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ESTIMATING CORE INFLATION IN NORWAY

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Abstract:

Central banks are continually considering the problem of how to identify which price changes should be considered permanent and which entirely temporary. Indeed, due to the delayed effect that monetary policy uses to put its choices into action, a wrong valuation of the type of inflation can prove extremely costly for the economy and does not produce the desired results. Since price indexes (as CPI) deliver a distorted picture of underlying inflation, it is necessary to devise a more appropriate target for monetary policy. The need to find a good measure for the latter variable becomes more marked when the central bank adopts price stability as the overriding aim of monetary policy.

In this paper we apply the Quah and Vahey (1995) methodology to Norway, oil producing OECD country, and derive measures of core inflation by imposing restrictions from economic theory within the context of a multivariate econometric analysis. To estimate long-term movements of inflation, we present two models that enable the distinction between core and non-core inflation and also between domestic and imported inflation. We conclude that in all the models presented core inflation is a 'prime mover' of inflation.

Keywords: Core inflation, Monetary Policy, Norway

JEL Classification: C51, E52, D58

1. Introduction

During the 1990s the central banks of many countries adopted the inflation targeting regime, directing their monetary policy choices towards the primary goal of low and stable inflation [see, e.g., Bernanke and Mishkin, (1997); Svensson, (1997); Haldane (1995); Neumann and Jurgen, (2002)]. The policy of inflation targeting has stimulated heated debate on the efficiency of monetary policy as a means of controlling price movements. Theoretically, inflation targeting resolves the problems of time inconsistency connected with the management of money [Svensson, (1997); Walsh, (2003)] and eliminates the typical trade-off between credibility (fixed rules) and flexibility (discretional policy) in the discussion about the best monetary policy [Kydland, Prescott, (1997); Barro, Gordon, (1983), Walsh, (1995)].

If the central bank wants to keep inflation under control it must have a precise measure of the inflationary pressure in the economy on which to base its choices.

In practice, making price stability the priority of monetary policy can be aimed in a different way. Price stability can be obtained in terms of a price index (HICP) or through the consumer price index (CPI), since the value of money is generally associated with the purchasing power of consumer money. This second reference applies in almost all countries that have adopted an inflation targeting regime but is flawed and raises serious problems for monetary policy. The CPI index is not intended to measure price trends but changes in the cost of living.

To prevent the difficulties linked to the use of an inappropriate measure of inflation (like the CPI), many central banks that have taken on inflation targeting, including Norway, have adopted a number of indicators as a reference point for their monetary policy choices.

Of these, core inflation, a net measure of inflation of noise price signals, takes on particular importance. Literature on this subject has proposed a different measure for underlying inflation. One is based on statistical methods for finding a measure of core inflation from the data on price indexes and inflation rates. The most elementary of these approaches (and probably the most widely used) is that of excluding some categories of consumer price index from the overall inflation rate. For instance, in the euro area a common measure of core inflation is the *Harmonised Index of Consumer Prices* (HICP), excluding some volatile categories of prices (the so called 'ex food and energy index'). Several attempts have been made to improve this methodology [Blinder, (1997); Dow, (1994); Macklem, (2001)].

A second approach is a modelling one, which focuses on the definition of core inflation. This approach was initially provided by Bryan and Cecchetti (1994) and implemented in Cecchetti (1996) and Bryan, Cecchetti and Wiggins (1997). It is applied to disaggregated CPI data using cross section and time series methodologies. In the literature of the modelling approach, four methods of defining core inflation emerged [Roger, (1995, 1997)]: the percentile method, the exclusion method, the trimmed means method, and the standard deviation trimmed method.

Although some of these methods could produce useful information about the inflation process, they could also misrepresent the core inflation. Since they do not provide a precise definition of core inflation, these methods are unacceptable for the formal criteria used to judge the accuracy of the measured rate of inflation.

Unlike this, the methodology used in this paper is the only one based on economic theory and this helps to reduce the mismatching of the theoretical concept of inflation and the actual inflation measurement.

This methodology enables the core inflation components to be identified through a structural approach as put forward in the article by Quah and Vahey (1995).

Following Quah and Vahey (1995) we define core (or underlying) inflation as the component of inflation that does not influence real output in the long-run and reflects the state of demand in the economy. This definition seems to reflect Milton Friedman's view that inflation is always and everywhere a monetary phenomenon.

Our identification method is based on the work of Blanchard and Quah (1989), Quah and Vahey (1995) and Bjornland (2001), even if it differs in two aspects. First of all the identification process put forward by Quah and Vahey (1995) suggests that non-core disturbances do not significantly contribute to inflationary movements or rather that the core shocks must be the leading force on price changes. This is a purely theoretical hypothesis and should not be taken too literally since it is known that some shocks have an effect on both output and inflation.

Secondly the use of a long term Phillips curve is based on the assumption that output and inflation are stationary. However, if inflation is not stationary then the use of a long term Phillips curve may not be necessary.

For monetary purposes it is relevant to distinguish persistent long-term price movements (core inflation) from short-term shifts in prices (no core inflation). The persistent price movements are induced by monetary factors (demand side) and do not reflect short-term shocks. Such an inflation measure must represent steady underlying economic fundamentals. Temporary shocks are driven by supply side factors and are outside the control of the central bank. So, the effectiveness of monetary policy, in terms of inflation control, depends on whether the inflation measure reflects long-term price movements or includes short-term structural shocks as well. On this point Bryan and Cecchetti (1994) argue that in some circumstances (during periods of poor weather, for example), food prices may rise owing to decreased supply, thereby producing transitory increases in the aggregate index. Because these changes do not constitute underlying monetary inflation, the monetary authorities should avoid basing their decisions on them. Thus, core inflation is the component of price changes which is expected to persist over the medium-run horizon of several years.

Quah and Vahey (1995) adopt a common view of core inflation that there is a well defined concept of monetary inflation that ought to be of interest for monetary policy makers. This kind of inflation cannot be captured by the development of a price index.

The purpose of applying the Quah and Vahey (1995) approach to Norway is to show how this technique provides a robust direction for inflationary control. We find that core inflation becomes the prime inflation mover and, from a policy point of view, the best inflation forecaster. Moreover, this application highlights the potential of the Quah and Vahey technique to forecast inflation in small oil exporting countries, highly exposed to the volatility of oil price fluctuations coming from external channels. In these countries the business cycle may be highly influenced by global macroeconomic shocks and cycles. In fact, cycles in real oil prices, real oil revenues or oil investment are correlated to the global business cycle, strongly impacting on small oil-exporting economies (such as Norway) in the short-term (see Bjornland, H.C., (1998)). This result may be confirmed by past episodes of supply driven oil price increases (e.g., OPEC shocks), which depressed worldwide demand. In the current global cycle the demand side drives increases: oil price increases may sharpen economic fluctuations. In the particular case of this paper, the Norwegian Central Bank has fully achieved the aim of low inflation and high growth, by keeping inflation impressively low without the need of any monetary intervention [OECD, (2007)]. The use of economic schemes and careful econometric estimates (as the Quah and Vahey approach described in this paper) made the job easier for Norwegian central bank making understandable the causes of inflation, forecasting more easily inflation dynamics as well distinguishing between internal and imported inflation [Bjornland, H.C., (2001)].

Furthermore, the widespread use of these techniques of estimates in many countries [see Vega, Wynne, (2001); Landau, (2000); Bagliano, Golinelli, and Morana, (2002)], has revealed that the Quah and Vahey technique of estimating inflation is very effective in controlling and forecasting inflation.

The paper is organised as follows. In section 2 we provide the theoretical background of SVAR approach and a short summary of the econometric technique followed in the assessment. In section 3 we present the empirical analysis and model specification to estimate core inflation for the Norwegian economy. Having identified the core inflation in a simple model with two variables we continue by separating the domestic and the imported inflation, introducing the foreign inflation as new variable and explaining the effect of imported inflation on monetary decisions. In section 4 we provide some limitations to the analysis and we indicate some interesting topics for future research. The conclusions are to be found in paragraph 5.

2. Core inflation in the Structural VAR approach: Methodology and theoretical framework

The Quah and Vahey methodology of measuring core inflation is based on an explicit long-term economic hypothesis. This long run identification scheme is implemented for the first time by Shapiro and Watson (1998) and Blanchard and Quah (1989). To disentangle core inflation, Quah and Vahey (1995) assume that inflation is affected by two types of shocks, identified by their effects on output and assumed to be uncorrelated at all leads and lags. The core inflation shock is output neutral (the long run impact is restricted to zero); the no core shock could influence output in the long run. Then, core inflation is the underlying movement in measured inflation associated only with the first kind of disturbance [Quah and Vahey, (1995)].

The theoretical presumption for the Quah and Vahey approach is the economic notion of the vertical long run Phillips curve. This assumption is not without problems and generates some issues on its economic interpretation.

At first it would seem that the acceptance of a vertical Phillips Curve in the long term means that monetary policy is neutral in its effect on real economy. In this interpretation, the inflation is purely a monetary phenomenon. This proposition is not so obvious, however: it would diminish the role of monetary policy, relegating the monetary authority to a simple guardian of purchasing power without effects on real economy.

Secondly the Quah and Vahey methodology does not state the speed of adjustment of the economy to core inflationary shocks. In particular, the SVAR approach does not restrict how quickly core inflationary shocks became output neutral, leaving indefinite the adjustment process of inflation toward long run (core) components. Such an adjustment may be explained with agents being subject to expectations errors (for information problems). In this sense the Quah and Vahey long period, provided by long term identification restrictions, is the time horizon of a correction adjustment process for expectations. At the end of this time the economic system is in a steady state and the (rational) expectations of agents are realized. This interpretation is in line with the theoretical predictions of an AD-AS model for supply and demand shocks.

For instance, imagine that the economic system (in the simplest framework) can be represented by the following equations (variables expressed in log):

$$\begin{aligned} y_t &= y_{t-1} + \Delta m - \pi_t + \varepsilon_t^D && AD \\ y_t &= y^\circ + \lambda(\pi_t - \pi_t^e) + \varepsilon_t^S && AS \end{aligned} \tag{1}$$

where y_t and π_t are, respectively, the level of current output and the inflation rate; Δm synthesizes the monetary tools; y° is the steady state output level and π_t^e the forward looking expectation on inflation rate. In the short term the difference between y_t and y° is due to $\pi_t - \pi_t^e$ (the λ parameter expresses the speed of expectation adjustment). This term identifies the unexpected inflation costs. In fact, once wage contracts have been fixed, increases in unexpected inflation (π_t) above π_t^e are benign for the real variables (y_t) (see AS schedule). Inflation is generated by supply and demand effects together (for a given Δm).

In the long term, when the expectations are realized and ε_t^S disappear, $\pi_t = \pi_t^e$ and the system (1) can be rewritten as:

$$\begin{aligned} \pi_t &= \Delta m + \varepsilon_t^D && AD \\ y_t &= y^\circ && AS \end{aligned} \tag{2}$$

In system (2) the supply schedule is vertical ($y_t = y^\circ$) and the only source of inflation are monetary shocks (demand side shocks) due to Δm. Implicitly, imposing long term restrictions to identify core inflation, the economic views of Quah and Vahey reflects the steady state status of the economy (see (2) equations).

From an econometric point of view, this is equivalent to estimate system (1) and imposing $\lambda = 0$ as a long run restriction.

More precisely we estimated a SVAR model in the growth rate of real output and inflation (CPI index) as in Quah and Vahey (1995). Their measure is based on long-term restrictions on this bivariate VAR model. We suppose that there are only two types of exogenous shocks that are distinguished by their long run impact on the level of real output. We have a supply shock that has permanent effects on output and aggregate prices, and the demand shock that has non long-term effects on output (but permanent effects on prices). The one type of shocks is allowed to influence the level of real output in the long term, the other type of shocks on the real output is brought to zero thought long-term restrictions.

With this system Quah and Vahey (1995) define the former type of shock as no core inflationary and the latter core inflationary shocks.

Taking first difference (to guarantee stationary state) the structural VAR representation can be written as follows:

$$B(L)x_t = \varepsilon_t \tag{3}$$

where x_t is the vector of endogenous variables: (as usual, y_t indicates the log of output and π_t the log of price level):

$$x_t = \begin{pmatrix} \Delta y_t \\ \Delta \pi_t \end{pmatrix} \tag{4}$$

and ε_t is the vector of shocks:

$$\varepsilon_t = \begin{pmatrix} \varepsilon^D \\ \varepsilon^S \end{pmatrix} \tag{5}$$

where ε^D and ε^S are, respectively, core and non-core shocks. These structural shocks are orthogonal, and white noise errors. They are normalized so their covariance matrix is:

$$E(\varepsilon_t \varepsilon_t^T) = \begin{pmatrix} \mathrm{var}(\varepsilon_t^D) & \mathrm{cov}(\varepsilon_t^D;\varepsilon_t^S) \\ \mathrm{cov}(\varepsilon_t^D;\varepsilon_t^S) & \mathrm{var}(\varepsilon_t^S) \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = I \tag{6}$$

where I is the identity matrix.

The matrix $B(L)$ provides us with the coefficient of the covariance stationary process with L lags. We assume $B(L)$ is a full rank matrix.

From the structural vector moving average (VMA) representation of x_t we can obtain:

$$\begin{aligned}\Delta y_t &= \sum_{k=0}^{\infty} c_{11,k}\varepsilon_{t-k}^{D} - \sum_{k=0}^{\infty} c_{12,k}\varepsilon_{t-k}^{S} \\ \Delta \pi_t &= \sum_{k=0}^{\infty} c_{21,k}\varepsilon_{t-k}^{D} - \sum_{k=0}^{\infty} c_{22,k}\varepsilon_{t-k}^{S}\end{aligned} \tag{7}$$

or

$$x_t = C(L)\varepsilon_t \tag{8}$$

where $C(L) = B(L)^{-1}$ is a polynomial in the lag operator whose individual coefficients are denoted by $c_{ij,t}$.

We want to identify the coefficient matrices $C(L)$ from the structural VMA representation and to estimate the structural shocks ε_t.

To find the $C(L)$ coefficient we must estimate the reduced form of the VAR system with the reduced-form innovations e_t:

$$x_t = Ax_{t-1} + e_t \tag{9}$$

If A is invertible, the reduced form Wold representation of x_t can be obtained:

$$\begin{pmatrix}\Delta y_t \\ \Delta \pi_t\end{pmatrix} = \begin{pmatrix}C_{11} & C_{12} \\ C_{21} & C_{22}\end{pmatrix} \tag{10}$$

or

$$x_t = D(L)e_t \tag{11}$$

where $D(L)$ is a polynomial in the lag operator.

If $D(1)$ is the matrix of long run effect of reduced form shocks then, after some algebra, we have:

$$D(1) = (I - A)^{-1} \tag{12}$$

Thereafter, we can assume that the reduced form innovations are linear combinations of the structural shocks:

$$\begin{pmatrix}\varepsilon_t^{D} \\ \varepsilon_t^{S}\end{pmatrix} = \begin{pmatrix}c_{11} & c_{12} \\ c_{21} & c_{22}\end{pmatrix} \tag{13}$$

or

$$e_t = C(0)\varepsilon_t \tag{14}$$

Given the relationship between the structural and reduced form shocks we must find the coefficient of $C(0)$. The estimation of $C(0)$ is obtained through some restrictions illustrated in the appendix C.

3. Identify internal and exported inflation

In this section we present two models applied to Norwegian data. In the first, we use Quah and Vahey (1995) methodology to identify core inflation in Norway, using quarterly changes in CPI and GDP variables and then distinguishing between domestic and imported shock.

Then, we present a model that captures the effects of global macroeconomic shocks with three variables: quarterly changes in CPI, GDP and CPI_F (foreign inflation) to decompose core inflation in domestic and imported core inflation, having identified and applied the methods of assessment of core inflation with just two variables as in the article by Quah and Vahey (1995) (inflation rate is measured by quarterly changes in Consumer Price Index CPI and output by quarterly changes in real Gross Domestic Product GDP). The introduction of foreign inflation is significant for a small oil exporting country such as Norway. The importance of CPI_F is clearly linked to the effects of globalisation, in which Norway is largely involved, supplying oil and others commodities at high prices and increasingly importing low-cost consumer products.

Quarterly changes in CPI and GDP of Norway from 1990q1 to 2006q2 are used to calculate a SVAR measure of core inflation.

To start with data is cleaned for seasonality and outliers (we did auxiliary regressions with constant and dummies) and then we performed some diagnostic tests (unit root test, lag length, residual normality, autocorrelation, co-integration, and invertibility) before estimating a Structural Vector Autoregression (SVAR) with constant and trend (see Appendix A).

Unit root tests confirm that for GDP and CPI we can reject the hypothesis of a unit root in favour of the stationary alternative (c.f. appendix A.1).

At a second stage, we determine the lag order of the model performing several selection criteria as Akaike information criterion (AIC) and sequential modified LR test statistic (LR). All tests indicate that in order to estimate the SVAR model one should use four lags, constant and seasonal dummies. Using four lags we could reject the hypothesis of autocorrelation and heteroskedasticity.

At the end, in the SVAR model specified above, we test co-integration relation between CPI and GDP (by Johansen co-integration test). By testing for co-integration we confirm that none of the variables in the SVAR model are co-integrated (see table A.3). Therefore, as explained above, we can identify the SVAR by long term restrictions imposed on $C(L)$ matrix.

Figure 1 shows the rates of variation in CPI and GDP from the sample period and from this it is possible to visualize the three phases that characterized the Norwegian economy.

In the first phase, from 1990 to 1995, the economy is stagnant and inflation is rather high. Indeed at the beginning of the nineties Norway imported high inflation because of an extreme negative supply shock (the Golf war). This situation created the expectation of further price increases, with negative effects on the on the growth of the real economy.

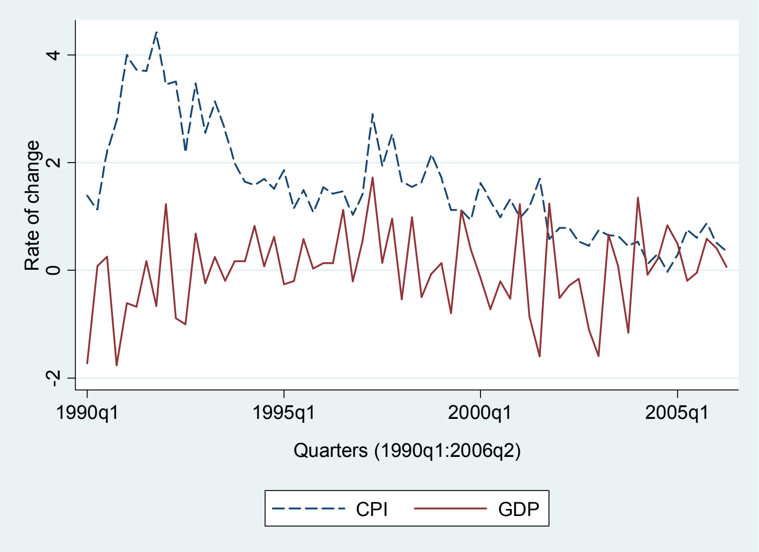


Figure 1. Norway; CPI and GDP quarterly changes from 1990q1 to 2006q2

From 1995 to 2000, with the war over, the expectations of inflation levelled off and the economy showed important signs of recovery, thanks also to the effective stabilization policies of the Norwegian government (e.g. Bjornland, 1996).

By 2002, as well as government stabilizing policies, the Norwegian central bank intervened several times with the objective of limiting inflation without compromising the an economic recovery. The effect of these interventions, which has been especially evident in recent years, is a sustained rate of GDP growth and low inflation.

In this particular case the difficulty in identifying the short term non monetary factors influencing inflation is rather evident. In the theoretical plan to the identifying mechanism analysed in the preceding paragraph, inflation can be generated by two sources: the demand side boosts and the productivity shocks. The first source produces inflation without GDP movements (we look at it by imposing long-term restrictions); the second source is linked to output movements (supply side shocks). So, the policy maker might be misled by two effects leading to mistaken monetary policy.

This creates the need for a reliable and careful measure for inflation on which to base ones own decisions.

If a negative (but temporary) shock impacts on productivity producing an increase in inflation, the central bank might be forced to restrict its monetary policy and thereby worsen the economic depression. These policy effects can reverberate through the economy for a long period and give out a worse inflation signal than agent's expectations. To avoid this, a measure that can identify core inflation would allow for more effective administration in the economy as a whole since temporary shocks on prices ought not to activate a reaction by the central banks.

In view of this, to best evaluate the effects derived from imported inflation, we introduce a second model in which we work with three variables: CPI, GDP and CPI_F (foreign inflation) in quarterly changes to decompose core inflation in domestic (CPI) and imported inflation (CPI_F). In this model we adopt the same methodology described above; we generalize the first model inserting CPI_F as an endogenous variable.

Once again in this case we have performed some diagnostic tests (unit root test, lag length, residual normality, autocorrelation, co-integration, and invertibility) before estimating a Structural Vector Autoregression with constant and trend (see Appendix B).

In fact, unit root tests confirm that for CPI_F we can reject the hypothesis of a unit root in favour of the stationary alternative (c.f. appendix B.1).

Then, we determine the lag order of the model by performing the same selection criteria used for the first model: Akaike information criterion (AIC) and sequential modified LR test statistic (LR). While the LR test of parameter reduction reported four lags, the AIC indicated two lags (see appendix

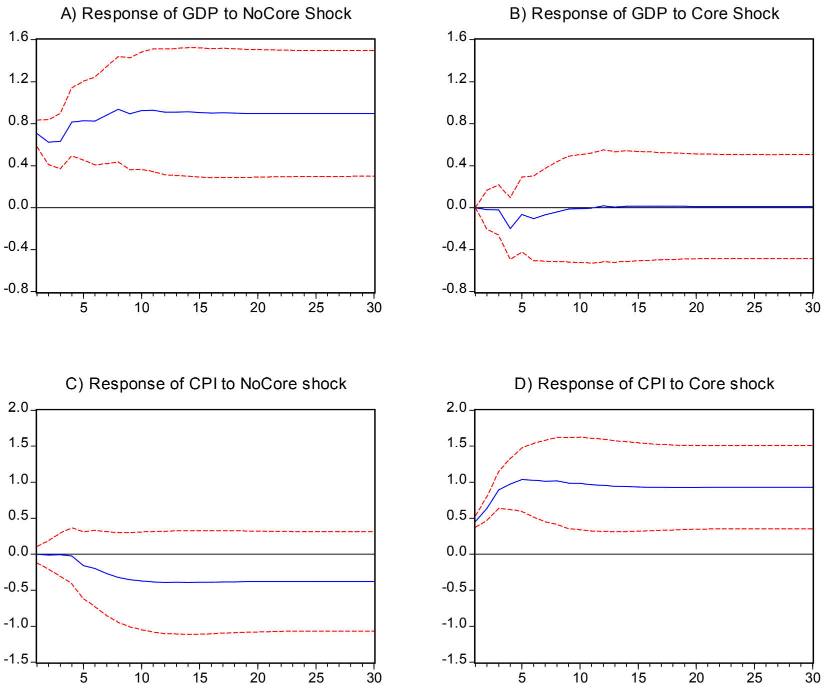
B.2). We have decided to rely on LR criteria estimating the SVAR model with four lags, constant and seasonal dummies.

Finally, in the SVAR model specified above, we test the co-integration relation between CPI, CPI_F and GDP (by a Johansen co-integration test). None of the variables in the SVAR model are co-integrated (see appendix B.3).

Presented below are firstly the impulse responses and then the variance decompositions from both models. The impulse response analysis gives the accumulated responses of inflation and real output to each shock, with a standard deviation band around the point estimates, reflecting uncertainty of estimated coefficients.

3.1 Impulse response analysis

The impulse response functions for Norway from the model with just two variables are depicted in Figure 2 (panel A-D). It shows the dynamic reactions of the GDP and the CPI to an unanticipated one-unit supply and demand shock over a period of thirty quarters, with one standard deviation band around the point estimates, reflecting the uncertainty of estimated coefficients. The standard errors reported are calculated using the Monte Carlo simulation based on normal random drawings from the distribution of the reduced form VAR. The standard errors that correspond to the distributions in the $C(L)$ matrix are the calculated using the estimate of $C(0)$.


A) Response of GDP to NoCore Shock

B) Response of GDP to Core Shock

C) Response of CPI to NoCore shock

D) Response of CPI to Core shock

Figure 2. Impulse responses with one standard error band (model with CPI and GDP)

The vertical axis refers to the log of the variable and reports the contribution of the structural supply and demand shocks, while the horizontal axis indicates the time horizon in quarters.

In panel A we note that a positive non core disturbance (e.g. productivity) has a strong impact on output stabilising its effect after 10 quarters. When the shock comes from the supply side the GDP is permanently affected.

But output is also impacted by core shocks. In panel B a positive core disturbance has a low impact on output (it goes to zero after 12 quarters) because of the long term restrictions, confirming the output (long term) neutrality assumption. Our dynamics match the predictions of AS-AD model in the long term (see equation 2) very well. A positive shock induces a permanent increase in the GDP, stabilizing after 12 quarters while a positive demand shock temporarily increases output.

This behaviour provides some evidence of a negative sloped short-term Phillips curve.

Norwegian output reaches a peak after ten quarters but output effect vanishes after some time, responding to the realization of agent expectations (see equation 3) . From an econometric point of view this is the equivalent of enforcing the long term restrictions that quash the effect of the output after just ten quarters.

In panel C and D we show the impulse response functions of the CPI depicting the different impact of supply and demand shocks.

The impulse response functions of CPI depict the different impact of supply and demand shocks on prices. While a negative supply shock induces a permanent reduction in the CPI, a positive demand shock induces a permanent increase of the CPI. In line with the stationary property of Norwegian inflation we have assumed, both shocks affect inflation only temporally. A CPI non core shock reduces inflation slightly at the beginning; then, after 12 quarters, it stabilises its effect (Panel C). However, at the same time the accumulated response of CPI to core shock has a permanent effect on inflation. The impulse response takes 12 quarters to settle down to its long term level.

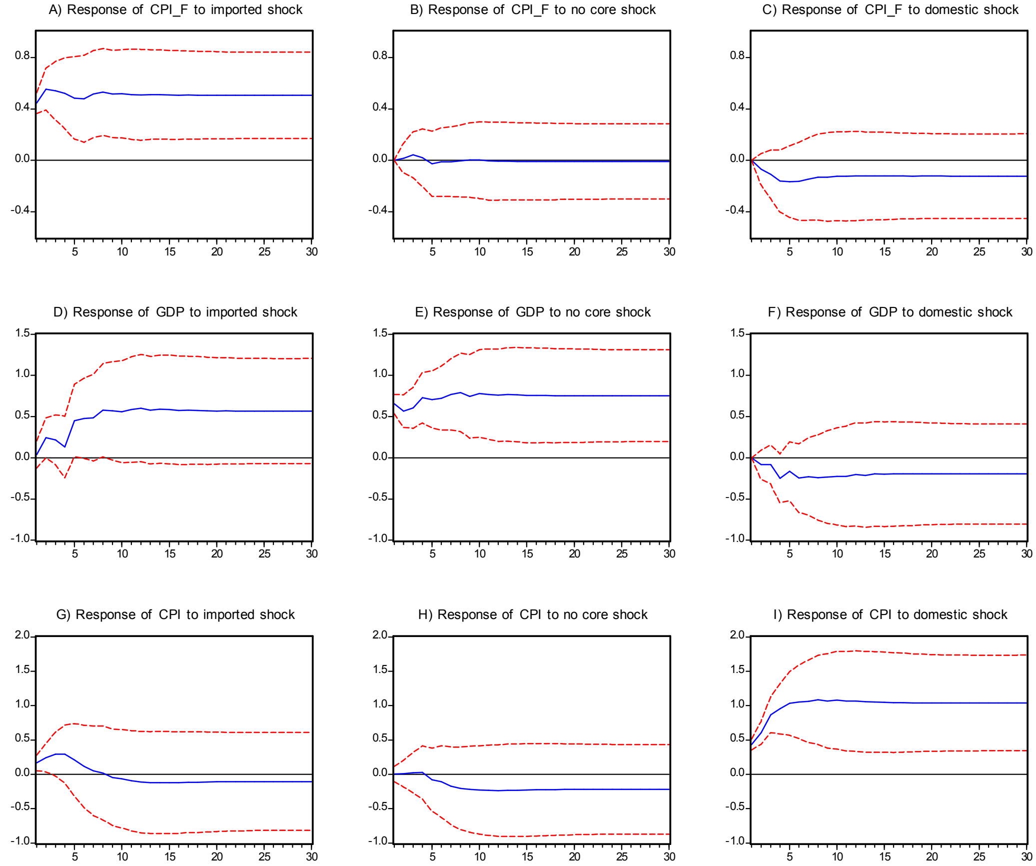


Figure 3. Impulse responses with one standard error band (model with CPI, CPI_F and GDP)

In figure 3 (panel A-I) there are the impulse functions in response to the second model. We can observe that a positive non core shocks have a strong effect on foreign prices in the long term. Domestic core shocks do not affect international prices in the long term (by restriction). In panel D we note that imported core shocks do not affect output in the long term; in panel F domestic core shocks do not affect output in the long term. As in the first model no core shocks have a low effect on the output in the long term; in addition imported core shocks have little effect on domestic prices.

3.2 Variance decomposition

The variance decomposition explains the contribution of some structural shocks to the variance of the n-step forecast errors of the variables. For each point in time the relative importance of the different structural shocks of the development of the variables can be assessed.

The variance decomposition for output and inflation over sixty quarters are reported in table 1.

In the model using only GDP and CPI , the variance decomposition of GDP reveals that the variation in output in Norway is attributable mainly to supply shocks. The long impact of the supply shocks on output approaches almost 100 percent, a result which is imposed by the identification procedure.

The variance decomposition of the CPI indicates that in Norway demand shocks exert the major contribution to the variability in the CPI on all levels. In the short-term, demand shocks account for about 92% increase of variance in CPI. This share converges to almost 100 percent in the longer term. It should be noted that this result in not due to any kind of imposed restriction. These results of the variance decomposition of the CPI are consistent with the concept of core inflation being demand driven. A demand driven measure captures the price trend, if the demand factors account for the predominant part of the variation in the price index in the medium to long-term.

Then we check if the measured CPI matches the estimated core inflation well.

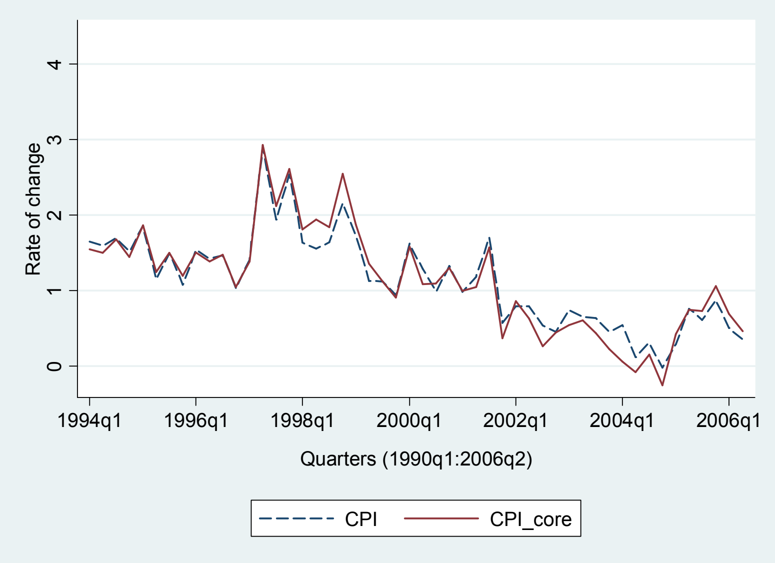


Figure 4. Norway; Core and measured CPI inflation

From figure 4 we can note that the core component of inflation appears to perform well in its role of first component of inflation. In particular, peaks and troughs of core match the headline well. In this sense it constitutes its prime mover of movements.

In general inflation was stronger than the measured one, this is probably because positive non core shocks pushed the supply side of the economy raising inflation (e.g. productivity shocks). This seems evident from 1998 to 2000. From 2002 to 2005 the inflationary process was weaker than indicated by CPI, non core disturbances (loss of productivity, competitiveness) generating an opposite impact on GDP. In the first six-months of 2006 the situation is inverted: core inflation runs (not randomly) very near to CPI measured in such a natural way; positive non core shocks drive the supply side of economy raising inflation (making productivity shocks likely).

The variance decomposition in the second model is fairly in line with expectations but again we observe a strange result. Imported shocks explain 24% of output variance after 12 periods against the long term restrictions (that do not have any effect in decomposition). The same results are found for CPI in the first model. In this model we are able to disentangle the domestic core inflation from the imported core inflation. The domestic core inflation looks quite similar to the core inflation. To show the differences we have to sum the other component of core inflation that is the imported core inflation. From 1999 to 2001 imported core shocks worked to reduce total core inflation. International prices fell at a much higher rate than in Norway. From 2002 to the end of 2004 total core was above domestic core, hence Norway imported inflation. Again in 2004 total core inflation lay below the CPI (as in the first model) suggesting that negative no core shocks reduced GDP. In the sixth-month of

2006 the situation was stable but international prices appeared to decrease at a higher rate than Norwegian prices.

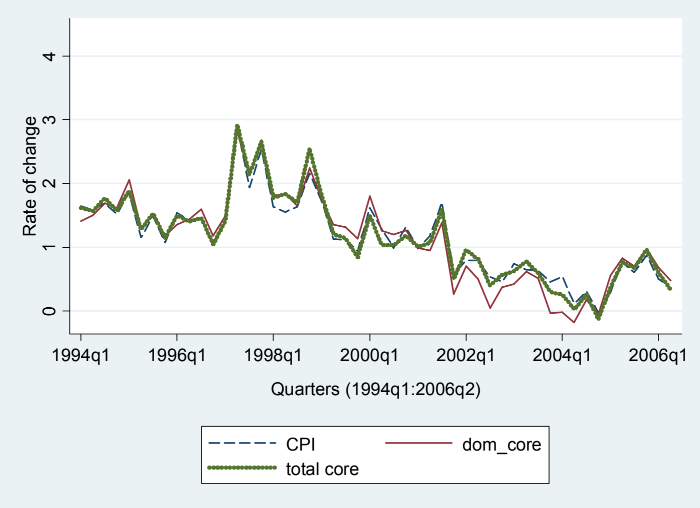


Figure 5. Norway; Core domestic, total core and measured CPI inflation

Table 1. Variance decomposition
(model with GDP and CPI)

GDP			CPI		
Period	No core	Core	Period	No core	Core
1	100.000	0.000	1	0.01	99.99
2	99.924	0.076	2	0.02	99.98
3	99.922	0.078	3	0.02	99.98
10	91.140	8.860	10	8.33	91.67
20	91.045	8.955	20	8.41	91.59
30	91.045	8.955	30	8.41	91.59
40	91.045	8.955	40	8.41	91.59
60	91.045	8.955	60	8.41	91.59

Table 2. Variance decomposition
(model with GDP, CPI and CPI_F)

GDP				CPI			
Period	Imported core	No core	Domestic Core	Period	Imported core	No core	Domestic Core
1	0.384	99.616	0.000	1	12.725	0.006	87.270
2	8.741	89.848	1.411	2	13.244	0.013	86.743
3	8.825	89.769	1.406	3	11.149	0.074	88.776
10	24.187	68.457	7.356	10	16.202	4.721	79.077
20	24.378	68.175	7.447	20	16.473	4.742	78.786
30	24.380	68.173	7.448	30	16.474	4.742	78.784
40	24.380	68.173	7.448	40	16.474	4.742	78.784
50	24.380	68.173	7.448	50	16.474	4.742	78.784
60	24.380	68.173	7.448	60	16.474	4.742	78.784

CPI_F			
Period	Imported core	No core	Domestic Core
1	100.000	0.000	0.000
2	97.704	0.131	2.165
3	96.650	0.458	2.892
10	94.050	1.709	4.241
20	94.018	1.738	4.244
30	94.018	1.738	4.244
40	94.018	1.738	4.244
50	94.018	1.738	4.244
60	94.018	1.738	4.244

4. Limitations and future research

In our analysis quarterly changes in CPI and GDP of Norway from 1990q1 to 2006q2 are used to calculate a SVAR measure of core inflation. Really, this is a limitation because it is a short sample to impose long term restrictions but data before 1990q1 and after 2006q2 are presently unavailable (as final release). An uploading of data could be interesting to deepen recent dynamic of inflation but for the purpose of the paper this uploading does hardly affect the results (impulse response analysis, variance decomposition) and, most of all, does not change the core of the application, i.e. an implementation of Quah and Vahey (1995) approach to Norway, to show how this technique provides a useful tool for inflationary control.

In future, core inflation research should focus on some topics connected with peculiar features of Norway.

In fact, being a small oil exporting country, Norway is highly exposed to the volatility of oil price fluctuations coming from external channels. The Norwegian business cycle may be highly influenced by global macroeconomic shocks and cycles. Cycles in real oil prices, real oil revenue cycles or oil investment are correlated to the global business cycle, strongly impacting on small oil-exporting economies in the short term [see Bjornland, H.C., (1998)].

By adopting inflation targeting the Norwegian central bank is obliged to defend the purchasing power of its own currency from the adverse effects of imported inflation (especially dangerous in Norway) with the aim of keeping price levels stable and in line with the chosen inflation objective and implicit in the monetary regime that has been adopted.

New uncertainty about the workings of the economy, and with globalisation becomes a more complex phenomenon, and the exogenous shocks affecting it, has presented the Norwegian Bank a new set of challenges.

Norwegian Bank must maintain high credibility in order to manage inflation stabilizing oil price expectations at that time. Certain external shocks could undermine its reputation and cause Norwegian Bank to level off and to deflect from its monetary pronouncements. This risk is sensible and foreseeable because of the higher Chinese and Indian inflation once the productivity growth there slows down. It will be critical to any further growth in credibility that while global conditions are difficult: the shocks of globalisation can put a solid economy in a difficult position by posing challenges even to such a highly successful monetary policy.

4. Conclusions

In this paper the structural VAR methodology developed by Quah and Vahey (1995) is applied to decompose Norwegian inflation in non-core shocks.

This decomposition has effects that are extremely relevant for economic policy since it is through this that a central bank can implement the most effective economic policy measures.

Indeed, due to the effects of monetary policy, mistaking the nature of price changes (temporary or permanent) can be extremely damaging to the economy. For example, difficulties in identifying the start of the inflationary process can lead to a sustained growth in inflation and require an extended period of restrictive policies. On the other hand an excessively strong reaction to a temporary price increase can lead to a swift crisis in economic activity.

When the system being implemented is that of inflation targeting the ability to find an accurate measure of the inflationary pressure becomes essential in order to reach price stability. The CPI is not an appropriate index for measuring inflation since it is strongly affected by the temporary effects (shocks exogenous or modifications of the fiscal rates).

For this reason, many central banks (including the Norwegian central bank) calculate a ‘correct’ inflation index by cleaning the CPI of the effects of ‘noise’ that are outside their control. Although many of these methods can provide useful information about underlying inflation they do not stand up to a formal criteria by which it is possible to judge the inflation rate measure or in general appraise the results.

In addition to this the process of defining and measuring the underlying inflation implicit in these methods involve an element of subjective opinion: it is difficult to identify a means of measuring underlying inflation that is at the same time useful to monetary policy and created according to scientific criteria.

Unlike these methods, in this paper we use Quah and Vahey (1995) methodology to identify core inflation in Norway, using quarterly changes in CPI and GDP variables and then distinguishing between domestic and imported shock.

We first discuss the notion of core inflation from a theoretical point of view, explaining why, in practice, the concept of core inflation in the formulation of policy aimed mostly at controlling inflation (e.g., inflation targeting), plays a crucial role in monetary prescriptions.

In this context the core inflation is the persistent (or underlying) component of measured inflation that has no medium to long term effect on output.

The results show that the core inflation is a prime mover movement of inflation, while the non-core shocks mainly contribute to the movements of output. Especially in Norway the movements that are caused by imported inflation (oil price shocks for example) are determined through the explanation of inflationary causes that are realized over long periods of time.

The empirical analysis also highlights the fact that in Norway the CPI inflation over or underestimates the core inflation in many periods while the shocks on productivity are responsible for the underestimation of inflation relative to core inflation from the beginning of the 1990s.

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Appendix A: First Model

Notes: All variables in this article are expressed in quarterly change in the log of original variables.

Table A1. Unit root tests

GDP	Confidence	t-Statistic	Prob.
Augmented Dickey-Fuller test		-9.3197	0.0000
Test critical values:	1% level	-4.1055	
	5% level	-3.4805	
	10% level	-3.1680	
CPI	Confidence	t-Statistic	Prob.
Augmented Dickey-Fuller test		-4.0186	0.0128
Test critical values:	1% level	-4.1079	
	5% level	-3.4816	
	10% level	-3.1687	

Table A2. Lag order tests

Lags	*LogL*	*LR*	*AIC*
0	98.02	*NA*	3.95
1	97.82	20.37	3.73
2	98.26	3.91	3.79
3	98.16	7.83	3.77
4	85.98	10.64 👎	3.70 👎

Notes: * indicates lag order selected by the criterion; LR is the sequential modified LR test statistic (each test at 5% level); AIC is Akaike information criterion

Table A3. Co-integration tests

Series: GDP CPI			
Lags interval (in first differences): 1 to 4			
Unrestricted Co-int. Rank Test (Trace)			
Hypothesized		Trace	
No. of CE(s)	Eigenvalue	Statistic	CriticalValue(5%)
None	0.16	17.05	25.87
At most 1	0.10	6.11	12.52
Trace test indicates no co-integration at the 0.05 level			
Unrestricted Co-int. Rank Test			
Hypothesized		Max-Eigen	
No. of CE(s)	Eigenvalue	Statistic	CriticalValue(5%)
None	0.16	10.94	19.39
At most 1	0.10	6.11	12.52
Max-eigenvalue test indicates no co-integration at the 0.05 level			

Appendix B: Second Model

Table B1. Unit root tests

CPI_F	Confidence	t-Statistic	Prob.
Augmented Dickey-Fuller test		-6.3259	0.0000
Test critical values:	1% level	-4.1055	
	5% level	-3.4805	
	10% level	-3.1680	

Table B2. Lag order tests

Lags	*LogL*	*LR*	*AIC*
0	✍151.01	*NA*	5.07
1	✍132.27	34.45	4.75 👎
2	128.37	6.81	4.92
3	✍122.91	8.98	5.03
4	✍111.91	17.03 👎	4.96

Notes: * indicates lag order selected by the criterion; LR is the sequential modified LR test statistic (each test at 5% level); AIC is Akaike information criterion.

Table B3. Co-integration tests

Series: CPI_F GDP CPI			
Lags interval (in first differences): 1 to 4			
Unrestricted Co-int. Rank Test (Trace)			
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	CriticalValue (5%)
None	0.25	34.62	42.92
At most 1	0.17	17.16	25.87
At most 2	0.09	5.44	12.52
Trace test indicates no co-integration at the 0.05 level			
Unrestricted Co-int. Rank Test			
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	CriticalValue (5%)
None	0.25	17.47	25.82
At most 1	0.17	11.71	19.39
At most 2	0.09	5.44	12.52
Max-eigenvalue test indicates no co-integration at the 0.05 level			

Appendix C: Restrictions and identification of shocks

In the first model described in paragraph 3 the $C(0)$ matrix contains four elements. The problem is, as always happens in identification issues, is that we find ourselves in a situation where we have more unknowns than equations. So, we have needed some restrictions, one for each coefficient. From the estimation of the reduced form VAR we can build the following matrix:

$$\Omega = C(0)C(0)^T \tag{15}$$

that represents the (known) variance-covariance matrix of the reduced form residuals.
The first restriction comes from the variance of the first VAR residuals:

$$Var(e^D) = c_{11}^2(0) + c_{12}^2(0) \tag{16}$$

Similarly we obtain the second restriction for the second residual:

$$Var(e^S) = c_{21}^2(0) + c_{22}^2(0) \tag{17}$$

The third restriction comes from the covariance of estimated residuals:

$$\operatorname{cov}(e^D, e^S) = c_{11}(0)c_{21}(0) + c_{12}(0)c_{22}(0) \tag{18}$$

The fourth restriction is backed by economic grounds. We must pose explicit long-term restrictions on the behaviour of the system. To find it, we consider equation (7). Because $D(1)$ matrix represents the long-term effect of the reduced form shocks, we can obtain the long-term matrix of the structural shocks denoted by $C(1)$:

$$\begin{pmatrix} C_{11}(1) & C_{12}(1) \\ C_{21}(1) & C_{22}(1) \end{pmatrix} = \begin{pmatrix} D_{11}(1) & D_{12}(1) \\ D_{21}(1) & D_{22}(1) \end{pmatrix} \begin{pmatrix} c_{11}(0) & c_{12}(0) \\ c_{21}(0) & c_{22}(0) \end{pmatrix} \tag{19}$$

or

$$C(1) = D(1)C(0) \tag{20}$$

If $C(1)$ is lower triangular, we can derive the necessary restriction.

It comes from the restriction of one of the original shocks not having any long run impact on one of the VAR variables:

This restriction is:

$$C_{12}(1) = 0 \tag{21}$$

or

$$D_{11}(1)c_{12}(0) + D_{12}(1)c_{22}(0) = 0 \tag{22}$$

Now we are able to estimate $C(0)$ and together with $D(1)$ to estimate the structural shocks.

In fact, these restrictions make $C(1)$ lower triangular and we can use this property to recover $C(0)$.

Putting long term expression (9) (see paragraph 2) and (15) together we have:

$$C(1)C(1)^T = D(1)\Omega D(1)^T \tag{23}$$

Using the Choleski decomposition of (supra), $C(0)$ can be identified by the following equation:

$$C(0) = D(1)^{-1} N \tag{24}$$

where N is the lower triangular Choleski decomposition.