IS THERE A PHILLIPS CURVE IN THE U.S. AND THE EU15 COUNTRIES? An empirical investigation*

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Abstract

This paper studies the comovement between output and inflation in the EU15 countries. Following den Haan (2000), I use the correlations of VAR forecast errors at different horizons in order to analyze the output-inflation relationship. The empirical results show that eight countries display a significant positive comovement between output and inflation. Moreover, the empirical evidence suggests that a Phillips curve phenomenom is more likely to be detected in countries where inflation is more stable.

Key words: comovement of output and inflation, *VAR* forecast errors
JEL classification numbers: E31, E47

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1 INTRODUCTION

For long economists widely accepted that output and inflation displayed a positive correlation at least in the short-run. For a large group of economists, the positive short-run correlation between output and inflation (the so-called Phillips curve phenomenon) is still considered a necessary building block of business cycle theory (for instance, Mankiw (2001)). Yet, this view is rather controversial in the literature. For instance, Kydland and Prescott (1990) argue that "*any theory in which procyclical prices figure crucially in accounting for postwar business cycle fluctuations is doomed to failure.*" Moreover, Cooley and Ohanian (1991) find evidence that the U.S. correlation between output and prices is negative during the postwar period. Furthermore, Atkeson and Ohanian (2001) show that Phillips curve-based models are no better for forecasting a change in the inflation rate than a naive forecast based on a coin flip.

Den Haan (2000) argues that an important source of disagreement in the literature is the focus on only the unconditional correlation between output and prices. As an alternative, Den Haan proposes to use the correlations of VAR forecast errors at different horizons. Proceeding in this way one can take into account valuable information about the comovement of variables. Moreover, variables need not to be stationary to analyze their comovement (that is, previous filtering of variables is not required). Den Haan (2000), Sumner and Den Haan (2001) and Vázquez (2001) have studied the comovement between output and prices using the correlations of VAR forecast errors at different horizons. Using U.S. data from the postwar period, Den Haan (2000) finds that the comovement between output and prices is positive in the short-run (up to two years horizons) and negative in the long-run (between five and seven years horizons). Sumner and Den Haan (2001) analyze data from the G7 countries. They find a negative long-run relationship for all countries. However, the evidence of a positive short-run comovement between output and prices is weaker. Similar to Sumner and Den Haan (2001), Vázquez (2001) finds evidence of a negative long-run relationship for a large group of EU15 countries, but only few countries (France, Italy and Portugal) exhibit a type of Phillips-curve effect, that is, a positive comovement between output and prices in the short-run.

In this paper, we argue that there are two another important sources of disagreement on the Phillips curve. One source is the variables involved in this relationship. Many papers have studied the comovement between output (or another indicator of economic activity) and prices. However, traditional and new Phillips curve proponents claim that the presence of a positive short-run correlation between output (or another indicator of economic activity) and inflation. As pointed out by Mankiw (2001), the dynamics of prices and inflation; and thus, the comovement of output with one of these variables, can be rather different. For instance, in the models of staggered price adjustment, the price level adjusts slowly, but the rate of inflation can jump instantaneously. Another source of disagreement is the definition of business cycle used. While real business cycle researchers look at horizons between two and eight years, new keynesian macroeconomists seem to look at closer horizons.

This paper carries out the methodology suggested by Den Haan (2000) to study the comovement between output and inflation in the postwar period using data from U.S. and the EU15 group of countries.[1] The aim of this paper is twofold. First, I analyze whether there is significant positive correlation between output and inflation. Second, by comparing the results found in this paper with those obtained by Vázquez (2001), I shall assess whether the comovement between output and inflation is similar to the comovement between output and prices. The empirical results show that U.S. and seven of EU15 countries (Belgium, Finland, France, Germany, Italy, Netherlands and United Kingdom) display a significant positive comovement between output and inflation at forecast horizons up to seven years. The empirical results also show that a Phillips curve is more likely to be observed in countries where inflation volatility is lower. Moreover, for almost all countries the comovement pattern of output and inflation is rather different from that found for output and prices.

The rest of the paper is organized as follows. Section 2 briefly describes how to use a *VAR* to study the correlation structure of output and inflation at several forecast horizons. Section 3 presents and discusses the empirical evidence. Section 4 shows the conclusions.

2 MEASURING CORRELATIONS AT DIFFERENT FORECAST HORIZONS

For illustrative purposes, this section describes the methodology suggested by Den Haan (2000) in order to measure correlations at different forecast horizons. Readers who are familiar with this methodology should skip this description and move on to Section 3.

[1] In alphabetical order, the EU15 group of countries includes Austria (AU), Belgium (BE), Denmark (DE), Finland (FI), France (FR), Germany (G), Greece (GR), Ireland (IR), Italy (IT), Luxembourg (LU), Netherlands (NE), Portugal (PO), Spain (SP), Sweden (SW) and United Kingdom (UK). The abbreviated name of each country is in parenthesis.

Let us consider an N-vector of random variables X_t. The vector X_t may include any combination of stationary processes and integrated processes of arbitrary order. In order to characterize the comovement of output, Y_t, and inflation, π_t, X_t must contain at least (the log of) Y_t and π_t. Consider the following VAR

$$X_t = \alpha + \beta t + \gamma t^2 + \sum_{l=1}^{L} A_l X_{t-l} + U_t, \tag{1}$$

where α, β, and γ denote fixed N-vectors of constants, A_l are fixed N x N coefficient matrices. U_t is an N-dimensional white noise process, that is, $E(U_t) = 0$, $E(U_t U_t') = \Omega_u$ and $E(U_t U_s') = 0$ for $s \neq t$. L is the total number of lags included. The K-period ahead forecast and the K-period ahead forecast error of the random variable Y_t are denoted by $E_t Y_{t+K}$ and $Y^{ue}_{t+K,t}$, respectively. Similarly, we can define $E_t \pi_{t+K}$ and $\pi^{ue}_{t+K,t}$. Let us denote the correlation coefficients between $Y^{ue}_{t+K,t}$ and $\pi^{ue}_{t+K,t}$ by $COR(K)$.

As pointed out by Den Haan (2000), if all time series included in X_t are stationary, then the correlation coefficient of the forecast errors will converge to the unconditional correlation coefficient between Y_t and π_t as K goes to infinity. If X_t includes integrated processes, then correlation coefficient may not converge but they can be estimated consistently for fixed K.

Using the correlation coefficient of the forecast error to analyze the output-inflation relationship at a particular horizon K can be viewed, roughly speaking, as involving an implicit trend-cycle decomposition where the 'trend' components of output and inflation are given by $E_t Y_{t+K}$ and $E_t \pi_{t+K}$, respectively; whereas the 'cycle' components of output and inflation are $Y^{ue}_{t+K,t}$ and $\pi^{ue}_{t+K,t}$, respectively. Therefore, when we analyze the correlations of the VAR forecast errors at different horizons we are studying the comovement between the "cyclical" components of output and inflation.

3 THE COMOVEMENT BETWEEN OUTPUT AND INFLATION

In this section, I implement the procedures describe in Section 2 to study the comovements between output and inflation in the EU15 group of countries and U.S. during the postwar period. The data for the EU15 countries used are monthly data taken from the OECD's Main Economic Indicators as released on line through license by DSI Data Service and Information GmbH, except for Ireland which is quarterly data since monthly data are not available. U.S. data were download from Den Haan's web-site. The price time series used for each country studied is the consumer price index. The output time series are index of industrial production.

Table 1 shows Phillips-Perron unit root tests applied to each country studied. These unit root tests provide strong support for the hypothesis that π_t is a stationary process. For a small group of countries (Greece, Ireland, Sweden and U.S.), the log of output is an $I(1)$ process. For the rest of countries, $\log(Y_t)$ seems to be stationary around a deterministic trend.

I estimate correlation coefficients based on VAR's that only includes output and inflation. The characteristics of these VAR's are described in Table 2. Akaike information criterion was used to determine the number of lags and whether linear and quadratic trend terms should be included. When estimating the VAR's for the countries for which $\log(Y_t)$ is nonstationary, the first-difference of $\log(Y_t)$ is included in X_t instead of $\log(Y_t)$ (that is, the unit restriction on output is included).

Following Den Haan (2000), we estimate the correlation coefficients of VAR forecast errors by, calculating the forecast errors for each horizon considered (from one quarter to 28 quarters) as the difference between the realizations and the corresponding forecasts and then calculating the correlations of these forecast errors for each horizon.[2] Since the estimated correlation coefficients are subject to sampling variation, confidence bands are constructed using bootstrap methods. More specifically, for each estimated VAR and its bootstrapped errors are used to generate 2500 simulated data sets. Then, for each simulated data set the correlation coefficients at different horizons are estimated and standard confidence bands are calculated.[3]

Figures 1-4 display a set of graphs, one for each country analyzed. Each graph shows the estimated correlation coefficients and the $10\% - 90\%$ and $5\% - 95\%$ confidence bands constructed using bootstrap methods. Looking at these graphs, we observe that eight countries (Belgium, Finland, France, Germany, Italy, Netherlands, United Kingdom and U.S.) exhibit a significant positive comovement between output and inflation at horizons up to seven years (28 quarters), but U.S. where a significant comovement between output and inflation does not appear for horizons greater than six quarters. For the

[2] Den Haan and Sumner (2001) use an alternative method to estimate the correlation coefficients. This alternative method uses the covariance obtained from the VAR coefficients and the variance-covariance matrix of the white noise process, U_t. They argue that using this method leads to efficiency gains especially in estimating the correlation coefficients associated with long-term forecast horizons. However, they also report that bias is larger with this second method.

[3] The programs for estimating the correlation coefficients and the confidence bands are adapted versions of programs written in RATS that were download from Den Haan's web-site.

rest of EU15 countries there is no evidence of a significant correlation between output and inflation. Only Sweden exhibits evidence of a negative correlation between output and inflation at horizons ranging from 10 to 28 quarters. The first two columns in Table 3 summarize the comovement between output and inflation at the different ranges of forecast horizons. The third and fourth columns summarize the evidence on comovement between output and prices found by Vázquez (2001). In general, one may conclude that the comovement between output and prices is rather different from the comovement between output and inflation.

Figure 5 ranks the EU15 countries and U.S. according to two sample statistics that measure inflation volatility: the standard deviation of inflation and the variation coefficient of inflation. Inside of a circle are the abbreviated names of the countries for which a significant positive correlation between output and inflation is found. We observe that the two volatility measures of inflation support the hypothesis that the Phillips curve is easier to detect (that is, a positive comovement between output and inflation is more likely) in those countries where inflation volatility is lower.

4 CONCLUSIONS

This paper uses the correlation coefficients of forecast errors at different forecast horizons obtained from estimated *VAR*'s to analyze the comovement between output and inflation in the EU15 countries and U.S. The empirical results show that eight countries (Belgium, Finland, France, Germany, Italy, Netherlands, United Kingdom and U.S.) exhibit a significant positive comovement between output and inflation at horizons up to seven years (28 quarters), except U.S. where a significant comovement between output and inflation does not appear for horizons greater than six quarters. For the rest of EU15 countries there is no evidence of a significant correlation between output and inflation. Moreover, the empirical evidence suggests that a Phillips curve phenomenon is more likely to be detected in countries where inflation volatility is lower.

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Table 1. Phillips-Perron Z_ρ tests

Country-Period	Variable	With Trend	Without Trend
Austria 1962:1-2001:1	Y_t	-127.39	-3.88
	P_t	1.30	-0.71
	ΔY_t	-372.11	-372.10
	ΔP_t	-355.03	-355.75
Belgium 1962:1-2001:1	Y_t	-234.04	-26.20
	P_t	1.77	-0.64
	ΔY_t	-428.29	-428.92
	ΔP_t	-279.92	-264.02
Denmark 1974:1-2001:1	Y_t	-68.14	-0.20
	P_t	-1.53	-2.12
	ΔY_t	-363.83	-364.25
	ΔP_t	-290.30	-268.51
Finland 1990:1-2001:2	Y_t	-85.09	-16.57
	P_t	-8.29	-1.60
	ΔY_t	-134.60	-134.83
	ΔP_t	-109.69	-108.01
France 1962:1-2001:1	Y_t	-259.22	-46.27
	P_t	-2.18	-0.64
	ΔY_t	-474.95	-474.96
	ΔP_t	-170.21	-145.30
Germany 1962:1-1994:12	Y_t	-65.35	-9.61
	P_t	-0.59	-0.26
	ΔY_t	-263.90	-264.01
	ΔP_t	-268.13	-267.11

Notes: The Phillips-Perron Z_ρ statistics are corrected for fourth-order serial correlation. The results are qualitatively similar to those obtained when considering augmented Dickey-Fuller tests, or when considering alternative orders of the serial correlation correction in computing Phillips-Perron statistics. For a sample size of 500 observations, the critical values for the Phillips-Perron Z_ρ test are: with trend: 10%, -18.1; 5%, -21.5; 1%, -28.9; without trend: 10%, -11.2; 5%, -14.0; 1%, -20.5. A table displaying the critical values for the Phillips-Perron Z_ρ test is reported in Fuller (1976, p. 371).

Table 1. Phillips-Perron Z_ρ tests (*continued*)

Country-Period	Variable	With Trend	Without Trend
	Y_t	-12.79	-5.48
Greece	P_t	-3.66	0.36
1962:1-2000:11	ΔY_t	-490.93	-492.25
	ΔP_t	-366.06	-364.76
	Y_t	-4.93	-1.54
Ireland	P_t	-2.59	-2.57
1975:3-2000:4	ΔY_t	-154.33	-158.73
	ΔP_t	-71.53	-29.46
	Y_t	-448.25	-113.07
Italy	P_t	1.18	-0.35
1962:1-2001:1	ΔY_t	-561.28	-561.29
	ΔP_t	-117.74	-113.27
	Y_t	-261.29	-28.99
Luxembourg	P_t	1.24	-0.49
1962:1-2000:12	ΔY_t	-494.79	-494.80
	ΔP_t	-465.23	-459.26
	Y_t	-65.32	-12.97
Netherlands	P_t	0.40	-1.08
1962:1-2000:12	ΔY_t	-379.60	-379.66
	ΔP_t	-453.46	-455.25
	Y_t	-232.31	-5.11
Portuguese	P_t	0.51	-0.21
1962:1-2001:1	ΔY_t	-535.75	-535.84
	ΔP_t	-389.02	-388.64

Table 1. Phillips-Perron Z_ρ tests (*continued*)

Country-Period	Variable	With Trend	Without Trend
	Y_t	-373.03	-110.17
Spain	P_t	2.01	-0.61
1962:1-2001:1	ΔY_t	-563.11	-563.15
	ΔP_t	-535.85	-529.74
	Y_t	-13.70	-1.75
Sweden	P_t	2.81	-0.48
1975:3-2000:4	ΔY_t	-553.55	-553.58
	ΔP_t	-469.66	-465.54
	Y_t	-231.21	-20.31
United Kingdom	P_t	1.42	-0.49
1962:1-2001:1	ΔY_t	-388.58	-388.58
	ΔP_t	-276.09	-267.66

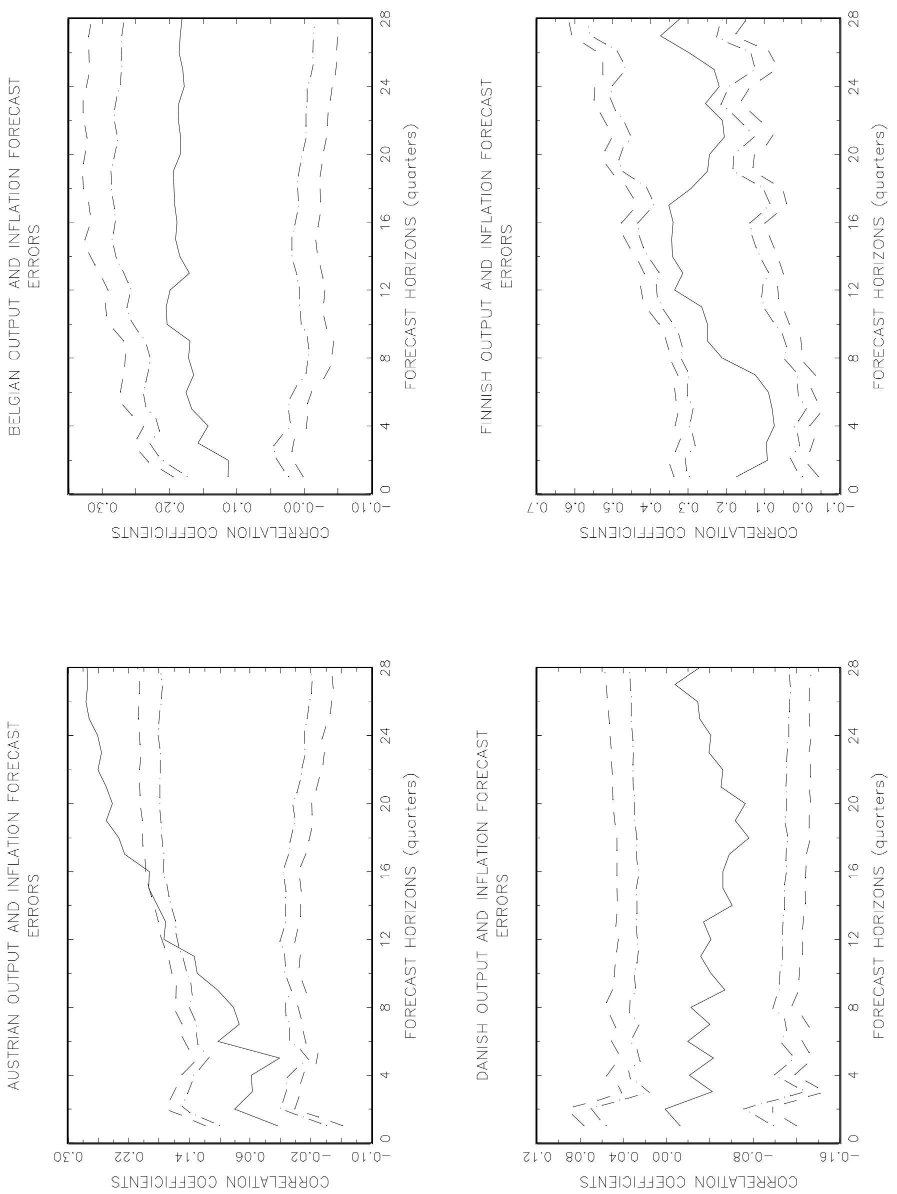
Table 2. Characteristics of the estimated bivariate *VAR*'s

Country	Sample Period	Unit Root for Output	No. Lags	Linear Trend	Quadratic Trend
Austria	1962:1-2001:1	No	24	Yes	Yes
Belgium	1962:1-2000:12	No	27	Yes	No
Denmark	1974:1-2001:1	No	25	Yes	Yes
Finland	1990:1-2001:2	No	27	Yes	Yes
France	1962:1-2001:1	No	24	Yes	Yes
Germany	1962:1-1994:12	No	26	Yes	No
Greece	1962:1-2000:11	Yes	27	Yes	No
Ireland	1975:3-2000:4	Yes	26	Yes	No
Italy	1962:1-2001:1	No	25	Yes	Yes
Luxembourg	1962:1-2000:12	No	28	Yes	Yes
Netherlands	1962:1-2000:12	No	25	Yes	Yes
Portugal	1962:1-2001:1	No	27	Yes	Yes
Spain	1962:1-2001:1	No	25	Yes	Yes
Sweden	1962:1-2001:1	Yes	12	Yes	No
UK	1962:1-2001:1	No	28	Yes	Yes
U.S.A	1960:2-1997:6	Yes	7	Yes	No

Table 3. Summary of the results

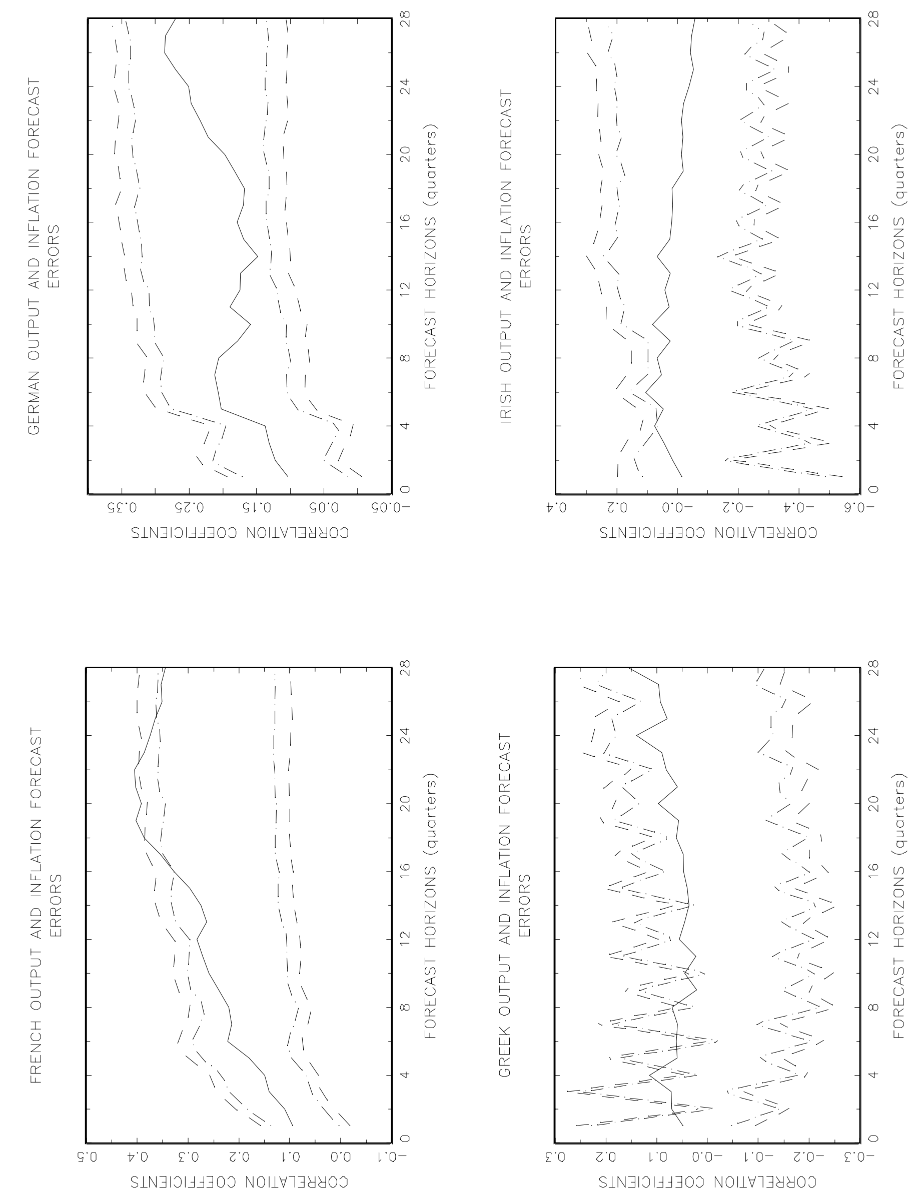
	Output vs Inflation		Output vs Prices	
	Horizons		Horizons	
Country	up to 6	from 6 to 28	up to 6	from 6 to 28
Austria	No	No	No	Negative
Belgium	Positive	Positive	No	Negative
Denmark	No	No	No	No
Finland	Positive	Positive	No	No
France	Positive	Positive	Positive	Negative
Germany	Positive	Positive	No	Negative
Greece	No	No	No	Negative
Ireland	No	No	No	No
Italy	Positive	Positive	Positive	Negative
Luxembourg	No	No	No	Negative
Netherlands	No	Positive	No	No
Portugal	No	No	Positive	No
Spain	No	No	No	Negative
Sweden	No	Negative	No	Negative
UK	No	Positive	No	Negative
U.S.A	Positive	No	Positive	Negative

Notes: the word "Positive" ("Negative") means that the correlation between the two variables is significantly positive at a standard confidence level. "No" means that the correlation is not significant. Horizons are measured in quarters.



AUSTRIAN OUTPUT AND INFLATION FORECAST ERRORS
BELGIAN OUTPUT AND INFLATION FORECAST ERRORS
DANISH OUTPUT AND INFLATION FORECAST ERRORS
FINNISH OUTPUT AND INFLATION FORECAST ERRORS
CORRELATION COEFFICIENTS
FORECAST HORIZONS (quarters)

Figure 1: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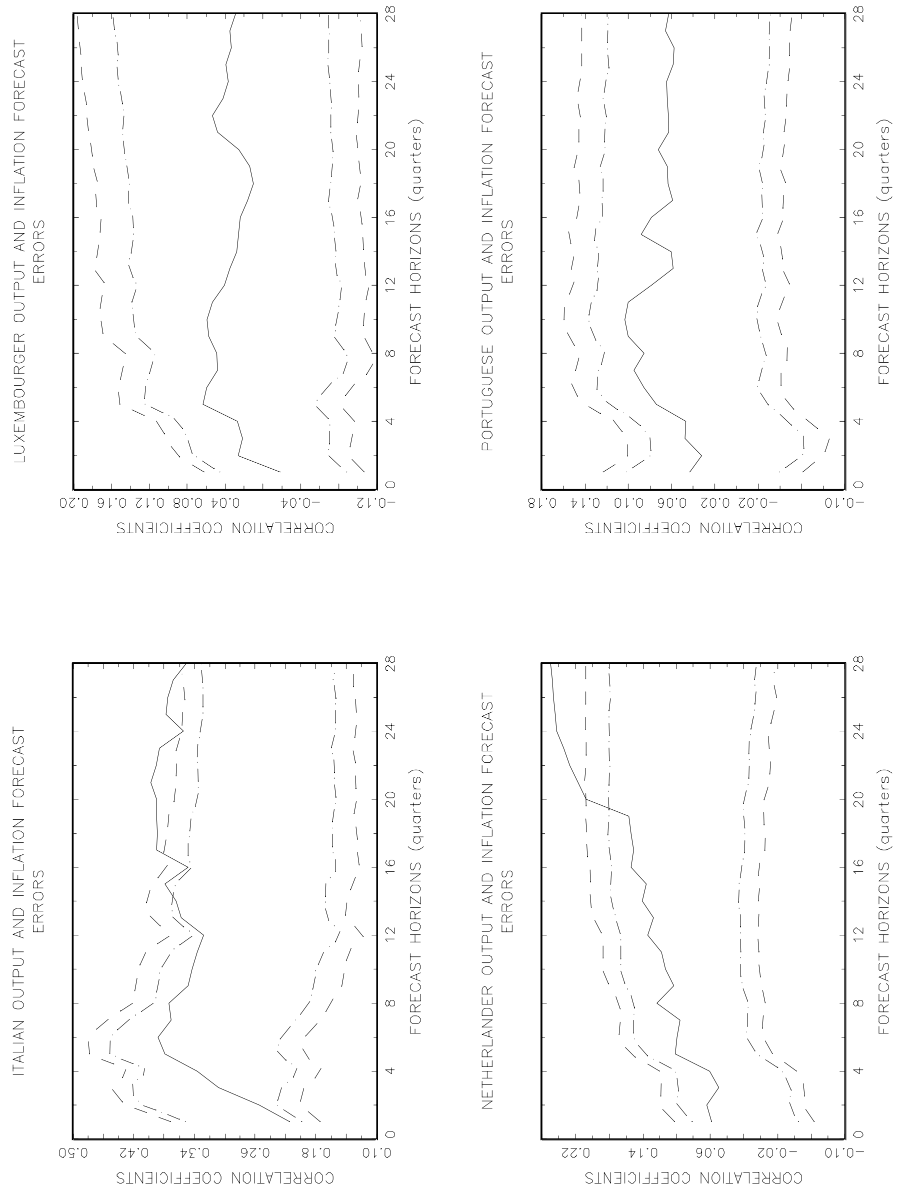
CORRELATION COEFFICIENTS
FORECAST HORIZONS (quarters)

Figure 2: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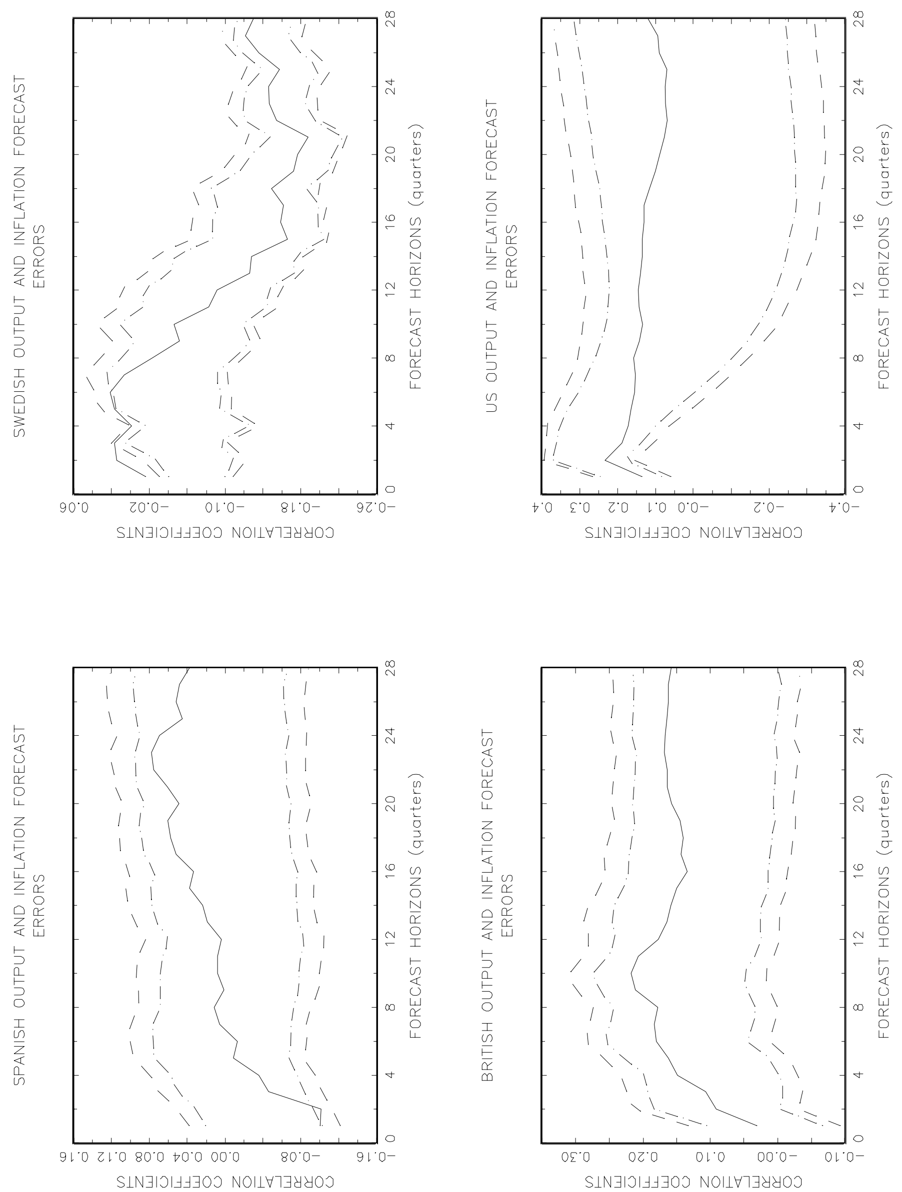
CORRELATION COEFFICIENTS
FORECAST HORIZONS (quarters)

Figure 3: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CORRELATION COEFFICIENTS
FORECAST HORIZONS (quarters)

Figure 4:

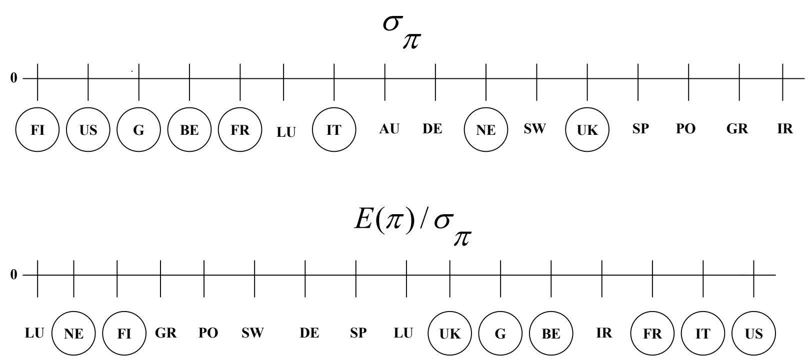

Figure 5: Ranking of countries according to two measures of inflation volatility