Will it float? The New Keynesian Phillips curve tested on OECD panel data

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The debatable NPC

The hybrid New Keynesian Phillips Curve, hereafter NPC, is an integral part (in fact the 'supply side') of the standard model of monetary policy.

\[ \Delta p_t = a^f \Delta p_{t+1}^e + a^b \Delta p_{t-1} + b \, ws_t, \]

Impact due to:

- Micro foundations with rational expectations—a "structural" macroeconometric equation.
The debatable NPC, cont’d

Nevertheless—a debate. A categorization of arguments can be made with reference to statistical and scientific inference (Koopmans and Reiersøl (1950)):

- **Statistical inference**: from sample to population—eg. the question of the right estimation method.
- **Scientific inference**: interpretation of the population in terms of theory and existing knowledge—a concern for *all* the properties and implications of a chosen or maintained interpretation of the correlations (not just chosen favourable traits), and also a mindfulness of alternatives.

GGL engage in the debate about statistical inference, and claim that ‘nothing’ can overturn their results. But issues of scientific inference may be just as important: alternative models exist already, and encompassing tests should therefore accompany statistical inference.
For example: Bårdsen, Jansen and Nymoen (2004) test the encompassing capabilities of the NPC on both GGL’s original euro area data and on Norwegian and UK time series data.

The results show that the NPC has little encompassing power: it does not explain existing findings.

Others have done even more careful econometrics, for example Boug, Cappelen and Swensen (2006).

Here, we assess the hybrid NPC on a panel data set from OECD countries.
The theoretical NPC

The hybrid NPC is given as

$$\Delta p_t = a^f \Delta p_{t+1}^e + a^b \Delta p_{t-1} + b \, ws_t,$$

(1)

where $\Delta p_{t+1}^e$ is expected inflation one period ahead, in our application the period is annual, conditional on the information available in period $t - 1$.\(^1\) $ws$ is the log of the wage-share, as an operational definition of marginal costs.

\(^1\) $\Delta p_t^e = E(\Delta p_{t+1} | I_{t-j})$ the mathematical expectation given information available in time period $t - j$. It has become custom to assume that $j = 0$. 
The typical empirical NPC

The typical NPC estimated by GGL gives the following results:

1. The two null hypotheses $a^f = 0$ and $a^b = 0$ are firmly rejected both individually and jointly.
2. The hypothesis $a^f + a^b = 1$ is typically not rejected at conventional levels of significance, although the estimated sum is usually a little less than one.
3. The estimated value of $a^f$ is larger than $a^b$, hence forward-looking behavior is dominant. $a^b$ is usually estimated in the range of 0.2 to 0.6.
4. When real marginal costs are proxied by the wage-share, as already assumed, the coefficient $b$ is positive and significantly different from zero at conventional levels of significance.

In the paper we show that all features depend crucially on not taking into consideration alternative and existing explanations and models.
OECD panel and the open economy NPC

We make use of data from 20 OECD countries. Because each country is an open economy, the closed economy equation (1) framework is a limitation. However:

\[ \Delta p_t = a^f \Delta p^e_{t+1} + a^b \Delta p_{t-1} + b ws_t + c x_t, \]

where \( x_t \) contains the open-economy variables, and \( c \) denotes the corresponding coefficient vector.

The change in the real import price, \( \Delta(p_i - p_t) \) is the single most important open economy augmentation of the NPC. The empirical results of the open economy variant align perfectly with the typical NPC properties 1.-4. above.
Testable hypotheses

Start from:

\[ ws_t = ulc_t - pd_t, \]  \hspace{1cm} (3)

where \( ulc \) denotes unit labour costs (in logs) and \( pd \) is the log of the price level on domestic goods and services. Let \((1 - \gamma)\) denote a constant import share, then the aggregate price level is defined as

\[ p_t = \gamma pd_t + (1 - \gamma)\pi_t \]  \hspace{1cm} (4)

Using (3) and (4) we can re-write the NPC as:
\[ \Delta p_t = \frac{a^f}{1 + \frac{b}{\gamma}} \Delta p^e_{t+1} + \frac{a^b}{1 + \frac{b}{\gamma}} \Delta p_{t-1} \]

\[ - \frac{b}{(\gamma + b)} [p_{t-1} - \gamma ulc_{t-1} - (1 - \gamma) p_{i t-1}] \]

\[ + \frac{\gamma b}{(\gamma + b)} \Delta ulc_t + \frac{b (1 - \gamma)}{(\gamma + b)} \Delta p_{i t} + \frac{\gamma c}{(\gamma + b)} x_t, \]

or

\[ \Delta p_t = \alpha^f \Delta p^e_{t+1} + \alpha^b \Delta p_{t-1} \]

\[ + \beta (ulc_{t-1} - p_{t-1}) - \beta (1 - \gamma) (ulc_{t-1} - p_{i t-1}) \]

\[ + \beta \gamma \Delta ulc_t + \beta (1 - \gamma) \Delta p_{i t} + \psi x_t, \]

where we have defined \( \alpha^f, \alpha^b, \beta \) and \( \psi \) as new coefficients for simplification.
This equation shows out that the NPC has an interpretation as an equilibrium correction model (ECM), of the price level, but with two important remarks:

1. The usual ECM for inflation is extended by the inclusion of the forward-looking term $\Delta p_{t+1}^e$.

2. The NPC-ECM contains more parameter restriction than usual since the coefficients of $\Delta ulc_t$, $\Delta pi_t$ and the ECM terms, $(ulc_{t-1} - p_{t-1})$ and $(ulc_{t-1} - pi_{t-1})$, are restricted to be functions of $b$ and $\gamma$. 
NPC encompassing hypotheses

An alternative model for price and wage formation is the imperfect competition model, ICM. The econometric specification and evaluation of the ICM was developed in the last 2 decades before the coming of the NPC. In simplified form the ICM implies a price equation:

$$\Delta p_t = \alpha^f \Delta p_{t+1} + \alpha^b \Delta p_{t-1} + \beta_1 (ulc_{t-1} - p_{t-1}) + \beta_2 (ulc_{t-1} - pi_{t-1}) + \beta_3 \Delta ulc_t + \beta_4 \Delta pi_t + \psi x_t. \quad (6)$$

The NPC implies restrictions on the coefficients:

- $H^a_0$: $\beta_3 = \beta_1 + \beta_2$ and
- $H^b_0$: $\beta_4 = -\beta_2$.

The ICM requires only that $\beta_1 > 0$ and $\beta_1 > -\beta_2$. The rejection of $H^a_0$ and/or $H^b_0$ would therefore appear to be telling evidence against the NPC.
Additional hypotheses

In addition to $H_0^a$ and $H_0^b$ we can test:

- $H_0^c$: $\alpha^f = 0$ and
- $H_0^d$: $\alpha^b = 0$.

This is essentially the usual econometric assessment of the NPC on country (or area) data.

Notice that the ICM does not imply $H_0^c$: $\alpha^f = 0$ though. Hence a ICM with elements of forward-looking behavior is a possible alternative to both the NPC and the ICM with (only) backward-looking expectations.
The OECD data set

- We use a data set for annual wages and prices for 20 OECD countries, for the time period 1960-2004.
- For some of the countries the time period is shorter, so the panel is unbalanced. Because of one lead and one lag we lose the observations from 1960 and 2004.
- We use the OECD unit labour cost index that covers the whole economy.
- The import price index is constructed by taking the ratio of the value and the volume of imported goods and services.
- We use the consumer price index as a measure for $p_t$
As a benchmark model we first estimate the NPC model (2) with the following variables in the $x$ vector:
- the rate of change in the oil price ($\Delta p_{0t}$),
- the change in the indirect tax rate ($\Delta VAT_t$), and
- the change in the real import price $\Delta (p_i - p_t)$.

The resulting equation is denoted M1 in the results section.
The more general inflation equation, M2

The open economy inflation equation (6), which we repeat here as

\[
\Delta p_{i,t} = \theta_i + \alpha^f \Delta p^e_{i,t+1} + \alpha^b \Delta p_{i,t-1} + \beta_1 (ulc_{i,t-1} - p_{i,t-1}) \\
+ \beta_2 (ulc_{i,t-1} - p_{i,t-1}) + \beta_3 \Delta ulc_{i,t} + \beta_4 \Delta p_{i,t} \\
+ \psi_1 \Delta po_{i,t} + \psi_2 \Delta VAT_{i,t} + \epsilon_{i,t}.
\]

We have added an extra subscript \(i\) for each country, country-specific fixed effects, \(\theta_i\), and a stochastic error term \(\epsilon_{i,t}\). This model is denoted M2 in the next section.
Some econometric issues

- Induced MA disturbances—GMM estimation
- Identification—instruments lagged two periods
- Common shocks—we include explicit common explanatory variables (oil price), and also use SURE estimation to check our main results, as an alternative to time dummies
- Homogenous slope coefficients
- Time series properties, cointegration
Estimation method

The models are estimated using GMM, where $\Delta p_{i,t+1}$, $\Delta ulc_{i,t}$ and $\Delta(p_{i,t} - p_{i,t})$ are treated as endogenous explanatory variables.

- Instruments in all models: $\Delta p_{i,t-2}$, $\Delta p_{i,t-1}$, $\Delta p_{0,i,t-1}$, $\Delta ulc_{i,t-1}$ and $ws_{i,t-1}$, the gross replacement rate ($BRR$) and its lags, and an index of employment protection ($EP$) and its lags.

- $(ulc_{i,t-1} - p_{i,t-1})$ and $(ulc_{i,t-1} - p_{i,t-1})$ are additional instruments in M1 and M1’.

- Ordinary GMM estimation, and, for robustness, GMM with Cross-Section SUR (PCSE) corrections of standard errors and covariances.
## Main results, GMM results, OECD panel data

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M1'</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta p_{i,t+1}$</td>
<td>0.56</td>
<td>0.57</td>
<td>-0.01</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.12)</td>
</tr>
<tr>
<td>$\Delta p_{i,t-1}$</td>
<td>0.47</td>
<td>0.46</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.02)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>$ws_{i,t}$</td>
<td>-0.011</td>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>(ulc$<em>{i,t} - p</em>{i,t}$)</td>
<td>-0.005</td>
<td>(0.008)</td>
<td></td>
</tr>
<tr>
<td>(ulc$<em>{i,t-1} - p</em>{i,t-1}$)</td>
<td>0.053</td>
<td>(0.014)</td>
<td></td>
</tr>
<tr>
<td>(ulc$<em>{i,t-1} - pi</em>{i,t-1}$)</td>
<td>-0.020</td>
<td>(0.006)</td>
<td></td>
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<tr>
<td>$\Delta ulc_{i,t}$</td>
<td>0.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta pi_{i,t}$</td>
<td></td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.014)</td>
<td></td>
</tr>
<tr>
<td>$\Delta (pi_{i,t} - p_{i,t})$</td>
<td>0.05</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>$\Delta po_{i,t}$</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>$\Delta VAT_{i,t}$</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(0.0005)</td>
<td>(0.0004)</td>
<td>(0.0004)</td>
</tr>
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</table>
### Main results, cont’d

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M1’</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td># observ</td>
<td>567</td>
<td>567</td>
<td>567</td>
</tr>
<tr>
<td>$\hat{\sigma} \cdot 100$</td>
<td>1.29</td>
<td>1.29</td>
<td>1.00</td>
</tr>
<tr>
<td>$\chi^2_{ival}$</td>
<td>41.49[0.000]</td>
<td>41.96[0.000]</td>
<td>10.96[0.204]</td>
</tr>
<tr>
<td>$N_{AR-1}$</td>
<td>$-3.07[0.002]$</td>
<td>$-3.02[0.002]$</td>
<td>$-0.26[0.81]$</td>
</tr>
<tr>
<td>$N_{AR-2}$</td>
<td>$-2.34[0.019]$</td>
<td>$-2.35[0.019]$</td>
<td>$-0.30[0.76]$</td>
</tr>
</tbody>
</table>
Encompassing tests

1. Significance of the forward-term in M1 should carry over to M2 if the NPC is the right theoretical framework. We observe the opposite: the hypothesis $H_0^c: \alpha^f = 0$ is not rejected in M2.

2. The dominance of the forward term in M1 is thus due to $\Delta p_{i,t+1}$ being correlated with $(ulc_{i,t-1} - p_{i,t-1})$ and $(ulc_{i,t-1} - pi_{i,t-1})$; there is no genuine correlation between the predictable part of $\Delta p_{i,t+1}$ and $\Delta p_{i,t}$.

3. The ‘t-statistics’ are 46.8 and 8.4 for $H_0^a$ and $H_0^b$, respectively.

4. The diagnostics test of M1 also rejects their respective nulls: $\chi^2_{ival}$ is significant, and there is indication of significant residual autocorrelation (also of 2nd order). No such problems for M2
Summary

- GGL claim that the NPC represents a significant advance in inflation modelling which finally substantiates the dominance of forward-looking behavior in price adjustment.

- We take the testing of the NPC model from the calm waters of US and euro area data to the vast data ocean represented by a panel data set from 20 OECD countries.

- We replicate all typical features of estimated NPC model — the NPC appears to float.

- However, this result is to be expected also when the NPC is encompassed by the imperfect competition model (ICM).

- Specifically, when the main explanatory variables of the ICM is introduced: the dominance of the forward term disappears completely—the NPC sinks.