:1–2007:4). The stars attached to the coefficients estimates show significance levels, where * denotes significance at the 10%, ** at the 5% and *** at the 1% level.

Table 7: GMM Estimates of the SOE NKPC with H-P Filtered Output Gap: Earlier Subsample (1970:1–1986:4)

	β		p-value	κ_α		p-value	α		p-value	p(J-stat)
Austria	0.30	***	0.00	-0.56	***	0.00	0.33	*	0.09	0.71
Germany	0.99	***	0.00	0.07	**	0.03	0.07	**	0.04	0.77
Italy	1.00	***	0.00	0.08		0.38	0.04		0.23	0.78
France	1.03	***	0.00	0.10	**	0.03	-0.04		0.37	0.72
Spain	0.98	***	0.00	0.08		0.47	0.00		0.79	0.63
Netherlands	0.97	***	0.00	0.20		0.11	0.21	**	0.01	0.58
UK	0.90	***	0.00	0.24		0.03	0.47	***	0.00	0.80
Canada	0.98	***	0.00	0.09		0.18	0.08		0.10	0.90
Sweden	0.91	***	0.00	-0.44	***	0.00	0.04	**	0.06	0.63
Switzerland	0.86	***	0.00	-0.14	**	0.01	0.10		0.41	0.69

Notes: Coefficients are estimated according to equation (7). The estimation period is 1970:1–1986:4 (except for Austria: 1980:1–1990:4; Germany: 1970:1–1990:4). The stars attached to the coefficients estimates show significance levels, where * denotes significance at the 10%, ** at the 5% and *** at the 1% level.

Table 8: GMM Estimates of the SOE NKPC with H-P Filtered Output Gap: Later Subsample (1987:1–2007:4)

	β		p-value	κ_α		p-value	α		p-value	p(J-stat)
Austria	0.96	***	0.00	0.00		0.99	0.12		0.58	0.77
Germany	0.83	***	0.00	-0.03		0.44	0.06		0.25	0.46
Italy	1.04	***	0.00	0.01		0.80	0.14	**	0.05	0.35
France	0.96	***	0.00	0.01		0.71	0.01		0.91	0.25
Spain	0.99	***	0.00	-0.05	**	0.02	0.01		0.65	0.90
Netherlands	0.86	***	0.00	-0.07	**	0.03	0.27	***	0.00	0.25
UK	0.72	***	0.00	0.24	**	0.03	0.84	***	0.00	0.68
Canada	0.97	***	0.00	0.02		0.65	0.05		0.40	0.91
Sweden	0.95	***	0.00	0.01		0.89	0.05		0.48	0.55
Switzerland	1.03	***	0.00	0.10	*	0.07	0.12		0.13	0.26

Notes: Coefficients are estimated according to equation (7). The estimation period is 1987:1–2007:4 (except for Austria and Germany: 1991:1–2007:4). The stars attached to the coefficients estimates show significance levels, where * denotes significance at the 10%, ** at the 5% and *** at the 1% level.