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The role of expectations in the inflation process in the euro area

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Suomen Pankki
Bank of Finland
P.O.Box 160
FIN-00101 HELSINKI
Finland
☎ + 358 10 8311

http://www.bof.fi

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The views expressed are those of the authors and do not necessarily reflect the views of the Bank of Finland.

* Economist, Bank of Finland,
e-mail: maritta.paloviita@bof.fi
** Professor of economics, University of Turku,
e-mail: matvir@utu.fi

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Maritta Paloviita – Matti Virén
Monetary Policy and Research Department

Abstract

This paper analyses the role of inflation expectations in the euro area. On one hand, the question is how inflation expectations affect both inflation and output, and, on the other hand, how inflation expectations reflect developments in these variables. The analyses make use of a simple VAR model of inflation, inflation expectations and the output gap that allows for an analysis of the dynamic interrelationship between these variables. This model is estimated on aggregate euro area data, pooled euro area country data and individual country data for the period 1979–2003. The empirical results give strong support for the idea that inflation expectations are the key ingredient of the inflationary process for the whole euro area and for most individual countries as well. Inflation expectations also have a significant negative impact on output. As for the determination of inflation expectations, it turns out that they are relatively persistent, almost as persistent as output. Even so, and especially in the medium term, inflation expectations adapt to developments in both output and (actual) inflation.

Key words: inflation, expectations, monetary policy, Phillips curve

JEL classification numbers: E31, E52

Odotusten rooli euroalueen inflaatioprosessissa

Suomen Pankin tutkimus
Keskustelualoitteita 6/2005

Maritta Paloviita – Matti Virén
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Tutkimuksessa analysoidaan inflaatio-odotusten roolia euroalueella. Kysymys on toisaalta siitä, kuinka inflaatio-odotukset vaikuttavat sekä inflaatioon että tuotantoon, ja toisaalta siitä, kuinka inflaatio-odotukset heijastavat näiden muuttujien kehitystä. Analyysi perustuu yksinkertaiseen VAR-mallin, jossa muuttujina ovat inflaatio, inflaatio-odotukset ja kokonaistuotanto; viimeksi mainitusta muuttujana on tarkemmin sanoen niin sanottu tuotantokuilu. Mallin avulla voidaan tutkia näiden muuttujien välisiä dynaamisia riippuvuuksia. Malli estimoidaan koko euroalueen kattavalla aikasarja-aineistolla, euroalueen maiden aikasarja–poikkileikkaus-aineistolla sekä yksittäisten maiden aikasarja-aineistoilla ajanjaksolta 1979–2003. Empiiriset tulokset osoittavat selvästi, että inflaatio-odotukset ovat keskeinen tekijä sekä koko euroalueen että useimpien yksittäisten maiden inflaatioprosessissa. Inflaatio-odotukset vaikuttavat (negatiivisesti) myös tuotantoon. Inflaatio-odotusten määräytymisen tarkastelu osoittaa, että odotukset ovat melko jäykkäliikkeisiä, lähes yhtä jäykkäliikkeisiä kuin tuotanto. Erityisesti keskipitkällä aikavälillä inflaatio-odotukset sopeutuvat sekä tuotannon että toteutuneen inflaation muutoksiin.

Avainsanat: inflaatio, odotukset, rahapolitiikka, Phillipsin käyrä

JEL-luokittelu: E31, E52

Contents

1 Introduction

Controlling inflation is the main object of central banks. For that purpose, central banks need to know both the determinants and the basic features of the transmission mechanism of inflation. Given the fact that both theoretical considerations and empirical evidence say that inflation expectations are a crucial element in these respects it is obvious that the nature of inflation expectations should be carefully examined.

Somewhat surprisingly, inflation expectations have been analysed relatively little. This is mainly because we have only limited amount of data on "realized" inflation expectations. In most cases, inflation expectations have been derived not from observed survey or published forecast data but by using the orthogonality conditions connected with the Rational Expectations Hypothesis (REH) by means of the GMM estimator. That allows estimating and testing key behavioural equations but it does not really allow for an analysis of the determinants inflation expectations. Thus, the estimation results of Phillips curves are not very informative in terms of the propagation mechanism of inflation and inflation expectations. Nor are they very informative in terms of policy conclusions. Take a simple question of how to reduce inflation. Conventional Phillips curve results just give the impact of the cyclical situation (say, output gap) on current inflation but the role of inflation expectations remains some sort of "black box" even if it is clear that inflation expectations is the most important variable.[1] Phillips curves suffer from other problems as well. They fit rather badly into the data and reasonable results can be obtained only by introducing some auxiliary variables to the estimating equations (like lags in the case of the so-called hybrid version of the New Keynesian Phillips curve). Against this background it is obvious that we need a more general – and more data consistent – representation of the model.

The situation is quite different if we use data on "realized" inflation expectations. Then we could see at least, what is the independent role of inflation expectations. Moreover we could find out how inflation expectations react to other variables or policies or policy regimes.

With the expectations data the main source is the regularly published macroeconomic forecasts made by government (finance ministries), research institutes and international organisations – like the OECD. All of these publish at least some form of inflation forecasts. The problem with most of the data is the fact that the values cannot be compared across countries and it difficult to construct a consistent aggregate Euro area data from these series. Thus, in these respects, we are left with the OECD data. Luckily, the so-called Consensus Forecast data also provide survey-based inflation forecasts in the same format for

[1] It is noticeable that published expectations (forecasts) are not even used as instruments for expected inflation in the REH framework. See, however, Paloviita and Mayes (2005).

all European countries. The problem is that the data only cover the period 1989–2003 which is very short for all analytical purposes.[2]

Recently, there has been growing interest in the issue of nature and role of inflation expectations. Thus, for instance Levin, Natalucci and Piger (2004) provide an analysis on volatility of inflation expectations and an analysis of sensitivity of expectations to realized inflation.[3] A special emphasis in the paper is the distinction between inflation targeting (and non-targeting) countries. In this paper we in a sense continue these analyses by specifying a small VAR model which not only includes inflation and inflation expectations but also the real economy driving variable, output, or more precisely the output gap. Quite obviously, this model can be seen as some sort of empirical generalization of the Phillips curve and in addition a some sort of nested model to various Phillips curve variants, which allows also an analysis of the determinants of inflation expectations.

In what follows, we shortly introduce the analytical framework. Then in section 3, we explain the reporting of results. In the following section they are evaluated and, finally, some concluding remarks are presented in section 5.

2 Analysis

Our empirical analysis deals with the Euro area thus the data come the Euro area countries only. The analysis is based on a simple VAR model which in the basic form consists of three variables: inflation Δp, inflation expectations Δp^e and the output gap. In some occasions the model is completed by world (US) inflation, which gives us a some sort of VARX representation. Moreover the output gap is replaced by the labour share LS, GDP growth, ΔGDP or by simple time trend deviation of GDP.[4] The choice between these measures is known to be a difficult conceptual and measurement issue but in this study the choice does not really play a crucial role as it turns out from subsequent estimation results. It may well be that the issue is more compelling when estimating a conventional one-equation Phillips curve.

[2] More precisely, Consensus Economics provides data for consumer prices. The data are monthly and thus include a large number of observations but when used with annual (output) data the high-frequency properties cannot be utilized. In what follows, we use the data only in the pooled cross-country analysis where the degrees of freedom are reasonable.

[3] In addition, a number of papers have recently been published using survey or forecast based inflation expectations data in estimating the Phillips curve(s). See, for instance, Adam and Padula (2003) and Paloviita (2005). Alternative measure for Euro area inflation expectations can be found in Gerlach (2004).

[4] In this connection, we bypass discussion on the proper concept or measure of the output gap. Results with alternative proxies suggest that the choice is not a crucial issue here.

The key variable is inflation expectations. As pointed out above, the series are derived from the OECD, although also the so-called Consensus Forecast values are used for it. In the basic set-up, Δp^e is the inflation forecast for the following year which is published by the OECD in June of the current year. Thus, it is assumed that the decision of pricing the output, determining the volume of output and forming inflation expectations are made at the same moment.[5] Obviously, we cannot pin down the exact timing of decisions with annual data and, therefore, we also make the analysis with forecast for the following year which is published in December of the current year and also with forecast for the current year, which is published in December of the previous year.[6] The quality of OECD forecasts from the point of view of Rational Expectations have been analyzed in several occasions (see eg OECD 1993 and Virén 1998). The analyses have shown that there are some problems with unbiasedness especially in early days but still the quality of the data is reasonable also in this respect. The same conclusion is reached also this time (see Appendix 1 for details).[7]

In identifying the shocks we use the simple Cholesky decomposition. This is mainly motivated by the fact that our VAR model encompasses several theoretical models and we do not want at this stage to nail it down to any of those. Moreover, if one considers the structural VAR identifications schemes none of those appears to be an obvious candidate in this case. The Blanchard-Quah (1989) identification scheme, which is widely applied, is not easily applicable in our three-variable case, considering especially the perceived different roles of actual inflation and expected inflation. As for more general schemes (cf eg Giannini (1992) and Amisano & Giannini (1997)), we found that adopting one of those might bring too much specification uncertainty into the analysis.

Moreover, the variable ordering with the Cholesky decomposition appears to be quite obvious and requires only a slight amount of experimenting. The recursive system which is in our mind boils down to the following variable ordering: output gap, inflation expectations (for the next period) and actual inflation. With the two first variables, there could be a reverse ordering so that altogether we might have the following alternatives to applied and compared: $var1 = \{y, \Delta p^e, \Delta p\}$ and $var2 = \{\Delta p^e, y, \Delta p\}$. These orderings can be seen from purely technical point of view although they obviously reflect some deeper differences in economic modelling strategies. First of all, one may consider the determination of output in a RBC framework and think that output shocks are mainly determined by non-monetary factors (technology and so on) and thus they

[5] Because we use annual data, one might imagine that the mid-year values correspond to the average annual values of production and the price level.

[6] The latter concept corresponds, in fact, to the Expectations Augmented Phillips curve specification.

[7] Similar result is, in fact, reached in Forsells and Kenny (2002) for the EU Commission's Consumer Survey.

will only weak respond to inflation shocks. Alternatively, one could think that the output gap is determined by the future path of real interest rate that makes it exogenous to both current inflation and inflation expectations.

These considerations would place the output gap as the first variable (ie give ordering var1). But we could also think that the inflation expectations have a more profound (in a sense “deeper”) role in the model. One may think that inflation expectations are related to expectations on future monetary policy. Thus, inflation expectations shocks are related to such things as changes in credibility of monetary policy, perceived changes in effectiveness of monetary policy and prerequisites of policy (eg from the institutional point of view). All of these do not need to be conditional to output developments and therefore, the var2 ordering could be quite plausible as well.

What is clear in our mind, however, that actual inflation cannot be the first variable ordering because actual inflation reflects both output and expected inflation shocks. In addition, it reflects all kinds of short-term shocks which are related to eg imperfect control over monetary policy and to price shocks induced by market imperfections. If we indeed had a recursive system in which both actual inflation and output would precede expected inflation we could interpret that system as a representation of the New Keynesian Phillips curve from the point of view of rational expectations. Then, however, there would be very little room for the independent role inflation expectations. They would just reflect changes in actual inflation and output – in the same way as in the “instrumental equations” for expected inflation in the one-equation model. The idea of estimating the VAR was, however, to get more sort of general assessment of the role of inflation expectations and not a priori to restrict its role to something not very important.

In what follows, we thus use the both above-mentioned orderings although we may already now mention that the results are qualitatively rather similar. In quantitative terms, the results differ somewhat because the residuals are contemporaneously correlated. This is obviously due to the annual frequency which, in turn, is dictated by the OECD forecasting system.

The analyses make use of the Euro area data which cover (after 2 lags) the period 1979–2003 (ie 25 observations). Needless to say, the sample is very short and the data partly artificial because the Euro area did not exist before 1999. Partly because of that we also use individual country data, and pooled cross-country data with different pooling and estimation restrictions. When the pooled data are used, total number of observations is 292.

The main problem in our analysis is the apparent non-stationarity of some of the time series (within our sample period). If we use the output gap as the real economy driving variable, it is, at least in its Hodrick-Prescott variant, stationary.[8] But with the sample period of 1977–2003 both inflation and inflation expectations are non-stationary according to standard tests. If we want to preserve the set of variables as it is in the Phillips curve we have to move to first differences of the three variables (ie second differences of the price level and output and first differences of inflation expectations). If we used the labour share as the driving variable we would end up with the case where all three variables (inflation, inflation expectations and the labour share) are non-stationary. Finally, we could use GDP (Gross Domestic Product in constant prices) directly. The change rate of GDP is roughly stationary in the same way as the deviation of GDP from linear time trend.[9] Both of these are used in analysis – mainly for the sake of evaluating the robustness of the results.

Using the Vector Error Correction Model would obviously solve some of the problems and we do indeed carry out the analysis also within that framework. More precisely, we want to impose an error-correction term in the terms of inflation and inflation expectations assuming that inflation and inflation expectations cannot diverge in the long-run. Unfortunately, the whole sample is characterized with falling inflation so that inflation expectations are always below current inflation. Hence, the cointegrating restriction $\Delta p^e = \Delta p$ in the long run is not consistent with the data in this sample.[10] Obviously, one can use a data-consistent error-correction term. That is in fact done in a set of estimation exercises reported in Appendix 2. These results do not seem differ from the general pattern and therefore we not proceed any longer with this approach.

Before turning to the results it is useful to point out that our VAR model is not really very suitable to open economy environment in which all countries have been most of the sample period. A tempting alternative would be to extend the model with some open-economy variables but that would unnecessarily complicate our analyses at this stage. Hence we only do the following: we add foreign (US) inflation as an exogenous variable in our VAR specification. The idea is again to see whether that makes any difference to the results with the basic three-variable VAR model.

The use of the VAR model suffers from some other well-known shortcomings as well. All analyses are related to shocks in different variables. Thus, we cannot consider the effects of expected changes in different variables. Shocks of inflation expectations may sound a bit difficult to interpret but recalling that, in our mind,

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[8] The generally used Hodrick-Prescott filter suffers from several problems which can potentially affect the results in crucial way (see eg Cogley and Nason 1995). Therefore, we also used the OECD own output gap to check the robustness of results. These data do not cover the whole period and therefore used the HP filtered output gap series.

[9] If the output gap is created by introducing a linear trend to the estimating equation all other variables are, of course, also (similarly) affected.

[10] The cointegration properties of actual and forecast variables is analysed in eg Aggarwal et al (1995).

inflation expectations basically reflect the general public's expectations on policy credibility and effectiveness corresponding shocks are equally plausible as the actual inflation and/or output shocks. Measurement is then another issue. It may well be that our measures (data) for inflation expectations suffer from measurement errors more that the actual inflation and output gap. Here we can do very little clarify this point. By using different (survey) data we obviously get some idea of the seriousness of this problem.

3 Reporting the results

The main data are illustrated in Figures 1 and 2. The former contains the aggregate data and latter the (pooled) individual country data. Figure 3 compares the June and December forecasts (from the OECD) which both are used in the analyses. Finally, Figure 4 illustrates the dynamic interactions between inflation and inflation expectations. This figure shows that for the sample period, these variables show the same non-stationary features (stochastic trends) but besides that the series are not completely randomly related. Thus, there are three episodes where some sort inflation – inflation expectations cycles can be detected (for 1986, 1990 and 1999). These obviously tell something about the effect of "third" variables (oil prices, German unification and the Euro).

As for the VAR analysis, we follow here the standard practice in reporting three sets of results: the parameter estimates of the VAR model(s), the variance decompositions and the impulse responses. Because we have so many alternatives in terms of specification of the output variable, price index, country set, and lag structure we have to be quite selective in presenting the results. Anyway, we try to cover all relevant combinations.[11]

When estimating the VAR, we of course have to fix the lag length. In our case, the choice turned out to be a bit tricky because it was not easy to choose between one lag, VAR(1), and two lags, VAR(2), which are the only relevant alternatives with our data. The problem is due to the fact that the second lag is only marginally significant. Generally, it is (only) the output gap which requires the second lag. Luckily the lag length does not really affect the qualitative nature of results but still it makes some difference as can been from the subsequent results (see Tables 1 and 4, in particular). As for the Cholesky decomposition, we report the majority of results with the var1 ordering. This can be motivated by the fact that output is more persistent than inflation expectations and that the var1 ordering is more conservative from the point of inflation expectations, Thus, in

[11] A full set of results is available (by E-mail) upon request from the authors.

terms of variance decompositions, it may give the lower bound for relative importance of various shocks.

In addition to the choice of the lag length and the variable ordering in the Cholesky decomposition, we face the choice of the inflation variable. Thus, we have to choose between the GDP deflator (DEF) and consumer prices (PC). Both alternatives can be defended and partly because of that we have estimated our models with both variables (concerning both the actual data and expected/forecast values). In what follows, we mainly report the results with the GDP deflator. That is because we feel that this choice is more consistent with the choice of the scale variable (ie the GDP gap) and because we really focus on the economy-wide developments of prices and output.

Technically, reporting goes as follows: The variance decompositions for different Cholesky decompositions and data sets are presented in Tables 1–7, estimation results in Tables 8–9 and impulse responses in Figures 5–6. When presenting the variance decompositions, we just scrutinize the very short-run results (for horizons of one and two years) and the long-run results (which in practice deal with the time horizon of 20 years). These three data points can in fact, illustrate most of the interesting changes because all changes are more or less monotonic (as can be seen already from the reported impulse responses).

4 Summary and interpretation of results

In what follows, we briefly summarize the main findings and discuss their implications to monetary policy and further research.

(1) In general, our VAR model performs reasonably well for both the aggregate data and pooled cross-country data.[12] Moreover, the results for different variable definitions and specifications of the VAR are very similar. True, differencing makes some difference and it is, of course, a bit alarming because it could reflect some weaknesses in the dynamic specification. Most obviously the result reflects the changing nature of inflation which, in turn, reflects the change in the inflation objectives. One way solve this problem

[12] This shows up in estimation results which are reported in Tables 8 and 9. If the VAR (inflation) equations are compared with Phillips curves which have been estimated using the same sample and data the VAR equations have slightly bigger standard errors. The problem is only that with eg the pooled cross-country data the coefficients of the New Keynesian Phillips curve are incorrect (the coefficient of output gap is negative and the coefficient of the expected inflation exceeds one). The Expectations Augmented Phillips curve performs much better especially in terms of the coefficient estimates. However, it cannot be directly compared with the VAR equations because it has current period values on the right-hand side. With the supply curve, similar arguments apply. See Tillmann (2005) for the most recent evaluation of the performance of the New Keynesian Phillips Curve.

would be to introduce an explicit inflation target to the system in the way of Gerlach and Svensson (2003) for instance. We have not experimented with this option but introducing world (US) inflation could be seen as one sort of solution to this problem. It does not, however, provide a solution to this open issue. For us, more important is, however, that introducing this variable does not change the basic results.

(2) Inflation expectations are very important in the determination of inflation. Thus, innovations in expectations account for more than one third of the (forecast) variance of inflation irrespectively of time horizon. Even in the long run inflation expectations exert a significant and independent effect on actual inflation developments and their relative importance rather increases than decreases with the length of the time horizon. The percentage share can go up to 50 per cent. In other words, changes in output growth and (past) inflation cannot fully explain the future path of inflation.

(3) Inflation and inflation expectations do explain only a small fraction of output (forecast) variance. This suggests that the direct linkage between monetary/price shocks and output is quite weak indeed. But the nature of this linkage still makes sense. Scrutinizing the impulse responses (Figures 5 and 6) it can be seen that inflation expectations shocks have negative, statistically significant and quite persistent effect on the output gap while the effect of the actual inflation on output is a bit sensitive to the specification and data. In general, it has either a positive or a negative short-run effect but in all cases a negative long-run effect. Interpretation of these results is not all clear because we do not have interest (exchange) rates in the model but it looks tempting to interpret the negative output effect of inflation expectations as coming from adverse supply (cost) shocks, and the positive effects of actual inflation as consequences of temporary demand disturbances.

(4) There seems to be only a minor difference between the effects with OECD forecasts and Consensus (survey) Forecasts (cf Table 6). Thus, the performance of inflation expectations is not due to the specific OECD data but it probably reflects the overall market sentiment in terms of future inflation. Future experiments with national data sets may allow for more affirmative conclusions in this respect.

(5) Inflation expectations react in the same way to both output and inflation shocks. It is hard to say which of these variables is “more important” in determining expectations because in this respect the variance decompositions produce a bit conflicting results depending on the specification and the data set. But clearly there is some propagation mechanism between output and inflation developments, on the one hand, and inflation expectations, on the other hand. Even then, the most important element is the persistence of inflation expectations: even after 20 years almost half of the forecast variance of inflation expectations can be attributed to this variable itself. Thus, within a

typical business-cycle period, errors in inflation expectations do not die out. It is interesting to compare this result with the behaviour of actual inflation; there the shocks are much more short-living and less persistent. This is remarkable even if the effects of own shocks to expectations diminish faster than in the case of the output gap variables.

(6) The impulse responses suggest that the effects of inflation and output shocks last more than ten years. With the aggregate data Euro area data, the duration of effects is typically shorter than with the pooled cross-country data. In the latter data, where individual country differences show up and where high-inflation countries have more weight, the duration of inflation effects, dealing with expected inflation, in particular, is much longer. In fact, this also shows up in individual country estimates (cf eg Table 8).

5 Concluding remarks

Inflation cannot be modelled or understood without analyzing inflation expectations. This fact is again confirmed in our analysis. The fact also shows up in the recent data. In the Euro area, inflation expectations have come down quite dramatically from the end of 1970s. Quite clearly, actual inflation has followed the same pattern and by itself reinforced the falling trend in inflation expectations. Although we cannot exactly say what has been the contribution of various factors, including the policy targets, to changes in inflation expectations we can conclude that (independent) role of expectations in the inflation process has been, and obviously still is, of crucial importance.

The central role of expectations in inflation dynamics has strong implications for the design of monetary policy. It means that if inflation expectations are anchored by credible monetary policy inflation will be more stable. Moreover, if the persistence of inflation indeed comes from the persistence of expectations, as this study shows, policies affecting expectations are crucial in all efforts towards disinflation. Stable and low inflation would, in turn, minimize losses to the economy and provide the best environment for strong and balanced growth.

Against this background, the role and nature of inflation expectations clearly deserves even more attention and analysis. Thus far, a lot time have been spent in trying to identify and measure inflation expectations but very little is known empirically about the possible independent role of expectations in the inflation process and, equally important, about the determinants of expectations.[13] Knowing merely the fact that inflation expectations are unbiased is not informative from the point of view a policy-maker or policy analysis. In this

[13] Some interesting analyses do exit, however. See eg Bonato et al (1999) who try to estimate the role policy announcements on (monetary conditions) expectations.

respect, the VAR analysis gives at least some rough idea of the nature and magnitude of main interrelationships.

Because the data strongly favours the interpretation that inflation expectations do not immediately adjust to changes in actual inflation and output we have good reasons study more thoroughly the origins of inflation expectations. The VARs which we have used here are one way of solving the problem but presumably there are several alternatives to this choice. One might think that event studies, say in the form of major policy decisions, might provide more insight to the determination of expectations. With survey based data we could also make use of the dispersion of expectations and focus on the possible role of forecast uncertainty.

Table 1 **Comparison of var1 and var2 variance decompositions**

Variable to be decomposed (below), horizon	**gap**	**Δp^e**	**Δp**	**Δp^e**	**gap**	**Δp**
gap, 1	100.0	0.0	0.0	17.7	82.3	0.0
gap, 2	97.7	2.0	0.2	27.0	72.7	0.2
gap, 20	93.1	5.2	1.7	31.0	67.3	1.7
Δp^e, 1	17.7	82.3	0	100.0	0.0	0.0
Δp^e, 2	36.0	63.2	0.8	91.3	7.9	0.8
Δp^e, 20	47.7	40.7	11.6	71.7	16.7	11.6
Δp, 1	2.7	20.8	76.5	23.3	0.2	76.5
Δp, 2	28.1	38.3	33.5	60.6	5.9	33.5
Δp, 20	42.9	28.3	28.8	56.0	15.2	28.8
	Δgap	**$\Delta^2 p^e$**	**$\Delta^2 p$**	**$\Delta^2 p^e$**	**Δgap**	**$\Delta^2 p$**
Δgap, 1	100	0.0	0.0	19.1	80.9	0.0
Δgap, 2	93.4	0.2	6.4	19.5	74.0	6.4
Δgap, 20	90.4	3.5	6.1	23.0	70.9	6.1
$\Delta^2 p^e$, 1	19.1	80.9	0.0	100.0	0.0	0.0
$\Delta^2 p^e$, 2	45.1	53.2	1.7	73.6	24.7	1.7
$\Delta^2 p^e$, 20	47.9	50.3	1.9	73.6	24.5	1.9
$\Delta^2 p$, 1	1.1	26.4	72.5	25.7	1.7	72.5
$\Delta^2 p$, 2	31.4	30.8	37.7	52.1	10.1	37.7
$\Delta^2 p$, 20	41.6	26.7	31.7	50.4	17.9	31.7

First 9 rows correspond to the level form model and the subsequent 9 rows correspond to first difference specification. The three left hand side columns correspond to var1 decomposition and the three right hand side columns the var2 decomposition. Δ^2 denotes second (log) differences. All equations include two lags. The data are aggregate Euro area data.

Table 2 **Comparison of variance decompositions with different inflation forecasts**

Variable to be decomposed (below), horizon	**gap**	Δp^e	Δp	**gap**	Δp^e	Δp
Data for Δp^e	December t forecast for t+1			December t-1 forecast for t		
gap, 1	100.0	0.0	0.0	100.0	0.0	0.0
gap, 2	99.4	0.2	0.4	95.7	0.9	3.4
gap, 20	97.1	2.4	0.5	84.8	7.2	7.9
Δp^e, 1	30.0	70.0	0	0.0	99.9	0
Δp^e, 2	55.1	41.8	3.1	22.8	62.2	14.9
Δp^e, 20	71.3	17.3	11.5	54.6	9.4	35.9
Δp, 1	8.0	23.0	69.0	7.5	44.8	47.7
Δp, 2	38.9	41.7	19.4	37.6	21.2	41.2
Δp, 20	67.5	15.1	17.4	51.9	4.4	43.7
	Δgap	$\Delta^2 p^e$	$\Delta^2 p$	**Δgap**	$\Delta^2 p^e$	$\Delta^2 p$
Δgap, 1	100	0.0	0.0	100	0.0	0.0
Δgap, 2	88.8	2.1	9.1	91.0	2.5	6.6
Δgap, 20	85.7	4.6	9.6	88.7	5.6	5.7
$\Delta^2 p^e$, 1	29.8	70.2	0.0	0.5	99.5	0.0
$\Delta^2 p^e$, 2	48.3	50.7	1.0	24.7	59.9	15.4
$\Delta^2 p^e$, 20	51.9	45.2	2.9	47.0	43.1	9.9
$\Delta^2 p$, 1	4.3	22.8	72.9	3.3	59.6	37.1
$\Delta^2 p$, 2	34.2	36.1	29.8	26.8	44.4	28.8
$\Delta^2 p$, 20	41.6	32.2	26.2	36.4	40.5	23.1

The Table corresponds to Table 1 except that the results in columns 2–4 correspond (for the part of Δp^e) to the December OECD forecast for the next year, and in columns 5–7 (previous) December OECD forecast for the current year. The var1 variance decomposition is used in all cases.

Table 3 **Comparison of variance decompositions using different specifications**

Variable to be decomposed (below), horizon	**gap**	**Δp^e**	**Δp**
Level, HP gap	42.9	28.3	28.8
Level, HP gap, December forecast	67.5	15.1	17.4
Level, HP gap, December forecast for the current year	51.9	4.4	43.7
Level, ls, trend	28.2	51.4	20.4
Level, ΔGDP	29.7	41.8	28.6
Level, GDP trend	39.9	41.5	18.5
Level, HP gap, + US Def	29.6	7.1	63.4
Level, HP gap, consumer prices	36.6	53.5	10.0
Difference, HP gap	41.6	26.7	31.7
Difference, Δ^2GDP	17.9	50.1	32.0
Difference, HP gap + US Def	25.6	18.1	56.2
Difference, HP gap, consumer prices	25.3	61.0	13.7
Difference, HP gap, December forecast	41.6	32.2	26.2
Difference, HP gap, December forecast for the current year	36.4	40.5	23.1

All numbers are the long-run inflation variance decompositions, Δp, 20 in a VAR(2) model with var1 variance decomposition. The data are aggregate Euro area data.

Table 4 **Comparison of variance decompositions with VAR(1) model**

Variable to be decomposed (below), lag, **var1**	**gap**	Δp^e	Δp
gap, 1	100	0.0	0.0
gap, 2	99.2	0.0	0.8
gap, 20	92.1	5.4	2.4
Δp^e, 1	25.5	74.5	0.0
Δp^e, 2	40.6	57.7	1.7
Δp^e, 20	64.7	33.9	1.4
Δp, 1	19.0	14.6	66.4
Δp, 2	30.9	30.9	38.2
Δp, 20	62.2	25.1	12.7
var1	**Δgap**	$\Delta^2 p^e$	$\Delta^2 p$
Δgap, 1	100	0.0	0.0
Δgap, 2	94.9	0.1	5.0
Δgap, 20	89.3	5.5	5.2
$\Delta^2 p^e$, 1	9.8	90.2	0.0
$\Delta^2 p^e$, 2	22.5	76.1	1.5
$\Delta^2 p^e$, 20	30.5	66.9	2.6
$\Delta^2 p$, 1	0.1	32.8	67.1
$\Delta^2 p$, 2	16.8	48.0	35.2
$\Delta^2 p$, 20	26.0	42.0	32.0
var2	$\Delta^2 p^e$	**Δgap**	$\Delta^2 p$
$\Delta^2 p^e$, 1	100.0	0.0	0.0
$\Delta^2 p^e$, 2	89.1	9.4	1.5
$\Delta^2 p^e$, 20	80.2	17.2	2.6
Δgap, 1	9.8	90.2	0.0
Δgap, 2	8.4	86.5	5.0
Δgap, 20	11.3	83.4	5.2
$\Delta^2 p$, 1	30.9	2.1	67.1
$\Delta^2 p$, 2	59.3	5.5	35.2
$\Delta^2 p$, 20	52.6	15.4	32.0

The data are aggregated Euro area data. The first two blocks (18 rows) correspond to the var1 decomposition with VAR(1) model and the third block (nine last rows) the var2 decomposition with the same model.

Table 5 **Variance decompositions with pooled cross-country data for the Euro area**

Variable to be decomposed (below), horizon	**gap**	**Δp^e**	**Δp**
gap, 1	100.0	0.0	0.0
gap, 2	99.2	0.0	0.8
gap, 20	95.1	2.3	2.6
Δp^e, 1	3.8	96.2	0.0
Δp^e, 2	7.3	92.6	0.1
Δp^e, 20	15.1	84.1	0.7
Δp, 1	2.0	35.6	62.4
Δp, 2	8.8	54.5	36.7
Δp, 20	13.5	69.2	17.3
	Δgap	**$\Delta^2 p^e$**	**$\Delta^2 p$**
Δgap, 1	100.0	0.0	0.0
Δgap, 2	99.5	0.4	0.1
Δgap, 20	97.8	2.1	0.1
$\Delta^2 p^e$, 1	2.6	97.4	0.0
$\Delta^2 p^e$, 2	5.4	94.4	0.2
$\Delta^2 p^e$, 20	9.5	90.2	0.4
$\Delta^2 p$, 1	0.3	29.3	70.4
$\Delta^2 p$, 2	3.9	29.4	66.6
$\Delta^2 p$, 20	5.6	29.1	65.3

Estimates are based on an artificial Euro economy which is obtained by stacking the time series of gap, Δp^e and Δp from the 12 countries' as a single (unweighted) time series. Var1 Cholesky decomposition with VAR(1) model is used in all cases.

Table 6 **Comparison of variance decompositions with different inflation expectations**

Variable to be decomposed (below), horizon	**gap**	**Δpc^e (consensus)**	**Δpc**	**gap**	**Δpc^e (OECD)**	**Δpc**
gap, 1	100.0	0.0	0.0	100.0	0.0	0.0
gap, 2	98.7	0.3	0.9	97.4	0.1	2.5
gap, 20	92.0	5.4	2.5	92.9	1.7	5.4
Δp^e, 1	4.3	95.7	0	6.5	93.5	0.0
Δp^e, 2	7.5	90.7	1.8	10.7	88.2	1.2
Δp^e, 20	26.1	71.8	2.1	25.0	73.7	1.2
Δp, 1	10.7	31.1	58.2	9.0	28.6	62.3
Δp, 2	24.6	35.3	40.1	19.5	41.0	39.5
Δp, 20	42.7	32.5	24.8	36.2	41.1	22.7
	Δgap	**$\Delta^2 pc^e$**	**$\Delta^2 pc$**	**Δgap**	**$\Delta^2 pc^e$**	**$\Delta^2 pc$**
Δgap, 1	100.0	0.0	0.0	100.0	0.0	0.0
Δgap, 2	99.0	0.8	0.2	99.7	0.0	0.3
Δgap, 20	98.4	1.3	0.3	99.6	0.0	0.3
$\Delta^2 p^e$, 1	0.2	99.8	0	4.7	95.3	0.0
$\Delta^2 p^e$, 2	7.5	87.3	5.2	9.9	88.8	1.3
$\Delta^2 p^e$, 20	10.5	84.4	5.1	11.8	86.9	1.4
$\Delta^2 p$, 1	7.1	33.6	59.2	5.0	41.6	53.4
$\Delta^2 p$, 2	12.6	34.4	53.1	13.4	41.9	44.6
$\Delta^2 p$, 20	15.5	33.1	51.4	15.8	40.7	43.5

These values are based on pooled, unweighted cross-country data. The variance decompositions are derived with var1 variable ordering with VAR(1) model. The results are comparable to those in Table 5 except for the fact that the sample period is considerably shorter 1991–2003, consumer prices are used instead of the GDP deflator and the OECD June forecast values are compared with Consensus Forecast June values.

Table 7 **Variance decompositions with individual country data**

variable to be decomposed (below), horizon	**gap**	**Δp^e**	**Δp**
Austria, Δp, 20	28.6	46.9	24.5
Belgium, Δp, 20	16.2	52.5	31.3
Finland, Δp, 20	37.8	44.6	17.6
France, Δp, 20	36.9	49.2	13.8
Germany, Δp, 20	30.7	42.1	27.2
Greece, Δp, 20	13.7	81.9	4.3
Ireland, Δp, 20	16.3	38.6	45.1
Italy, Δp, 20	51.9	20.4	27.7
Luxembourg, Δp, 20	1.0	29.9	69.1
Netherlands, Δp, 20	36.9	30.2	32.9
Portugal, Δp, 20	54.4	33.9	11.6
Spain, Δp, 20	16.2	47.4	36.3
	Δgap	**$\Delta^2 p^e$**	**$\Delta^2 p$**
Austria, Δp^e, 20	38.5	18.5	43.0
Belgium, Δp^e, 20	4.6	33.2	62.2
Finland, Δp^e, 20	13.6	28.2	58.3
France, Δp^e, 20	6.5	57.3	36.2
Germany, Δp^e, 20	34.4	7.0	58.6
Greece, Δp^e, 20	0.7	44.9	54.4
Ireland, Δp^e, 20	9.6	26.1	64.3
Italy, Δp^e, 20	26.0	47.4	26.6
Luxembourg, Δp^e, 20	1.7	12.7	85.6
Netherlands, Δp^e, 20	24.0	25.5	50.5
Portugal, Δp^e, 20	19.3	42.2	38.5
Spain, Δp^e, 20	3.9	30.8	65.3

With all countries, var1 variance decomposition is used.

Table 8 **Estimation results with aggregate Euro area and pooled (stacked) cross-country data**

Dependent variable	**gap**	**Δp^e**	**Δp**	**gap**	**Δp^e**	**Δp**
Data	Aggregate Euro area			Pooled cross-country		
gap, 1	1.047	.370	.300	1.094	.137	.223
	(4.33)	(1.79)	(1.81)	(19.42)	(2.46)	(3.71)
gap, 2	-.509	-.177	-.172	-.489	-.050	-.172
	(2.60)	(1.06)	(1.28)	(8.95)	(0.92)	(2.95)
Δp^e, 1	.333	.604	.643	-.105	.797	.735
	(0.94)	(2.00)	(2.64)	(1.37)	(10.51)	(9.01)
Δp^e, 2	-.527	-.139	-.396	-.150	-.022	.022
	(1.33)	(0.41)	(1.46)	(1.76)	(0.26)	(0.24)
Δp, 1	-.127	.174	.317	.155	.044	.171
	(0.33)	(0.53)	(1.21)	(2.19)	(0.63)	(2.27)
Δp, 2	.243	.172	.383	.025	.008	.055
	(0.73)	(0.61)	(1.68)	(0.40)	(0.14)	(0.83)
R2/SEE	0.795	0.912	0.959	.703	.890	.915
	0.825	0.705	0.568	1.409	1.396	1.503
	Δgap	**$\Delta^2 p^e$**	**$\Delta^2 p$**	**Δgap**	**$\Delta^2 p^e$**	**$\Delta^2 p$**
Δgap, 1	.449	.553	.275	.365	.153	.156
	(1.63)	(2.57)	(1.65)	(5.58)	(2.60)	(2.38)
Δgap, 2	-.101	-.164	-.079	-.053	.120	.036
	(0.38)	(0.80)	(0.50)	(0.81)	(2.04)	(0.55)
$\Delta^2 p^e$, 1	.330	-.056	.805	-.101	-.001	.608
	(0.85)	(0.19)	(3.44)	(1.23)	(0.01)	(7.41)
$\Delta^2 p^e$, 2	-.127	.009	.334	.127	-.031	.293
	(0.26)	(0.02)	(1.15)	(1.49)	(0.39)	(3.46)
$\Delta^2 p$, 1	-.576	.244	-.484	.040	.047	-.463
	(1.23)	(0.67)	(1.70)	(0.55)	(0.71)	(6.32)
$\Delta^2 p$, 2	-.180	.396	-.006	-.005	.060	-.147
	(0.45)	(1.26)	(0.02)	(0.07)	(0.98)	(2.17)
R2/SEE	.336	0.349	0.591	.134	.010	.203
	1.029	0.801	0.622	1.690	1.518	1.683

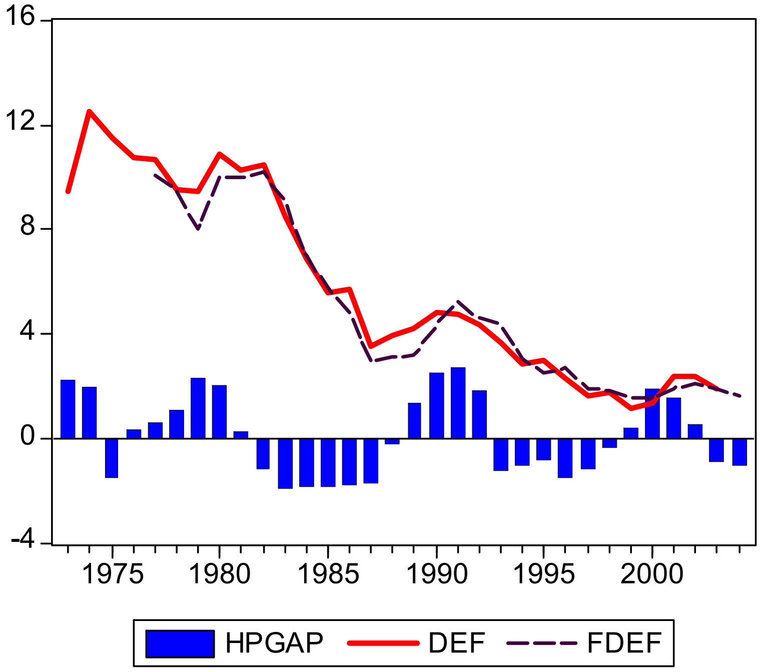
First 6 rows correspond to the level form model while the subsequent 6 rows are derived from the first difference specification. Pooled cross-country data are unweighted; the corresponding variance decompositions are reported in Tables 5 and 6). All estimates are PNS estimates.

Table 9 **Estimation results with pooled cross-country data**

Dependent variable	**gap**	**Δp^e**	**Δp**
gap, 1	1.119	.158	.257
	(21.79)	(4.05)	(4.87)
gap, 2	-.529	-.105	-.188
	(10.89)	(2.82)	(3.76)
Δp^e, 1	-.048	.634	.579
	(0.73)	(8.85)	(7.38)
Δp^e, 2	-.158	.081	.064
	(2.20)	(1.17)	(0.79)
Δp,1	.108	.122	.304
	(1.68)	(2.24)	(4.26)
Δp,2	.028	-.054	.001
	(0.50)	(1.06)	(0.01)
R2/SEE	0.705/1.374	0.889/1.364	0.913/1.485
Wald	7.30	74.78	3.72
	Δgap	**$\Delta^2 p^e$**	**$\Delta^2 p$**
Δgap, 1	.417	.161	.223
	(6.86)	(3.78)	(3.82)
Δgap, 2	-.120	.026	.057
	(1.95)	(0.59)	(0.98)
$\Delta^2 p^e$, 1	-.044	-.069	.502
	(0.60)	(0.98)	(6.53)
$\Delta^2 p^e$, 2	-.115	-.032	.270
	(1.58)	(0.47)	(3.52)
$\Delta^2 p$,1	.003	.137	-.349
	(0.45)	(2.54)	(4.94)
$\Delta^2 p$,2	-.052	.042	-.166
	(0.83)	(0.82)	(2.51)
R2/SEE	0.135/1.646	0.027/1.492	0.187/1.663
Wald	11.48	109.22	68.96

In the same way as in Table 8, the first 6 rows correspond to the level form model and the subsequent 6 rows the first difference model. Wald test statistics test the hypothesis that lagged inflation terms in the gap equal sum up to zero and in the inflation and expected inflation equations to one. The 5 % critical value is 3.80. Estimates are (un-weighted) OLS estimates with Pool-OLS estimator; the level form equations are estimated with the fixed-effects specification.

Figure 1 **Time series with aggregate Euro area data**



HPGAP denotes the HP filtered output gap, DEF inflation in terms the GDP deflator and FDEF the corresponding OECD December inflation forecasts.

Figure 2 **Time series with pooled Euro area data**

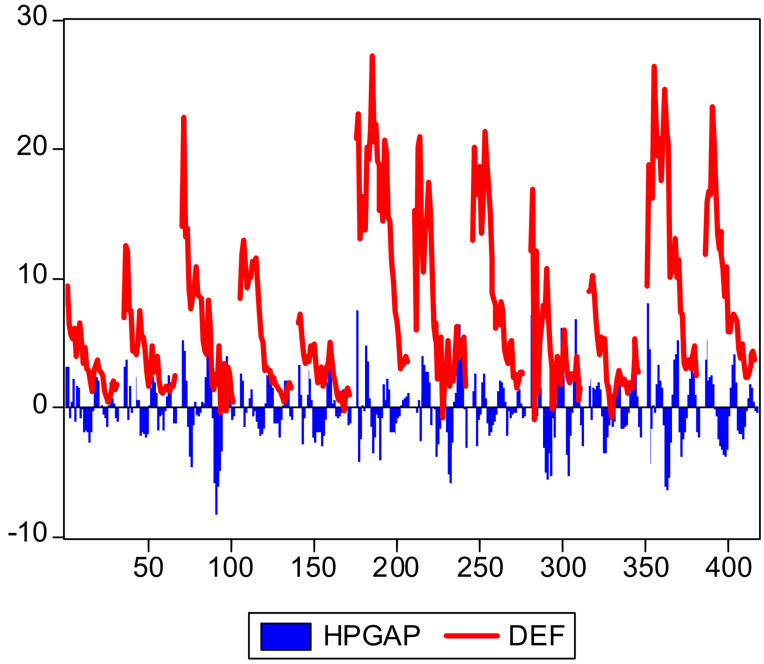


Figure 3 **OECD inflation forecasts for the following year**

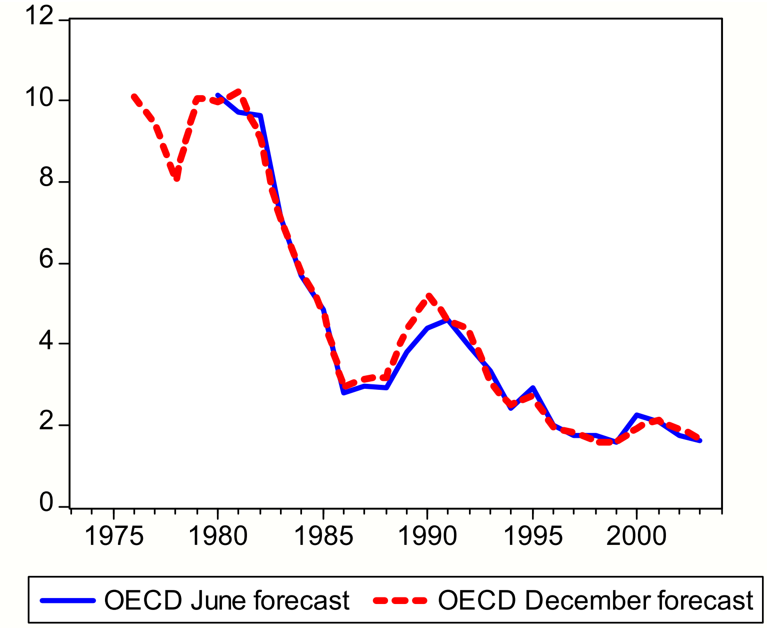


Figure 4 **Evolution of inflation and inflation expectations (OECD June forecasts)**

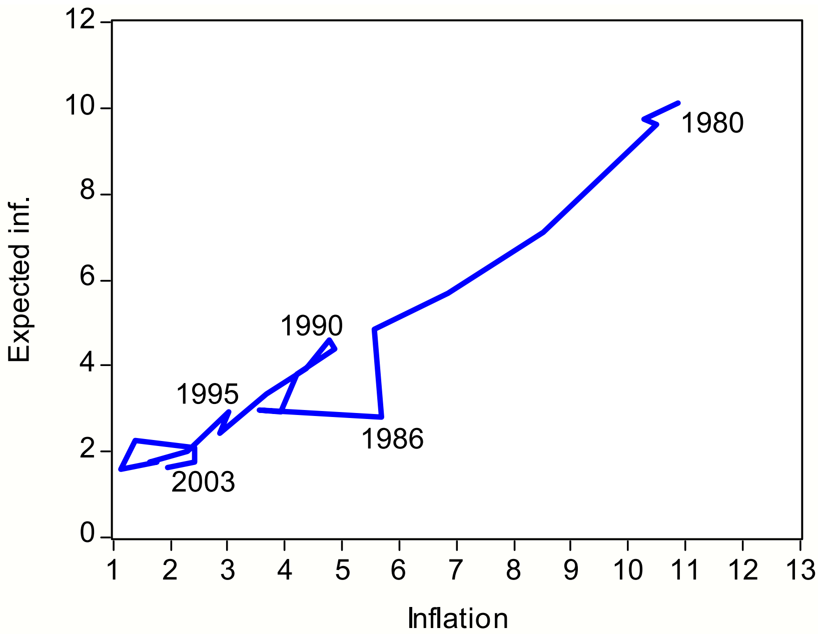


Figure 5 **Impulse responses from aggregate Euro area data**

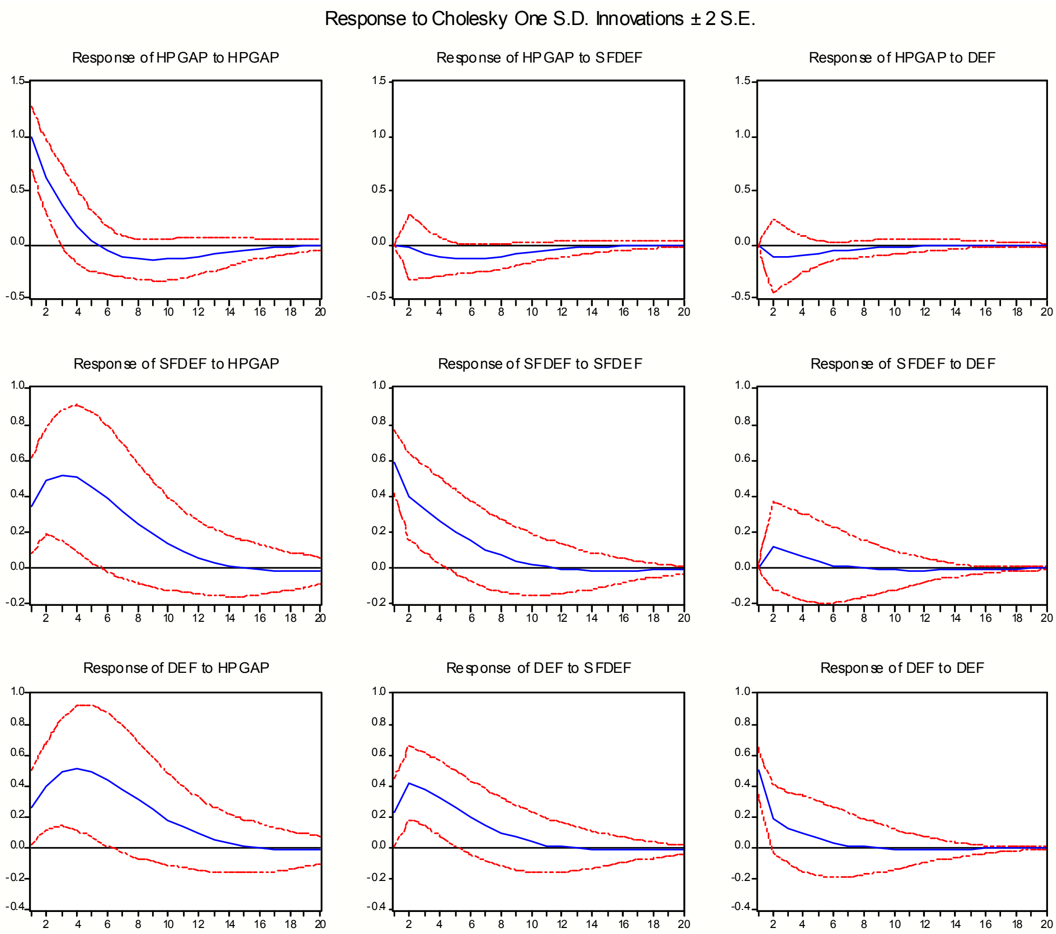
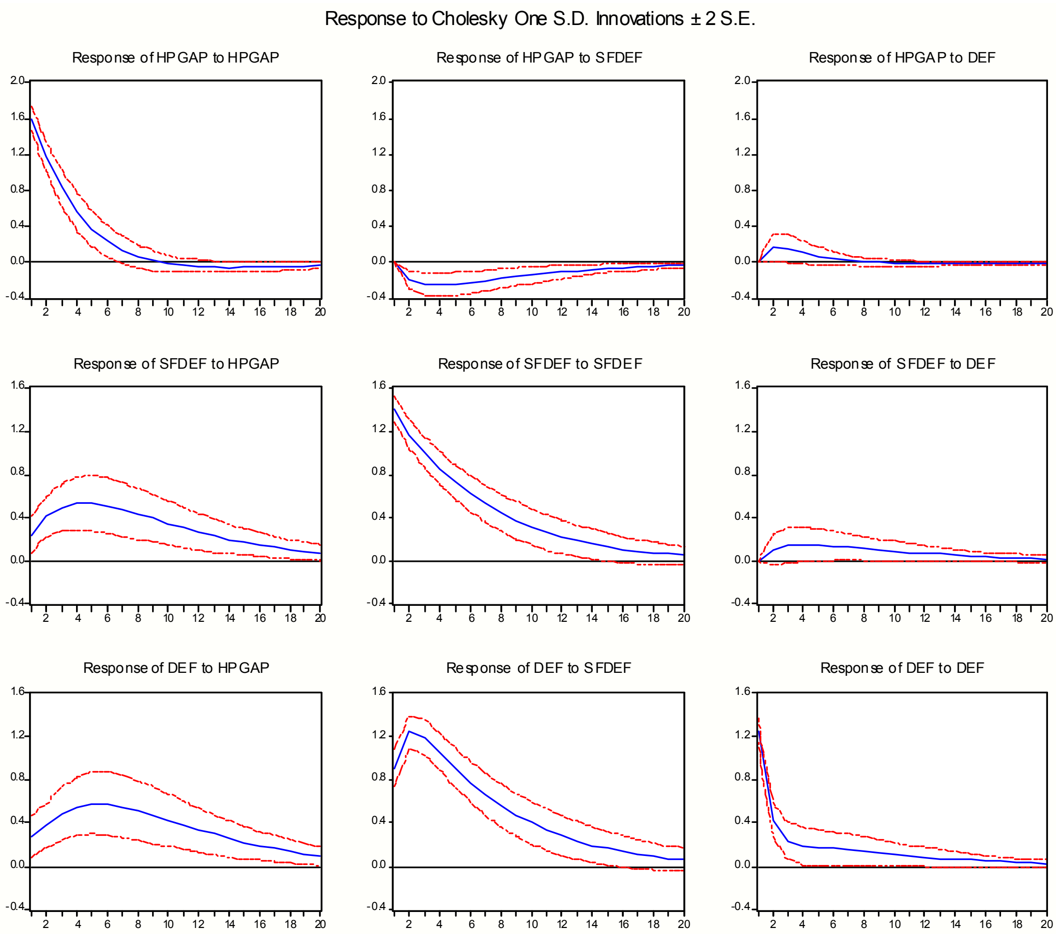


Figure 6 **Impulse responses from pooled Euro area data**



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Appendix 1

Wald tests for unbiasedness of inflation expectations

Euro area/country	June forecast		December forecast	
	F-statistic	Probability	F-statistic	Probability
Euro area, aggregated	0.757	0.482	1.938	0.165
Euro area, pooled	5.532	0.004	5.883	0.003
Austria	0.481	0.625	1.008	0.379
Belgium	1.952	0.167	9.994	0.001
Finland	0.488	0.621	1.346	0.279
France	4.234	0.029	0.516	0.603
Germany	0.550	0.585	0.268	0.767
Greece	4.716	0.020	3.928	0.033
Ireland	1.088	0.355	0.518	0.602
Italy	3.419	0.052	3.636	0.041
Luxembourg	0.433	0.655	1.436	0.261
Netherlands	1.374	0.275	2.710	0.086
Portugal	2.400	0.115	1.992	0.160
Spain	3.892	0.037	2.099	0.144

All Wald tests are computed for the parameter restrictions $a_0 = 0$ and $a_1 = 1$ in $\Delta p_t^e = a_0 + a_1 \cdot p_t + e_t$.

Appendix 2

Pooled cross-country results with a VECM(2) model

Dependent variable	**Δgap**	**$\Delta^2 p^e$**	**$\Delta^2 p$**
EC-term	-.176	-.112	.085
	(7.43)	(3.54)	(3.45)
Δgap, 1	.334	.141	.179
	(5.52)	(2.66)	(2.84)
Δgap, 2	-.022	.166	.051
	(0.37)	(3.11)	(0.80)
$\Delta^2 p^e$, 1	.433	.256	.263
	(4.02)	(2.71)	(2.34)
$\Delta^2 p^e$, 2	.183	.110	.084
	(2.01)	(1.38)	(0.88)
$\Delta^2 p$,1	-.299	-.196	-.326
	(3.66)	(2.65)	(3.82)
$\Delta^2 p$,2	-.125	-.049	-.125
	(1.91)	(0.86)	(1.85)
R2/SEE	0.306	0.226	0.300
	1.555	1.365	1.621
Variance decompositions	**Gap**	**Δp^e**	**Δp**
Δgap, 2	96.7	0.5	2.8
Δgap, 20	72.6	10.5	16.9
$\Delta^2 p^e$, 2	0.3	97.7	2.0
$\Delta^2 p^e$, 20	1.7	74.7	23.6
$\Delta^2 p$,2	6.9	55.5	37.5
$\Delta^2 p$,20	14.3	47.6	38.1

EC-term: HPGAP + 4.54Δp^e - 3.58Δp

EC-term: 1.00Δp^e - 0.76Δp, $\chi^2(1) = 8.04$

EC-term: 1.00Δp^e - 1.00Δp, $\chi^2(2) = 71.74$

Numbers inside parentheses are t-ratios. The χ^2–test statistics are related to the restrictions of the β-matrix. The first EC is used in deriving the variance decompositions.

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