Riksbank forecasts of import prices and inflation

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Summary

This article assesses the Riksbank's forecasts of imported inflation and discusses to what extent errors in this respect have affected the Bank's forecasts of overall inflation. The assessment mainly refers to the period from 2000 onwards. The results show that inflation about two years ahead was overestimated in the Riksbank's forecasts by an average of about 0.2 percentage points per quarter. The Riksbank also tended to count on the kronor being stronger than was actually the case, particularly about one year ahead. This tendency was offset, however, by an overestimation of changes in foreign prices and margins, which has accordingly lowered the error in forecasting imported inflation. The forecast error in imported inflation may have been of relatively considerable importance for the inflation forecasts in certain periods but – according to the simulations for this article – not in the whole of the period considered here.

Introduction

The forecasts of UND1X inflation[2] are used as a basis for monetary policy decisions. The overestimation of inflation in recent years has been mainly attributed to two factors: underestimation of productivity growth and overestimation of import prices. The following excerpts from the *Inflation Report* indicate the importance that has been attached to the underestimation of imported inflation as a cause of the overshooting in inflation forecasts:

> The underlying inflation using the UND1X measure, where interest expenditure and changes in indirect taxes and subsidies have been excluded from the consumer price index (CPI), was

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[2] UND1X is the consumer price index (CPI) excluding households' mortgage interest expenditure and direct effects of changes in indirect taxes and subsidies; see also http://www.scb.se/statistik/PR/PR0101/PR0101_BS_2007.doc. Further details are to be found in a technical memorandum in Swedish (UND1X och UNDINHX: beräkningar efter en SCB-modell, 1998-09-15) that can be ordered from Statistics Sweden.

> 0.9 per cent in January. This was lower than the Riksbank's forecast in December. Imported inflation in particular was unexpectedly low [*Inflation Report* 2006:1]
>
> Inflation was unexpectedly low in 2005 despite low interest rates and good economic growth – it was overestimated in the Riksbank's forecasts until the beginning of 2005. The unexpectedly low inflation can be linked to supply factors that have restrained inflationary pressure in the economy to a surprisingly large extent, in particular through high productivity growth and low import prices. [Inflation Report 2006:1]
>
> Since the previous Inflation Report, inflation has been lower than expected. The unexpected fall stems mainly from imported inflation, while domestic inflation has developed well in line with the forecast. [Inflation Report 2005:1]
>
> However, the most recent data shows that inflation has been even lower than expected, with CPI inflation at –0.3 per cent and UND1X at 0.1 per cent. This is mainly due to unexpectedly low import prices, … [Inflation Report 2004:1]

These excerpts clearly show that the forecast error in imported inflation has often been seen as the most important explanation for the forecast error in overall inflation. The low imported inflation can, of course, have been part of the reason why Sweden had a period of low inflation. What concerns us here, however, is not the expected development but the role that the forecast error in import prices (unexpectedly low imported inflation) has had for the Riksbank's (on average) overestimation of inflation (unexpectedly low inflation) in the period with an inflation target: have the forecasts of imported inflation been particularly poor?

Background

The decomposition of Swedish inflation (UND1X) into domestic (UNDINHX) and imported (UNDIMPX) components involves an attempt to classify goods and services by their import content. Other countries do the same. It has been found, however, that for Sweden as well as other countries (see Burstein, Neves & Rebelo 2003) many of the goods and services assigned to imported inflation have a large domestic component in the form of domestic margins, distribution costs for transportation, shops, etc. It should therefore be borne in mind that in practice this decomposition does not succeed in completely separating domestic from imported inflation.[3]

[3] See Hansson and Johansson (2007) for a further discussion.

The *relevance* of the distinction for monetary policy decisions is also debatable. The academic literature on this suggests that, for the choice of a target variable in monetary policy, it is rather price rigidity that is important, whether this concerns domestic prices, wages or import prices. The relevance of a price as a component in a target variable increases with its rigidity (see Benigno 2004; Christiano, Eichenbaum & Evans 2005; Corsetti & Pesenti 2005; Faia 2006; Huang & Liu 2005; Mankiw & Reis 2003; Marzo 2006; Monacelli 2005; Schmitt-Grohe & Uribe 2004; Woodford 2003).[4]

Studying forecasts for components of inflation can be of interest in an *evaluation* of the forecasts of inflation. Caution should be exercised, however, about interpreting the former in terms of the latter. A price change for one of the components may represent a relative price shift and then does not necessarily have anything to do with inflation. Relative price shifts can still affect inflation (in the short run) but that is a consequence of rigidities in nominal price adjustments.[5] There are grounds for being sceptical in general about seeing inflation as "the sum of price changes for a number of goods and services". Inflation should mainly be seen, in the spirit of Friedman, as "an entirely monetary phenomenon".

Fundamental macro theory holds that in the long run, inflation is determined by domestic monetary policy. In keeping with this, it is monetary policy abroad that determines import prices, which ultimately do *not* affect domestic inflation. This is because the *law of one price* is assumed to apply in the longer run, that is, the prices for equivalent goods and services in one and the same currency will be the same in different countries. In the short run, however, many prices are sticky and cause departures from this *law*. So import prices, particularly those that are rigid, can affect inflation in the short run. On average, imported inflation can be 4 per cent and domestic inflation 2 per cent while the krona appreciates 2 per cent.

Aims and scope

In this article I disregard such problems as the fundamental importance and relevance of import prices and concentrate instead of an evaluation of the forecasts of UNDIMPX the Riksbank actually produced from 2000 onwards[6], a period for which data are available for this purpose. If

[4] The problem for monetary policy is to achieve an allocation of resources that corresponds to what markets would generate if all prices were flexible (see Woodford 2003).

[5] For a fuller discussion of the significance of relative prices for inflation, see Assarsson (2004).

[6] An updated forecast data base is available for UND1X with outcomes and forecasts in real time for the period from 2000 onwards. For UND1X excluding oil there are data from 2003 onwards and for the foreign producer price index from 2004 onwards. Here I concentrate above all on data for the longer period because it is most meaningful to study systematic patterns in data for longer periods with many observations.

UNDIMPX is particularly difficult to forecast, it could contribute to larger errors in forecasts of UND1X.

This article has two aims:

- to analyse forecast errors in imported inflation
  – describe statistical characteristics of the forecast errors
  – compare with forecast errors for other variables
- to analyse how forecast errors for imported inflation affect inflation forecasts

The forecast error – the unexpected element – is the difference between forecast and outcome. The purely statistical analysis aims to elucidate interesting characteristics of the forecast error and its quality, for example whether the forecasts vary more, or less, than outcomes, the size of the forecast errors, whether they are biased, etc. Forecast errors for imported inflation are also compared with those for domestic inflation. The forecasts of imported inflation are composed of forecasts of underlying components such as the TCW exchange rate index and the foreign producer price index. Forecast errors in the underlying components are also analysed.

Besides the purely statistical analysis, there is the question – perhaps more interesting but also much more complex – of the importance of import prices for forecast errors for inflation. This is analysed with the aid of two models: a VAR model and the Riksbank's large macro model Ramses.[7] The aim is to arrive at the development of inflation that would have occurred if the Riksbank had forecast imported inflation more accurately.

The article continues with a description of how the forecast error for inflation can be decomposed into domestic and imported inflation, respectively, and the latter in turn into the exchange rate, domestic distribution costs and foreign prices and margins.[8] This is followed by the descriptive statistical analysis of forecast errors for these components. Simulations with the economic models are then presented.

[7] See Adolfson et al. (2007a) for a description of RAMSES.
[8] See also Andersson et. al. (2007) for an evaluation of UND1X forecast.

Inflation's components

Inflation's components, which are the object of the following statistical analysis, are defined in this section. Upper case signifies levels, lower case percentage changes. The aggregated level of consumer prices, UND1X, denoted here by P^C, is a weighted sum of domestic and imported price levels:

$$P^C \approx W^d P^d + (1 - W^d) P^i \tag{1}$$

where $W^d \approx \frac{P^d Q^d}{P^d Q^d + P^i Q^i}$ is the weight for domestic goods and services, P^d is the domestic price level, P^i the import price level in SEK and *Q* the corresponding volumes.[9]

Imports of goods and services are at foreign prices, which are assumed to be determined by $P^f = M^f \cdot MC^f$, where M^f is the foreign firms' mark-up and MC^f their marginal costs. The Riksbank does not either identify or forecast margins and marginal costs, only the foreign producer price index P^p, which can deviate from P^f. Let $\theta = \frac{P^f}{P^p}$ be a correction factor that measures the relative difference between P^f and P^p. The import price level can then be written:

$$P^i = S \cdot P^p \cdot M \cdot \theta \tag{2}$$

where *S* is the exchange rate defined as SEK per unit foreign currency. In practice and in aggregated terms, index figures are used, with the exchange rate represented by the nominal TCW index. A falling TCW index represents an appreciation of the krona. *M* is domestic distributors' mark-up, which includes distributors' margins as well as other distribution costs, e.g. wage costs. Data on forecasts and outcomes for P^i and *S* are available for the entire period from 2000 onwards and for P^p for the period from 2004 onwards. Let $P^r = M \cdot \theta \cdot P^p$ and $M^r = M \cdot \theta$. I denote P^r the price residual and M^r the distribution margin. Import prices can then be decomposed into the exchange rate and the price residual for the entire period from 2000 onwards and into the exchange rate, the foreign producer price index and the distribution margin for the later period from 2004 onwards.

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[9] The definition of UND1X in the Swedish CPI is somewhat more complicated. For instance one can start from a particular point in time, e.g. 0 for the beginning of the year (the Laspeyres type) $W_0^d \approx \frac{P_0^d Q_0^d}{P_0^d Q_0^d + P_0^i Q_0^i}$ or from the year-end (the Paasche tytpe) $W_1^d \approx \frac{P_1^d Q_1^d}{P_1^d Q_1^d + P_1^i Q_1^i}$. The CPI is a superlative index (an approximation of a true index of the cost of living), which tends to be in the interval between Laspeyres and Paasche indices, see Carling (2000).

The Riksbank publishes forecasts as annual changes, that is, for quarterly data as $p_t^C = 100\frac{P_t^C - P_{t-4}^C}{P_{t-4}^C}$. In the following I disregard the time index. Forecasts are indexed with *e* and forecast errors or unexpected values with *u*, that is, $p^C = p_e^C + p_u^C$.[10] This means that p_u^C is positive when inflation is underestimated and negative when it is overestimated.

We can now study forecast errors for the decomposition of UND1X, that is, for p_u^C, p_u^d, p_u^i as well as for the decomposed imported inflation as

$$p_u^i = s_u + p_u^r \tag{3a}$$

$$p_u^i = s_u + p_u^p + m_u^r \tag{3b}$$

First I shall describe the measures that are used in the statistical evaluation and then the data that are used. In the latter context there is the problem of overlapping data in the published annual forecasts; in an evaluation it can be preferable to use data in quarterly changes instead. After that the statistical characteristics of the forecast errors are presented.

Statistical measures

The evaluation uses a number of statistical measures that are more or less standard in this context. *Bias* – the tendency for a forecast error to point in a particular direction – is measured simply as the mean error: $ME = \frac{\sum(x_t - \hat{x}_t)}{n}$, where $\hat{x}$ is the forecast. A negative ME means overestimation of the variable. The *size* of the forecast error is often measured by using the mean square error: $MSE = \frac{\sum(x_t - \hat{x}_t)^2}{n}$), the root mean square error (RMSE), or the mean absolute error: $MAE = \frac{\sum|(x_t - \hat{x}_t)|}{n}$. MSE can be split into three components: bias, variance and covariance, see Pindyck & Rubinfeld (1998):

$$MSE = \frac{\sum(x_t - \hat{x}_t)^2}{n} = \left(\bar{x} - \left(\frac{\sum \hat{x}_t}{n}\right)\right)^2 + (\sigma_x - \sigma_{\hat{x}})^2 + 2(1-\tau)\sigma_x\sigma_{\hat{x}} \tag{4}$$

where $\bar{x}$ is the mean of outcomes, σ_x the standard deviation and τ the correlation between actual and expected *x*. MSE can be decomposed into three shares, for

bias: $\frac{\left(\bar{x} - \left(\frac{\sum \hat{x}_t}{n}\right)\right)^2}{\frac{\sum(x_t - \hat{x}_t)^2}{n}}$ (4a)

[10] We can write $p_{et}^C = E_{t-j}p_t^C$ where E_{t-j} is the expectations operator, showing that in period t-j there is an expectation of p_t^C in period t. Thus one starts from information that is known in period t-j.

variance: $\frac{(\sigma_x - \sigma_{\hat{x}})^2}{\frac{\sum (x_t - \hat{x}_t)^2}{n}}$ (4b)

and covariance: $\frac{2(1-\tau)\sigma_x\sigma_{\hat{x}}}{\frac{\sum (x_t - \hat{x}_t)^2}{n}}$ (4c)

The share for bias indicates the part of the forecast error that consists of bias, i.e. by how much the mean of the forecasts deviates from the mean of the outcomes. The share for variance indicates the part of the forecast error that consists of differences in variance, i.e. by how much the variance in the forecasts deviates from the variance in the outcomes. These two components represent the systematic part of the forecast errors, while the third component, the share for covariance, represents the unsystematic deviations.[11]

Data

The Riksbank's data on forecasts and outcomes, reported and published as annual changes for all variables, are analysed as regards UND1X inflation, decomposed in accordance (3a), for the period 2000Q1 – 2006Q3 and in accordance with (3b) for the period 2004Q2 – 2006Q2. The observations accordingly overlap – forecasts in a given quarter overlap the forecasts that are made in the next four quarters. The forecast errors will then normally be autocorrelated without necessarily being irrational.[12] There is then a risk that tests of bias and other aspects will be misleading. The problem can be reduced by using quarterly changes instead, that is, $100\frac{x_t - x_{t-1}}{x_{t-1}}$. The problem of overlapping observations is usually disregarded in evaluations and the statistical evaluations are then liable to be misleading. A possible alternative would be to start from the forecast annual changes but only use every fourth observation. However, such an approach excludes so much information that it will not be efficient.

In each period (quarter) the Riksbank produces forecasts for a range of horizons up to 13 quarters ahead. The first period in this evaluation is 2000Q1 and the last is 2006Q3, which gives a total of 27 quarters with quarterly changes. However, as the forecasts for the longer horizons, 10–13 quarters ahead, are available only from 2005Q3 onwards, the evaluation is mainly based on forecasts with 9 quarters as the longest horizon. This gives about 27x9=243 forecasts to evaluate. The data have been organised as a panel data base (data with both a temporal

[11] This decomposition is serviceable but differs from the more usual $MSE = \left(\bar{x} - \frac{\sum \hat{x}_t}{n}\right)^2 + \sigma_x^2$.

[12] Forecast errors generated in a model with rational expectations do not normally display any patterns (provided the observations do not overlap).

and a cross-sectional dimension) with the horizons as cross-sections.[13] The evaluation therefore makes it easy to study the characteristics of the forecasts for different horizons, for example those that are particularly relevant for monetary policy, but also the averages for all horizons.

The calculations of UND1X were revised as of 2005Q1. Forecasts made up to and including 2004Q4 followed the earlier definition. A forecast made at the end of 2003 for inflation two years ahead, that is, $E_{2003:4}P^{C}_{2005:4}$, can then be said to refer to the earlier definition and it is then most reasonable to evaluate it in terms of that definition. Calculations with the earlier definition were not published after 2004Q4 but the Riksbank has calculated a "synthetic" index that can be used for evaluating forecasts. The CPI Committee adopted the new method in May 2004 and the first forecast of the index with this method was made in 2004Q2. The 2004Q2 forecasts accordingly used the earlier definition for 2004Q2 – 2004Q4 and the new definition for 2005Q1 – 2006Q2. So in the evaluation it is necessary to use two different series for different forecasting occasions and horizons.

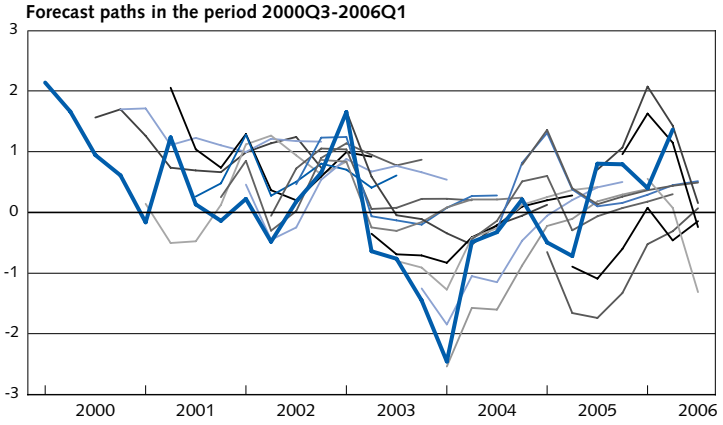
The forecasts are evaluated as far as possible from real-time data, i.e. the evaluations start from the information that was available at the time of the forecast, and in relation to what was actually being forecast. This applies, for instance, to the forecasts with the VAR model below (apart from foreign GDP) but not to the simulations with Ramses. Let us now begin the evaluation of the forecasts with a descriptive statistical analysis of the forecast errors.

A statistical analysis of the Riksbank's forecasts

Chart 1 illustrates how forecasts and outcomes for p^{i} developed in the period 2000Q3 – 2006Q1 in terms of annual changes based on quarterly data. Outcomes are represented by the thick curve. The other curves show how a forecast develops from the time it was made and up to the longest horizon 9 quarters ahead. For example, the curve that starts in 2001Q1 shows that the forecast for 1 quarter ahead was almost on the mark but the one-year forecast overestimated inflation by more than one percentage point. Forecasts and outcomes can be followed in this way for each forecasting occasion and horizon but the chart is primarily intended to present a general picture of the forecast errors.

[13] A balanced panel means in practice that the forecasts are evaluated for horizons that do not exceed 9 quarters.

Chart 1. Forecasts and outcomes for UNDIMPX
Forecast paths in the period 2000Q3-2006Q1



Note. The thick curve represents outcomes and the other curves represent forecasts made in different periods (one curve per period).

Sources: Statistics Sweden and the Riksbank.

The course of the curves shows that forecast errors usually grow with the forecast horizon. It will be seen that imported inflation was overestimated in 2001–03, while performance in 2004–06 was more mixed.

During 2001 the Riksbank foresaw that imported inflation would decline but not as much as it actually did. During 2002 the Riksbank expected an increase in imported inflation that was somewhat stronger than actually occurred. The unusually sharp drop in imported inflation during 2003 seems to have been largely unexpected; the forecasts were revised downwards as inflation slackened. When inflation rose again in 2004, the Riksbank's forecasts were on the low side to begin with but, as mentioned, the picture of 2004–05 is rather mixed. But the overall impression is that there tended to be some overestimation of imported inflation.

Corresponding charts for the other variables in decomposition (3a) are presented in Appendix 1. There it will be seen, for instance in Chart A1, that the Riksbank did not anticipate the increase in domestic inflation, p^h, to levels above 2 per cent 2001–02. The fall in 2002 seems to have been foreseen, on the other hand, but the temporary increase in 2003 was not expected. During 2004–06 domestic inflation was mostly overestimated, markedly at times. Thus, the overall impression is mixed: underestimation 2000–03 followed by overestimation 2004–06. The charts suggest that in the latter period it was domestic rather than imported inflation that was overestimated.

Chart A2 illustrates a tendency to "guide" the forecast towards 2 per cent. Inflation's upswing during 2001 was missed by the Riksbank, which predicted a slow increase towards 2 per cent. During 2002–03 inflation was close to the target and the Riksbank roughly foresaw both this and the marked drop at the end of 2003. Inflation in 2004–05, on the other hand, was markedly overestimated. To judge from the charts, it was domestic rather than imported inflation that lay behind the latter result.

The charts in Appendix 1 also show that the Riksbank underestimated the development of oil prices. The underestimation of imported inflation is much greater when the oil price is excluded. This is a questionable exercise, however, because in principle one could exclude some other price that was overestimated. To sum up, the picture of the period studied here is somewhat mixed and variable. A closer statistical analysis of characteristics of the forecast errors is presented in the next section.

Analysis of the forecast errors' characteristics

Chart 2 shows how the bias in the forecasts of annual rates varies over the range of horizons. The bias is small up to and including five quarters, after which it increases with the horizon and entails an overestimation of imported inflation. This agrees with the picture in Chart 1.

The size of the forecast error for different horizons is shown in Chart 3. It will be seen that the error is already relatively large for the second quarter. Forecasting power seems to be of short duration and the size of the forecast error appears to stabilise fairly soon at just under 1 percentage point.

Chart 2. Mean error in forecasts of UNDIMPX (measure of bias)

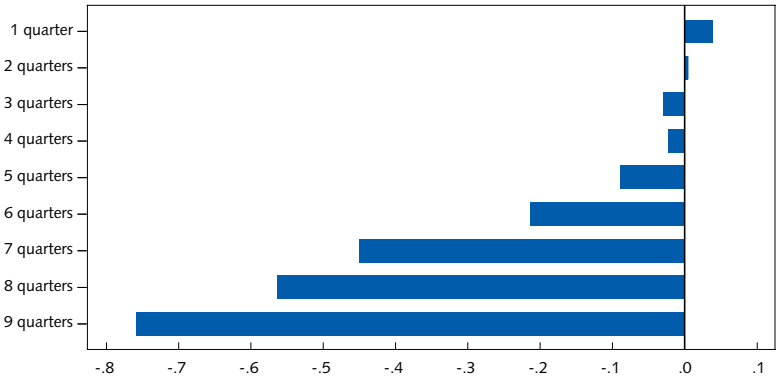


Chart 3. RMSE in forecasts of UNDIMPX (measure of size), quarter/quarters

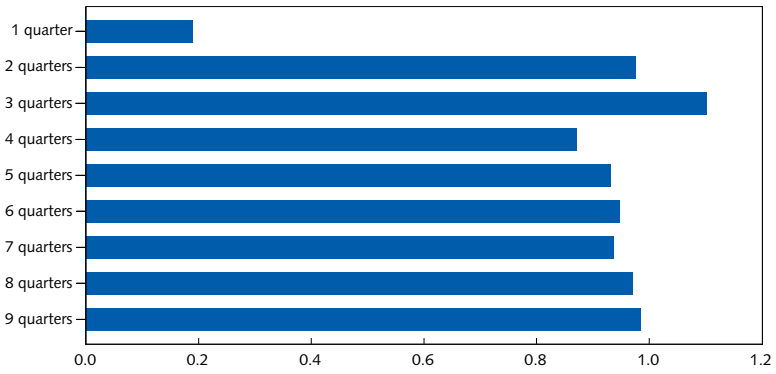


Table 1 summarises the mean errors (ME) of the forecasts as a measure of bias for UNDIMPX and the other variables in the decomposition (3). More detailed results are given in Appendix 2. The p value for the null hypothesis of no bias is shown in parentheses; a value of 0.1 is assumed to show that the hypothesis of no bias can be rejected with 90 per cent probability. With annual changes, the forecasts overlap, so a forecast error in one period persists for three more periods; the statistical inference should therefore be taken with a large pinch of salt. Another reason for doing so is that this is a total survey, not a sample. The classic statistical inference presupposes that the forecasts are assumed to be repeated many times. Here, however, it is reasonable to suppose that the future forecasts are generated differently because the Riksbank changes its staff, models, executives and so on. However, statistical inference is usually reported in these contexts and the p values are included here mostly as a service to readers.

Besides bias, Table 1 shows the size of the errors, measured as RMSE. The standard deviation in the forecast variable is shown in parentheses for comparison with the RMSE. If they are approximately equal, there is no forecasting power. The results are shown for three sets of horizons: 1, 2–5 and 6–9. The short horizon gives an indication of awareness of the current situation, while it is the longer horizon, 6–9, that is presumably most relevant for monetary policy.

Table 1. Forecast errors for different variables and horizons 2000Q1 – 2006Q3. Bias (ME) and size (RMSE). Data as annual changes. The p values for the no-bias hypothesis are in parentheses under Bias and the standard deviation for each variable in parentheses under Size. Data for PPI and distribution margin are for 2004Q2–2006Q3.

	Bias (ME)			Size (RMSE)		
Horizon	1	2-5	6-9	1	2-5	6-9
UNDIMPX	0.039 (0.298)	-0.033 (0.728)	-0.483 (0.000)	0.189 (1.237)	0.970 (1.055)	0.960 (0.992)
UNDINHX	0.029 (0.228)	0.337 (0.000)	0.085 (0.526)	0.122 (1.292)	0.733 (1.230)	1.233 (1.226)
UND1X	0.024 (0.209)	0.207 (0.000)	-0.104 (0.245)	0.097 (0.868)	0.564 (0.884)	0.799 (0.890)
TCW index	0.212 (0.436)	2.680 (0.000)	1.868 (0.000)	1.308 (4.858)	3.491 (4.961)	3.953 (4.339)
Residual price	-0.173 (0.525)	-2.749 (0.000)	-2.389 (0.000)	1.315 (4.675)	3.322 (4.613)	3.776 (4.024)
PPI	0.250 (0.095)	1.349 (0.000)	1.970 (0.000)	0.423 (1.998)	0.443 (1.905)	0.342 (1.886)
Distrib. margin	-0.122 (0.629)	-3.195 (0.000)	-5.378 (0.000)	0.727 (4.805)	2.234 (4.899)	2.275 (4.532)

For all variables the one-quarter errors are relatively small, with no significant bias. But soon after the one-year horizon the errors are already considerably larger and there is bias for several variables. Imported inflation was marginally overestimated and domestic inflation was underestimated by just over 0.3 percentage points. Overall inflation one year ahead was underestimated by 0.2 percentage points. Somewhat further ahead towards two years, imported inflation was markedly overestimated and this coincides with some overestimation of overall inflation.

From the decomposition of import prices it is evident that the krona was systematically overvalued (the TCW index is underestimated) both one and two years ahead. The residual price change was, however, markedly overestimated. The combined result is an absence of bias in imported inflation about one year ahead but an overestimation of about 0.5 percentage points at the two-year horizon.

The residual price change has been decomposed in turn into the change in the global producer price index and the distribution margin. The table shows that the change in the global producer price index was *underestimated* by an average of just over 1.5 percentage points and that consequently the distribution margin was greatly *overestimated*, by 3.2 percentage points one year ahead and 5.4 percentage points two years ahead.

The Riksbank publishes its forecasts mainly as annual changes, which means, for example that $E_t p_{t+9} = 100 \cdot \frac{P_{t+9} - P_{t+5}}{P_{t+5}}$ for annual changes and $E_t p_{t+9} = 100 \cdot \frac{P_{t+9} - P_{t+8}}{P_{t+8}}$ for first differences. While the former are perhaps most relevant, the latter are more suitable for statistical evaluations because the problem of overlapping observations is minimised here. It is therefore of interest to look at how using first differences alters the results. This is evident from Table 2.

Table 2. Forecast errors for different variables and horizons 2000Q1 – 2006Q3. Bias (ME) and size (RMSE). Data as annual changes. The p values for the no-bias hypothesis are in parentheses under Bias and the standard deviation for each variable in parentheses under Size. Data for PPI and distribution margin are for 2004Q2–2006Q3.

	Bias (ME)			Size (RMSE)		
Horizon	1	2-5	6-9	1	2-5	6-9
UNDIMPX	0,039 (0,292)	-0,054 (0,559)	-0,208 (0,053)	0,187 (1,761)	0,932 (1,776)	0,999 (1,744)
UNDINHX	0,028 (0,226)	0,114 (0,005)	-0,042 (0,335)	0,119 (0,561)	0,403 (0,627)	0,380 (0,508)
UND1X	0,024 (0,209)	0,059 (0,149)	-0,096 (0,022)	0,095 (0,564)	0,414 (0,572)	0,376 (0,533)
TCW index	0,185 (0,466)	0,891 (0,000)	0,033 (0,845)	1,221 (1,840)	1,847 (1,828)	1,559 (1,615)
Residual price	-0,146 (0,565)	-0,963 (0,000)	-0,287 (0,089)	1,228 (2,462)	1,756 (2,414)	1,517 (2,233)
PPI	0,224 (0,875)	0,106 (0,715)	0,586 (0,001)	4,358 (3,858)	1,036 (3,685)	0,566 (3,751)
Distrib. margin	-0,100 (0,952)	-0,839 (0,050)	-0,532 (0,145)	4,815 (5,447)	1,990 (5,273)	1,091 (5,180)

With first differences there is an overestimation of inflation about two years ahead but no underestimation one year ahead. Imported inflation is overestimated about two years ahead. There is a systematic underestimation of the exchange rate one year ahead but not two years ahead in this case, while the distribution margin is still systematically overestimated.

Another difference is that the changes in the global producer price index and the distribution margin now are smaller. The overestimation of the price residual may have to do with covariation between the forecast errors in the global producer price index and the distribution margin, respectively.

The size of the error in inflation forecasts still increases markedly with the horizon but not as distinctly as with forecasts as annual changes. There is, in fact, little increase in the case of the forecasts of the exchange rate, the global producer price index and the variables calculated as residuals.

Furthermore, the components of imported inflation vary much more than do the aggregates imported inflation and domestic inflation. It is the exchange rate's covariation with the other components that accounts for the forecast error for imported inflation not being larger. The Riksbank counted to some extent on an unduly strong krona but this was counterbalanced by the overestimation of prices abroad and margins.

Finally we have the decomposition of MSE into bias, variance and covariance in accordance with (4a)–(4c). Table 3 shows the results for data as annual changes. It will be seen that the main systematic deviations are bias at horizons 7–9 and variance at horizons 5–9.

Table 3. Decomposition (4a)–(4c) of errors in forecasts of UNDIMPX. Annual-rate forecasts.

	Horizon								
Variable	1	2	3	4	5	6	7	8	9
MSE	0.035	0.549	0.605	0.657	0.628	0.696	1.063	1.180	1.495
Bias' share	0.0	9.4	3.3	1.8	1.7	3.7	14.2	26.2	38.5
Variansandel	0.5	0.1	1.8	10.5	41.1	44.0	32.2	28.8	23.0
Covariance's share	99.5	90.5	94.9	87.7	57.2	52.3	53.6	45.0	38.5

Using data as quarterly changes instead (Table 4) gives much smaller shares for the systematic deviations, bias in particular. The deviations are larger for variance, with an appreciably higher variance in the outcomes compared with the forecasts. This may have to do with the familiar forecasting behaviour of not being sufficiently "bold".

Table 4. Decomposition (4a)–(4c) of errors in forecasts of UNDIMPX. First-difference forecasts.

	Horizon								
Variable	1	2	3	4	5	6	7	8	9
MSE	0.035	0.718	0.870	0.840	0.928	0.981	0.911	0.894	1.207
Bias' share	4.3	0.5	0.8	0.1	0.7	0.1	8.0	0.3	2.1
Variance's share	12.9	11.5	15.6	9.9	8.4	13.4	15.0	7.1	6.5
Covariance's share	82.8	88.0	83.6	90.0	90.9	86.5	77.0	92.5	91.4

All in all, the calculations, particularly the statistically more reliable set with first differences, show:

- an overestimation of imported and overall inflation two years ahead
- a systematic overvaluation of the krona's path in the coming year
- a systematic overestimation of the residual price both one and two years ahead
- a rapid loss of forecasting power as the horizon lengthens
- larger forecast errors for imported compared with domestic inflation
- large forecast errors for the global producer price index and distribution margins
- much greater variations in imported inflation's components than in aggregated imported and domestic inflation
- less variance in the Riksbank's imported inflation forecasts than in the outcomes
- the possibility of erroneous conclusions from evaluations using annual changes and overlapping observations

An analysis in economic models

This section presents simulations with alternative models in order to investigate whether the forecasts of import prices were an important factor behind the errors in recent years' inflation forecasts. This calls

for a model that has an economic structure with which to clarify causal relationships. There are a number of alternatives that can be said to be attractive for this purpose, though none of them is definitely better than the others. The Riksbank currently uses a dynamic stochastic general equilibrium model, Ramses, that is close to the cutting edge of research and accordingly meets high requirements from the research community.[14] It seems reasonable to use this model for the present purpose. Ramses has an economic structure based on optimising, forward-looking behaviour of economic agents. It is a highly aggregated model even though its theory is formulated for individual agents. The model performs calculations of shocks in variables, for example in prices of imported goods for investment and consumption.

A VAR (Vector AutoRegression) model is used as an alternative to Ramses. The specification of such a model does *not* start from economic theory. Instead, the variables that are considered relevant (they may be the same as in a structural model) are selected and allowed to influence each other. A simple version with two variables x_1 and x_2 could be written as follows:

$$x_{1t} = a_{10} + a_{11}x_{1t-1} + a_{12}x_{2t-1} + \varepsilon_{1t}$$
$$x_{2t} = a_{20} + a_{21}x_{1t-1} + a_{22}x_{2t-1} + \varepsilon_{2t}$$

that is, with only 2 variables and 1 time lag. Here, ε_{1t} cannot automatically be interpreted (identified) as a shock in x_1. This is because x_1 is not derived from economic theory, which is the case with a shock in, for instance, Ramses. If ε_{1t} correlates with ε_{2t}, a shock in x_1 in period *t* will not be solely a shock in x_1 but will also derive in part from a shock in x_2. So when effects of shocks are evaluated in VAR models it is customary to arrange for the shocks to be uncorrelated, which is done by a transformation of the matrix with shocks.[15] Instead of doing this, I have used the original matrix, which is practical and in this case reasonable because the highest correlation coefficient between the shocks in the system estimated below is 0.17 and not statistically significantly different from zero.

VAR model

A VAR (Vector AutoRegression) model is estimated here in the form of error correction, i.e. a model consisting of variables in levels as well as

[14] See Adolfson et al. (2007a) for a description of RAMSES.

[15] The most usual form of transformation is Choleski decomposition. However, it entails that the way in which the variables are incorporated in the system influences the effects of shocks, which makes the transformation more or less arbitrary.

changes.[16] It is then assumed to catch both long-term equilibrium relationships and short-term dynamics. The relationships are based solely on historical data. The VAR model is estimated for the period 1994–2006 so as to avoid the structural changes connected with the monetary policy realignment in the mid 1990s. The evaluation is made in relation to outcomes for the period 2004Q1 – 2006Q2 using real-time data, that is, the data that were actually forecast and the information that was available at the time of the forecast. The model is re-estimated for each forecasting occasion. Real-time data are used for all variables except international GDP.

THE VAR MODEL CONTAINS

- domestic variables:
  - GDP
  - UNDINHX
  - UNDIMPX
  - 3-month interest rate
  - real TCW exchange rate
- external variables:
  - international GDP (TCW-weighted)
  - international inflation (TCW-weighted)

A 2-quarter time lag is used. First of all, unconditional forecasts are made with the VAR model, after which the shocks are generated that are required in the model to generate the Riksbank's forecast of import prices. A new forecast is then made with these shocks and it yields forecasts of the variables in the model that are conditioned on the Riksbank's import price forecast.[17] Here, however, we are only interested in the forecast of inflation. As an additional alternative, I also condition the forecast of the *import price outcome* to check that that the model does not deliver a very odd forecast of inflation even when import prices are fully known.

The alternative forecasts of inflation can then be compared, see Chart 4, which shows forecasts and outcomes for UND1X inflation. The results show that the VAR model overestimates inflation in the period 2004Q1 – 2006Q2 by an average of 0.15 percentage points. The forecast conditioned on the Riksbank's forecast of import prices overestimates inflation little more than half as much; the difference is small but still statistically significant. So there does not seem to be any particular

[16] The model is estimated in the econometrics programme Eviews, which tests how many equilbrium relationships are contained in the data. These equilibrium relationships are then included as level terms in a VAR model of difference form. In the model estimated here there are 4 equilibrium relationships.

[17] Forecasts of p^d och p^i are generated in the VAR model and inflation is derived from (1).

inflation bias in the error in the Riksbank's forecast of import prices compared with the VAR model's forecast error. Moreover, the Riksbank's forecast error is somewhat smaller than the VAR model's, about 0.05 of a percentage point (statistically significant at the 5 per cent level using the test in Diebold & Mariano, 1995). Thus, these calculations indicate that it is not the error in the Riksbank's forecasts of import prices that lies behind the overestimation of inflation.

Chart 4. The VAR model's simulations of UND1X inflation 2004Q1-2006Q3

Anm. De olika kurvorna visar – utfall (fet heldragen kurva) – obetingad prognos (blå kurva) – VAR-prognos betingad på Riksbankens prognos på UNDIMPX (röd kurva) samt – VAR-prognos betingad på utfallet i UNDIMPX (grön kurva)

We can now take a closer look at the simulations, using the one that begins at 2005Q2 as an example (the second one in the forth row). We see a gross overestimation of inflation, with forecasts that are much the same regardless of whether they are unconditioned, conditioned on the Riksbank's forecast or on the outcome. This means that the forecast of import prices was of no major importance for the inflation forecast in this period, which was dominated by other changes.

Matters are different for the forecasts for 2006Q1, using information as of 2005Q4. The unconditioned forecasts with the VAR model are much the same as those conditioned on the Riksbank's forecast, while forecasts conditioned on the outcome gave a considerably lower path. So here it can be said that the overestimation of inflation was due to the error in forecasting imported inflation. However, this seems to have been the case only for inflation assessments in the past year, not for either earlier years or the period as a whole.

Ramses

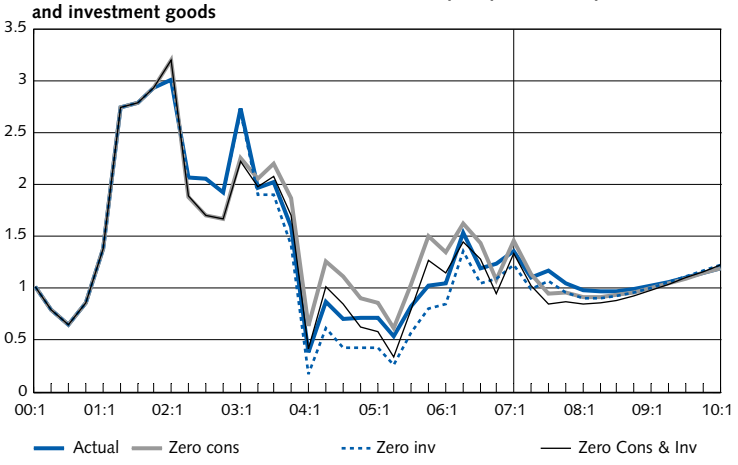
Ramses is a dynamic stochastic general equilibrium model (DSGE) of the Swedish economy.[18] The model incorporates explicit assumptions about the economic motives behind the behaviour of households and firms: it assumes that households and firms are forward-looking and aim to maximise utility and value, respectively. Decisions are based on predictions of the future. So when the Riksbank uses Ramses to forecast private sector behaviour, there is a presumption that the effects of monetary policy, for example, are influenced by the private sector's predictions of the Riksbank's actions.

The model has been tailored to describe the development of a number of macroeconomic variables with the help of Bayesian estimations. The model estimates 15 equations (12 domestic and 3 TCW-weighted external variables) for the period 1986–2006 and takes the change of monetary policy regime in the mid 1990s into account. The estimation method also makes it possible to estimate a number of unobservable variables, for example a number of shocks that drive the model's dynamics.

Two examples of such shocks are shocks in the price mark-up on imported consumer goods and on imported investment goods. The estimation calculates a whole sequence of shocks that affect the dynamic course of the model's variables. The course of inflation (UND1X) with and without these shocks in the external price mark-up is shown in Chart 5.

[18] See Adolfson et al. (2007b).

Chart 5. Effect on UND1X of shocks in the mark-up on prices for imported consumer and investment goods



The grey and the dotted curves represent inflation without the shock in the mark-up on consumer goods and on investment goods, respectively. It turns out that the shock in consumer goods pulls inflation up and the shock in investment goods pulls it down. The combined effect of these import price shocks on inflation is marginal, as can be seen by comparing the combined effect (the black curve) with actual outcome (the thick blue curve). In Ramses the source of the unexpectedly low inflation is instead the unexpectedly high productivity growth.

Conclusions

The evaluation is mainly of historical interest because the Riksbank no longer forecasts UND1X decomposed into domestic and imported inflation. As mentioned above, neither is it perhaps the most interesting in the context of monetary policy.

So what lessons can be drawn from the results presented here? The detection of systematic errors is interesting because it indicates the possibility of improvements. They might concern forecasts of inflation and imported inflation about two years ahead and of domestic inflation and the TCW index about one year ahead.

In the case of what I have called the price residual and the distribution margin, potential improvements may have less to do with models and more with obtaining better statistics on prices to importers.

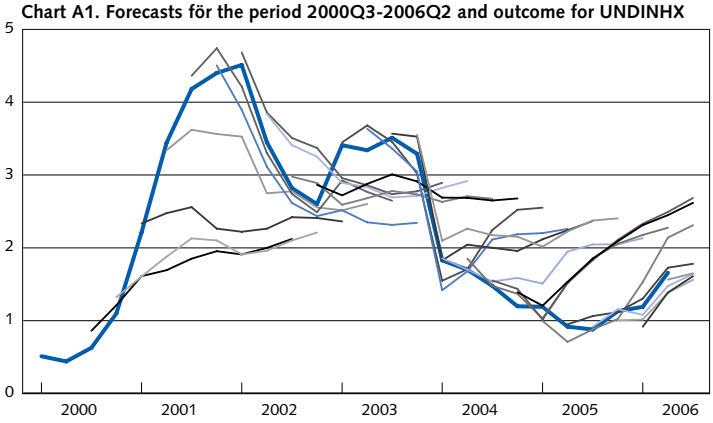
Another observation is that the systematic deviations in the forecast errors for imported inflation apply not only to the mean but also to the variance. They show that the variance in the Riksbank's forecasts is lower than in outcomes. So perhaps one should forecast somewhat more boldly than has been the case.

The conclusions from the evaluation can be summarised as follows:

- imported inflation and inflation two years ahead were significantly overestimated
- the exchange rate one year ahead was systematically overvalued
- the residual price was systematically overestimated both one and two years ahead
- forecasting power decreases rapidly as the horizon becomes longer
- forecast errors were larger for imported inflation than for domestic inflation
- there were large forecast errors for the global producer price index and the distribution margin
- evaluations using annual changes and overlapping observations can lead to erroneous conclusions
- the variance in the Riksbank's forecasts of imported inflation is smaller than in the outcomes
- the forecast errors in imported inflation were, according to simulations with a VAR model, an important factor behind the overestimation of inflation in 2006 but not for the period 2004–06 as a whole
- the forecast errors in imported inflation – prices for imported consumer and investment goods – were not important, according to simulations with the Ramses model, for the path of inflation from 2003 onwards

Appendix 1: Description of forecasts and outcomes

Chart A1. Forecasts för the period 2000Q3-2006Q2 and outcome for UNDINHX



Note. The thick blue curve is the outcome and each of the other curves represents a forecast made at a particular time.

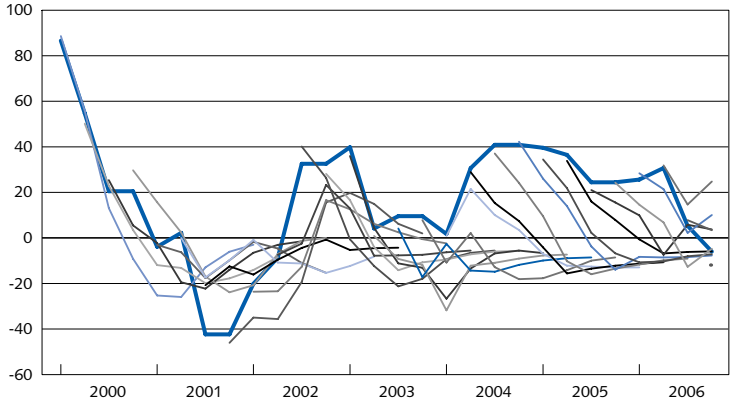
Sources: Statistics Sweden and the Riksbank.

Chart A2. Forecasts for the period 2000Q3-2006Q2 and outcome for UNDIX

Note. The thick blue curve is the outcome and each of the other curves represents a forecast made at a particular time.

Sources: Statistics Sweden and the Riksbank.

Chart A3. Forecasts for the period 2000Q1-2006Q4 and outcome for the price of oil in USD



Note. The thick blue curve is the outcome and each of the other curves represents a forecast made at a particular time.

Sources: Statistics Sweden and the Riksbank.

Appendix 2: Tables

Table A1. Forecast errors for particular variables and horizons 2000Q1 – 2006Q3. Mean error (ME) for particlar horizons and all horizons. Forecasts as annual rates

Horizon	All	1	2	3	4	5	6	7	8	9
UNDIMPX	-0.271	-0.001	-0.227	-0.141	-0.109	-0.103	-0.160	-0.388	-0.556	-0.758
UNDINHX	0.152	0.014	0.126	0.262	0.350	0.403	0.335	0.163	-0.022	-0.261
UND1X	0.012	0.007	0.010	0.129	0.198	0.236	0.173	-0.020	-0.198	-0.426
TCW index	2.071	0.212	1.154	2.383	3.404	3.962	3.329	2.247	1.223	0.450
Residual price	-2.309	-0.173	-1.229	-2.412	-3.428	-4.052	-3.542	-2.697	-1.787	-1.303
PPI	1.306	0.250	0.716	1.349	1.708	1.881	1.933	1.908	2.006	2.130
Distrib. margin	-3.250	-0.122	-1.184	-2.641	-4.212	-5.762	-6.271	-5.997	-4.765	-2.828

Table A2. RMSE for particular variables and horizons 2000Q1 – 2006Q3. Means for particular horizons and all horizons. Forecasts as annual rates

Horizon	All	1	2	3	4	5	6	7	8	9
UNDIMPX	0.879	0.189	0.975	1.103	0.872	0.931	0.948	0.938	0.970	0.985
UNDINHX	0.887	0.122	0.415	0.635	0.854	1.029	1.214	1.277	1.257	1.182
UND1X	0.617	0.097	0.460	0.555	0.584	0.655	0.812	0.814	0.827	0.744
TCW index	3.453	1.308	2.426	3.178	3.861	4.498	5.014	4.363	3.569	2.864
Residual price	3.301	1.315	2.277	2.934	3.736	4.341	4.763	4.272	3.492	2.578
PPI	0.396	0.423	0.827	0.460	0.253	0.232	0.306	0.384	0.293	0.385
Distrib. margin	2.085	0.727	1.577	2.153	2.546	2.660	2.993	3.379	2.300	0.429

Table A3. Forecast errors for particular variables and horizons 2000Q3 – 2006Q3. Mean error (ME) for particlar horizons and all horizons. Forecasts as first differences

Horizon	All	1	2	3	4	5	6	7	8	9
UNDIMPX	-0.104	0.039	-0.032	-0.035	-0.091	-0.059	-0.204	-0.236	-0.194	-0.197
UNDINHX	0.041	0.028	0.134	0.144	0.104	0.069	0.054	-0.013	-0.062	-0.167
UND1X	-0.007	0.024	0.080	0.083	0.043	0.027	-0.028	-0.089	-0.102	-0.180
TCW index	0.467	0.185	0.954	1.148	0.859	0.575	0.348	0.112	-0.089	-0.322
Residual price	-0.599	-0.146	-1.059	-1.182	-0.950	-0.634	-0.552	-0.348	-0.105	-0.075
PPI	0.252	0.224	-0.664	0.392	0.404	0.530	0.585	0.437	0.627	0.824
Distrib. margin	-0.635	-0.100	0.060	-1.115	-1.323	-1.256	-1.159	-0.550	0.286	0.221

Table A4. RMSE for particular variables and horizons 2000Q3 – 2006Q3. Means for particular horizons and all horizons. Forecasts as first differences

Horizon	All	1	2	3	4	5	6	7	8	9
UNDIMPX	0.879	0.187	0.863	0.951	0.931	0.982	0.991	0.947	0.948	1.110
UNDINHX	0.361	0.119	0.360	0.390	0.412	0.448	0.511	0.381	0.367	0.261
UND1X	0.362	0.095	0.414	0.390	0.411	0.439	0.472	0.344	0.339	0.349
TCW index	1.649	1.221	1.761	1.999	1.886	1.740	1.700	1.573	1.499	1.462
Residual price	1.591	1.228	1.560	1.879	1.935	1.651	1.676	1.596	1.397	1.400
PPI	1.196	4.358	2.738	0.488	0.421	0.496	0.480	0.531	0.438	0.812
Distrib. margin	2.006	4.815	3.437	1.704	1.371	1.448	1.445	1.237	0.590	-

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