Do Aggregate Demand Factors Influence Current Inflation Developments?

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The relationship between inflation developments and aggregate demand is usually modeled with a Phillips curve. This study estimates the Phillips curve for Austria and, for the sake of comparison, for the euro area as well as for four euro area member countries. In order to test the robustness of our results, we estimate both the traditional and the New Keynesian Phillips Curve (NKPC) for the period from 1970 to 2007. We also investigate whether the relationship between economic activity and inflation has changed over time.

The results show that there was indeed a significant relationship between inflation and the output gap in most countries; but its coefficient diminished over the years, and became insignificant in almost all countries toward the end of the estimation period. Exceptions are Austria and the Netherlands: For these countries the estimates are not significant, and for Austria we get contradictory results. We can conclude from this and from the observation that the output gap in the countries under review is now slightly negative, or at best closed, that the current rise in inflation is not the result of an overheating economy.

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The inflation rate in Austria has exceeded 3% since November 2007 ranking among the highest levels recorded since the high inflation years 1992–1993. In a series of articles, the Oesterreichische Nationalbank (OeNB) is now examining possible causes for the rise in inflation. This article deals with aggregate demand factors. We ask how the business cycle influences inflation dynamics in Austria in comparison to other euro area countries and to what extent aggregate demand factors affect current inflation. This study is structured as follows: Section 1 explains the Phillips curve framework, section 2 estimates the influence of the output gap on inflation and section 3 gives a summary and conclusions.

1 The Phillips Curve as an Explanatory Model for Demand-Driven Inflation

Economic activity can influence inflation developments through several channels. Higher consumer demand, stronger investment and an increase in government spending can all exert upward pressure on prices. Export demand is another source of such upward pressure, key factors being the exchange rate and price competitiveness. The output gap serves as a measure for excess demand from all these sources.[2] The relation between inflation developments and the output gap is known as the Phillips curve. In its original form the Phillips curve, which traces back to the New Zealand-born economist

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[2] *In theory, the output gap is defined as the difference between output in an economy with nominal rigidities and the hypothetical output that would be produced if all prices and wages were flexible. For empirical purposes, it is usually calculated as the difference between actual and potential output, which is generally proxied by trend output.*

A. W. Phillips (1958), was formulated as the relation between wage inflation and unemployment. However, in empirical applications it usually relates to the goods market. Thus, the Phillips curve is used to analyze the relationship between inflation and the output gap.

In its simplest form, the Phillips curve shows that inflation is a function of lagged inflation π_{t-1} and the current output gap y_t^*:

$$\pi_t = \alpha + \beta\pi_{t-1} + \kappa y_t^* \qquad (1)$$

where α is a constant and both β and κ represent the coefficients in the estimation. Lagged inflation is included in the equation because inflation developments show a certain persistence and the inflation rate of the preceding period often has strong explanatory power for the current inflation rate. In empirical applications, this dependence on the past inflationary development is modeled by including several (up to k) lags of the rate of inflation. Moreover, we include l additional variables that contribute to increasing the explanatory power of the equation (e.g. oil prices, import prices), represented here by x_i:

$$\pi_t = \alpha + \sum_{i=1}^{k} \beta_i \pi_{t-i} + \kappa y_t^* + \sum_{i=1}^{l} \gamma_i x_i \qquad (2)$$

In this study we estimate the Phillips curve to determine whether excess demand (as measured by the output gap) can explain inflation developments in Austria. In order to put these results in perspective, we also estimate the Phillips curve for the euro area and for some members of the euro area such as Germany, Italy, France and the Netherlands. The selection of countries was made, on one hand, by the availability of suitable data and, on the other, by the relevance of each country as trade partner for Austria. Moreover, the Netherlands represents another small open economy which yields an interesting comparison with Austria.

The relationship presented in equations (1) and (2) is denoted as the traditional Phillips curve. This representation has been often criticized over the past 15 years. On one hand, the model lacks theoretical foundations, and empirically the relationship has either weakened or even completely ceased to exist in many countries since the mid-1980s.

Contributors to New Keynesian theory subsequently formulated a relationship between inflation and the real economy that became known as the New Keynesian Phillips Curve (NKPC):

$$\pi_t = E_t \beta\pi_{t+1} + \lambda mc_t \qquad (3)$$

where the inflation-driving variables are the real marginal cost of production mc_t and expected next-period – rather than lagged – inflation (E_t represents the expectations operator at time t). This form of the NKPC was introduced by Galí und Gertler (1999). Under certain assumptions, the NKPC could be written in a form that includes the output gap instead of marginal cost:[3]

$$\pi_t = E_t \beta\pi_{t+1} + \kappa y_t^* \qquad (4)$$

where and are proportional. Hence, the only difference between the New Keynesian and the traditional Phillips curve in equation (1) is that the former relies on expected rather than lagged inflation, to determine current inflation. However, the concepts differ fun-

[3] *For a more extensive discussion on the background and derivation of the New Keynesian Phillips Curve, see Rumler (2006).*

damentally as, in contrast to the traditional Phillips curve, the NKPC is based on theoretical microfoundations.

Even though, from a theoretical perspective, the NKPC describes a supply-side relationship between prices and production costs (the real marginal cost are in turn determined by factor prices such as wages and input costs), the formulation in terms of output gap is often used in practice to relate inflation to developments of the real economy, see Galí und Gertler (2007).

Since we have two empirical models for explaining demand-induced inflation, each of which has a different conceptual background, this study estimates both the traditional Phillips curve and the NKPC for the countries mentioned above. This approach takes into account model uncertainty and enables us to compare the results and the explanatory power of the traditional and the New Keynesian Phillips Curves, and – ideally – to draw robust conclusions.[4]

2 Declining Influence of the Output Gap on Inflation

This section first describes the data used for the analysis, then presents the estimations of both the traditional Phillips curve and the NKPC, and concludes by comparing and interpreting the results of both estimations.

2.1 Data

The estimations of both Phillips curve models rely on quarterly data. The estimated period for Austria runs from the first quarter of 1980 to the fourth quarter of 2007 (since national accounts data start in 1980), and for the remaining countries and the euro area from the first quarter of 1970 to the fourth quarter of 2007. The data on inflation (national CPIs) and GDP used in constructing the output gap are from the OECD Economic Outlook Database. The output gap is calculated as the deviation from the trend of real GDP, as filtered by a Hodrick-Prescott filter (HP filter) ($\lambda = 1600$).[5] The GDP (ESA 95) data for Austria are from the Austrian Institute of Economic Research (WIFO). The import and export prices that are used as control variables in the traditional Phillips curve and as instrumental variables in the estimation of the New Keynesian Phillips Curve are also from the Economic Outlook Database and the commodity prices from the Hamburg Institute of International Economics,[6] while oil prices and exchange rates are taken from Datastream. All national accounts data are seasonally adjusted.

[4] *A general objection to Phillips curve models frequently found in the literature is the possible endogeneity of the variables on the right-hand side of the equation; see e.g. Woodford (2003). The interaction of inflation and real economic activity has to be safely assumed in an interdependent economy, since monetary policy will ultimately respond to inflation developments. A way around this objection would be to estimate a multi-equation model in which the dependencies are explicitly modeled (e.g. in the form of a monetary rule). Since the estimation of such a multi-equation model would go beyond the scope of this study, the implicit assumption here – as in the whole Phillips curve literature – is that economic activity is exogenous for inflation.*

[5] *To avoid the well-known end-point problem of the HP filter, the calculation of the output gap includes forecasts up to the fourth quarter of 2009.*

[6] *Following the closure of the HWWA Institute at end-2006, the Hamburg Institute of International Economics continued the data series for various commodity prices. See: http://hwwi-rohindex.org/*

2.2 Estimate of the Traditional Phillips Curve with Time-Varying Coefficients

This section examines whether and to what extent inflation in Austria, in the euro area as a whole and in four other members of the Economic and Monetary Union (EMU) is affected by their respective domestic output gap.

To test this hypothesis empirically, we use the Phillips curve described in section 1, which represents a reduced form model that sets inflation against a measure of excess demand and a measure of a foreign supply shock. The parameters of such a Phillips curve often show signs of instability (Lucas critique).[7] This study uses an estimation method for testing whether the relationship between the output gap and inflation changes over time. We are particularly interested in whether the latest increase in inflation has been caused by excess demand.

Chart 1 shows inflation and output gap developments in the past 37 years in the euro area and in the five member states in the sample. What stands out is that current inflation is still comparatively low in the context of this longer-term historical observation. The relationship between inflation and the output gap was relatively strong in some countries (euro area, the Netherlands, France and Italy) up to the mid-1980s, and in Germany and Austria up to the early 1990s, but weakened afterwards. The chart not only shows a decline in the inflation rate, which is, moreover, no longer in line with the evolution of the output gap, but also a decline in its volatility.

To test the hypothesis that this statistical relationship has changed over time, changes in the coefficients on the domestic output gap, on lagged inflation, and on imported inflation were included in the regression of inflation.

We used the following so-called state space model:

$$\pi_t = \beta_t^1 \pi_{t-1} + \beta_t^2 y_t^* + \beta_t^3 x_t + \varepsilon_t$$
$$\text{where } \beta_t^i = \beta_{t-1}^i + \mu_t^i; i = 1,2,3 \qquad (5)$$

β^i_t are the time-varying coefficients of lagged inflation, the domestic output gap and imported inflation, respectively. The latter is measured by the changes in oil prices; both inflation variables are the standardized fourth or first differences, depending on the country. The assumption underlying this model is that the time-varying coefficients β^i follow a random walk. The symbols ε_t and μ^i_t represent the error terms, which are independent of each other.

In estimating the time-varying coefficients, we applied the Kalman filter, which estimates the coefficients β^i up to a certain point in time. After adding another observation, the coefficients are updated taking the new information into account. Chart 2 presents both the smoothed parameters and the associated confidence intervals; the parameters are optimized to incorporate the whole information available.[8]

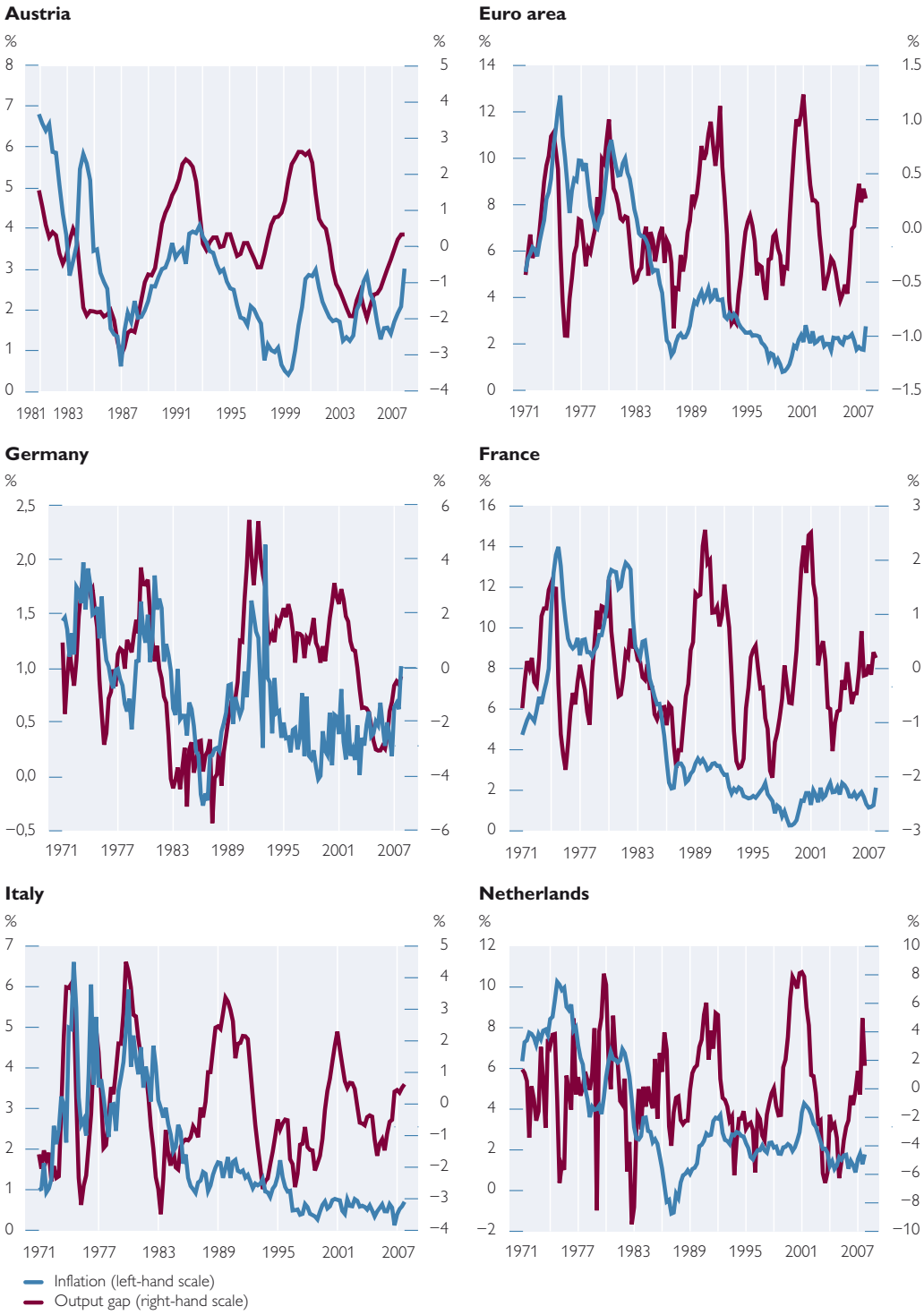
The results confirm that the relationship between inflation and the domestic output gap in the euro area and in the five Member States has indeed changed over time. In view of the relatively long period of time and the many

[7] *The Lucas critique states that the structural relationships between the variables could have changed over time, see Turner (1997).*

[8] *See Zentrum für Europäische Wirtschaftsforschung (2001), among others, for a detailed explanation of the estimation method.*

Chart 1

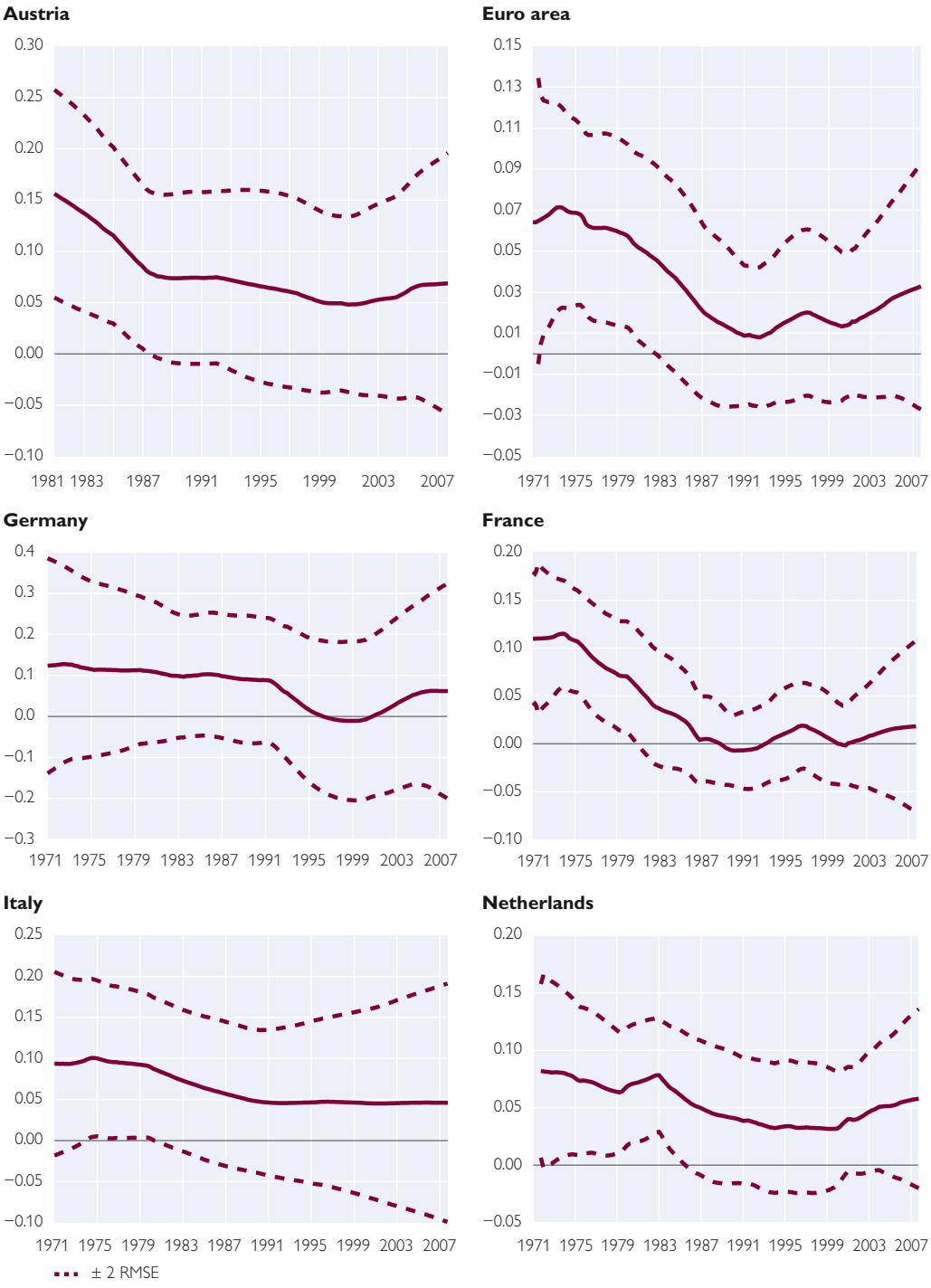
Output Gap and Inflation



Source: OECD, authors' calculations.

Chart 2

Smoothed State Estimates for the Output Gap ($ß_t^2$)



Source: OeNB, authors' calculations.

Note: RMSE stands for Root Mean Squared Error. The dashed lines represent the 95% confidence intervals of the estimated coefficients.

monetary policy regime changes in place in these countries during those years, such a result is not surprising.

While the output gap played a significant role in explaining inflation in all of the countries up to the early 1980s, its coefficient clearly fell in almost all countries and became completely insignificant toward the end of the period (except in the Netherlands). The most pronounced decline in the coefficient is seen in France and Germany, where this coefficient halved in the past 37 years.

In Austria the influence of the output gap on inflation fell sharply in the 1980s, with the coefficient almost halving over this decade. It continued to fall up to the beginning of 2000, but the trend reversed in 2004. The confidence intervals are, however, very wide so that, despite this small increase, the coefficient has been statistically insignificant since the early 1990s.

The development of the time-varying coefficients are very similar in almost all countries. Although the rise in the coefficients over the past five to seven years (in all countries besides Italy) is striking, they remained insignificant in all countries (with the exception of the Netherlands).

These results show that, toward the end of the reporting period, the domestic output gap does not seem to have a significant influence on inflation. The results are thus consistent with the analysis of chart 1, especially in the most recent period: Following a prolonged phase of lower growth rates, the output gap in the countries in the sample are closed, but only very recently. At the same time, however, inflation rates are at their highest since 1992. Thus, the hypothesis of a demand-driven inflation surge in the most recent past cannot be confirmed, neither on a descriptive level nor by the estimation results.

This result is also consistent with a series of studies that have found a worldwide change in the dynamics of inflation and real economic activity over time (Canova et al., 2006). This indicates that other factors (a change in the monetary policy regime, changes in inflation expectations or other variables that are not taken into account, such as the development of labor productivity, globalization etc.), have significantly stronger effects on inflation.[9]

2.3 Estimation of the New Keynesian Phillips Curve

The NKPC assumes that firms set prices in a forward-looking manner. They take into account future inflation and production costs in their decision. In empirical applications, future inflation is assumed to be based on rational expectations. This enables us to include the realized future inflation rate in the equation, which is then estimated with Generalized Method of Moments (GMM).[10]

The equation, which is estimated for the same data of the six economies and the same period as the traditional Phillips curve, is:

$$\pi_t = E_t \beta \pi_{t+1} + \kappa y_t^* + \varepsilon_t \qquad (6)$$

We also estimate the equation for two subsamples, so that we can explore whether the relationship between inflation and the output gap in the individual countries varies over time.[11] A com-

[9] *See both Gnan and Valderrama (2006) and Glatzer et al. (2006).*

[10] *For a detailed explanation of the GMM estimation method, see Verbeek (2000).*

[11] *An estimation with time-varying coefficients is very difficult to implement in the Generalized Method of Moments.*

Table 1

Estimation of the NKPC Coefficients for the Entire Estimation Period

Dependent variable: quarter-on-quarter CPI inflation

	$\hat{\beta}$	$\hat{\kappa}$	J-Test
Austria	0.93*** (18.04)	0.03 (1.38)	0.13 (0.42)
Euro area	0.98*** (77.40)	0.01 (0.57)	0.12 (0.20)
Germany	0.99*** (39.39)	0.05* (1.78)	0.09 (0.31)
France	0.99*** (51.02)	0.13** (2.27)	0.10 (0.18)
Italy	0.99*** (52.60)	0.11** (2.31)	0.08 (0.25)
Netherlands	0.97*** (32.20)	0.01 (0.44)	0.11 (0.15)

Instrumental variables for Austria: Inflation rate lags 1–6, output gap lags 1–6, change in EUR/USD exchange rate lags 1–4

Instrumental variables for the euro area: Inflation rate lags 1–6, output gap lags 1–4, change in EUR/USD exchange rate lags 1–6

Instrumental variables for Germany: Inflation rate lags 1–6, output gap lags 1–4, change in commodity prices lags 1–4

Instrumental variables for France: Inflation rate lags 1–4, output gap lags 1–6, change in terms of trade lags 1–4

Instrumental variables for Italy: Inflation rate lags 1–4, output gap lags 1–4, change in terms of trade lags 1–4

Instrumental variables for the Netherlands: Inflation rate lags 1–6, output gap lags 1–4, change in EUR/USD exchange rate lags 1–4

Source: Authors' calculations.

*Note: The estimation method is GMM. The t-values are shown in parentheses. The estimation period is Q1 1970 to Q4 2007, for Austria Q1 1980 to Q4 2007. * indicates the significance of the coefficient at the 10% significance level, ** at the 5% significance level and *** at the 1% significance level.*

parison of the results for both periods shows a possible variation in the relationship postulated by the NKPC. The breakpoint of the total period (in both subsamples) was determined by means of the structural changes in the individual countries visible in chart 2 as well as with the help of a structural break test. This evidence reveals that a structural break in the Phillips curve relationship occurred in most countries between 1987 and the early 1990s. We chose 1987 as the split points of the subsamples for all countries apart from Germany and Austria. Thus, in addition to the entire period, the equation is estimated separately for the first quarter of 1970 up to the fourth quarter of 1986 and for the first quarter of 1987 to the fourth quarter of 2007. For Germany, the breakpoint was selected to coincide with the German reunification in 1991. We selected that year as the breakpoint for Austria too, in view of the later start of data (1980) and Austria's close ties with Germany.

The results in table 1 show plausible β-values for all countries. In the theoretical model, β denotes the discount factor applied to future profits of firms. The value should accordingly be close to but below 1. When calibrating the (quarterly) model, a value of 0.99 is often assumed for the discount factor, since this corresponds to an equilibrium real interest rate of 4% per annum. For all countries but Austria, the results in this study are in line with this value, which is often used in the literature.

However, the estimated coefficient of excess demand, κ, has greater bearing on our research question. The output gap for Germany, France and Italy appears to be significant in explaining inflation developments, whereas those for Austria, the Netherlands and the euro area are not. With regard to scale, the estimated values for France and Italy are comparable to those of the traditional Phillips curve in section 2.2. But those for the other countries fall short of the results in the previous section, in some cases by a large margin.

The J test assesses the validity of the instrumental variables used. To be precise, the test checks whether the moment conditions of the GMM estimations are satisfied, i.e. whether the instruments are orthogonal to the residuals. The values listed in the last column are the values of the J test and, in brackets, the p-values under the null hypothesis that the moment conditions are satisfied. (A p-value below 0.1 would indicate that the applied instruments were inadmissible.) In all cases, the J test shows that the applied instrumental variables are indeed valid.

The result that the output gap is not significant in explaining inflation developments is not new in the literature. In many newer estimations of the NKPC, researchers hence use proxy variables other than the output gap for the real marginal costs (such variables can, however, no longer be interpreted as demand variables). Galí and Gertler (1999) for instance use real unit labor cost instead of the output gap. In the literature on the traditional Phillips curve, this observation led to a discussion on the influence of global factors (globalization) on inflation developments[12]. Indeed, if we look at this sample excluding the euro area, the output gap does not help to explain inflation developments in Austria and the Netherlands, which as smaller and more open economies are most affected by globalization.[13]

The results presented in table 2 provide an approximate answer to the question whether the explanatory power of the output gap, and so the influence of excess demand on inflation in the context of the NKPC, has changed over time. The upper section sets out the results for the first subsample (1970–1986, for Austria and

Table 2

Estimation of NKPC Coefficients for Different Subsamples

Dependent variable: quarter-on-quarter CPI inflation

	$\hat{\beta}$	$\hat{\kappa}$	J-Test[1]
Estimation period Q1 1970–Q4 1986, for Austria Q1 1980–Q4 1990 and Germany Q1 1970–Q4 1990			
Austria	0.91*** (15.49)	0.06 (1.16)	0.23 (0.79)
Euro area	0.97*** (101.96)	0.07*** (2.91)	0.20 (0.52)
Germany	0.99*** (41.46)	0.06* (1.99)	0.10 (0.77)
France	0.99*** (59.59)	0.04* (1.66)	0.12 (0.67)
Italy	0.99*** (39.62)	0.10*** (3.10)	0.11 (0.62)
Netherlands	0.99*** (40.96)	0.08 (0.74)	0.17 (0.51)
Estimation period Q1 1987–Q4 2007, for Austria and Germany Q1 1991–Q4 2007			
Austria	0.96*** (27.30)	0.09*** (4.71)	0.21 (0.39)
Euro area	0.99*** (41.83)	0.01 (0.56)	0.15 (0.50)
Germany	0.91*** (19.50)	0.02 (0.44)	0.19 (0.33)
France	0.94*** (25.77)	0.06*** (3.13)	0.12 (0.62)
Italy	0.98*** (67.84)	0.05*** (3.04)	0.12 (0.37)
Netherlands	0.95*** (27.39)	0.002 (0.19)	0.18 (0.18)

Instrumental variables: See table 1.

Source: Authors' calculations.

*Note: The estimation method is GMM. * indicates the significance of the coefficient at the 10% significance level, ** at the 5% significance level and *** at the 1% significance level.*

[1] *A p-value below 0.1 (in parentheses) would indicate that the used instruments are not valid.*

[12] *For an overview of the relevant literature and a corresponding estimation, see Gnan und Valderrama (2006).*

[13] *An estimation of the New Keynesian Phillips Curve with real unit labor cost as a proxy for marginal cost and for open economies would go beyond the scope of this study. See Rumler (2007) for both.*

Germany up to 1990) and the lower section the second subsample.

For the euro area and for Germany, the results show that the explanatory power of the output gap has declined over the past 37 years: it was indeed significant in the first subsample but no longer in the second subsample. For France and Italy, the output gap remains significant in both subsamples while for the Netherlands it is insignificant in both subsamples. Austria is the only country to show the opposite: the output gap in the first subsample has no significant effect on inflation developments whereas it becomes significant in the second subsample. This suggests that excess demand is becoming more important for explaining inflation in Austria.

2.4 Comparison and Interpretation of the Results of both Phillips Curves

While the results of the estimation of the traditional Phillips curve with time-varying coefficients reveal a more or less unified picture for all countries, in which the output gap loses significance in explaining inflation over time and has recently become insignificant, the results for the NKPC are diverging. Whereas the coefficient for Austria actually increases over time, it barely changes for France, and gradually decreases in the case of the other countries and the euro area and, contrary to the results of the traditional Phillips curve, remains significant for Italy. In establishing that the output gap becomes less significant in explaining inflation over time, the results of both estimation methods are thus at least qualitatively similar for all countries apart from Austria and France.

Although the different estimation methods preclude a direct comparison of the values, the results show similar values for the coefficients of the output gap (chart 3).

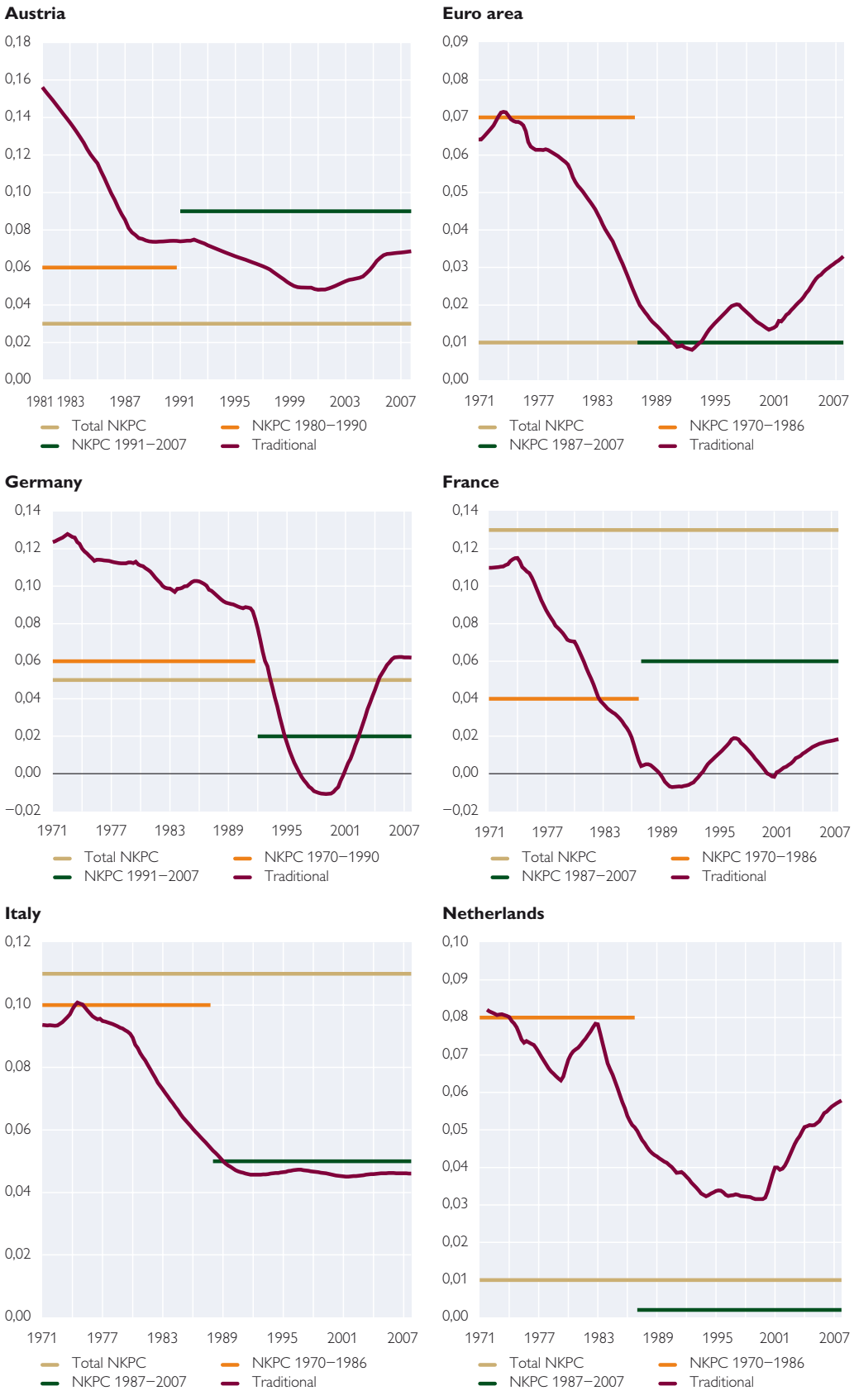
The results for Austria were in part contradictory. Whereas the result of the traditional Phillips curve (chart 2) suggests that the output gap has lost its explanatory power, the results of the NKPC show that the explanatory power of the output gap is extremely low if the time period is not split. However, if the estimation is divided into two periods, the results for the second subsample show that the output gap makes a stronger (coefficient of 0.09) and significant contribution to explaining Austrian inflation, which contrasts with the results of the traditional Phillips curve.[14]

Both estimation methods yield very similar results for the euro area. In the early 1970s the output gap played a major role in explaining inflation with a coefficient of 0.07 (for both estimation methods). This coefficient subsequently declined and is now insignificant, suggesting that the output gap is no longer relevant in explaining inflation. This also has implications for monetary policy. The recent empirical finding that the link between the domestic output gap and inflation has weakened suggests that cyclical fluctuations have less bearing than before on deviations of inflation from the price stability objective. This simultaneously erodes the influence of monetary policy on inflation through the traditional demand channel, making it more difficult to bring inflation back on target once it has deviated from the price stability objective. However, this is not to say that monetary policy has generally become

[14] *It should be noted, however, that the relatively short estimation period for the first subsample for Austria (first quarter of 1980 to fourth quarter of 1990) may have a negative effect on the significance of the estimated coefficients.*

Chart 3

Comparison of the Estimated Coefficients of the Output Gap of the Traditional and the New Keynesian Phillips Curves



Source: OeNB, authors' calculations.

Note: NKPC= New Keynesian Phillips Curve.

less effective over time, but that the effectiveness of monetary policy now relies more heavily on channels other than the traditional interest rate channel, for example the credit or the expectation channels.

3 Summary

Inflation has often been in the headlines since its steep rise in Austria over recent months. As part of an OeNB series devoted to inflationary developments, this study explores the influence of aggregate demand on inflation in Austria, in the euro area and in four other EMU member states (Germany, France, Italy and the Netherlands).

At first sight, the evolution of the inflation rate and the output gap in the past 37 years shows that up to the mid-1980s for most countries in the sample, and up to the early 1990s for Austria and Germany a strong link between these measures existed. This link became weaker afterwards. In the current phase of the business cycle it is hence difficult to argue that the present rise in inflation is caused by an overheating economy. In Austria, too, an above-average rise in inflation cannot be attributed to above-average real economic activity.

In order to formally test this statement, we estimated two Phillips curves in this study. The results show that, over time, the coefficients of both the traditional Phillips curve and the NKPC have changed for the euro area, Germany, Italy and the Netherlands. The output gap was significant in explaining inflation in the early 1970s and up to the mid-1980s. Its influence on inflation diminished, becoming finally insignificant. For Austria the two models show contradictory results:. While according to the traditional Phillips curve, the output gap has no longer been significant in explaining inflation since the early 1990s, the estimation of the NKPC shows that the link has actually strengthened over time.

Studies that use the output gap as an explanatory variable for inflation are often criticized for the poor quality of output-gap data. Moreover, a frequent critique is whether such findings are of any use at all for monetary policy, since the data are only available with a lag and are often revised. Many argue that a monetary policy response to false estimations of the output gap could further undermine the relationship between the output gap and inflation.

But these results do not rule out the impact of international shocks – through production costs (oil and food prices, etc.) – on domestic inflation. One way of testing this hypothesis would be to include a foreign or global output gap in the regression. That is not really feasible, however, given the correlation among business cycles and the measurement errors in the foreign or global output gap (Gnan and Valderrama, 2006).

Nonetheless, the findings of this study have important implications for monetary policy. The weaker relationship between inflation and aggregate demand implies that it will be more difficult for monetary policy to bring inflation under control by reducing demand once inflation or inflation expectations have risen. The effectiveness of monetary policy thus depends more heavily on channels other than the traditional interest rate channel, for example the credit channel and the expectations channel.

For monetary policy, this implies that more attention should be paid to other indicators besides domestic economic activity, which represent other transmission channels (e.g. credit growth, inflation expectations and supply factors).

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