Evaluating Phillips Curve Based Inflation Forecasts in Europe: A Note

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JEL classification: C53, E31, E37
Keywords: Phillips Curve, Forecasting, Europe, RMSE

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We run out-of-sample forecasts for the inflation rate of 15 euro-zone countries using a NAIRU Phillips curve and a naïve reference model. Comparisons show that the naïve model returns better forecasts in almost all cases. We provide evidence that the Phillips curves' goodness of fit is rather high. However, forecasting power is comparatively low.

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1 Introduction

The Phillips curve was established by Phillips (1958) as an empirical relationship between unemployment and nominal wage growth rate. Furthermore, additional research led to the development of the modified Phillips curve showing the relationship between unemployment rate and inflation rate. Friedman (1968) added the natural rate of unemployment, thus establishing the NAIRU Phillips curve. More recent developments refine the theory by adding a system of stochastic price shocks, where the new macroeconomic price level is determined by, basically, discounted marginal costs and is only obtained at a given probability. This model framework is known as "New Keynesian Phillips curve", Galí and Gertler (1999) provide a thorough overview.
Empirical research on the topic has been twofold:

- The first branch of research emphasizes model fit, i.e. questioning whether the model is a good proxy for the data observed in the real world. Paloviita (2008) checks the model fit of several specifications using European data. Blinder (1997) pointed out already that the Phillips curve is known to apply rather badly there. Most recently, Koop and Onorante (2012) challenge estimating the Phillips curve in the anxious times of the financial crisis.

- The second branch of research focuses on forecasting power. The Phillips curve has been used as a tool for inflation rate forecasting. However, many studies find that the Phillips curve's usefulness as a forecasting tool is limited. For example, Atkeson and Ohanian (2001) find that Phillips curve based forecasters are regularly outperformed by simple persistence forecasters. Matheson (2008) gets a better forecasting performance out of a univariate AR(1) forecaster than from Phillips curve forecasting models. Stock and Watson (1999) use generalized Phillips curve forecasters and find mostly useful performances in a 12-months-forecasting horizon. Stock and Watson (2008) compare Phillips curve forecasters to several multivariate specifications of forecasting models and find a good Phillips curve performance for the US. However, Clausen and Clausen (2010) find that the Phillips curve performs badly oftentimes when analyzing data from Germany, the UK and the US.

In this paper we evaluate the NAIRU Phillips curve with adaptive expectations and compare their forecasting performance to the persistence benchmark forecaster suggested by Atkeson and Ohanian (2001). While their study focuses on the US we examine 15 euro-zone countries as well as the Euro area on average from 2001 to 2012 including a "pre-crisis" time frame and a period affected by the financial crisis starting in 2008. We show that the Phillips curve forecasters perform remarkably poor and are regularly outperformed compared to a naïve benchmark.

The paper is structured as follows: Section 2 provides an overview of the methodology used. Section 3 describes the data set. Section 4 presents the results and Section 5 concludes.

2 Phillips Curve Based Methods

This Section shortly describes the Phillips curve specification for forecasting, the reference forecaster and the applied methodology regarding result comparison.

2.1 Phillips Curve Specification

Phillips (1958) specified the empirical relationship between the nominal wage growth rate and unemployment either as a non-linear or log-linear relationship. Usually, a linearized version is applied focusing on the relationship between inflation rate π_t and the unemployment rate u_t. This so-called modified Phillips curve can be written as:

$$\pi_t = bu_t, \tag{1}$$

where b is a scaling parameter which is empirically found to be negative. Taking expectations with respect to the inflation rate ($E_{t-1}[\pi_t]$) and integrating the difference between the actual unemployment rate and the non-accelerating inflation rate of unemployment $\bar{u}$ (i.e. the unemployment rate at which inflation rate does not change), a common specification is given by:

$$\pi_t - E_{t-1}[\pi_t] = b(u_t - \bar{u}). \tag{2}$$

Since expectations usually cannot be observed, the model is simplified by the assumption of adaptive expectations, i.e. it is assumed that agents form their expectations exclusively based on previous inflations rates:

$$E_{t-1}[\pi_t] = \pi_{t-1}. \tag{3}$$

Therefore, the model can be rewritten as

$$\pi_t = a\pi_{t-1} + b(u_t - \bar{u}). \tag{4}$$

Since $-b\bar{u}$ is constant over time this term can be separated to obtain

$$\pi_t = -b\bar{u} + a\pi_{t-1} + bu_t \tag{5}$$

or, in a notation for a linear regression model,

$$\pi_t = \beta_1 + \beta_2\pi_{t-1} + \beta_3 u_t + \varepsilon_t, \tag{6}$$

where ε_t is assumed white noise. Shifting Equation (6) one period ahead, this model results in the following forecasting equation:[1]

$$\pi_{t+1} = \beta_1 + \beta_2\pi_t + \beta_3 u_{t+1} + \varepsilon_{t+1}. \tag{7}$$

Equations (6) and (7) collapse to a random walk type stochastic process in case that β_2 does not differ significantly from one and both β_1 and β_3 do not differ significantly from zero. In that case, the Phillips curve model does not predict inflation rates more accurately than a pure random process. Thus, we test for that in Section 4 using these formal hypotheses:

$$H_0^A : \beta_1 = 0 \wedge \beta_3 = 0 \text{ vs. } H_1^A : \neg H_0^A \tag{8}$$

and

$$H_0^B : \beta_2 = 1 \text{ vs. } H_1^B : \neg H_0^B. \tag{9}$$

2.2 Reference Forecaster

Atkeson and Ohanian (2001) compare Phillips curve forecasts to naïve benchmark forecasts usually called "persistence":

$$\pi_{t+1} = \pi_t. \tag{10}$$

[1]Note that u_{t+1} itself must be forecasted. We use a univariate autoregressive method, i.e. $u_{t+1} = \alpha_1 + \alpha_2 u_t + \alpha_3 u_{t-1} + \nu_t$.

Furthermore, (Atkeson and Ohanian, 2001, p. 3) point out that they use this as a reference "*...not because we think that it is the best forecast of inflation available, but rather because we think that any inflation forecasting model based on some hypothesized economic relationship cannot be considered a useful guide for policy if its forecasts are no more accurate than such a simple atheoretical forecast.*"

2.3 Result Comparison

Comparing two models' forecasting power is usually done in two steps: In the first step, both models are calculated pseudo-out-of-sample, i.e. by using a sub-sample for fitting and then calculating forecasts for another sub-sample period. In the second step, these forecasts are compared to actual realizations in that time frame. The difference between actual values and forecasted values is the forecasting error, e_t. We aggregate these errors by:

$$MAE = \sum_{t=1}^{h} |e_t|, \tag{11}$$

$$MSE = \sum_{t=1}^{h} e_t^2 \text{ and} \tag{12}$$

$$RMSE = \sqrt{MSE}, \tag{13}$$

where h is the number of forecasting errors.[2]

3 The Data Set

We use monthly inflation rates and unemployment rates from January 2001 to August 2012 for Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Slovakia, Slovenia and Spain.[3] Furthermore, we employ aggregated data for the euro-zone.[4] As an

[2]MAE = Mean Absolute Error, MSE = Mean Squared Error, RMSE = Root Mean Squared Error.

[3]These are the so-called Euro-17 countries as of the year 2011 excluding Estonia and Malta which both do not report complete unemployment rate data during the investigated time frame.

[4]These are countries that use the Euro as their national currency. The set of countries in that group changed during the investigated time frame, e.g. Cyprus uses the Euro since January 2008.

inflation rate measure we chose both the original Harmonized Consumer Price Index (HCPI overall) and a core inflation measure, i.e. HCPI without energy and unprocessed food (HCPI core inflation). Additionally, we utilize seasonally adjusted unemployment rate data. All data have been acquired from the ECB's statistical data warehouse.[5] The data set consists of 140 monthly observations per country and variable.

4 Empirical Findings

We run a linear regression of the model described in Equation (6) through the whole sample set for each country and for both the HCPI overall index and HCPI core inflation index. Results are presented in Tables 1 and 2. Hypothesis H_0^A is not rejected most of the times, at least at a 5% level of significance. Exceptions are Finland, Slovenia and Slovakia for HCPI overall and Finland, France, Netherlands, Slovenia, Slovakia and the aggregated euro-zone for HCPI core inflation. Hypothesis H_0^B is rejected at a 5% level for Germany, Spain, Finland, France, Italy, Luxembourg, Netherlands, Portugal, Slovenia, Slovakia and the aggregated euro-zone for HCPI overall and Germany, France, Netherlands, Portugal, Slovenia, Slovakia and the aggregated euro-zone for HCPI core inflation.

The Phillips curve therefore empirically seems to collapse to a random walk for Austria, Belgium, Greece and Ireland. However, the coefficient of determination (R^2) is rather high for all countries and spans from 0.7457 for Cyprus to 0.9699 for Ireland using HCPI overall index data. The adjusted coefficient of determination ($\overline{R}^2$) is comparably high. Both R^2 and $\overline{R}^2$ are slightly higher for HCPI core inflation data in tendency. After all it can be retained that the Phillips curve represents a rather good quality of fit.

[Insert Table 1 about here]

[Insert Table 2 about here]

After running out-of-sample forecasts as described in Section 2.3 by using a rolling window with a fixed size of 70 observations (i.e. "half" of the data set) we obtain aggregated forecasting measures MAE, MSE and RMSE for both forecasters and both index data. Results are presented in Tables 3 and 4. The

[5] Internet source for HCPI: `http://sdw.ecb.europa.eu/browse.do?node=2120778` and unemployment rate: `http://sdw.ecb.europa.eu/browse.do?node=2120805`.

Tables also contain information with respect to the percentage at which the persistence forecaster returns more precise forecasts than the Phillips curve forecaster, denoted as "Δ%".

[Insert Table 3 about here]

[Insert Table 4 about here]

With respect to the HCPI overall index data this measure is always positive, indicating that the Phillips curve did not return a better forecast than the reference forecaster in any case. For the case of HCPI core inflation index data this indicator is negative only for Belgium (for MAE, MSE and RMSE). However, the magnitude is comparatively small and Belgium is one of the few countries for which the empirical fit even collapses to a random walk. Figure (1) gives an example of the way typical actual-vs.-forecasted plots look like.[6] As Figure (2) shows, Belgium looks similar.

[Insert Figure 1 about here]

[Insert Figure 2 about here]

5 Conclusion

In this paper we ran out-of-sample forecasts for the inflation rates in 15 euro-zone countries and the aggregated euro-zone. We use HCPI overall and HCPI core inflation index data and compute the MAE, the MSE and the RMSE for a forecaster based on the NAIRU Phillips curve with adaptive expectations as well as for a naïve benchmark forecaster. We provide evidence that the Phillips curves' goodness of fit is rather high. However, forecasting power is comparatively low. Only Belgium returns smaller aggregated forecasting error measures for Phillips curve forecasts rather than persistence forecasts, but only for the HCPI core inflation index data. Additionally, their numerical magnitude is rather small. In all other cases Phillips curve forecasting errors are much higher than those from the reference forecaster, in some cases even more than twice as high. This suggests that policy makers should not rely on Phillips curve based forecasting methods for euro-zone countries.

[6] It should be mentioned that the reference forecaster is by definition identical to the lagged actual values. The rest of the 30 plots have been omitted to conserve space and are available from the authors upon request.

Stock and Watson (1999) conclude that Phillips curve can be a useful forecaster in the US. This is in line with Blinder (1997), who argues that the Phillips curve is an important tool in the US, admitting that it looks differently in other regions. (Atkeson and Ohanian, 2001, p. 7) however conclude more strongly, stating that "*...the search for yet another Phillips curve based forecasting model should be abandoned*". This paper's results suggest to agree.

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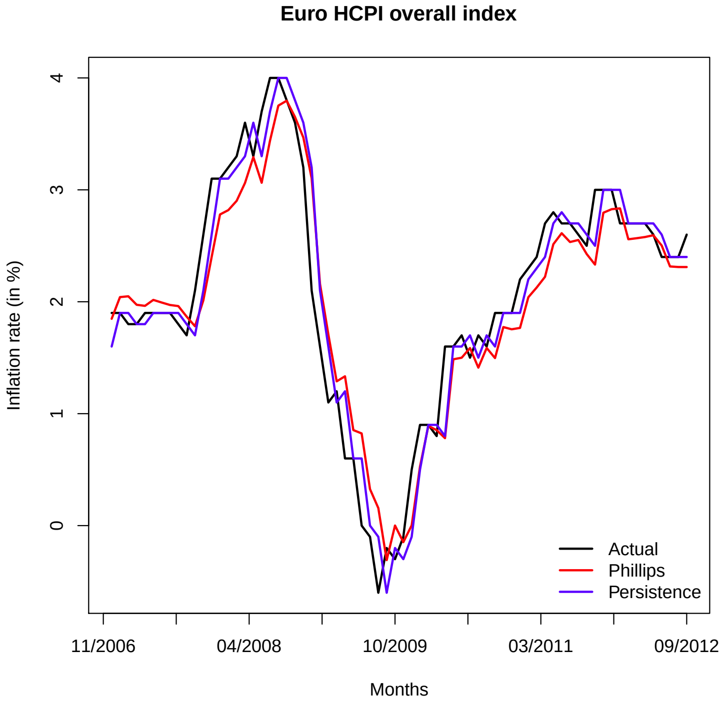

Figure 1: Euro overall inflation - Actual vs. forecasted.

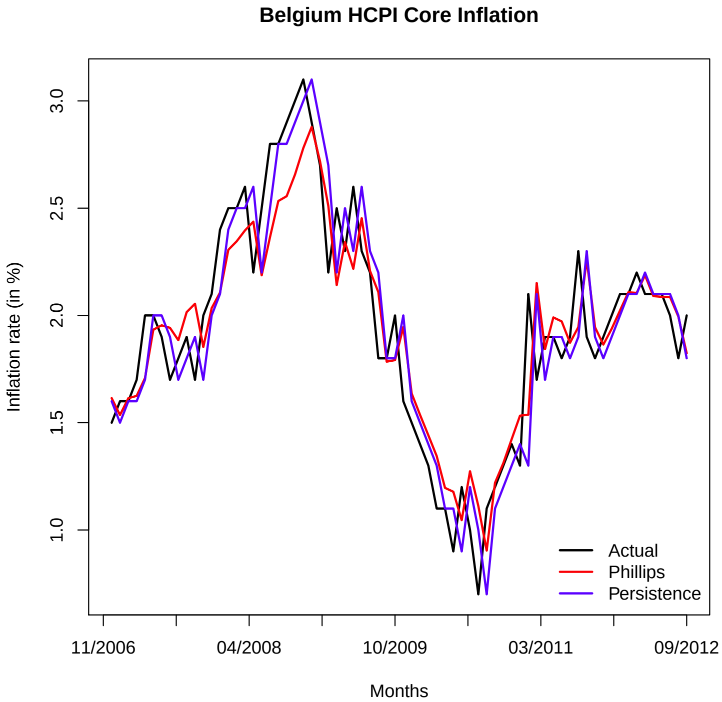

Figure 2: Belgium core inflation - Actual vs. forecasted.

Table 1: Results regression fit (HCPI overall index).

Country	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	p-Value for $\beta_2 = 1$	p-Value for $\beta_1 = 0 \wedge \beta_3 = 0$	R^2	$\overline{R}^2$
Austria	0.9264	0.8955	-0.1624	0.0020	0.0054	0.8801	0.8784
Belgium	1.0689	0.9158	-0.1138	0.0089	0.0323	0.8791	0.8773
Cyprus	0.4149	0.8606	-0.0148	0.0016	0.0232	0.7457	0.7419
Finland	0.0543	0.9468	0.0054	0.0922	0.2402	0.8975	0.8959
France	0.6307	0.9112	-0.0518	0.0101	0.0536	0.8547	0.8526
Germany	0.2411	0.9093	-0.0106	0.0114	0.0817	0.8332	0.8307
Greece	0.2998	0.9084	0.0012	0.0102	0.0242	0.8443	0.8420
Ireland	0.3510	0.9421	-0.0294	0.0086	0.0151	0.9699	0.9695
Italy	0.1526	0.9201	0.0038	0.0164	0.0849	0.8567	0.8546
Luxembourg	0.1994	0.8996	0.0186	0.0081	0.0530	0.8119	0.8091
Netherlands	0.3607	0.9583	-0.0630	0.1013	0.1439	0.9458	0.9450
Portugal	0.3545	0.9490	-0.0239	0.0464	0.0708	0.9234	0.9223
Slovenia	0.4683	0.9758	-0.0527	0.2616	0.2769	0.9427	0.9418
Slovakia	-0.1052	0.9623	0.0191	0.1419	0.3000	0.9401	0.9392
Spain	0.3945	0.9164	-0.0118	0.0127	0.0577	0.8848	0.8831
Euro	0.4292	0.9292	-0.0316	0.0191	0.0694	0.8872	0.8855

Table 2: Results regression fit (HCPI core inflation index).

Country	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	p-Value for $\beta_2 = 1$	p-Value for $\beta_1 = 0 \wedge \beta_3 = 0$	R^2	$\overline{R}^2$
Austria	0.4519	0.8926	-0.0581	0.0099	0.0414	0.8503	0.8481
Belgium	0.5917	0.8555	-0.0428	0.0055	0.0183	0.7973	0.7943
Cyprus	0.3103	0.8686	-0.0210	0.0015	0.0323	0.7804	0.7772
Finland	-0.5148	0.9901	0.0653	0.6134	0.0120	0.9527	0.9520
France	-0.0599	0.9657	0.0124	0.2551	0.3192	0.9065	0.9051
Germany	0.1362	0.9103	-0.0029	0.0230	0.1262	0.8062	0.8033
Greece	0.7861	0.8249	-0.0226	0.0003	0.0007	0.8384	0.8360
Ireland	0.2735	0.9562	-0.0241	0.0212	0.0390	0.9813	0.9810
Italy	0.2418	0.8283	0.0164	0.0005	0.0037	0.6927	0.6881
Luxembourg	0.3804	0.8575	-0.0046	0.0030	0.0078	0.7463	0.7426
Netherlands	-0.0436	0.9993	0.0136	0.9739	0.6636	0.9717	0.9713
Portugal	0.3970	0.9231	-0.0233	0.0223	0.0761	0.9169	0.9156
Slovenia	0.2192	0.9891	-0.0222	0.4450	0.4266	0.9761	0.9757
Slovakia	-0.1430	0.9747	0.0167	0.1593	0.2574	0.9705	0.9701
Spain	0.5629	0.8692	-0.0181	0.0031	0.0144	0.8921	0.8905
Euro	0.0480	0.9591	0.0025	0.2080	0.3165	0.9034	0.9020

Table 3: Forecasting results (HCPI overall index).

Country	MSE Phillips	MSE Persistence	Δ% MSE	MAE Phillips	MAE Persistence	Δ% MAE	RMSE Phillips	RMSE Persistence	Δ% RMSE
Austria	0.1447	0.1171	23.5520	0.2965	0.2600	0.1405	0.3804	0.3423	0.1115
Belgium	0.3472	0.2584	34.3424	0.4434	0.3786	0.1712	0.5892	0.5084	0.1591
Cyprus	0.5223	0.3849	35.7118	0.5874	0.4743	0.2385	0.7227	0.6204	0.1650
Finland	0.1941	0.1531	26.7645	0.3196	0.2771	0.1530	0.4406	0.3913	0.1259
France	0.1488	0.0949	56.8555	0.3121	0.2314	0.3486	0.3857	0.3080	0.2524
Germany	0.1616	0.1284	25.8574	0.3060	0.2729	0.1214	0.4020	0.3584	0.1219
Greece	0.3598	0.2150	67.3665	0.4897	0.3329	0.4712	0.5999	0.4637	0.2937
Ireland	0.3974	0.1540	158.0583	0.4742	0.3029	0.5658	0.6304	0.3924	0.6064
Italy	0.1626	0.1254	29.6046	0.2994	0.2486	0.2044	0.4032	0.3542	0.1384
Luxembourg	0.4416	0.3700	19.3502	0.4995	0.4400	0.1352	0.6645	0.6083	0.0925
Netherlands	0.1436	0.1180	21.7320	0.2657	0.2314	0.1480	0.3790	0.3435	0.1033
Portugal	0.3408	0.1680	102.8605	0.4535	0.3143	0.4430	0.5838	0.4099	0.4243
Slovenia	0.4484	0.3549	26.3685	0.5376	0.4686	0.1473	0.6696	0.5957	0.1241
Slovakia	0.2135	0.1736	22.9795	0.3482	0.2786	0.2499	0.4620	0.4166	0.1090
Spain	0.3987	0.2627	51.7528	0.4471	0.3557	0.2569	0.6314	0.5126	0.2319
Euro	0.1330	0.0917	44.9918	0.2771	0.2057	0.3471	0.3647	0.3028	0.2041

$\Delta\%$ MSE $= \left(\frac{MSE_{Phillips}}{MSE_{Persistence}} - 1\right) \cdot 100$, for MAE and RMSE analogously.

Table 4: Forecasting results (HCPI core inflation index).

Country	MSE Phillips	MSE Persistence	Δ% MSE	MAE Phillips	MAE Persistence	Δ% MAE	RMSE Phillips	RMSE Persistence	Δ% RMSE
Austria	0.0478	0.0460	0.0390	0.1774	0.1686	0.0526	0.2186	0.2145	0.0193
Belgium	0.0493	0.0526	-0.0617	0.1770	0.1771	-0.0008	0.2221	0.2293	-0.0313
Cyprus	0.1749	0.1491	0.1724	0.3236	0.2914	0.1104	0.4182	0.3862	0.0828
Finland	0.0880	0.0609	0.4455	0.2159	0.1629	0.3260	0.2966	0.2467	0.2023
France	0.0271	0.0207	0.3098	0.1341	0.1129	0.1880	0.1647	0.1439	0.1445
Germany	0.0534	0.0477	0.1200	0.1714	0.1514	0.1319	0.2312	0.2184	0.0583
Greece	0.2356	0.1763	0.3362	0.3879	0.2914	0.3309	0.4853	0.4199	0.1560
Ireland	0.2740	0.1300	1.1080	0.3913	0.2657	0.4725	0.5235	0.3606	0.4519
Italy	0.1190	0.1177	0.0112	0.2387	0.2286	0.0445	0.3450	0.3431	0.0056
Luxembourg	0.0409	0.0377	0.0832	0.1599	0.1457	0.0970	0.2021	0.1942	0.0408
Netherlands	0.0579	0.0477	0.2129	0.1733	0.1600	0.0830	0.2406	0.2184	0.1013
Portugal	0.1720	0.1094	0.5719	0.2994	0.2514	0.1906	0.4147	0.3308	0.2538
Slovenia	0.2108	0.1491	0.4134	0.3702	0.3200	0.1570	0.4591	0.3862	0.1889
Slovakia	0.1102	0.0626	0.7611	0.2714	0.1971	0.3766	0.3320	0.2501	0.3270
Spain	0.1897	0.1657	0.1447	0.2937	0.2400	0.2238	0.4355	0.4071	0.0699
Euro	0.0312	0.0253	0.2326	0.1399	0.1100	0.2718	0.1765	0.1590	0.1102

$\Delta\%$ MSE $= \left(\frac{MSE_{Phillips}}{MSE_{Persistence}} - 1\right) \cdot 100$, for MAE and RMSE analogously.