The New Keynesian Phillips Curve and the Role of Expectations: Evidence from the Ifo World Economic Survey

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Abstract

We provide evidence on the fit of the hybrid New Keynesian Phillips curve for selected euro zone countries, the US and the UK. Instead of imposing rational expectations and estimating the Phillips curve by the Generalized Method of Moments, we follow Roberts (1997) and Adam and Padula (2003) and use direct measures of inflation expectations. The data source is the Ifo World Economic Survey which quarterly polls economic experts about their expected future development of inflation. Our main findings are as follows: (i) In comparison with the rational expectations approach backward-looking behavior turns out to more relevant for most countries in our sample. (ii) The use of survey data for inflation expectations yields a positive and significant slope of the Phillips curve when the output gap is used as a measure for real marginal costs.

JEL classifications: C52; E31
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Contents

1 Introduction

The relationship between inflation and real variables is of crucial importance for an understanding of the effects of monetary policy on inflation. In recent years, some kind of consensus has emerged, generally referred to as New Keynesian macroeconomics, that integrates Keynesian elements (imperfect competition, nominal rigidities) into a dynamic general equilibrium framework traditionally used in the Real Business Cycle literature. The nature of inflation dynamics is arguably the most distinctive feature of the New Keynesian paradigm. It is captured by the so-called New Keynesian Phillips curve which is based on Calvo's (1983) model of staggered price setting. While theoretically appealing, a number of authors (e.g. Fuhrer and Moore (1995)) criticized this version of the Phillips curve since the implied 'jump' behavior of inflation was completely at odds with the hump-shaped behavior that can be observed in VAR analyses. As a consequence, Galí and Gertler (1999) extended Calvo's theoretical framework to the so-called hybrid New Keynesian Phillips curve (HNKPC) by allowing for a fraction of firms that set prices according to a backward-looking rule-of-thumb.

The empirical findings are encouraging for the New Keynesian Phillips curve. Empirical work mainly centers around the question of which variable to use for measuring real activity and whether backward-looking behavior is relevant. Concerning the first question, theory tells us that real marginal costs are the driving force underlying changes in inflation. In a recent survey article Galí (2003) emphasizes that empirical results are promising when the New Keynesian Phillips curve is estimated in a way consistent with theory, implying that labor income share is used instead of detrended GDP as a proxy for real marginal costs. Concerning the second question he continues: "Although backward-looking behavior is often statistically significant, it appears to have limited quantitative importance. In other words, although the baseline pure forward-looking model is rejected on statistical grounds, it is still likely to be a reasonable first approximation to the inflation dynamics of both Europe and the United States." (ibid., p. 162).

The standard econometric tool for estimating the New Keynesian Phillips curve is the Instrumental Variables or, more generally, the Generalized Method of Moments (GMM). In this estimation procedure, expectations about future variables are replaced by their ex-post realizations, and expectational errors are assumed to be uncorrelated with all variables in the information set of agents available at the time expectations are formed. In other words, expectations are assumed to be rational.

The contribution of this paper is twofold. On a theoretical level we derive the HNKPC under the assumption that firms may have non-rational expectations. Available evidence from surveys suggests that inflation expectations are in many cases biased and inefficient predictors of future inflation, thereby questioning the assumption of rationality (see Roberts (1997) and the papers cited there). We extent the theoretical framework developed by Adam and Padula (2003) so as to allow for the existence of both, forward-looking and backward-looking firms. On an empirical level we follow Roberts (1997) and Adam and Padula (2003) and use direct measures of inflation expectations, instead of imposing rational expectations and estimating the Phillips curve by GMM. The data source is the Ifo World Economic Survey which quarterly polls economic experts about their expected future development of inflation. The main results are that (i) in comparison with the rational expectations approach backward-looking behavior turns out to more relevant for most countries in our sample and that (ii) the use of survey data for inflation expectations yields a positive and significant slope of the Phillips curve when the output gap is used as a measure for real marginal costs.

The paper is organized as follows. In section 2 we present the standard version of the HNKPC that results from a rational expectations approach and we modify it so as to account for expectations of firms that are subjective and potentially non-rational. Section 3 gives an overview of the data. The main focus is on the presentation of the inflation expectations from the Ifo WES, but we also briefly discuss the variables that are used as proxies for real marginal costs. Our estimation results and a comparison with other empirical work (mainly using the rational expectations approach) are presented in section 4. Section 5 finally summarizes the main results and concludes.

2 The Hybrid New Keynesian Phillips Curve

2.1 Rational Expectations

The version of the HNKPC that is mostly used in the literature has been introduced by Galí and Gertler (1999) and extended by Galí, Gertler, and López-Salido (2001). It is based on Calvo's (1983) staggered price setting framework in which each firm has a probability $1-\theta$ of being able to reset its price in any given period, independently of the time elapsed since the most recent price adjustment. In contrast to Calvo (1983), however, they assume that of those firms being able to adjust prices in a given period, there is only a fraction of firms $1-\omega$ that sets prices optimally in a forward-looking manner. The remaining part uses a rule-of-thumb that simply augments last period's average reset price by the inflation rate prevailing in that period. It can then be shown that the HNKPC is given by

$$\pi_t = \gamma_f E_t[\pi_{t+1}] + \gamma_b \pi_{t-1} + \lambda mc_t + \varepsilon_t \tag{1}$$

where π_t denotes the inflation rate, $E[\cdot]$ the rational expectations operator, and mc_t the logarithm of real marginal costs, and where the coefficients can be expressed in terms of the structural parameters

$$\gamma_f = \frac{\beta\theta}{\theta + \omega[1-\theta(1-\beta)]},$$

$$\gamma_b = \frac{\omega}{\theta + \omega[1-\theta(1-\beta)]},$$

$$\lambda = \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\theta + \omega[1-\theta(1-\beta)]}.$$

β is the discount factor of the firms' intertemporal maximization problem. An important assumption underlying the derivation of the structural parameters was that firms operate under monopolistic competition with a Cobb-Douglas production technology and constant returns to scale. If returns to scale are decreasing, Galí, Gertler, and López-Salido (2001) showed that λ additionally becomes a function of the labor elasticity of production and the price elasticity of demand.

This very general formulation of the Phillips curve comprises two special cases. First, when the discount factor β is restricted to unity, $\gamma_f + \gamma_b = 1$, which implies that in the long-run the Phillips curve is vertical. Second, when $\omega = 0$ all firms set their prices optimally and the model converges to the pure forward-looking New Keynesian Phillips curve ($\gamma_f = \beta$, $\gamma_b = 0$, $\lambda = [(1-\theta)(1-\beta\theta)]/\theta$).

2.2 Subjective Expectations

As in the previous section we distinguish between two groups of firms: forward-looking firms which set prices according to an intertemporal optimization procedure, and backward-looking firms which set prices according to a simple rule-of-thumb. The main difference to the previous section is the way forward-looking firms form their expectation. Instead of imposing rational expectations (i.e. all firms form expectations homogenously, using the same model and the same information set), we allow for subjective expectations of each single forward-looking firm which may be rational or not and which may be heterogeneous across firms.

In the following we will derive the HNKPC under the assumption that firms form subjective expectations. We will extend the theoretical framework of Adam and Padula (2003) by explicitly introducing backward-looking firms. In contrast to their paper which describes the price-setting behavior of firms from the point of view of professional forecasters, we assume that the source of potential non-rationalities in expectations are the firms themselves. This has the advantage that we can continue to distinguish between two types of firms as in the case of rational expectations. If we had extended the professional forecasters' approach of Adam and Padula (2003), we would have faced the problem of finding an economic rationale for the additional consideration of π_{t-1} in the Phillips curve. The reason for this is that professional forecasters should take into account the existence of backward-looking firms when forming their expectations.

In accordance with the rational expectations approach the starting point is Calvo's (1983) staggered price setting framework which defines the log of the aggregate price level p_t as

$$p_t = (1-\theta)p_t^* + \theta p_{t-1}, \tag{2}$$

where p_t^* is the average reset price and $1-\theta$ the probability that firms reset prices. The average reset price is a weighted sum of the average price set by forward-looking firms and the average price set by backward-looking firms

$$p_t^* = (1-\omega)\frac{1}{I}\sum_{i=1}^{I} p_t^{f,i} + \omega\frac{1}{J}\sum_{i=1}^{J} p_t^{b,i}, \tag{3}$$

where I (J) is the number of forward-looking (backward-looking) firms, ω the fraction of backward-looking firms ($\omega = J/(I+J)$), and $p_t^{b,i}$ $(p_t^{f,i})$ the price set by the backward-looking (forward-looking) firm i. All firms which set prices in a backward-looking manner follow an identical rule-of-thumb according to which last period's average reset price is simply corrected by lagged inflation. Forming the average of all backward-looking firms gives

$$p_t^b = \frac{1}{J}\sum_{i=1}^{J} p_t^{b,i} = p_{t-1}^* + \pi_{t-1}. \tag{4}$$

Firms which behave in a forward-looking manner maximize expected discounted profits given technology, factor prices and the constraint on price adjustment (defined by $1-\theta$) which results in the following log-linear rule:

$$\begin{aligned} p_t^{f,i} &= (1-\beta\theta)F_t^i[\sum_{k=0}^{\infty}(\beta\theta)^k(mc_{t+k}+p_{t+k})] = \\ &= (1-\beta\theta)(mc_t+p_t) + \beta\theta F_t^i[p_{t+1}^{f,i}], \end{aligned} \tag{5}$$

where $F_t^i[\cdot]$ denotes the subjective expectations operator of firm i[1]. While individual firms produce differentiated products under monopolistic competition, they are all assumed to have the same Cobb-Douglas production technology and to face demand curves with constant and equal demand elasticities. The crucial problem now is the aggregation of individual prices set by forward-looking firms. Following Adam and Padula (2003) we assume that firm i forms expectations about other firms' optimum prices and aggregates them to the average forward-looking price:

$$F_t^i[p_{t+1}^f] = F_t^i[\frac{1}{I}\sum_{h=1}^{I} p_{t+1}^{f,h}]. \tag{6}$$

Defining the average current forward-looking price by

$$p_t^f = \frac{1}{I}\sum_{h=1}^{I} p_t^{f,h} \tag{7}$$

and assuming that the 'law of iterated expectations' holds which implies that agents do not expect that current forecasts of future variables z will be revised in a particular direction in the next period

$$F_t^i[F_{t+1}^h[z_{t+s}] - F_t^h[z_{t+s}]] = 0 \quad \forall\ i, h, s > 0, \tag{8}$$

Adam and Padula (2003) show that equation (6) can be expressed as

$$F_t^i[\pi_{t+1}^f] = (1-\beta\theta)(F_t^i[p_{t+1}^f] - mc_t - p_t), \tag{9}$$

where $\pi_{t+1}^f = p_{t+1}^f - p_t^f$. In order to get this equation they took the difference between equation (6) and (7), replaced $p_t^{f,h}$ with the first expression of equation (5) and applied the law of iterated expectations (see appendix A).

Combining equations (2), (3) and (4) gives a relationship between p_t^f and p_t (see appendix B),

$$p_t^f = \frac{p_t + (\theta\omega - 2\omega - \theta)p_{t-1} + \omega p_{t-2}}{(1-\theta)(1-\omega)}, \tag{10}$$

which can be shifted one period forward by applying the $F_t^i[\cdot]$ operator:

$$F_t^i[p_{t+1}^f] = \frac{F_t^i[p_{t+1}] + (\theta\omega - 2\omega - \theta)p_t + \omega p_{t-1}}{(1-\theta)(1-\omega)}. \tag{11}$$

[1] Apart from the $F_t^i[\cdot]$ operator equation (5) is identical with the optimum pricing rule under rational expectations. For a derivation see Galí and Gertler (1999) and Galí, Gertler, and López-Salido (2001).

Inserting equations (10) and (11) into equation (9) and aggregating over all subjective expectations, $\bar{F}_t[\cdot] = (1/I)\sum_{i=1}^{I} F_t^i[\cdot]$, finally gives the HNKPC based on average subjective expectations (see appendix C),

$$\pi_t = \gamma_f \bar{F}_t[\pi_{t+1}] + \gamma_b \pi_{t-1} + \lambda mc_t, \qquad (12)$$

where $\pi_t = p_t - p_{t-1}$. Note that equation (12) is identical with the specification derived under rational expectations, except for the way expectations are formed.

3 Data Description

3.1 Inflation Expectations from the Ifo World Economic Survey

Subjective inflation expectations are taken from the Ifo World Economic Survey (WES) which assesses trends in the world economy by polling transnational as well as national organizations worldwide about economic developments. It is conducted in co-operation of Ifo Institute for Economic Research and the International Chamber of Commerce (ICC) in Paris. The questionnaire of the WES which is distributed every quarter (January, April, July and October) and which was first conducted in March 1983 asks participants to give their assessment of the general economic situation and expectations regarding important macroeconomic indicators of the country they inhabit. Currently, the WES asks about 1100 experts in 90 countries. Thus, in order to be able to apply this data to our theoretical framework described in section 2.2 we have to assume that the survey responses are a representative subset of the expectations of all firms.

A question on the expected inflation rate, which is in the focus of the present paper, was only included since July 1991. Survey participants are asked to give their expectations on the inflation rate by the end of the next six months. They indicate UP for an expected rise in the inflation rate, SAME for no change in the inflation rate and DOWN for an expected fall in the inflation rate by the end of the next six months. The questionnaire therefore reveals qualitative information on the participants' expectations. In Henzel and Wollmershäuser (2005) we presented a new methodology for the quantification of qualitative survey data. Traditional conversion methods, such as the Carlson and Parkin (1975) method or the time-varying parameters model of Seitz (1988), require very restrictive assumptions concerning the expectations formation process of survey respondents. Above all, the unbiasedness of expectations, which is a necessary condition for rationality, is imposed. Our approach avoids this assumption. The novelty was the way the boundaries inside of which survey respondents expect the variable under consideration to remain unchanged are determined. Instead of deriving these boundaries from the statistical properties of the reference time-series (which necessitates the unbiasedness assumption), we directly queried them from survey respondents by a special question in the Ifo WES. The new methodology was then applied to expectations about the future development of inflation obtained from the Ifo WES.

For Germany, France, Italy, the Euro zone[2], the UK and the US the converted inflation expectations and the actual inflation rate are shown in figure 1. Inflation rates are taken from the OECD database, except for the Euro zone inflation which was taken from Eurostat. Note that there are two outliers in the expectations time-series, namely in France (third quarter of 2000) and in Italy (second quarter of 1996), for which we controlled in our empirical analysis below by adding a dummy variable to the regression. The occurrence of these outliers is an unavoidable shortcoming of all conversion methods when at a given point in time the assumption of normally distributed survey responses is violated[3]. Inflation expectations from the Ifo WES are 6-months-ahead inflation expectations which are queried every three months in the first two weeks of January, April, July and October. In Henzel and Wollmershäuser (2005) we showed that the information set that is available to the survey respondents at the time they fill in the questionnaire is the past quarter (that is the first quarter for the questionnaires returned at the beginning of April, the second quarter for the questionnaires returned at the beginning of July, and so on). Thus, the April survey produces inflation expectations $E_t\pi_{t+2}$, where t refers to the first quarter and $t+2$ to the third quarter. In a quarterly Phillips curve model, however, the required expectation's horizon for $E_t\pi_{t+1}$ should be a quarter of a year. Thus, in order to correctly apply the Ifo WES 6-months-ahead inflation expectations to the theoretical model, it is more suitable to use semiannual data. To see whether the frequency of the data matters for the empirical results, we will present our estimates for both, quarterly and semiannual data. For the European countries our data starts in the first quarter of 1993 in order to exclude the crisis of the European Monetary System which took place in September 1992.

[2]Euro zone inflation expectations have been calculated as a weighted sum of the responses for the individual member countries. The weights are the country weights used by Eurostat to calculate the Harmonized Index of Consumer Prices for the Euro zone. See Henzel and Wollmershäuser (2005) for further details.

[3]In the case of France, for example, in the October 2000 survey 13 out of 21 respondents indicated UP and 7 indicated DOWN. The problem was that only 1 respondent expected inflation to remain the same, which is a clear violation of the normality assumption.

By contrast, for the US we use the entire sample of inflation expectations which is available from the second quarter of 1991 to the second quarter of 2004. Compared to many other empirical Phillips curve studies this rather short estimation period is a novelty. Galí, Gertler, and López-Salido (2001) and Jondeau and LeBihan (2001) for example started in 1970 (see table 9).

Using survey data for inflation expectations instead of imposing rational expectations when estimating a Phillips curve relationship should only produce different results if survey expectations are not being formed rationally. The reason why we are questioning the rationality of survey expectations is due to the mixed evidence reported in the literature. Many papers that have examined survey measures of inflation expectations have concluded that these expectations are not rational in the sense of Muth (1961) (see for example Roberts (1997) and the papers cited there).

A necessary condition for rational expectations is the unbiasedness of expectations. In order to find out whether Ifo WES expectations are unbiased predictors of future inflation we regressed the forecast error (defined as $\pi_t - E_{t-2}\pi_t$) on a constant c and tested whether it is significantly different from zero. Table (1) reveals that most of the inflation expectations were unbiased during the period 1993:1 (1991:2 in the case of the US) to 2004:2. Italy, the UK and the US are the only countries in which expectations do not fulfill the necessary condition for rationality[4]. From the negative sign of the constant we can conclude that expectations were biased upwards throughout the period of disinflation in the beginning of the 1990s.

A further necessary condition for rational expectations is the efficiency of expectations which implies that no piece of information known at time $t-2$ or earlier can be used to explain the forecast error. A first indication for the inefficiency of expectations is given by the p-values of the Ljung-Box Q test (H_0: no autocorrelation up to the fourth lag) and the serial correlation LM-test (H_0: no autocorrelation up to the second and fourth lag) in table 1 which indicate that, except for Italy, the residuals are not free of autocorrelation[5]. Autocorrelation in the forecast error implies that a shock to the inflation rate or to some other economic variable was not taken into account when the inflation forecast was made and that the same mistake was repeated in subsequent periods. In other words, efficiency of

[4]Using the Livingston Survey of Professional Forecasters (which queries quantitative inflation expectations) Adam and Padula (2003) also find that expectations in the US were biased during the nineties.

[5]As the forecast horizon does not correspond to the frequency of the survey, shocks to the inflation rate can not be taken into account until the second period after the forecast and the same error may be repeated again. Thus, autocorrelation of order one in the error constitutes no irrationality.

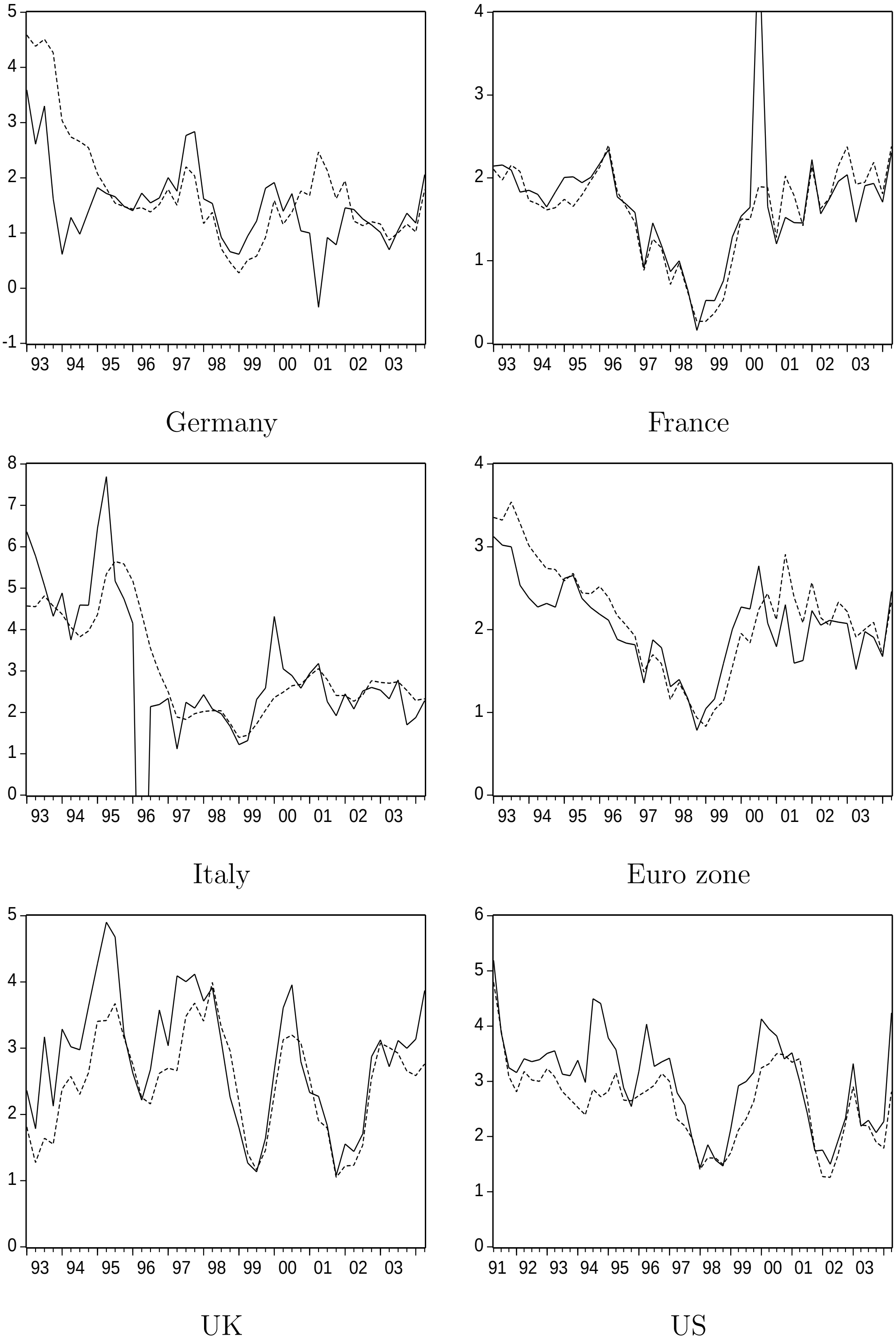


Figure 1: Actual (dashed line) and expected (continuous line) inflation

Country	c	Q 4 Lags	LM(2)	LM(4)
Germany	0.19 (1.04)	0.000	0.000	0.001
France	0.02 (0.30)	0.001	0.069	0.001
Italy	-0.24^{*} (-1.86)	0.246	0.125	0.380
Euro zone	0.04 (0.63)	0.005	0.739	0.001
UK	-0.35^{**} (-2.23)	0.000	0.000	0.000
US	-0.43^{**} (-3.73)	0.007	0.001	0.003

Note: We set a dummy variable to control for the outliers in France and Italy which are due to the conversion of inflation expectations from qualitative into quantitative data. The t-values which have been calculated using Newey-West standard errors to correct for overlapping forecast errors, are reported in parantheses. ** (*) indicates significance at the 5%-(10%-) level.

Table 1: Unbiasedness of expectations

expectations requires that the forecast could not have been improved by adding additional information. In order to test for this, the forecast error is regressed on a number of exogenous variables that are known at time $t-2$ and that are possibly relevant when forecasting inflation[6]. Table (2) reports p-values related to F-statistics testing the null hypothesis that the coefficients on the aforementioned lags of these regressors are jointly equal to zero. In the Euro zone, France, Italy and the UK lagged values of the forecast error can explain the movement of the forecast error at the five percent level which is a hint that survey respondents seem to be sluggish when correcting their expectations after having recognized the last forecast error. Also past inflation rates are of explanatory use in all countries. This

[6]Our proceeding basically follows Roberts (1997) who introduced as potentially omitted variables the output gap as a measure of overall economic activity (see section 3.2 for a definition), the inflation rate to capture the persistence of inflation, and the three-month interest rate as an indicator for the stance of monetary policy. Since unit root tests indicated that the interest rates are non-stationary, we used first differences. In addition to that, we included real unit labor costs (see section 3.2 for a definition) and lagged terms of the forecast error. The explanatory power of each group of variables (which comprises four lags of the variable under consideration) was tested separately. The forecast error, real unit labor cost and the output gap enter the regression only from $t-3$ on, for reasons of overlapping forecast errors and because we assume a publication lag of one quarter.

means that respondents underestimate the inertia of the inflation rate. In none of the countries except France the output gap has a significant influence, indicating that the respondents seem to take it into account when forming their expectations. By contrast, real unit labor costs seem to be omitted in France, Germany and the US. The three-month interest rate only helps explain the forecast error in Germany and the UK[7].

Country	Error lags 3 to 6	Inflation lags 2 to 5	Output gap lags 3 to 6	RULC lags 3 to 6	3M Rate lags 2 to 5
Germany	0.188	0.002	0.364	0.000	0.024
France	0.000	0.002	0.000	0.050	0.144
Italy	0.000	0.000	0.371	0.331	0.445
Euro zone	0.000	0.014	0.101	0.093	0.710
UK	0.012	0.000	0.248	0.831	0.003
US	0.572	0.001	0.147	0.043	0.061

Note: Dummy variables are set like before. The table shows p-values for a Wald-test on joint significance of each group of lagged variables (Error = forecast error, RULC = real unit labor cost, 3M Rate = three-month nominal interest rate).

Table 2: Efficiency tests

3.2 Measures for Real Marginal Costs

There has been an extensive discussion in the literature about the correct proxy for real marginal costs (see for example Galí and Gertler, 1999, and Galí, Gertler, and López-Salido, 2001). There are basically two candidates that are considered: real unit labor costs and the output gap. The hypothesis that real unit labor costs is a good proxy for real marginal costs can be justified by the assumption that the production technology is Cobb-Douglas and that capital is constant over time. Real marginal costs are then defined as the ratio of real wages to the marginal product of labor

$$MC_t = \frac{1}{\alpha} \frac{W_t N_t}{P_t Y_t} \tag{13}$$

where α is the labor elasticity of production, W_t the nominal wage rate, N_t employment, P_t the price level, and Y_t aggregate output. The second term

[7]Roberts (1997) and the studies cited there also find no support of the efficiency hypothesis for the US. Adam and Padula (2003) come to the same conclusion. For the Euro zone Forsells and Kenny (2002) who investigated qualitative inflation expectations from the European Commission's Consumer Survey also find that expectation were not efficient during the nineties.

on the right-hand-side is typically referred to as the labor income share or real unit labor costs. Log-linearizing equation (13) around the steady state gives

$$mc_t = w_t + n_t - p_t - y_t \tag{14}$$

where lower case-letters denote the percentage deviation of a variable around its steady state. Thus, under the assumption that α is constant over time, equation (14) shows that real marginal cost and real unit labor costs move in a one-to-one relation around their steady state.

While real unit labor costs are a direct measure of a firm's real marginal costs, it can be shown that, under certain conditions, the output gap is a close proxy. We will not go into the details of the derivation of this relationship because it has been well documented in standard textbooks on monetary economics (see for example Walsh, 2003, chapter 5.4). The idea is that, after combining the households' labor supply decision (real wage equals the marginal rate of substitution between consumption and labor) with the firms' price-setting condition (price equals a mark-up over nominal marginal costs), an expression for the output level under both, flexible and rigid prices, can be derived. Under the assumption that labor market frictions exist, but do not vary over time, real marginal costs are then a linear function of the output gap x_t

$$mc_t = (\sigma + \eta)(y_t - y_t^{flex}) = (\sigma + \eta)x_t \tag{15}$$

where $1/\sigma$ is the intertemporal elasticity of substitution in consumption, η the elasticity of marginal disutility with respect to labor supply, and y_t^{flex} the log of the level of output that would prevail if prices were perfectly flexible (i.e. $\theta = 0$). The HNKPC then becomes

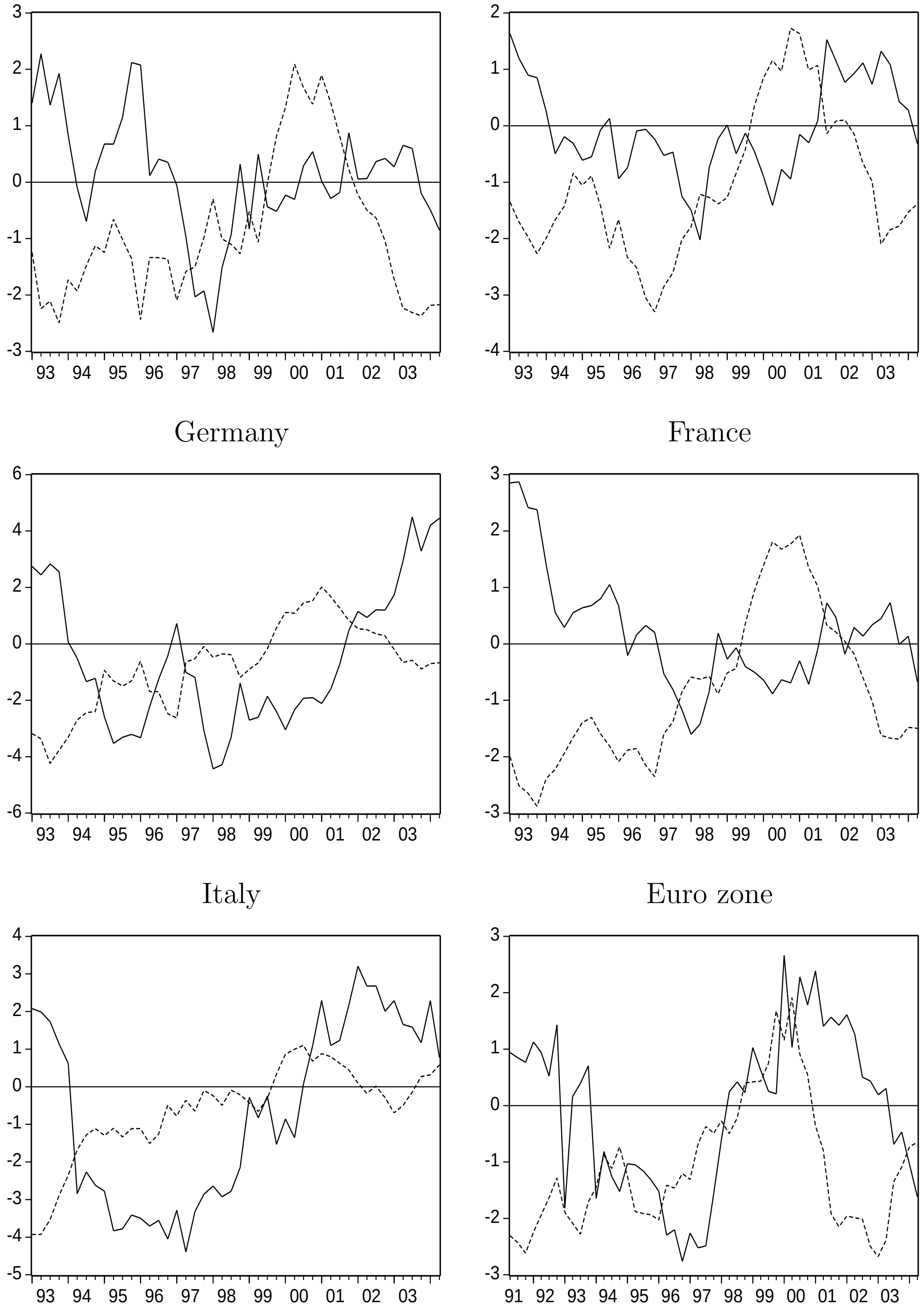
$$\pi_t = \gamma_f \bar{F}_t[\pi_{t+1}] + \gamma_b \pi_{t-1} + \lambda' x_t + \varepsilon_t \tag{16}$$

where $\lambda' = \lambda(\sigma + \eta)$.

In our empirical analysis we consider both types of measures for real marginal costs. Specifically we use

- the deviation of the logarithm of CPI-deflated unit labor costs (of the total economy)[8] from a linear trend (over the period 1990:1-2004:3): RULC;

[8] Unit labor costs of the total economy are taken from the OECD database. Italian unit labor costs are only available for the business sector (which is defined as total economy minus public sector).



UK US

Figure 2: OECD output gap (dashed line) and RULC (continuous line)

- and the OECD output gap (as published in the OECD Economic Outlook, Vol. 2004/2, No. 76)[9]: GAP.

For each of the countries in our study figure 2 shows both measures in a single graph.

4 Empirical Results

4.1 Estimation of the Phillips Curve

We begin by presenting estimates for the pure forward-looking New Keynesian Phillips curve which can be derived as a special case from the HNKPC by setting $\omega = 0$ (see tables 3 and 4). In the pure forward-looking case the estimated parameter of inflation expectations is equal to the discount factor β. Irrespective of the model specification and of the frequency of the data, the β's are all statistically significant and in the neighborhood of one. For all countries except for the UK and the US (where β is smaller than one), Wald tests can not reject the null hypothesis that β equals one. Interestingly, these are the only two countries for which the Ifo WES inflation expectations turned out to be biased (see section 3.1). Concerning the slope coefficient λ our results are to some extent in line with those obtained by Galí, Gertler, and López-Salido (2001) who used a rational expectations-GMM approach. While the estimated λ's of the RULC model are positive and significant (the latter except for Italy and the UK), the λ's of the output gap model are negative in most countries (except for France and the UK), and even significantly so in the case of the US. These results are perfectly in line with the cross correlations between inflation and RULC on the one hand, and inflation and the output gap on the other hand (see figure 3). For $k = 0$ (that is, contemporaneous correlation) correlations are positive only in those cases where λ is positive and significant. The frequency of the data is irrelevant for the results as the estimated parameters are approximately the same in the semiannual and in the quarterly model. In many cases, however, the estimations of the pure forward-looking New Keynesian Phillips curve produce residuals which are strongly auto-correlated which indicates that some important explanatory variables are missing.

We therefore turn to the estimation of the HNKPC which explicitly allows lagged inflation to have additional explanatory power for current inflation. Tables 5 and 6 reveal that in all of our estimations of the HNKPC

[9] Alternative measures of the output gap, such as a Hodrick-Prescott-filtered GDP series or the rate of capacity utilization, gave qualitatively similar results and are available from the authors upon request.

	β	λ	$\beta=1$	β	λ'	$\beta=1$
	RULC			GAP		
Germany	1.11^{**}	0.40^{**}	[0.28]	1.13^{**}	-0.04	[0.46]
	(10.84)	(2.60)		(6.65)	(-0.20)	
France	0.99^{**}	0.10^{**}	[0.82]	1.02^{**}	0.02	[0.66]
	(45.57)	(2.55)		(26.95)	(0.89)	
Italy	0.91^{**}	0.05	[0.07]	0.88^{**}	-0.09	[0.06]
	(19.26)	(0.94)		(13.84)	(-0.79)	
Euro zone	1.05^{**}	0.16^{**}	[0.14]	1.04^{**}	-0.08	[0.47]
	(33.28)	(2.93)		(19.02)	(-1.14)	
UK	0.86^{**}	0.00	[0.00]	0.88^{**}	0.12^{**}	[0.00]
	(24.47)	(0.02)		(31.14)	(3.27)	
US	0.86^{**}	0.09^{*}	[0.00]	0.83^{**}	-0.08^{*}	[0.00]
	(34.54)	(1.71)		(19.71)	(-1.80)	

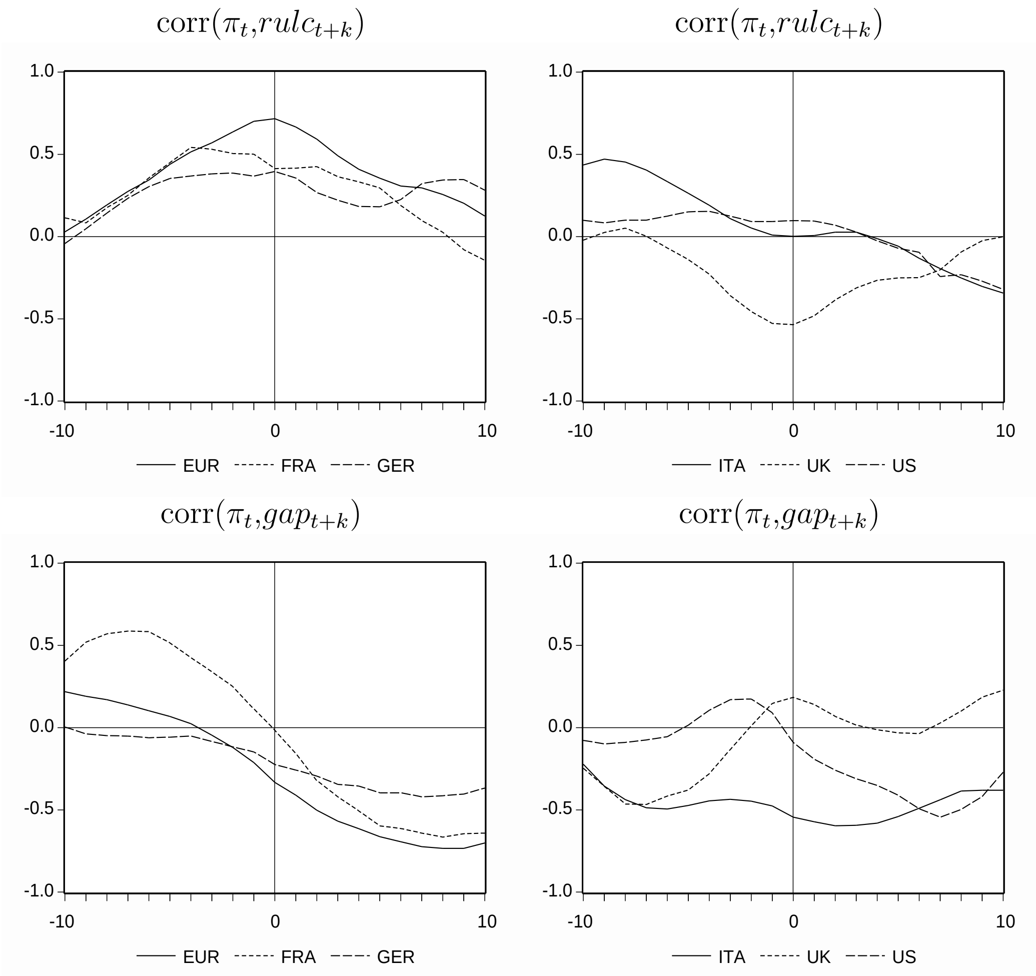
Notes: Numbers in parentheses are t-values which were calculated using heteroscedasticity and autocorrelation-consistent Newey-West standard errors. ** (*) indicates significance at the 5%-(10%-) level. For France and Italy we set a dummy variable in 2000:2 and 1996:1, respectively (see section 3.1). Numbers in brackets are p-values for the null hypothesis indicated in the first row.

Table 3: Estimation results for the forward-looking Phillips curve, semiannual model

	β	λ	$\beta=1$	β	λ'	$\beta=1$
	RULC			GAP		
Germany	1.08^{**}	0.37^{**}	[0.31]	1.05^{**}	-0.10	[0.67]
	(13.21)	(2.50)		(8.40)	(-0.56)	
France	1.00^{**}	0.07^{*}	[0.99]	1.02^{**}	0.03	[0.57]
	(43.93)	(1.81)		(29.82)	(1.00)	
Italy	0.91^{**}	0.02	[0.07]	0.89^{**}	-0.07	[0.07]
	(18.84)	(0.46)		(14.59)	(-0.78)	
Euro zone	1.05^{**}	0.15^{**}	[0.17]	1.04^{**}	-0.08	[0.51]
	(30.82)	(2.74)		(18.65)	(-1.13)	
UK	0.85^{**}	0.00	[0.00]	0.87^{**}	0.11^{**}	[0.00]
	(25.07)	(0.08)		(28.92)	(2.71)	
US	0.86^{**}	0.09^{*}	[0.00]	0.83^{**}	-0.09^{**}	[0.00]
	(35.64)	(1.82)		(21.69)	(-2.03)	

Notes: Numbers in parentheses are t-values which were calculated using heteroscedasticity and autocorrelation-consistent Newey-West standard errors. ** (*) indicates significance at the 5%-(10%-) level. For France and Italy we set a dummy variable in 2000:3 and 1996:2, respectively (see section 3.1). Numbers in brackets are p-values for the null hypothesis indicated in the first row.

Table 4: Estimation results for the forward-looking Phillips curve, quarterly model



Note: The correlation coefficient is depicted on the vertical axis, and k on the horizontal axis.

Figure 3: Cross correlograms

the coefficients for both, subjective inflation expectations and lagged inflation, are positive and significant. As a general rule the point estimates of γ_b turn out to be higher in the output gap model whereas the γ_f's are somewhat lower. In comparison with the semiannual model the estimates for γ_f are generally lower in the quarterly model. Except for the UK and the US (and the Euro zone and France in the semiannual output gap model) Wald tests cannot reject the null hypothesis that $\gamma_f + \gamma_b = 1$. Looking at the individual countries, we can distinguish between three groups. In Germany and Italy the degree of backwardness is relatively high. Irrespective of the measure for marginal costs and of the frequency of the data, γ_b exceeds γ_f and the t-statistics for γ_b are higher than those for γ_f. In France the opposite is true. The estimated γ_f's are higher and more significant than the γ_b's, implying that French firms are more forward-looking than their German or Italian competitors. In the Euro zone as a whole, the US and, to some extent, the UK optimizing firms and rule-of-thumb price setters are more or less balanced. In the UK this result only holds if the frequency of the data is quarterly. In the semiannual model, by contrast, the UK belongs to the group in which forward-looking price-setting behavior dominates.

The significance of the measure for real marginal costs crucially depends on the empirical specification of the HNKPC and differs from the results obtained from the estimation of the pure forward-looking Phillips curve. The most striking result is that the output gap becomes an important explanatory variable for inflation in all countries except for the US as well as Germany and the Euro zone in the quarterly model, which is astonishing, given the low and mostly negative contemporaneous correlation between the output gap and inflation (see figure 3). From an econometric point of view the significant output gap coefficients can be explained by the high correlation of the output gap with the unexplained part of a regression of inflation on lagged and expected inflation. When RULC are used as a measure for marginal costs the results are more or less in line with those for the pure forward-looking Phillips curve. Only for Germany (and the Euro zone in the semiannual model) λ becomes insignificant, even though it remains positive.

Given the result that γ_b is statistically greater than zero in most of the estimations of the HNKPC, one would be tempted to conclude that the pure forward-looking model (which results from the HNKPC for $\omega = 0$, see section 2.1) is rejected by the data. Such a conclusion, however, should be drawn very cautiously. An important issue that we need to address when estimating equation (12) is multicollinearity. As inflation expectations are likely to depend on past inflation rates a regression model like equation (12), may result in collinearity between $\bar{F}_t[\pi_{t+1}]$ and π_{t-1}. In order to check whether there is a role for lagged inflation in explaining the dynamics of current inflation beyond its contribution to inflation expectations we ran the following auxiliary regression

$$\bar{F}_t[\pi_{t+1}] = \delta\pi_{t-1} + \pi^{\perp}_{t+1}. \tag{17}$$

The residuals of equation (17), $\pi^{\perp}_{t+1}$, represent that part of expected inflation which is orthogonal to lagged inflation and, thus, cannot be explained by changes in lagged inflation. In a next step we replaced $\bar{F}_t[\pi_{t+1}]$ in equation (12) with $\pi^{\perp}_{t+1}$ and we estimated the following equation

$$\pi_t = \gamma_f \pi^{\perp}_{t+1} + \tilde{\gamma}_b \pi_{t-1} + \lambda mc_t + \epsilon_t. \tag{18}$$

where $\tilde{\gamma}_b = \delta\gamma_f + \gamma_b$.

	γ_f	γ_b	λ	γ_f+γ_b=1	γ_f	γ_b	λ'	γ_f+γ_b=1
		RULC				GAP		
Germany	0.37**	0.65**	0.11	[0.66]	0.37**	0.72**	0.12**	[0.14]
	(3.66)	(8.03)	(0.91)		(6.11)	(11.67)	(2.30)	
France	0.79**	0.21**	0.08**	[0.92]	0.73**	0.32**	0.07**	[0.03]
	(10.59)	(2.73)	(2.37)		(12.09)	(4.97)	(5.19)	
Italy	0.40**	0.56**	-0.01	[0.12]	0.39**	0.60**	0.08**	[0.66]
	(5.61)	(7.29)	(-0.21)		(7.05)	(9.00)	(2.90)	
Euro zone	0.55**	0.47**	0.07	[0.32]	0.43**	0.61**	0.05**	[0.00]
	(10.67)	(8.69)	(1.53)		(15.54)	(21.54)	(2.19)	
UK	0.67**	0.23**	-0.01	[0.01]	0.68**	0.25**	0.14**	[0.02]
	(9.79)	(3.17)	(-0.22)		(14.67)	(4.11)	(4.09)	
US	0.58**	0.33**	0.06*	[0.00]	0.55**	0.37**	0.03	[0.04]
	(6.91)	(3.71)	(1.83)		(5.39)	(2.97)	(0.46)	

Notes: See table 3.

Table 5: Estimation results for the HNKPC, semiannual model

	γ_f	γ_b	λ	γ_f+γ_b=1	γ_f	γ_b	λ'	γ_f+γ_b=1
		RULC				GAP		
Germany	0.28**	0.75**	0.08	[0.36]	0.27**	0.79**	0.04	[0.25]
	(2.93)	(9.63)	(1.05)		(4.01)	(13.68)	(1.00)	
France	0.78**	0.22**	0.05*	[0.78]	0.77**	0.27**	0.04**	[0.25]
	(14.22)	(4.41)	(1.79)		(10.18)	(3.76)	(2.62)	
Italy	0.25**	0.73**	-0.01	[0.12]	0.25**	0.75**	0.05**	[0.80]
	(6.90)	(19.82)	(-0.72)		(8.02)	(23.20)	(2.91)	
Euro zone	0.55**	0.48**	0.06*	[0.11]	0.51**	0.53**	-0.00	[0.15]
	(9.60)	(9.27)	(1.88)		(9.28)	(11.26)	(-0.05)	
UK	0.48**	0.44**	-0.00	[0.00]	0.51**	0.44**	0.10**	[0.00]
	(10.05)	(9.12)	(-0.13)		(12.14)	(9.97)	(3.16)	
US	0.47**	0.45**	0.04*	[0.00]	0.45**	0.48**	0.01	[0.00]
	(8.46)	(7.71)	(1.93)		(6.67)	(5.97)	(0.33)	

Notes: See table 4.

Table 6: Estimation results for the HNKPC, quarterly model

	γ_f	$\tilde{\gamma}_b$	λ	γ_f	$\tilde{\gamma}_b$	λ'
	RULC			GAP		
Germany	0.37^{**}	0.89^{**}	0.11	0.37^{**}	0.96^{**}	0.12^{**}
	(3.66)	(22.62)	(0.91)	(6.11)	(18.23)	(2.30)
France	0.79^{**}	1.00^{**}	0.08^{**}	0.73^{**}	1.06^{**}	0.07^{**}
	(10.59)	(50.36)	(2.37)	(12.09)	(49.91)	(5.19)
Italy	0.40^{**}	0.90^{**}	-0.01	0.39^{**}	0.93^{**}	0.08^{**}
	(5.61)	(32.38)	(-0.21)	(7.05)	(33.84)	(2.90)
Euro zone	0.55^{**}	0.95^{**}	0.07	0.43^{**}	0.99^{**}	0.05^{**}
	(10.67)	(46.33)	(1.53)	(15.54)	(78.46)	(2.19)
UK	0.67^{**}	0.94^{**}	-0.01	0.68^{**}	0.98^{**}	0.14^{**}
	(9.79)	(25.69)	(-0.22)	(14.67)	(35.89)	(4.09)
US	0.58^{**}	0.96^{**}	0.06^{*}	0.55^{**}	0.97^{**}	0.03
	(6.91)	(60.56)	(1.83)	(5.39)	(29.35)	(0.46)

Notes: $\tilde{\gamma}_b = \delta\gamma_f + \gamma_b$. See also table 3.

Table 7: Estimation results for the HNKPC, orthogonalized inflation expectations, semiannual model

	γ_f	$\tilde{\gamma}_b$	λ	γ_f	$\tilde{\gamma}_b$	λ'
	RULC			GAP		
Germany	0.28^{**}	0.94^{**}	0.08	0.27^{**}	0.98^{**}	0.04
	(2.93)	(30.58)	(1.05)	(4.01)	(21.57)	(1.00)
France	0.78^{**}	1.01^{**}	0.05^{*}	0.77^{**}	1.04^{**}	0.04^{**}
	(14.22)	(53.37)	(1.79)	(10.18)	(44.39)	(2.62)
Italy	0.25^{**}	0.95^{**}	-0.01	0.25^{**}	0.97^{**}	0.05^{**}
	(6.90)	(69.70)	(-0.72)	(8.02)	(77.86)	(2.91)
Euro zone	0.55^{**}	0.97^{**}	0.06^{*}	0.51^{**}	0.98^{**}	-0.00
	(9.60)	(60.74)	(1.88)	(9.28)	(46.56)	(-0.05)
UK	0.48^{**}	0.98^{**}	-0.00	0.51^{**}	1.00^{**}	0.10^{**}
	(10.05)	(38.06)	(-0.13)	(12.14)	(53.08)	(3.16)
US	0.47^{**}	0.97^{**}	0.04^{*}	0.45^{**}	0.97^{**}	0.01
	(8.46)	(80.82)	(1.93)	(6.67)	(49.16)	(0.33)

Notes: $\tilde{\gamma}_b = \delta\gamma_f + \gamma_b$. See also table 4.

Table 8: Estimation results for the HNKPC, orthogonalized inflation expectations, quarterly model

The results are shown in tables 7 and 8. All the $\tilde{\gamma}_b$ coefficients are positive and significant, implying that the part of lagged inflation which is not yet incorporated in inflation expectations is important for current inflation. The point estimates for δ in the auxiliary regression are in the neighborhood of one, which can be seen from the estimated values of $\tilde{\gamma}_b$ which are all close to $\gamma_f + \gamma_b$. However, the explanatory power of π_{t-1} for $\bar{F}_t[\pi_{t+1}]$ is relatively low since the R^2's are all around 20%. The point estimates and the t-values for γ_f and λ remain unchanged in comparison with the results shown in tables 5 and 6.

4.2 Comparison with other Studies

In this section we want to compare our results with those obtained in other empirical studies. As has already been mentioned in the introduction of this paper the great majority of empirical work on the validity of the New Keynesian Phillips curve uses the so-called rational expectations approach. A standard estimation technique is the Generalized Method of Moments (GMM) which explicitly exploits the orthogonality conditions between the expectational error and the information set of agents. Table 9 summarizes some of the most recent papers applying the rational expectations approach. The direct use of measures for inflation expectations which naturally avoids any assumptions on the expectations formation process is much less popular. We only found three studies using either survey data or OECD forecasts for expectations which are summarized in table 10.

	γ_f	γ_b	λ	mc	sample	method*	source
Ger-	0.89	0.11	0.06	output gap	1970:1-1999:4	GMM	Jondeau and LeBihan (2001)
many	0.56	0.44	0.00	output gap	1970:1-1999:4	ML	Jondeau and LeBihan (2001)
	0.90	0.10	0.01	RULC	1970:1-1999:4	GMM	Jondeau and LeBihan (2001)
	0.56	0.44	0.15	RULC	1970:1-1999:4	ML	Jondeau and LeBihan (2001)
	0.70	0.09	0.10	RULC	1970:1-1997:1	GMM	Benigno and López-Salido (2002)
	0.66	0.21	$\diamond$	RULC	1960:1-1999:4	GMM10	Leith and Malley (2003)
	0.66	0.22	$\diamond$	RULC	1960:1-1999:4	GMM40	Leith and Malley (2003)
France	0.62	0.38	-0.02	output gap	1970:1-1999:4	GMM	Jondeau and LeBihan (2001)
	0.54	0.46	0.00	output gap	1970:1-1999:4	ML	Jondeau and LeBihan (2001)
	0.62	0.38	0.00	RULC	1970:1-1999:4	GMM	Jondeau and LeBihan (2001)
	0.54	0.46	0.01	RULC	1970:1-1999:4	ML	Jondeau and LeBihan (2001)
	0.65	0.30	0.04	RULC	1970:1-1997:1	GMM	Benigno and López-Salido (2002)
	0.85	0.10	$\diamond$	RULC	1960:1-1999:4	GMM10	Leith and Malley (2003)
	0.85	0.11	$\diamond$	RULC	1960:1-1999:4	GMM40	Leith and Malley (2003)
Italy	0.51	0.49	0.04	output gap	1970:1-1999:4	GMM	Jondeau and LeBihan (2001)
	0.53	0.47	-0.01	output gap	1970:1-1999:4	ML	Jondeau and LeBihan (2001)
	0.51	0.49	-0.01	RULC	1970:1-1999:4	GMM	Jondeau and LeBihan (2001)
	0.54	0.46	0.01	RULC	1970:1-1999:4	ML	Jondeau and LeBihan (2001)
	0.41	0.52	0.06	RULC	1970:1-1997:1	GMM	Benigno and López-Salido (2002)
	0.47	0.45	$\diamond$	RULC	1960:1-1999:4	GMM10	Leith and Malley (2003)
	0.47	0.46	$\diamond$	RULC	1960:1-1999:4	GMM40	Leith and Malley (2003)

Table 9: Estimation results using the rational expectations approach

	γ_f	γ_b	λ	mc	sample	method*	source
Euro	0.54	0.46	0.09	output gap	1998:1-2003:2	PI	Angeloni and Ehrmann (2004)
zone	0.52	0.48	0.18	output gap	1977-1997	GMM	Smets (2003)
	0.88	0.03	0.02	RULC	1970:1-1998:2	GMM1	Galí, Gertler, and López-Salido (2001)
	0.69	0.27	0.01	RULC	1970:1-1998:2	GMM2	Galí, Gertler, and López-Salido (2001)
	0.73	0.27	0.07	output gap	1970:1-1999:4	GMM	Jondeau and LeBihan (2001)
	0.49	0.51	0.03	output gap	1970:1-1999:4	ML	Jondeau and LeBihan (2001)
	0.77	0.23	0.00	RULC	1970:1-1999:4	GMM	Jondeau and LeBihan (2001)
	0.60	0.40	0.04	RULC	1970:1-1999:4	ML	Jondeau and LeBihan (2001)
UK	0.83	0.17	-0.14	output gap	1970:1-1999:4	GMM	Jondeau and LeBihan (2001)
	0.58	0.42	0.00	output gap	1970:1-1999:4	ML	Jondeau and LeBihan (2001)
	0.82	0.18	0.03	RULC	1970:1-1999:4	GMM	Jondeau and LeBihan (2001)
	0.71	0.29	0.39	RULC	1970:1-1999:4	ML	Jondeau and LeBihan (2001)
	0.74	0.10	$\diamond$	RULC	1960:1-1999:4	GMM10	Leith and Malley (2003)
	0.74	0.11	$\diamond$	RULC	1960:1-1999:4	GMM40	Leith and Malley (2003)

Table 9 (continued): Estimation results using the rational expectations approach

	γ_f	γ_b	λ	mc	sample	method*	source
US	0.77	0.23	0.03	RULC	1960:1-1997:4	GMM1	Galí and Gertler (1999)
	0.62	0.38	0.01	RULC	1960:1-1997:4	GMM2	Galí and Gertler (1999)
	0.61	0.34	0.03	RULC	1970:1-1998:2	GMM1	Galí, Gertler, and López-Salido (2001)
	0.60	0.36	0.02	RULC	1970:1-1998:2	GMM2	Galí, Gertler, and López-Salido (2001)
	0.66	0.34	-0.04	output gap	1970:1-1999:4	GMM	Jondeau and LeBihan (2001)
	0.53	0.47	0.00	output gap	1970:1-1999:4	ML	Jondeau and LeBihan (2001)
	0.63	0.37	0.00	RULC	1970:1-1999:4	GMM	Jondeau and LeBihan (2001)
	0.54	0.46	0.06	RULC	1970:1-1999:4	ML	Jondeau and LeBihan (2001)
	0.59	0.36	$\diamond$	RULC	1960:1-1999:4	GMM10	Leith and Malley (2003)
	0.59	0.36	$\diamond$	RULC	1960:1-1999:4	GMM40	Leith and Malley (2003)

* GMM=Generalized Method of Moments, ML=Maximum Likelihood Estimation, PI=Panel Instrumental Estimation

Note: Galí and Gertler (1999) and Galí, Gertler, and López-Salido (2001) considered two alternative specifications (GMM1 and GMM2) of the orthogonality condition. Leith and Malley (2003) modeled a time-varying slope of the Phillips curve λ_t which implies that they had to calibrate the households' price elasticity of demand, and hence the mark-up of prices over nominal marginal costs. Specifically, they assumed a mark-up of 10% and 40% (GMM10 and GMM40). For more details see these papers.

Table 9 (continued): Estimation results using the rational expectations approach

	γ_f	γ_b	λ	mc	inflation expectations	sample	source
Germany	0.43	0.57	0.03	output gap	GfK Consumer Survey	1986:1-1996:4	Reckwerth (1997)
France	-	-	-	-	-	-	-
Italy	-	-	-	-	-	-	-
Euro	0.51	0.49	0.02	RULC	OECD forecasts	1977-2003	Paloviita (2004)
zone	0.46	0.54	0.08	output gap	OECD forecasts	1977-2003	Paloviita (2004)
UK	-	-	-	-	-	-	-
US	0.35	0.53	0.08	RULC	Livingston Survey	1968:4-2000:1	Adam and Padula (2003)
	0.36	0.63	0.04	output gap	Livingston Survey	1968:4-2000:1	Adam and Padula (2003)

Table 10: Estimation results using the survey data approach

A great part of the discussion in most of the empirical work is concerned with the question about the correct proxy variable for real marginal costs. While Galí and Gertler (1999) and Galí, Gertler, and López-Salido (2001) show that real unit labor costs empirically perform much better than the output gap, Jondeau and LeBihan (2001) come to the conclusion that the output gap model is the preferred specification in Germany, Italy and the Euro zone. Our results are also mixed and depend on the country under consideration.

The main difference between our results and those obtained with the rational expectations approach is that, except for France, the degree of forward-looking behavior is found to be significantly lower when using survey data instead imposing rational expectations. And this finding is qualitatively confirmed by the other three survey data studies. Germany is a very striking example. While studies using the rational expectations approach find an average coefficient for γ_f of 0.70 (± 0.13), our estimates for γ_f are much lower, with an average value of 0.32 (± 0.05)[10]. Reckwerth (1997) who uses another source for German inflation expectations also finds estimates for γ_f which are smaller than under the rational expectations approach (see table 10). The results for the US point into the same direction. While the average value for γ_f under rational expectations is 0.61 (± 0.06), our regressions returned an average value for γ_f of 0.51 (± 0.05). Again, this tendency of a lower degree of forwardness when survey data is used, is confirmed by another study. In Adam and Padula (2003) who take US inflation expectations from the Livingston Survey, γ_f takes a value of 0.36 which is even lower than our estimates.

There are two possible explanations for the differences in the estimated coefficients γ_f and γ_b. First, our sample only starts at the beginning of the 1990s whereas most of the other studies begin in 1960 or 1970. Since the price setting behavior of firms depends to a large extent on expectations about future inflation, the monetary policy regime that is in force plays a crucial role for the estimated behavioral parameters. Most of the countries in our sample, however, underwent one or even more significant changes in their monetary policy strategy so that lower estimates for γ_f for the period 1991/1993 to present cannot be excluded from the GMM results.

Second, non-rationalities which are incorporated in survey expectations may matter for the price-setting process of firms. In section 3.1 we showed that inflation expectations of the Ifo WES are inefficient and in some cases

[10] We calculated the average value of the estimated parameters shown in table 9 (for the rational expectations approach) and in tables 5 and 6 (for the survey data approach). The values in parentheses refer to the standard deviation of the point estimates.

even biased predictors of future inflation. This is in clear contrast to the assumption made when GMM is used as estimation technique. An indication in favor of this explanation are the results of Adam and Padula (2003) (see table 10). Their sample ranges from 1968 to 2000 which is more or less similar to the time span covered by most rational expectations studies, and their point estimates for γ_f are even lower than ours.

An alternative way to check whether the first or the second explanation is relevant is to apply the GMM approach to a shorter sample. Starting in 1993 instead of 1960 or 1970 would provide some evidence on the stability of the structural parameters. The problem, however, is that GMM has very poor small sample properties, meaning that estimators are often found to be biased, widely dispersed and sensitive to the normalization of the orthogonality conditions as well as to the choice of the instruments (see for example Fuhrer, Moore, and Schuh (1995) for a recent paper on this issue).

5 Conclusions

In this paper we provided evidence on the fit of the hybrid New Keynesian Phillips curve for selected euro zone countries, the US and the UK. Instead of imposing rational expectations and estimating the Phillips curve by the Generalized Method of Moments, we followed Roberts (1997) and Adam and Padula (2003) and used direct measures of inflation expectations from the Ifo World Economic Survey.

Our main findings are that in comparison with the rational expectations approach backward-looking behavior is more relevant for most countries in our sample and that the use of survey data for inflation expectations yields a positive and sometimes even significant slope of the Phillips curve when the output gap is used as a measure for real marginal costs.

One explanation for these results is that non-rationalities which are incorporated in survey expectations may matter for the price-setting process of firms. If we are correct in using a survey among economic experts for approximating firms' expectations, such an explanation would have an important impact on the policy conclusions that are typically drawn on the basis of models where agents are assumed to form expectations rationally. Some first attempts to model deviations from perfectly rational expectations have been developed by Mankiw and Reis (2002). In their sticky-information model, they impose a constraint on the information that people use when forming expectations. They assume that in each period there is a fixed probability that a person updates his information set; otherwise he continues to set prices on outdated information. In Ball, Mankiw, and Reis (2003) they provide a normative monetary policy analysis that accounts for these deviations from rationality. And their central conclusion is that under such a setting the central bank should target the price level rather than the the inflation rate.

Appendix

A Derivation of Equation (9)

Equation (9) can be derived by subtracting equation (7) from equation (6)

$$F_t^i[p_{t+1}^f] - p_t^f = F_t^i[\pi_{t+1}^f] = \frac{1}{I} F_t^i[\sum_{h=1}^{I}(p_{t+1}^{f,h} - p_t^{f,h})]$$

and by replacing $p_{t+1}^{f,h}$ and $p_t^{f,h}$ with the first expression of equation (5):

$$\begin{aligned} F_t^i[\pi_{t+1}^f] &= \frac{1-\beta\theta}{I} F_t^i[\sum_{h=1}^{I}\{F_{t+1}^h[\sum_{k=0}^{\infty}(\beta\theta)^k(mc_{t+k+1} + p_{t+k+1})] - \\ &\quad - F_t^h[\sum_{k=0}^{\infty}(\beta\theta)^k(mc_{t+k} + p_{t+k})]\}]. \end{aligned}$$

Applying the law of iterated expectations (equation (8)) this expression can be simplified to

$$F_t^i[\pi_{t+1}^f] = \frac{1-\beta\theta}{I} F_t^i[\sum_{h=1}^{I}\{(1-\beta\theta)F_t^h[\sum_{k=0}^{\infty}(\beta\theta)^k(mc_{t+k+1}+p_{t+k+1})]-(mc_t+p_t)\}].$$

Replacing $(1-\beta\theta)F_t^h[\sum_{k=0}^{\infty}(\beta\theta)^k(mc_{t+k+1}+p_{t+k+1})]$ with $p_{t+1}^{f,h}$ (equation (5)) and using equation (6) finally gives equation (9):

$$F_t^i[\pi_{t+1}^f] = (1-\beta\theta)(F_t^i[p_{t+1}^f] - mc_t - p_t).$$

B Derivation of Equation (10)

Equation (10) can be derived by aggregating equation (3) to

$$p_t^* = (1-\omega)p_t^f + \omega p_t^b,$$

solving the resulting expression for p_t^f and replacing p_t^b with equation (4):

$$p_t^f = \frac{p_t^* - \omega(p_{t-1}^* + p_{t-1} - p_{t-2})}{1-\omega}.$$

Next, solve equation (2) for p_t^* and replace it in the preceding expression. After a little algebra, equation (10) is obtained:

$$p_t^f = \frac{p_t + (\theta\omega - 2\omega - \theta)p_{t-1} + \omega p_{t-2}}{(1-\theta)(1-\omega)}.$$

C Derivation of Equation (12)

Inserting equation (11) on the right-hand-side of equation (9) gives

$$F_t^i[\pi_{t+1}^f] = (1-\beta\theta)\left(\frac{F_t^i[\pi_{t+1}] - \omega\pi_t}{(1-\theta)(1-\beta)} - mc_t\right).$$

Forming average subjective expectations, $\bar{F}_t[\cdot] = (1/I)\sum_{i=1}^{I} F_t^i[\cdot]$, yields

$$\bar{F}_t[\pi_{t+1}^f] = (1-\beta\theta)\left(\frac{\bar{F}_t[\pi_{t+1}] - \omega\pi_t}{(1-\theta)(1-\beta)} - mc_t\right).$$

An alternative expression for $F_t^i[\pi_{t+1}^f]$ can de derived by subtracting equation (10) from equation (11):

$$F_t^i[\pi_{t+1}^f] = \frac{F_t^i[\pi_{t+1}] + (\theta\omega - 2\omega - \theta)\pi_t + \omega\pi_{t-1}}{(1-\theta)(1-\omega)}.$$

Forming average subjective expectations yields

$$\bar{F}_t[\pi_{t+1}^f] = \frac{\bar{F}_t[\pi_{t+1}] + (\theta\omega - 2\omega - \theta)\pi_t + \omega\pi_{t-1}}{(1-\theta)(1-\omega)}.$$

Equating both expressions for $\bar{F}_t[\pi_{t+1}^f]$ and solving for π_t finally results in equation (12):

$$\pi_t = \gamma_f \bar{F}_t[\pi_{t+1}] + \gamma_b\pi_{t-1} + \lambda mc_t, \tag{19}$$

where

$$\gamma_f = \frac{\beta\theta}{\theta + \omega[1-\theta(1-\beta)]},$$

$$\gamma_b = \frac{\omega}{\theta + \omega[1-\theta(1-\beta)]},$$

$$\lambda = \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\theta + \omega[1-\theta(1-\beta)]}.$$

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	γ_f	γ_b	λ	γ_f	γ_b	λ'
	OLS			TSLS		
Germany	0.28^{**}	0.75^{**}	0.08	0.20^{**}	0.82^{**}	0.11
	(2.93)	(9.63)	(1.05)	(2.10)	(12.46)	(1.35)
France	0.78^{**}	0.22^{**}	0.05^{*}	0.95^{**}	0.05	0.10^{**}
	(14.22)	(4.41)	(1.79)	(6.54)	(0.33)	(2.20)
Italy	0.25^{**}	0.73^{**}	-0.01	0.25^{**}	0.74^{**}	-0.02
	(6.90)	(19.82)	(-0.72)	(2.75)	(7.73)	(-1.06)
Euro zone	0.55^{**}	0.48^{**}	0.06^{*}	0.59^{**}	0.44^{**}	0.08^{**}
	(9.60)	(9.27)	(1.88)	(4.44)	(3.69)	(2.81)
UK	0.48^{**}	0.44^{**}	-0.00	0.56^{**}	0.35^{**}	-0.01
	(10.05)	(9.12)	(-0.13)	(6.12)	(3.44)	(-0.32)
US	0.47^{**}	0.45^{**}	0.04^{*}	0.45^{**}	0.48^{**}	0.05^{**}
	(8.46)	(7.71)	(1.93)	(4.16)	(3.91)	(2.03)

Notes: See table 3.

Table 11: Estimation results for the HNKPC (RULC), instrumental variables

	γ_f	γ_b	λ	γ_f	γ_b	λ'
	OLS			TSLS		
Germany	0.27^{**}	0.79^{**}	0.04	0.13	0.91^{**}	0.07
	(4.01)	(13.68)	(1.00)	(0.97)	(7.28)	(1.49)
France	0.77^{**}	0.27^{**}	0.04^{**}	0.89^{**}	0.16	0.06^{**}
	(10.18)	(3.76)	(2.62)	(4.14)	(0.80)	(2.52)
Italy	0.25^{**}	0.75^{**}	0.05^{**}	0.29^{**}	0.71^{**}	0.06^{**}
	(8.02)	(23.20)	(2.91)	(13.24)	(26.54)	(2.63)
Euro zone	0.51^{**}	0.53^{**}	-0.00	0.40^{**}	0.64^{**}	0.02
	(9.28)	(11.26)	(-0.05)	(4.53)	(8.10)	(0.63)
UK	0.51^{**}	0.44^{**}	0.10^{**}	0.56^{**}	0.38^{**}	0.12^{**}
	(12.14)	(9.97)	(3.16)	(8.94)	(5.12)	(4.39)
US	0.45^{**}	0.48^{**}	0.01	0.41^{**}	0.54^{**}	0.04
	(6.67)	(5.97)	(0.33)	(4.20)	(4.47)	(0.98)

Notes: See table 4.

Table 12: Estimation results for the HNKPC (GAP), instrumental variables