THE NEW KEYNESIAN PHILLIPS CURVE
FOR THE EURO AREA: WHICH SPECIFICATION?

EMMANUEL CARRÉ

ABSTRACT:
The New Keynesian Phillips Curve (NKPC) specification in the Euro area is controversial. For some it is purely forward-looking, when others incorporate a backward-looking component into a ‘hybrid’ NKPC (HNKPC). This article contributes to this debate first by drawing stylised facts of the Euro area (H)NKPC from a quantitative review of 88 comparable empirical estimates from 21 articles. If the forward-looking share dominates, a substantial backward-looking fraction is found (about one-third). This result is fairly robust to sub-sample and simple tests. It is also shown that micro evidence from firms’ pricing surveys is favourable to this result. Since the observed variations in estimates could be a limitation to this otherwise clear result, the second contribution of this article is to explore the factors driving these variations. Finally, policy implications are examined.

JEL CLASSIFICATION: E31; E52; E58.

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INTRODUCTION

The New Keynesian Phillips Curve (NKPC), new version of the old curve proposed by Phillips (1958), is popular in the academic literature and is ‘the closest thing there is to a standard specification’ (McCallum, 1997:357). It is the standard inflation theory of the ‘New Consensus’ in macroeconomics: the New Neo-Classical Synthesis (NNS)\(^1\). It is also the core equation of the ‘state of the art’ in business cycles modelling, the Dynamic Stochastic General Equilibrium (DSGE) models\(^2\). It is micro-founded on the New Keynesian theory of price stickiness cum rational expectations hypothesis (Calvo, 1983). This results in a purely forward-looking formula as the baseline or ‘canonical’ NKPC\(^3\) describing inflation as a purely ‘expectational’ phenomenon, a ‘jump’ and not a persistent variable. With these micro-foundations it should surpass the old Phillips curve or its expectations augmented and accelerationist versions that had the disadvantages of emerging from empirical results and being mostly backward-looking, with little emphasis on expectations\(^4\). Furthermore, it is supposed to be an empirically valid description of inflation dynamics, in the euro area in particular (Gali et al., 2001:1237). At the centre of the New Keynesian ‘science’ of optimal monetary policy, the NKPC recommends policymakers to pursue an ‘expectation management strategy’ relying on communications\(^5\). Indeed it asserts that if the central bank controls future inflation expectations, it controls the present value of inflation.

These advices from the NKPC are apparently accepted by central bankers, particularly the European Central Bank (ECB) that endorses the DSGE class of models with Calvo pricing\(^6\). The ECB also integrates the emphasis on expectations in monetary policy transmission mechanisms, the expectations management strategy as well as the communication policy\(^7\). Hence, the NKPC specification is a vital policy question.

Nevertheless, beyond the veil of polite academic and central bankers’ consensus, the Calvo-NKPC specification is controversial: ‘there are reasons, however, to be somewhat dissatisfied with this state of affairs’ (McCallum, 2008:1481). Empirically, the purely forward-looking NKPC seems unable to reproduce the inflation dynamics observed in euro area data\(^8\); in particular inflation persistence, i.e. the hump-shaped, gradual and delayed response of inflation to a shock\(^9\). This empirical failure is a severe drawback because inflation persistence is considered as a stylised fact of European inflation.

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\(^{1}\) Goodfriend (2007).

\(^{2}\) A benchmark DSGE model is Smets and Wouters (2003).

\(^{3}\) It is generally considered that the analysis of the NKPC began with Roberts (1995).

\(^{4}\) See Gali and Gertler (2007:33): ‘Another important way that the new Phillips curve differs from the old is that it is fully forward-looking’.

\(^{5}\) Woodford (2003:15).

\(^{6}\) On its web site, the ECB mentions the Smets and Wouters model as one of the ‘macroeconomic models of the euro area’. See [http://www.ecb.int/home/html/researcher.en.html](http://www.ecb.int/home/html/researcher.en.html).

\(^{7}\) For the use of the expectations management, see ECB, Monthly Bulletin, May 2009, p.86.

\(^{8}\) As acknowledged by NKPC promoters themselves: ‘The macroeconomic variables within the baseline model appear to display greater persistence in practice than the basic framework can capture’ (Gali and Gertler, 2007:42).

\(^{9}\) See Mankiw (2001).
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dynamics by some New Keynesians\(^{10}\) and is a research subject of the ECB\(^{11}\). It also suggests that the purely forward-looking NKPC is not a perfectly robust theory of inflation that can be used in practice by central bankers without any limitations.

Due to these limits, the purely forward-looking NKPC is increasingly challenged by a hybrid NKPC (HNKPC). This includes a backward-looking component to deal with the empirical question of inflation persistence, and more generally intends to reconcile the theory of inflation with empirical inflation dynamics. One thus returns, to a certain extent, to the previous accelerationist Phillips Curve which relied on adaptive expectations.

This NKPC versus HNKC debate is magnified by a controversy on the optimal econometric methodology to measure the respective forward-looking and backward-looking fractions. Different econometric methods of estimation give conflicting results since it could be empirically mainly either forward or backward-looking: there is ‘an extreme range of opinions from researchers examining the same equation’ (Rudd and Whelan, 2007:167).

This article makes two contributions to this debate on euro area (H)NKPC specification. First, in the spirit of the meta-analysis technique, a quantitative review of empirical estimates is realised. It results in stylized facts on the empirical specification of the (H)NKPC in the euro area. This method of evaluation of the forward and backward fractions of the HNKPC seems appropriate in the face of the intractable controversy on the empirical estimates and estimation techniques of the NKPC. Results of this quantitative analysis could indicate a basic ‘calibration’ of the euro area HNKPC. The second contribution to the euro area HNKPC discussion is the analysis of factors driving heterogeneity in reported empirical estimates. Indeed, the observed variations in estimates could be a limitation to the otherwise clear result of the quantitative review.

The article is organised as follows. The first section explains the competing specifications of the HNKPC and the quantitative review methodology chosen in the article. The second section analyses results, and checks their robustness by inspecting HNKPC empirical microfoundations, i.e. the consistency of macro evidence with micro evidence from surveys of firms’ prices formation. This second section also investigates the factors explaining the observed variations in estimates using a regression analysis. Finally, the third section draws implications of the results for the conduct of monetary policy in the euro area.

\(^{10}\) See O’Reilly and Whelan (2004), Angeloni et al. (2006) for evidence on inflation persistence in the Euro area.

\(^{11}\) The ECB has an ‘Inflation Persistence Network’:
http://www.ecb.int/home/html/researcher_ipn.en.html
1. METHODOLOGY

A quantitative survey of empirical estimates of the HNKPC in the euro area is performed, aimed at quantifying the forward and backward-looking shares. We extend the HNKPC estimates review realised by Altissimo et al. (2006:17) and Henzel and Wollmershäuser (2008:827) to build an estimates database. The survey includes 88 empirical estimates of the HNKPC from 21 articles, for the period from 2001 to 2010. To our knowledge, it is the first time such a vast quantitative review is carried out. The econometric analysis of the database follows the quantitative review methodology employed in De Grauwe and Costa Storti (2004). We first give the reasons for the choice of a quantitative survey, then the data selection process is presented.

1.1. WHY A QUANTITATIVE SURVEY?

The (H)NKPC debate: three competing specifications. The first reason for the quantitative survey choice is conflicting estimation results: the NKPC could be empirically mainly either forward or backward-looking (Jondeau and Le Bihan, 2005:522). There are three competing views regarding the (H)NKPC empirical specification that can be presented on the basis of its more general form, the HNKPC, that includes both a forward-looking share ($\beta_f$) and a backward-looking share ($\beta_b$):

$$\pi_t = \beta_f E_t \pi_{t+1} + \beta_b \pi_{t-1} + kx_t$$

where $\pi$ is the inflation rate, $x$ the output gap with $x = y - y^*$, $y$ represents the output and $y^*$ the potential output, finally $E$ is the expectation operator (rational expectations hypothesis).

The mainstream view on the (H)NKPC (specification 1) defends a purely forward-looking form ($\beta_f = 1; \beta_b = 0$):

$$\pi_t = \beta E_t \pi_{t+1} + kx_t$$

They claim that $\beta_b$ is different from 0, but is small enough to be neglected: ‘the estimates imply that backward-looking price setting [...] has been a relatively unimportant factor behind the dynamics of Euro area inflation’ (Gali et al., 2001:1256). On the contrary, advocates of specification 2 consider that $\beta_b > 0$, but admit that the forward-looking share dominates ($\beta_f > \beta_b$). Finally, specification 3 defenders state that the HNKPC is predominantly backward-looking ($\beta_f < \beta_b$). This view is relatively similar to the traditional accelerationist Phillips curve. Controversy on (H)NKPC estimation technique is the second reason for the choice of a quantitative review.

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12 As a comparison Altissimo et al. (2006:17) and Henzel and Wollmershäuser (2008) review respectively 6 studies (11 estimates) and 6 studies (12 estimates) of the euro area HNKPC.
13 See Hondroyiannis et al. (2008).
An intractable controversy on the NKPC estimation technique. This debate on the (H)NKPC empirical specification could partly result from econometric techniques, with the $\beta_b$ value varying considerably depending on the estimation method. The traditional method to estimate the HNKPC, the Generalised Method of Moments (GMM), has been criticised for its bias (overestimating $\beta_f$) and its weak identification problem leading to a lack of reliability of its estimates\textsuperscript{15}. This is why a Full Information Maximum Likelihood (FIML) method is often preferred\textsuperscript{16}, but there are some indications it overestimates $\beta_b$\textsuperscript{17}. Hence, some authors consider it can generate fragile results, so they prefer a Bayesian estimation\textsuperscript{18}. Accordingly, there is an intractable controversy on the econometric technique to empirically evaluate the HNKPC: ‘the debate on the appropriate technique to use when estimating Phillips curve remains open’ (Barkbu et al., 2005:6). This dispute is the second reason for the choice of a quantitative review, having the advantage of offering results that can be judged more consensual than those coming from a single article or estimation technique considered in isolation.

Numerous other arguments justify this quantitative approach. First, several studies doing this exercise have been mentioned, testifying it is common in the literature. Secondly, it permits the combination, integration and comparison of disparate estimates coming from various techniques, thus allowing for their global comparative assessment, facilitating a comprehensive survey of the literature. Thirdly, it suits to the growing volume of literature on the empirical NKPC since, due to the large number of studies on this issue, a narrative survey and synthesis would only have been manageable with difficulty. It is the appropriate technique to review this flourishing literature while preserving a synthetic view of its current state. Nevertheless, this review should be done carefully, requiring the construction a robust database, based on rigorous criteria of exclusion and inclusion that are now exposed.

1.2. DATA SELECTION PROCEDURES

Collected estimates concern the coefficients $\beta_f$ and $\beta_b$ (eq. 1). Estimates for the HNKPC are selected, and not for the NKPC, because the latter does not allow for backward-looking elements, not permitting to investigate the debate between the three competing specifications. Inspired from the meta-analysis approach, the selection of estimations available in the literature has been made according to the two criterions of coverage and precision. Homogeneity of estimates is the third selection criteria\textsuperscript{19}.

In terms of coverage, the papers chosen cover the period from 2001 and 2010 since to our knowledge the euro area HNKPC literature begins with Gali et al. (2001). As to precision –that is to say if estimations are representative of the literature – articles and working papers in EconLit, Repec-Ideas and central

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\textsuperscript{17} Jondeau and Le Bihan (2005 :539).
\textsuperscript{18} Benati (2008 :1026).
\textsuperscript{19} I wish to thank the referee for stressing the necessity to elaborate more on this point.
banks websites were consulted. Journal articles is an incomplete resource limiting the number of available estimations because the (H)NKPC is a recent literature with many working papers still unpublished due to the publication delays. Statistically non significant estimates are also included. Estimates homogeneity is a major concern to make them comparable, and is set up via several strict criteria. First, sample homogeneity is checked: articles with relatively similar long sample of 20 or 30 years have been collected. Estimates from comparatively shorter subsample (ten years) or very long sample (since 1945) are not included. Yet samples cannot be perfectly similar, leading potentially to differences in estimates (an issue inspected later). Secondly, all studies use quarterly data, inflation being always measured as GDP deflator, usually from the data set of the ECB Area-Wide Model (Fagan et al., 2001). Studies using annual data or other inflation measures have not been considered. Moreover, all studies consider the euro area as a single economy. Barkbu et al. (2005) is the only exception in the database, estimating the HNKPC for the whole euro area but also for its approximation by the aggregation of France, Germany and Italy. This procedure is accepted in the literature because these three countries cover 70% of the area-wide GDP and are the three largest countries in terms of population. On top of that it serves as a robustness check for the whole euro area estimates. The third homogeneity basis is the micro-foundation: studies with micro-foundations for the HNKPC included in the analysis are based only on the Calvo (1983) price setting, as in the reference article of Gali et al. (2001). Other micro-foundations such as the Taylor (1980) price setting, state dependent pricing or sticky information are not considered. Furthermore, HNKPC based on inflation expectations from surveys instead of rational expectations are not taken into account. The fourth criterion to respect homogeneity is an exclusive focus on closed-economy estimates. Estimates with an explicit open economy component in the HNKPC specification have been excluded, even those incorporating implicitly open economy elements, for instance via the marginal cost formulation. The final homogeneity factor is that all estimates result from a general specification common across studies: the HNKPC. It is preferred to the purely forward looking NKPC that is often, but not always, rejected by the data for the euro area, so that data sometimes support the HNKPC. Studies estimating a HNKPC specification adding an extra right hand side money term, are also not included. Due to all these selection criteria, the quantitative does not pretend to be exhaustive.

Promoters of the microfounded HNKPC claim it rests upon structural parameters thus is supposed to be relatively robust to the Lucas critique: its parameters $\beta_f$ and $\beta_b$ are supposed to be time invariant, as confirmed by some empirical results for the euro area. Even if some studies stress this stability is imperfect, it is taken as a consensual result in the first step of the analysis. A particular attention is given in the selection to estimates that fulfil $\beta_f + \beta_b = 1$. This condition implies that the HNKPC respects the natural rate hypothesis.

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20 As argued by Jondeau and Sahuc (2008:40) who find results for these three countries which ‘look very similar’ to those for the whole euro area.
21 Gali et al. (2001:1249).
Having considered all these factors, the database includes 88 comparable estimates from 21 papers for the euro area (Table 1)\(^2\). The same weight is put on each of these estimates despite the risk that results can be biased by the large number of estimates from a single article that would be over-represented. The solution of selecting the ‘best’ or more representative estimates is not chosen because of the multiple selection criteria possible in practice. It risks introducing subjective judgment and a potential selection bias. Results are now presented and analysed.

### TABLE 1. REFERENCES OF ESTIMATIONS INCLUDED IN THE QUANTITATIVE REVIEW, CLASSIFIED BY DATE

<table>
<thead>
<tr>
<th>References</th>
<th>Number of estimates</th>
<th>Sample</th>
<th>Estimation techniques</th>
<th>Driving variable: output gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bardsen et al. (2002)</td>
<td>4</td>
<td>1972:2-1998:1</td>
<td>GMM; TSLS</td>
<td>No</td>
</tr>
<tr>
<td>Bardsen et al. (2004)</td>
<td>4</td>
<td>1971:3-1998:1</td>
<td>GMM; TSLS</td>
<td>No</td>
</tr>
<tr>
<td>Barkhu et al. (2005)</td>
<td>6</td>
<td>1975:1-2002:4</td>
<td>GMM</td>
<td>No</td>
</tr>
<tr>
<td>De Walque, Smets and Wouters (2006b)</td>
<td>1</td>
<td>1970:2-2002:2</td>
<td>Bayesian</td>
<td>No</td>
</tr>
<tr>
<td>Hondroyiannis et al. (2008)</td>
<td>2</td>
<td>1970:1-2005:3</td>
<td>GMM; TVC</td>
<td>No</td>
</tr>
<tr>
<td>Onatski and Williams (2010)</td>
<td>1</td>
<td>1970-1999</td>
<td>Bayesian</td>
<td>No</td>
</tr>
</tbody>
</table>

Notes: GMM: Generalized Method of Moments; ML: Maximum Likelihood; TSLS: Two-Stage Least Squares; TVC: time-varying coefficient. *: to take into account errors in this article, stressed by Gali et al. (2003), only 4 estimates are considered and 2 are rejected. The latter are replaced by those presented in Gali et al. (2003). ‘No’, ‘Yes’ in the last column of the table means that the study is estimating a HNKPC without and with the output gap as the driving variable.

### 2. RESULTS

This quantitative review is interested in the NKPC versus HNKPC debate for the euro area: that is to say the validity of the three competing specifications. Results are examined in four steps. First, results are represented graphically and descriptive statistics are studied. The same is done for results of the sub-sample made of estimates respecting the natural rate hypothesis. Secondly, simple t-tests are undertaken to give indication of the strength of the three competing specifications. Thirdly, results are confronted to the previous literature and micro-level evidence. Finally, a regression analysis is undertaken to analyse results further.

\(^{2}\) Database available upon request.
2.1. DESCRIPTIVE STATISTICS

All estimations. Quantitative review results are reported in the scatter graph (Figure 1). The visual impression is one where the $\beta_b$ component is not nil. Consequently, specification 1, the purely forward-looking NKPC, does not seem observed since only a minority of estimates is on the horizontal axis. On the contrary, a majority of estimates favours the HNKPC. However, most of them are in the scatter graph bottom right-hand corner, visually indicating that $\beta_f$ dominates $\beta_b$. It gives simple evidence in favour of specification 2 of the HNKPC while specifications 1 and 3 seem rejected.

FIGURE 1. ESTIMATIONS OF THE FORWARD AND BACKWARD SHARES OF THE HNKPC FOR EURO AREA

Notes: N=88 estimations from 21 articles; period 2001-2010. Each scatter plot in lozenge form represents a collected estimation. The $x$ axis shows the forward-looking share of the HNKPC ($\beta_f$), while the $y$ axis indicates the backward-looking share ($\beta_b$). The square form scatter plot is the mean of the estimates, while that with triangular form is the median.

Data are further analysed with descriptive statistics (Table 2, Figures 2 to 5). The $\beta_f$ median is 0.69, while its mean is 0.68 (Table 2). The distribution is not symmetric, with a distribution bias on the left (negative Pearson coefficient). The $\beta_b$ median is 0.252 and the mean 0.278. The distribution bias is on the contrary on the right (positive Pearson coefficient). Wide variation and dispersion in estimates is also observed (standard deviation, Figures 2 and 3). These descriptive statistics are more in line with HNKPC specification 2 than with specification 3 with a large $\beta_f$ but not equal to one, and $\beta_b$ does not seem superior to 0.5.

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26 As in De Grauwe and Costa-Storti (2004 :5).
TABLE 2. EURO AREA HNKPC ESTIMATES: DESCRIPTIVE STATISTICS

<table>
<thead>
<tr>
<th></th>
<th>All estimates</th>
<th>Estimates respecting the natural rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta_f$</td>
<td>$\beta_b$</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.000</td>
<td>0.401</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.990</td>
<td>0.990</td>
</tr>
<tr>
<td>Median</td>
<td>0.690</td>
<td>0.659</td>
</tr>
<tr>
<td>Mean</td>
<td>0.680</td>
<td>0.667</td>
</tr>
<tr>
<td>Variance</td>
<td>0.019</td>
<td>0.021</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.138</td>
<td>0.145</td>
</tr>
<tr>
<td>Skewness (Pearson)</td>
<td>-1.197</td>
<td>0.188</td>
</tr>
</tbody>
</table>

FIGURES 2 TO 5. HISTOGRAMS OF EURO AREA HNKPC ESTIMATES: ALL ESTIMATES AND THOSE RESPECTING THE NATURAL RATE

Notes: Figures 2 and 3 relate to all estimates (88 observations) while Figures 4 and 5 correspond to estimates respecting the natural rate (39 observations).

As a first simple robustness check of these results, the database sub-sample composed of estimates respecting the natural rate hypothesis is inspected.

Estimates respecting the natural rate hypothesis. The selection of empirical estimates respecting the natural rate hypothesis leads to keep 39 estimates from 15 articles with estimation points on the same line (diagonal, Figure 1), because of the restriction they respect. In the detail of descriptive statistics (Table 2, Figures 4-5), the $\beta_f$ median is 0.659 with a distribution bias on the right, while the $\beta_b$ median is 0.34 with a distribution bias on the left. Variation in reported estimates is also present (Figures 4-5). This corroborates previous indications in favour of specification 2 with about two-thirds on forward-looking inflation and one-third on backward-looking inflation. This conclusion is examined via simple $t$-tests.

2.2. SIMPLE TESTS ON THE COMPETING SPECIFICATIONS OF THE HNKPC

The competing (H)NKPC specifications are examined using simple $t$-tests on collected estimates (Table 3)\(^\text{27}\). The purely forward-looking NKPC (on average $\beta_f=1$) corresponding to specification 1 is not validated. Yet, another simple test (Table 3, column 2) suggests that $\beta_f$ is not absent. Specification 1 is also inspected by testing if on average $\beta_b=0$. Results are not significant, confirming that the purely forward-looking NKPC is not necessarily an accurate specification of euro area inflation dynamics. A further $t$-test examines if, as

\(^{27}\) As in De Grauwe and Costa Storti (2004:6).
defended by specification 2 and suggested by previous evidence, we have mean \( \beta_f > \beta_b \); this hypothesis is reasserted. Finally, specification 2 is studied more deeply by testing the HNKPC ‘calibration’ emerging from previous analysis: \( \beta_f=2/3 \) and \( \beta_b=1/3 \). It is accepted only for estimates respecting the natural rate. However, the t-test validity can be limited since estimates come from different econometric methods so that the population homogeneity is not perfect.

**Table 3. Simple T-Tests On HNKPC Estimates For The Euro Area**

<table>
<thead>
<tr>
<th></th>
<th>Mean ( \beta_f=1 ) (t-test)</th>
<th>Mean ( \beta_f=0 ) (t-test)</th>
<th>Mean ( \beta_b=0 ) (t-test)</th>
<th>Mean ( \beta_f &gt; \beta_b ) (t-test)</th>
<th>Mean ( \beta_f=2/3 ) (t-test)</th>
<th>Mean ( \beta_b=1/3 ) (t-test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All estimates</td>
<td>Rejected</td>
<td>Rejected</td>
<td>Rejected</td>
<td>Accepted</td>
<td>Accepted</td>
<td>Accepted</td>
</tr>
<tr>
<td>Estimates respecting the natural rate hypothesis</td>
<td>Rejected</td>
<td>Rejected</td>
<td>Rejected</td>
<td>Accepted</td>
<td>Accepted</td>
<td>Accepted</td>
</tr>
</tbody>
</table>

*Note:* Acceptation or rejection at the 1% level.

The conclusion of this quantitative review is that specification 2 appears to be dominant: the HNKPC is preferred to a NKPC, but is mainly forward-looking. The specification for fractions \( \beta_f \) and \( \beta_b \) in the euro area seems approximately two-third/one third:

- \( \beta_f=2/3 \) and \( \beta_b=1/3 \)

Although indicative, these results must be received with caution, and cannot claim to provide a definitive answer to the question of the HNKPC form. Additional robustness check on related literature and micro-data from firms’ pricing surveys is conducted.

### 2.3. Robustness Checks

**Related literature.** These conclusions are in line with some previous reviews of the literature on the euro area. McAdam and Willman (2003:37) conclude that \( \beta_b \) is between 0.3 and 0.5, while Altissimo et al. (2006:17) indicate it is ‘less than 0.5’. Finally, Henzel and Wollmershäuser (2008:823) find that the mean \( \beta_f \) of the studies they review is 0.62, suggesting that \( \beta_b \) could be about one third.

**Robustness check on micro evidence.** (H)NKPC promoters claim it is superior to previous Phillips curves since it benefits from micro-foundations on firms’ optimising behaviour. Firms’ prices formation on past or future inflation and information are thus crucial determinants of the HNKPC specification (\( \beta_f \) and \( \beta_b \)). As an illustration, the backward-lookingness is introduced via indexation of firms’ prices on past inflation. The analysis of micro surveys of firms’ pricing behaviour is therefore a relevant robustness check for the quantitative surveys results on HNKPC estimates at the aggregate macro level. Firms’ micro evidence in the euro area confirms previous results of \( \beta_f=2/3 \) and \( \beta_b=1/3 \) since one of the stylised facts highlighted by micro-level studies is that about 30% or one third of firms’ prices are indexed on past inflation: ‘it is found that around one third of firms employ some simple rule of thumb when setting prices’
The specification $\beta_f \approx 2/3$ and $\beta_b \approx 1/3$ seems realistic at the microeconomic level, leading to a macro-micro evidence consistency. A regression analysis is now undertaken for a deeper investigation of these results.

### 2.4. Regression Analysis

While the quantitative review clearly signals a substantial backward share, it also points out an important limitation to this result: significant variations in reported empirical estimates. A regression on both series of $\beta_f$ and $\beta_b$ estimates is performed to explore the factors driving these variations (Table 7). Debates in the HNKPC literature direct to three main factors: the estimation technique, the sample and the driving variable. This statistical analysis offers some rough indications on their effect on estimates, if they matter for estimates heterogeneity.

Estimation techniques are evaluated because, as stressed in the ‘intractable controversy’ discussion, they can be biased, favouring either $\beta_f$ or $\beta_b$. Four main estimation methods are distinguished: GMM, ML, Bayesian and TSLS (Table 1). A dummy captures the estimation technique by putting 1 when a technique is used, 0 when it is not. The second factor explaining differences in estimates could be the sample. Variation in the inflation level can be important for this variable persistence. Inflation was high in the 1970s in Europe with a shift in trend inflation, the so called ‘Great Inflation’. That could be a source of inflation persistence (high $\beta_b$, low $\beta_f$). On the contrary, a downward shift in trend inflation is observed in the 1980s. All samples include the 1980s (Table 1), but not all include the 1970s. The latter’s effect on estimates is tested. Since the euro area is analysed, we also test the presence of the post-1999 period in the data, since the European Monetary Union (EMU) creation could have reduced inflation persistence (high $\beta_f$, low $\beta_b$). Yet, this regime shift being recent, it is only partly included in the samples considered. Hence uncertainty on the relevance of tests on this period is simply unavoidable. The dummy for the sample is 1 when the 1970s or the post-1999 period are present in the sample, 0 when they are not. This is an implicit test of the debate on the HNKPC parameter stability and robustness to the Lucas critique. Thirdly, the literature informs that the choice of the driving variable serving as indicator of the real economic activity ($x$) can impact on estimates: employing an output gap proxy (detrended output) or instead a marginal cost proxy could make a difference. Yet, the expected effect is not clear since while it is generally admitted that the choice of the output gap impacts on the slope $k$ of the HNKPC, its effect on $\beta_f$ or $\beta_b$ is more ambiguous. It can lead to higher estimates of $\beta_b$ (lower $\beta_f$) or the...
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contrary\textsuperscript{35}. Consequently, it possibly has no significant effect on $\beta_f$ and $\beta_b$. The dummy value is 1 when the output gap is used as the driving variable, 0 otherwise. The tested regression on the estimates $Z$ ($\beta_f$ and $\beta_b$) is \textit{in fine}\textsuperscript{36}:

$$Z = \text{intercept} + \zeta_d \text{dummy technique} + \zeta_s \text{dummy sample} + \zeta_{OG} \text{dummy output gap} \quad (3)$$

This regression could suffer from several limitations. First, it can omit important factors influencing the estimates, for example the choice of the instrument set (GMM) or exogenous crucial open economy shock (cost push) or global structural factors such as the Great Moderation. Secondly, interaction terms are not considered, so that interaction for instance of the estimation technique and the driving variable are not studied. Finally, since each estimate is weighted equally, results of articles with a large number of studies can be outweighed compared to those with a small number of estimates. For all these reasons the regression results remain simply an indication and have to be taken carefully, as underlined by the relatively limited value of the R-squared (Table 7).

**TABLE 7. RESULTS OF REGRESSIONS ON THE HNKPC ESTIMATES DATABASE**

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Dependent variables ($Z$)</th>
<th>$\beta_f$ (A)</th>
<th>S.E.</th>
<th>$\beta_f$ (B)</th>
<th>S.E.</th>
<th>$\beta_b$ (C)</th>
<th>S.E.</th>
<th>$\beta_b$ (D)</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td></td>
<td>0.919***</td>
<td>0.152</td>
<td>-0.078</td>
<td>0.14</td>
<td>0.819***</td>
<td>0.041</td>
<td>-0.134</td>
<td>0.129</td>
</tr>
<tr>
<td>Estimation techniques</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>GMM</td>
<td></td>
<td>-0.292*</td>
<td>0.133</td>
<td>0.377**</td>
<td>0.129</td>
<td>-0.126**</td>
<td>0.039</td>
<td>0.373**</td>
<td>0.128</td>
</tr>
<tr>
<td>ML</td>
<td></td>
<td>-0.354*</td>
<td>0.140</td>
<td>0.444**</td>
<td>0.136</td>
<td>-0.192***</td>
<td>0.055</td>
<td>0.435**</td>
<td>0.133</td>
</tr>
<tr>
<td>TSLS</td>
<td></td>
<td>-0.340*</td>
<td>0.153</td>
<td>0.452**</td>
<td>0.148</td>
<td>-0.174*</td>
<td>0.085</td>
<td>0.451**</td>
<td>0.147</td>
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<td>Bayesian</td>
<td></td>
<td>-0.167</td>
<td>0.134</td>
<td>0.263*</td>
<td>0.130</td>
<td>-</td>
<td>-</td>
<td>0.273*</td>
<td>0.129</td>
</tr>
<tr>
<td>Driving variable</td>
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<td>Output gap</td>
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<td>0.053</td>
<td>-0.042</td>
<td>0.051</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Sample</td>
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<tr>
<td>Includes the 1970s</td>
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<td>0.065</td>
<td>0.064</td>
<td>-0.057</td>
<td>0.062</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Includes post 1999</td>
<td></td>
<td>-0.070*</td>
<td>0.034</td>
<td>0.156**</td>
<td>0.033</td>
<td>-0.074*</td>
<td>0.032</td>
<td>0.134***</td>
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<td>Multiple R\textsuperscript{2}</td>
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<td>0.287</td>
<td>0.167</td>
<td>0.167</td>
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<tr>
<td>Adjusted R\textsuperscript{2}</td>
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<td>0.126</td>
<td>0.227</td>
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</table>

This table reports the Ordinary Least Squares linear regression of equation (3). In columns are indicated the estimates on which the regression is leaded (dependent variables $Z$): estimates of the forward-looking share $\beta_f$ of the HNKPC or estimates of its backward-looking fraction $\beta_b$. For each of these estimates, the whole database is used, i.e. N=88 observations for each fraction for the period 2001-2010. Columns A and B are regressions with all the dummies. In columns C and D statistically non significant explanatory variables (dummies) are removed. S.E.: Standard Error. ***, ** and * indicate the coefficient is statistically significant respectively at the 0%, 0.1% and 1% levels.

We focus on results of regressions with all the dummies (Table 7, columns A and B) since regressions with only the statistically significant dummies (Table 7, columns C and D) confirm their results. For all explanatory variables the signs of coefficients are consistent: opposite signs for $\beta_f$ and $\beta_b$. All statistically

\textsuperscript{35} Henzel and Wollmershäuser (2008:821), Fanelli (2005:19).

\textsuperscript{36} It seems valuable to test both $\beta_f$ and $\beta_b$ because not all studies follow the condition $\beta_f + \beta_b = 1$. 

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significant coefficients point to a negative effect on $\beta_f$ and a positive effect on $\beta_b$. Moreover, when comparing the three explanatory variables blocks, the magnitude of estimated coefficients shows that estimation techniques have more effect on estimates than the ‘output gap’ or the ‘sample’. All techniques coefficients have a negative sign for the fraction $\beta_f$, and on the contrary a positive sign for $\beta_b$. It suggests that they could be biased: underestimating $\beta_f$ while overestimating $\beta_b$. This bias was expected for the ML technique, but the opposite was expected for the GMM. The Bayesian technique seems to have less effect on estimates than other methods in terms of the coefficients values, but also because one coefficient is not statistically significant (Table 7, column A). From regression coefficients emerges the following ranking of estimation technique from the more to the least important effect on estimates: TSLS, ML, GMM, Bayesian. This reinforces the recent shift in the literature from the standard GMM to the Bayesian estimation of the HNKPC. The output gap dummy coefficient is not statistically significant, in accordance with the view that it impacts more on $k$ than on $\beta_f$ and $\beta_b$. The sample dummy is not statistically significant for the 1970s but is for the ‘post-1999’. In contrast with common wisdom, there is no clear evidence that the 1970s Great Inflation has an effect on estimates. On the contrary, the EMU launch seems to matter, but not in the direction expected by the ECB: it tends to increase $\beta_b$ instead of $\beta_f$. Nevertheless, compared to other factors, this effect is limited, the coefficient on EMU for $\beta_f$ being more than five time less than the coefficient for ML, and it is less than 0.1. This small gap with the ECB expectations, and its policy implications for the conduct of monetary policy, are now to be studied.

3. POLICY IMPLICATIONS

We discuss the implications for the conduct of monetary policy of this result of a significant $\beta_b$, i.e. some indications of a HNKPC instead of a NKPC for the euro area. First, monetary policy under the HNKPC is briefly presented. Next, the ECB position in favour of the NKPC is examined. Finally, the reasons that could account for this gap between the quantitative survey results and the ECB are inspected.

**Standard policy under inflation persistence.** The quantitative review indicates that $\beta_b>0$. The literature documents that this inflation persistence matters for the conduct of monetary policy because it makes disinflation more costly and ‘in the presence of a large inertial component in inflation, it is instead optimal to bring inflation down gradually’ (Fuhrer and Olivei, 2004:16). More specifically, in case of uncertainty on the degree of inflation persistence, this literature recommends to act as if it was important, and to behave as if the economy was characterized by a HNKPC (Angeloni et al., 2003:545).

**ECB members** are not perfectly in accordance with the quantitative review results, since they claim that inflation persistence has now almost disappeared,
so that $\beta_b=0$. They allege it could have been important in the past, but that it is not structural since it varies with monetary policy shifts. They say that the EMU launch has been accompanied by a reduction to zero of inflation persistence: $\beta_b=0$. Hence, the euro area inflation dynamics follows a purely forward NKPC, not a HNKPC. This ECB’s view is consistent with the Gali et al. (2001) conclusion. In this interpretation, $\beta_b>0$ signals an imperfectly credible central bank unable to anchor inflation expectations. On the contrary, a perfectly credible central bank, intensively using communication, leads firms to form their prices on the inflation target and in a forward-looking manner, abandoning indexation on past inflation.

**The debate.** This ECB case for $\beta_b=0$ is tempered by the previous quantitative review indicating instead that $\beta_b>0$ and that the EMU launch is apparently not totally encouraging $\beta_b=0$. This difference could signal that the ECB officials’ approach can be questioned on several grounds. First, the ECB is only a recent creation, so that it can be premature to conclude that $\beta_b=0$ is structural. Secondly, only a few studies indicate this result for the EMU era and they are recent, their conclusions can be thus regarded as tentative, as stressed by ECB members themselves. It contrasts with estimates integrated in the quantitative review that have been intensively debated in the literature. Moreover, some studies confirm our results that the EMU launch in 1999 had little impact on inflation persistence: change happened before (Angeloni et al., 2006:382). Furthermore, the decline in $\beta_b$ can be due to other structural changes in the economy, to a global exogenous shock such as the Great Moderation or the reduction of exogenous cost push shock. The EMU is not necessarily the only cause, and the causality is more often suggested than formally demonstrated by ECB members. More generally, as stressed in the introduction, the inflation persistence decline is not perfectly consensual in the literature. And even if it is highly plausible that the ECB strategy has reduced inflation persistence, the claim that it has totally disappeared is far from being consensual.

Thirdly, the ECB explanation of the decline of $\beta_b$ to zero rests upon the elusive inflation expectations that are difficult to understand. Expectations are crucial since the contraction of $\beta_b$ defended by the ECB cannot be achieved by the sole effect of a monetary policy regime shift, for instance with an increase in the response coefficient on inflation in the monetary policy rule (Benati, 2008:1035). Communication and the expectations management can help to reduce inflation persistence but it has also to be formally demonstrated that they can completely eradicate inflation persistence. Some countries under inflation targeting have a longer experience than the ECB regarding the creation of a new monetary regime since they began at the beginning of the 1990s. Their experience stresses that inflation expectations anchorage and reduction cannot be taken for granted. Consequently, it appears that a structural change in the

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42 ECB officials generally only quote Benati (2008). It is mentioned in eight ECB members’ speeches, while the article giving a different view (Angeloni, Aucremanne and Ciccarelli, 2006) is mentioned once.
44 This is mentioned in Angeloni et al. (2006:366), Benati (2008:1040).
economy could be required on top of the policy change to induce the move to the canonical NKPC.

Fourth, the transition to $\beta_b=0$ can be expected to be seen at the micro-level of firms’ price formation. If their expectations evolve from backward to forward-looking, it should impact their pricing rule. Microeconomic surveys of firms *prima facie* do not support this idea since they show that firms’ price behaviour has not radically change next to the EMU launch (Angeloni et al., 2006:366). Yet, this is indirect evidence on their pricing rule, but to our knowledge there is no study of the evolution, before and after EMU, of the firms’ share indexing their prices on past inflation. Nevertheless, we highlighted that these surveys report a significant share of backward-looking price setters. Hence, compared to our results, the micro-macro consistency of the purely forward NKPC for the euro area is less obvious or, at least, needs more empirical investigation.

Finally, the analysis has stressed that not only the sample, but also the estimation technique can influence estimates. Thus studies showing that $\beta_b=0$ have to carefully demonstrate that there is no limitation to the estimation technique they use, and it is not always the case in the state of art of this literature that generally does not discuss the Bayesian estimation for instance.

For all these reasons, it is difficult to consider that uncertainty on inflation persistence is nil, implying that the central bank could act as if it was a fairly important phenomenon. The ECB should avoid the ‘risk of conducting monetary policy under the assumption that inflation is not structurally persistent when it is’ (Benati, 2008:1008). Hence $\beta_b>0$ is consistent with a conservative and cautious central banker. The value of $\beta_b$ emerging from the quantitative review could constitute this conservative calibration of inflation persistence.

**CONCLUSION AND DIRECTIONS FOR FUTURE RESEARCH**

According to common wisdom, the purely forward-looking NKPC is robustly based on micro-foundations and capable of reproducing the empirical dynamics of inflation observed in the euro area. As a first contribution of this article, stylised facts on empirical estimates of the HNKPC, highlighted by the quantitative review, indicate that this perceived wisdom has to be taken carefully. It suggests that the NKPC is empirically more hybrid than pure, as it contains a backward looking fraction: approximately two-thirds forward and one-third backward. This result is roughly in agreement with firms microeconomic surveys, also indicating that about one-third of firms form their prices based on past inflation. Nevertheless, several limitations qualify this result and give some directions for future research. Due to strict and numerous selection criteria, the estimates number is limited. For future research, the database can be extended to other price setting microfoundations such as Taylor (1980) that is often judged to lead a NKPC similar to the Calvo pricing. Another avenue for future research is to examine in more details the various marginal cost proxies. Estimates from HINKPC specifications incorporating open economy elements, at least implicitly, could also be included.

Even if these results of the quantitative review should be received with caution, they propose a substantial departure from the optimal monetary policy derived from the purely forward looking NKPC. In particular, the Divine Coincidence
and the expectations management – the cornerstones of the ECB priority on price stability – are not fully valid under a hybrid NKPC. Empirical results invite to a more flexible monetary policy, more gradual, with a longer optimal time horizon.

Another cautionary note to this otherwise clear diagnostic in favour of the HNKPC is the presence of substantial variations in reported estimates. The second contribution of this article is to explore these variations with a regression analysis, which results could be of interest for researchers in their future methodological choice of the HNKPC estimation. It reveals that the estimation techniques have a significant effect on estimates; the Bayesian method currently used in DSGE models having the weaker effect. On the contrary, the use of output gap proxies instead of marginal cost proxies does not have a significant effect. Finally, in comparison to estimation techniques, the sample employed has apparently little or no effect on estimates. Samples containing post-1999 data have a little but significant positive effect on $\beta_b$ (negative on $\beta_f$). The ECB is expecting the opposite effect from its creation: a reduction of $\beta_b$. This gap stressing uncertainty on inflation persistence (approximated by $\beta_b$) is a subject for future research on the recent EMU period to obtain more robust analysis of the effect of its launch on the HNKPC. This also requires more investigations at the firms’ micro-level to see how the EMU has affected their price-setting behaviour. In the current state of the art, characterized by uncertainty on inflation persistence, a large part of the literature recommends the central bank to overestimate inflation persistence. This leads to a policy environment close to the HNKPC enlightened by our quantitative review.
REFERENCES


