

The role of assessments and judgement in the use of the macroeconomic model RIMINI

By Kjetil Olsen, Senior Economist, Economics Department and Fredrik Wulfsberg, Senior Advisor, Research Department¹

The *Inflation Report's* projections for economic developments are important for Norges Bank's conduct of monetary policy. The macroeconomic model RIMINI is used as a tool in developing these projections. This article provides insight into key aspects of the model's description of the inflation mechanism and how the model is used to make economic forecasts. Assessments and judgement play an important role in this work. The assessments are partly based on systematic analysis of current statistics and information from other models that shed light on temporary factors. Historical forecast errors also provide insight into the use of the model. Knowledge of this kind provides the basis for steering the model in the forecast period. The article also illustrates how the model may be used to study effects of interest rate changes.

1 Introduction

Norges Bank's projections are based on analyses of the most significant relationships in the economy and on key assumptions about economic policy and international conditions. The projections reflect an overall assessment of economic developments. Norges Bank also analyses the effects of monetary policy and the impact of various shocks on the Norwegian economy. Such shift analyses are published regularly in the *Inflation Report*.

The macroeconomic model RIMINI is an important forecasting tool in this work. Smaller models that have been developed to study special issues are also used. The results from this type of analysis are incorporated in the RIMINI model. Thus, the projections published in the *Inflation Report* express an overall assessment of the results from different models and current developments in the Norwegian economy. This article looks more closely at our use of the RIMINI model for projections and analysis, with special emphasis on price and cost inflation and the effects of monetary policy.

RIMINI is a macroeconomic model that has been developed by the Research Department of Norges Bank. The model takes account of many of the most important relationships in the Norwegian economy and explains both real and nominal variables. It combines and takes account of empirical and theoretical knowledge about these relationships as they have functioned in the past and contributes to a consistent analysis of the interaction between them. Using a set of assumptions about future economic policy, among other things, the model provides quarterly projections for developments in the Norwegian economy.

The RIMINI model does not necessarily reflect Norges Bank's view of the economy. However, the model and our use of it provide the basis for the projections and especially for assessing how changes in the assumptions may affect the projections. The model attempts to explain the main systematic features, but not every detail of economic developments. Therefore, as we work on the *Inflation Report*, the model is changed regularly. In addition, we frequently use information from other

models or from current economic developments. Thus, the projections in the *Inflation Report* are not merely a result of the RIMINI model's properties. The assessments of model users are equally important.²

Section 2 presents a brief overview of the RIMINI model's scope, structure and background data. Section 3 looks more closely at price and wage formation in the model and how the model is used. Section 4 discusses how we use the model to study the effects of interest rate changes. Section 5 provides a summary.

2 General information about the RIMINI model

The RIMINI model is designed to make short and medium-term projections for the Norwegian economy as well as for policy analyses. Within a one-year time horizon, current developments in the Norwegian economy as they are presented in monthly statistics play a prominent role in preparing the projections. For medium-term projections, ie from 2 to 5 years, the model's results are used to a larger extent as guidance in making the projections.

Developments in economic variables depend on a number of mutually dependent mechanisms that are often complex and difficult to quantify. Overall demand, for example, affects both activity level and employment, which in turn determines income levels, which again affect overall demand. Changes in real variables affect nominal prices for goods, services and labour. Therefore, in the RIMINI model, the endogenous variables are determined in a simultaneous system of equations.

The interest rate functions as a monetary policy instrument and is therefore a key exogenous variable in the model. A technical assumption underlying the *Inflation Report's* baseline scenario is that interest rates follow expectations in the money and bond markets as reflected in forward rates. Projections are also made on the basis of unchanged interest rates. The exchange rate is also an exogenous variable in the RIMINI model and the baseline scenario assumes that exchange rates remain unchanged. When the model is used to calculate the effect of changes in different variables such as the interest

¹We are grateful to colleagues at Norges Bank for their comments and suggestions.

² See, for example, Turner (1990) which illustrates the significance of assessments and judgement for economic projections.

rate, the exchange rate is endogenised by, for example, assuming uncovered interest parity. This will be discussed in further detail later in the article. The RIMINI model contains a good 100 exogenous variables that are not determined by the model and which must therefore be estimated outside the model when making projections. In addition to the monetary policy stance, the exogenous variables primarily describe developments among our trading partners, main world market prices and policy variables that describe fiscal policy.

Expectations about future inflation, demand and other economic variables may affect household and corporate behaviour. Expectations formation is not explicitly modelled in RIMINI, but the model contains a number of explanatory variables that may capture economic agents' expectations. To take account of adjustment lags in the economy, the model has been given a dynamic specification where lagged variables play an important role. Forward-dated variables are not included. This does not imply, however, that the model is inconsistent with forward-looking behaviour.

In the RIMINI model, a main distinction is made between production sectors including manufacturing and construction on the one hand and private services on the other. The former may be characterised as internationally exposed sectors, while the latter is largely sheltered from international competition. The public sector, primary industries and the oil and shipping industries are also represented in the model. Economic developments in these sectors are treated exogenously, in contrast to private services and manufacturing and construction. The model not only reflects conditions in the real economy but also financial and monetary conditions. It also includes an income account for different sectors.

The RIMINI model is based on quarterly data. The quarterly national accounts are the most important data source together with other statistics from the national accounting system and from Norges Bank's database for financial sector balance sheets (FINDATR). Other statistical sources also provide important data for the model. The most recent version of the model (RIMINI 3.14) has been calculated on the basis of national accounts figures in accordance with the European National Accounting System (ENS95).

Like other econometric models, the RIMINI model is changing constantly. New knowledge about methods or economic theory will improve the properties of a model based on research. New observations, evaluation of projections and experience in using the model also provide new insight. Computer tools are under constant development as well, making calculations and simulations more precise and effective. The RIMINI model currently comprises 375 equations, 74 of which are estimated behavioural relationships. These equations will contain add factors that capture the unexplained variation in the left-hand-side variables. Later in the article, we will

explain how these add factors may be used when simulating the model to make projections.

The mechanisms and relationships between the model's variables may be regarded as a representation of a large simultaneous probability distribution. However, the number of relationships are too numerous and complex to model simultaneously.³ Instead, we primarily model single equations separately from the rest. Modelling consists of developing clearly specified single equations where residuals do not contain systematic information that can give the equation increased explanatory power. Further, emphasis is placed on accurate estimation of the parameters and identification of parameters that are likely to be constant over the model's horizon for projections or policy assessments. Finally, the single equations are combined into a complete system.

It is important to use several criteria in evaluating the system's (model's) properties in addition to the properties of the individual equations. First, the individual equations and the model as a whole must be capable of explaining the key features of the data, eg systematic developments and trends in the medium term. The objective is to explain systematic changes in the data and not random variations. Second, the model's long-term equilibrium relationships should be supported by generally accepted economic theory. As the economy is constantly exposed to disturbances, it will seldom be in equilibrium, but there will always be mechanisms that set the economy in motion towards equilibrium. This is taken into account in the modelling of empirical relationships in the model. Third, the dynamic effects of various shocks should be reasonable, and finally, the model should contain acceptable forecast properties.⁴ Occasionally, some of the criteria will conflict and must be counterbalanced against each other.

Using the RIMINI model

Some economic relationships are easier to quantify than others. Many of the equations in the model may explain historical trends effectively, while the explanatory power of other equations is poorer. This makes it necessary to correct the model where it clearly shows an unlikely development in the model's variables. Corrections of this kind must of necessity be discretionary. This may be accomplished by steering the add factors in the model's behavioural equations. In the projections, the add factors are used to make the necessary corrections in the model. In the literature, this practice is called intercept correction (see Hendry and Clements (1999)).

For the observed history, an add factor constitutes the unexplained deviation in an equation and is thus an important indicator of the equation's explanatory power. If the equation effectively captures actual developments, the add factor will have an average value of zero. Thus, the add factor does not systematically contribute to

³ See Jansen (2000) for a detailed discussion of the methodology underlying the work on RIMINI.

⁴ Eitheim, Husebø and Nymoen (1999) compare the RIMINI model's forecasting features with alternative model specifications.

explaining the development in the economic variable that is to be explained.

The term "neutral add factor" usually means that the add factor is valued at zero when simulating the model. One interpretation of this is that the add factor does not make an independent contribution to growth in the variable. However, setting an add factor at zero in connection with projections may generate unreasonable results if the latest historical observations of an add factor deviate systematically from zero. If this is the case, a neutral use of the add factor will instead contribute to maintaining this deviation so that the add factor does not make an independent contribution to changes in growth in the variable during the forecast period.

The add factors may also be given a value other than zero in the projections if we have transient or permanent information that we believe is not taken into account by the model's equations. This is exemplified and discussed in further detail in connection with the assessment of the price and wage equations below.

3 Wage and price formation

This section discusses how the core of the inflation process is modelled in RIMINI. We also assess the model's features for price and wage determination and comment on our use of the model in this area.

In the model, consumer prices rise in proportion to domestic producer prices and import prices in the long run. Import prices are primarily determined abroad and by the exchange rate, while domestic producer prices are determined in product markets, which are characterised by imperfect competition. The producers have a certain degree of market power such that producer prices are determined by a mark-up on unit labour costs. This means that producers have the possibility of passing on higher costs to prices. As a result, inflation depends both on imported price inflation and the interaction between wage and price formation. Therefore, wage formation is important for price inflation.

Wage determination

In the RIMINI model, wage determination is based on negotiations between companies and trade unions. The exposed sector is assumed to be a wage leader, as this has traditionally been the case in Norway. Consequently, wage growth in the private, sheltered sector and in the public sector is generally determined by developments in manufacturing industry.

In the long term, unit labour costs (ULC) are determined by consumer prices (CPI), producer prices (PY) and the unemployment level (U). Somewhat simplified, the estimated long-term solution of the wage equation in level terms may be written as follows:

$$ulc = wc - zy = k_1 + 0.58cpi + 0.42py - 0.10u \quad (1)$$

where WC is wage costs, ZY is productivity and k_1 is a constant. Small letters indicate logarithmic form, eg $cpi = \ln(CPI)$. With this function, the coefficients may be interpreted as elasticities. Thus, the equation implies that a 1% increase in consumer prices contributes to increasing unit labour costs by 0.58%, while a 1% increase in producer prices contributes to increasing unit labour costs by 0.42% in the long run. Thus, unit labour costs increase proportionally to consumer and producer prices. At the same time, a 1% increase in unemployment (eg from 5% to 5.05%) contributes to reducing unit labour costs by 0.1% in the long run.

The long-term relationship between labour costs, productivity, prices and unemployment may be interpreted as an expression of the social partners' compromise between wage demands (consumer real wage) and profitability requirements (product real wage). Historically, an increase in consumer prices has triggered wage compensation. Thus, by way of wage negotiations, higher consumer prices contribute to increasing wages. The relationship between unit labour costs and producer prices provides an indication of profitability and thus the business sector's capacity to pay. High profitability in companies will contribute over time to increasing the wage level.⁵

The compromise between wage demands and profitability requirements is influenced by labour market developments. The unemployment level may be interpreted as an expression of the bargaining position between the social partners. The non-linear relationship implies that the situation in the labour market has a somewhat stronger effect on wages when unemployment is low than when it is high. This means that a reduction in the unemployment rate of 1 percentage point will have a more significant impact on wage growth if unemployment falls from 4% to 3% (a reduction of 25%) than if it declines from 10% to 9% (a reduction of 10%).

The long-term relationship (1) indicates the wage level approached by the model in equilibrium. If we move all the variables in (1) to the left-hand side of the equation, we can write the long-term relationship as:

$$ulc - k_1 - 0.58cpi - 0.42py + 0.10u = 0 \quad (1')$$

Since the economy is seldom in equilibrium, the long-term relationship (1') will not be satisfied at all times. This will influence short-term wage growth. If the left-hand side of the equation is greater than zero, the cost level is higher than what is compatible with equilibrium. Thus, wage growth will be reduced in the short run. Similarly, wage growth will increase if the cost level is lower than indicated by the long-term relationship. This represents a self-correcting mechanism in the wage equation which ensures that the wage level moves toward an equilibrium level.

⁵ In the December 2000 *Inflation Report*, we discussed the effects of moderating the wage-curling impact of low profitability in the business sector.

However, the movement toward equilibrium will take time. Nominal and real inertia in the economy slow the adjustment towards equilibrium which is modelled in a dynamic wage relationship. According to this wage equation, wage growth (Δwc_t) is affected in the short run by previous changes in wages (Δwc_{t-1}) and prices (Δkpi_{t-1}). This reflects the fact that in general, changing the growth rate in nominal variables takes time. In addition, wage growth varies in relation to productivity growth in the short run (Δzy_{t-1}). Wage growth also depends on changes in unemployment (Δu_{t-1}) in addition to the level of unemployment (u) as it is included in the long-term relationship. Somewhat simplified, the dynamic wage equation is as follows:

$$\Delta wc_t = \quad (2)$$

$$a + b_1 \Delta wc_{t-1} + b_2 \Delta kpi_{t-1} + b_3 \Delta zy_{t-1} - b_4 \Delta u_{t-1}$$

$$- c[ulc - k_1 - 0.58cpi - 0.42py + 0.1u]_{t-1} + add\ factor$$

where a , b_1 , b_2 , b_3 , b_4 and c are positive variables and the add factor captures the variation in data that is not explained by the other variables on the right-hand side of the equation. The estimated relationship is presented in the appendix. The long-term relationship is in brackets. If the value in brackets is positive, the wage level is higher than indicated by the equilibrium relationship and this contributes to reducing wage growth.

In order to serve as a forecasting tool, RIMINI must be able to explain general developments in data over time.⁶ As mentioned in section 2, each equation is evaluated according to a number of criteria. The appendix includes various statistical measures for the wage equation's features evaluated independently of the other equations in the model. Each equation must also be evaluated in relation to how it functions with the other equations in the model's simultaneous equation system. Although the wage equation in isolation has good predictive properties, the model's ability to predict wage growth also depends on the model's ability to explain developments in the endogenous explanatory variables in the wage equation. Only by simulating the entire model is it possible to assess the model's overall predictive properties. This may be done by simulating the model over an historic period when both exogenous and endogenous variables are known. Any deviations between wage projections and actual wage growth may be partly due to the wage equation itself, but may also be due to deviations in important endogenous explanatory variables in the wage equation. These deviations may come from other equations in the model, eg the employment and unemployment equations or the equation for productivity growth. Expressed in another way, poor predictive properties in a single equation may be the source of forecast errors in many of the model's variables. A large part of the assessments made in working with the projections in the

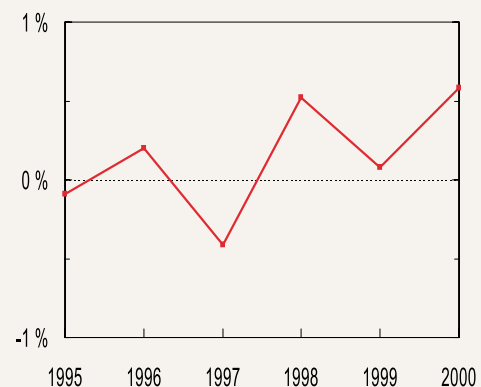
Inflation Report consists of explaining these kinds of systematic deviations in equations and adjusting for this in the forecast period. Therefore, projections in the *Inflation Report* are not only based on the model's properties, but also on a systematic assessment of all the estimated equations in the model and their historical contribution to forecast errors. On the basis of this work, we arrive at a set of adjustment factors for the forecast period. Next, we will look more closely at the wage equation's contribution to deviations between the actual, observed values and the simulated values for wage growth and comment on the use of add factors in the wage equation.

Assessment

Although forecast errors for wage growth may be due to many factors that are not necessarily related to the actual wage equation, the error may also be due to the inability of the wage equation to capture all systematic factors that affect wage growth. While working with our projections, the RIMINI model's simulated add factor values are studied in order to expose such failures, if possible. Chart 1 illustrates the simulated historical add factor values for the wage equation for the years 1995-2000. These add factors illustrate the wage equation's contribution to explaining historical deviations between the model's simulated values and the actual observed values for wage growth.

We see that the add factor in the wage equation has been positive in recent years. This means that the wage equation has generally contributed to underpredicting wage growth in the last half of the 1990s. The positive add factor values may be related to the inability of the wage equation to fully capture the effects of pressures in the labour market when unemployment is low. Chart 1 shows a positive add factor in the wage equation in the years with a main wage settlement, ie in 1996, 1998 and 2000. The add factor was more or less zero in the inter-

Chart 1. Simulated annual add factor values for the wage equation



⁶ This is illustrated by a number of examples in Eitheim and Gulbrandsen (2001).

vening years with interim wage settlements, with the exception of 1997, when an expansion of the contractual pension scheme probably contributed to curbing wage growth measured in NOK.

An evaluation of the projections in the *Inflation Report* shows that we also underpredicted wage growth somewhat in 1996, 1998 and 2000. An important reason for this underprediction was that the add factor was set at zero in the projections for these years. Therefore, in the December 2000 *Inflation Report*, we adjusted the add factor in the wage equation. For the years with a main wage settlement (2002 and 2004), we included a positive contribution from the add factor in the projections, whereas the add factor was set at zero in the years with an interim wage settlement (2001 and 2003). The positive add factor contribution was set slightly below the average add factor correction for the last three main wage settlements (1996, 1998 and 2000) and must be assessed on the basis of the tightness of the labour market.

The consumer price equation

In the consumer price equation, consumer prices (*CPI*) increase in the long run proportionally to unit labour costs (*ULC*) and import prices (*PB*). This means that long-term domestic inflation is a weighted sum of the rise in labour costs and import price inflation. Somewhat simplified, the estimated long-term solution of the equation in level terms may be written:

$$cpi = k_2 + 0.60ulc + 0.40pb \quad (3)$$

Lower case letters indicate logarithmic form as in the wage equation. Thus, equation (3) says that in the long term a 1% increase in *ulc* will translate into a 0.6% rise in the level of consumer prices, while a similar increase in the level of import prices will result in a 0.4% rise in consumer prices.

As with wages, achieving the long-term solution will take time. In the short run, the consumer price equation allows for real and nominal inertia in price formation (see equation 4). First, consumer price inflation today (Δcpi_t) depends on consumer price inflation in previous periods (Δcpi_{t-1}). This effect is relatively strong and means that it will normally take time before inflation returns to the starting point after a shock. Earlier import price inflation (Δpb_{t-1}) and wage growth (Δwc_{t-1}) also affect consumer price inflation. At the same time, when there are pressures in the economy and the output gap (gap_{t-1}) is positive, companies can more easily pass on cost increases to prices than when there are idle resources and the output gap is negative. On the other hand, increased international trade (uei_{t-1}) will intensify competition and squeeze profit margins. Somewhat simplified, the dynamic price equation is as follows:

$$\Delta cpi_t = \alpha + \beta_1 \Delta cpi_{t-1} + \beta_2 \Delta wc_{t-1} + \beta_3 \Delta uei_t + \beta_4 gap_{t-1} + \beta_5 \Delta pb_t - \gamma [cpi - k_2 - 0.6ulc - 0.4pb]_{t-1} + add\ factor_t \quad (4)$$

where α , β_1 , β_2 , β_3 , β_4 , β_5 and γ are positive variables and the add factor captures variation in data that is not explained by the other variables on the right-hand side of the equation. The estimated relationship is presented in the appendix. We recognise the long-term relationship (3), which represents the relationship between consumer prices, labour costs and import prices in equilibrium, in brackets in (4). The long-term relationship contributes to reducing consumer price inflation if the level of consumer prices is higher at the outset than indicated by the long-term solution.

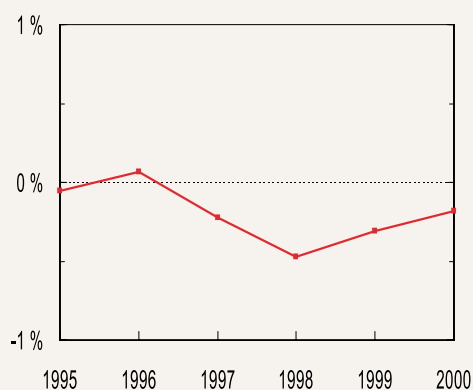
Because the Norwegian economy is open, external inflationary pressures play an important role. In the RIMINI model, import prices are endogenously determined in a relationship where import prices follow foreign export prices in NOK in the long term. It is assumed that foreign export prices are set as a mark-up on producers' costs. This means that import prices in the short term also depend on domestic conditions, such as competition from Norwegian producers and cyclical factors such as demand and unemployment. The estimated consumer price relationship is shown in the appendix together with the equation's statistical properties which have been assessed independently of the others.

Assessment

We base our assessment of the consumer price equation's contribution to explaining the development on historically simulated add factor values for the years 1995-2000 (see Chart 2). The chart shows that in the last half of the 1990s, the equation's add factor has on average been slightly below zero. This means that the consumer price equation has contributed to overpredicting consumer price inflation in recent years.

This may imply that the constant in the consumer price equation has been overestimated. There may be several reasons for this. One explanation may be that consumer price inflation in the simulation period has in general been considerably lower than the observations on which the estimation of the model's coefficients are based. Another explanation that can probably contribute to explaining the deviations is that a number of factors, such as market deregulation, the liberalisation of trade and increased international competition, are not captured in the equation. Since the mid-1990s, prices for imported clothing have shown a downward trend. This may be seen in the light of intensified competition in the textile industry, a reduction of tariff rates and removal of quota regulations, for example in connection with the 1995 WTO Agreement. Price trends for telecommunication services

Chart 2. Simulated annual add factor values for the consumer price equation



and equipment have also been falling the last few years. Intensified competition among an increasing number of market participants and rapid technological developments have triggered the price decline. At the same time, deregulation of the telecommunication services market has probably fuelled the fall in prices for these types of services. The electricity market has also been deregulated, making it easier for companies and private households to change electricity supplier. Increased competition in the electricity market has probably led to lower electricity prices than would otherwise have been the case.

The effects of deregulation and trade liberalisation are difficult to capture in an aggregated price equation such as the one in the RIMINI model. Therefore, these factors may be the cause of the overprediction. However, errors in the historical values that are components on the right-hand side of the price equation cannot be ruled out. If a revision of the national accounts leads to an upward revision of productivity growth the last few years, the model's price forecast will be brought more in line with actual developments.

In view of recent years' experience, with stable negative values in the consumer price equation's add factors, a negative value for the add factor equal to the average over the last few years was used when we prepared the baseline scenario for the December 2000 *Inflation Report*. Such an adjustment may be interpreted as a change in the equation's constant with the result that consumer price inflation for a given development in the right-hand variables will be lower than otherwise. We also adjusted for estimated first-round effects of changes in oil prices, for example, changes in petrol prices. In addition, we adjusted for estimated first-round effects of the indirect tax programme for 2001.

As indicated above, a number of conditions are not captured by the aggregated price equation (4). Therefore, we have developed a set of equations that

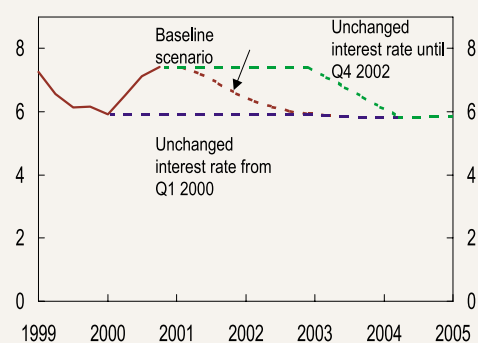
provide a picture of the contributions of the sub-indices in the CPI. This may improve the basis for estimating short-term consumer price inflation and at the same time provide a better basis for analysing current developments in consumer prices. This detailed information will also be useful in adjusting the aggregated consumer price equation.

4 Shift analysis

In addition to providing a basis for our assessment of the projections, calculations performed on the RIMINI model are regularly used to analyse the effects of policy changes and various shocks on the Norwegian economy. Norges Bank places particular emphasis on analysing the effect of interest rate changes on the Norwegian economy.

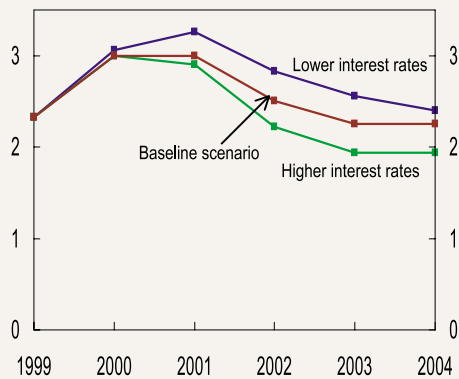
In the December 2000 *Inflation Report*, the RIMINI model was used to illustrate possible effects on the projections of two interest rate scenarios that differed from the baseline scenario (see Chart 3). The projections in the baseline scenario were based on the assumption that interest rates developed in line with market expectations as reflected in forward rates in December 2000. At that time, the market expected a relatively marked decline in money market rates the next two years. In one alternative, we studied the effects of unchanged interest rates the next two years. In the other alternative, we showed what the effects would have been if Norges Bank had kept the key rates unchanged from the beginning of 2000. The projections in the baseline scenario pointed to 2¼% price inflation in 2003. If the interest rate remains high for an additional two years, we suggested that price inflation could be somewhat below 2% in 2003 (see Chart 4). In the alternative where the interest rate was unchanged from the first quarter of 2000, we indicated that price inflation could reach 2½% in 2003. Below we will discuss how the RIMINI model was used in calculating these effects.

Chart 3. Different forward rates paths



Source: Norges Bank

Chart 4. Annual consumer price inflation with different interest rate scenarios. Percentage



Source: Statistics Norway and Norges Bank

Transmission mechanism in RIMINI

Chart 5 illustrates the most important aspects of the transmission mechanism for a given exchange rate as it is modelled in RIMINI. The chart indicates that monetary policy affects consumer price inflation indirectly through a number of channels.

In the RIMINI model, a change in the deposit rate causes an immediate equivalent change in money market rates. Banks' deposit and lending rates are fully adjusted to the change in the following quarter. However, most of the adjustment occurs in the same quarter. A change in interest rates influences household and corporate investment decisions. Chart 5 shows that a change in the decisions of households and businesses will be reflected in aggregate supply factors such as output, productivity and employment as well as in demand factors such as investment and private consumption.

Although there is a strong interaction between supply

and demand in the model, all markets will not be in long-term equilibrium at all times due to nominal and real price inertia. This results in an output gap and unemployment. High unemployment indicates low utilisation of resources and implies a low or negative output gap. This contributes to curbing price inflation and wage growth. Similarly, low unemployment and a positive output gap will be inflationary. Productivity trends are also decisive for price formation. Strong productivity growth will contribute to reducing inflation. In addition, in the RIMINI model, both the interaction between price and wage formation and the repercussions on supply and demand factors are strong.

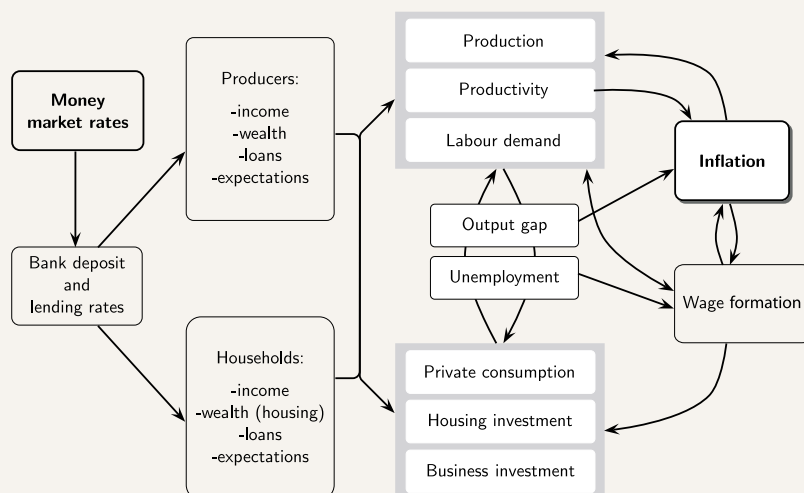
Private consumption accounts for about half of mainland demand. The effect of a change in interest rates on household decisions is therefore of substantial importance for the overall impact on the economy. In the basic version of the RIMINI model, consumption depends primarily on disposable income and then on household wealth. A change in interest rates will affect consumer demand through household disposable income (income effect) and wealth (wealth effect). When the household sector as a whole is in a net debt position, an increase in interest rates will reduce total disposable income and thereby contribute to reducing consumption. Higher interest rates will also contribute, through a lower activity level, to reducing total household wage income. An increase in interest rates will also curb house price inflation, leading to a weaker development in household wealth. Experience shows that the wealth effect will induce households to increase saving as a percentage of income in order to compensate for the wealth loss (see Brodin and Nymoene (1992)).

Developments in house prices are difficult to project, however, and this increases the uncertainty of the consumption projections. Experience in recent years may also indicate that changes in interest rates affect private consumption more rapidly than the wealth effect is capable of capturing. To reduce the dependence of private consumption estimates on projections

for developments in house prices, we have used an alternative equation for private consumption since the June 2000 *Inflation Report*. In this equation, after-tax real interest rates have a direct effect in addition to the income and wealth effects. Thus, the value of housing wealth plays a less significant role than in the basic version of the RIMINI model. Such a relationship is supported by data for the period from 1988.

A possible explanation for the direct effect of interest rates on private consumption is that a rise in interest rates makes saving

Chart 5.



more profitable (substitution effect). It could also be argued that the interest rate level is an indicator of household expectations concerning their own financial situation and domestic economic developments. This possible relationship was discussed in a separate box on the consumer confidence indicator in the June 2000 *Inflation Report*. Experience shows that an increase in interest rates coincided with lower expectations, heightened caution and lower consumption. How stable this relationship will be over time is still an open question, however.

A change in the interest rate will usually have an attendant effect on the exchange rate. This effect will generally depend on the situation, and the formation of expectations will probably have a significant impact on the result. The exchange rate is an exogenous variable in the RIMINI model, which means that it must be determined by the model user when he/she makes the projections. When we conduct shift analyses, we normally assume that the exchange rate changes in line with uncovered interest rate parity. A higher interest rate on NOK denominated instruments is then offset by an immediate appreciation and thereafter a steady depreciation so that the expected return on NOK investments is unchanged.

Through the exchange rate effect, the interest rate affects price inflation more directly than indicated in Chart 5 by influencing imported price inflation. In addition, changes in export and import prices also have an effect on import and export volume and thus aggregate supply and demand. This will in turn affect price and wage formation, as mentioned above. Thus, changes in the exchange rate affect prices both directly and indirectly.

Assessment

The way the RIMINI model is estimated, demand reacts quickly to a change in interest rates. There is, however, a time lag before the supply side (output, employment) responds to the changes in demand. In the short term, most of the adjustment to changes in demand will come in the form of changes in imports and inventories. Even after 2-3 years, output has not adjusted to demand. When we use the RIMINI model, we do not consider this to be a completely reasonable mechanism. We assume that changes in forward-looking behaviour may contribute to hastening the effects of interest rate changes, also on the supply side, compared with the basic version of the RIMINI model. When we employ the alternative consumption function in the model, we advance the effects of interest rate changes on employment and output by one year in relation to what is indicated by the basic version of the RIMINI model.

In the discussion of wage formation, we indicated that the wage equation in the RIMINI model probably does not fully capture the effects of pressures in the labour

market when unemployment is low. Therefore, we correct the add factors in the wage equation so that the simulated wage growth is more in line with wage developments in the last five years. In addition, we adjust the add factor in the wage equation somewhat in those cases where unemployment changes as a result of interest rate changes. Based on our assessment, the wage curve is somewhat steeper for unemployment levels similar to today's level than implied by the estimated relationship.

As mentioned earlier, the exchange rate is an exogenous variable in the RIMINI model. When we use the model to analyse policy, we must make assumptions about how the interest rate affects the exchange rate. If an increase in interest rates is primarily due to domestic factors, a temporary appreciation of the krone exchange rate may be expected. If interest rates are increased to counteract a depreciation of the exchange rate, the effects may be the same, but the relationship will be difficult to identify in retrospect. Due to Norway's long history of a fixed exchange rate regime, it is difficult to estimate how interest rates have affected the krone exchange rate over time.

When our calculations are based on the technical assumption that the exchange rate changes in accordance with the theory of uncovered interest rate parity, the effect on price inflation will come more quickly than if the interest rate only operates through the real economy. As the effects via the exchange rate recede, the effect via the real economy will dominate.

In practice, the exchange rate is influenced by many factors. Evidence supports the validity of purchasing power parity in the long term.⁷ This implies that a particularly high level of price inflation in Norway over time will result in a depreciation of the krone. However, in the short term, factors such as international risk assessments⁸, economic policy credibility, oil prices and terms of trade may affect the exchange rate. When we use the RIMINI model in our work to make a baseline scenario for the *Inflation Report*, we normally assume that the exchange rate is unchanged compared with the level of the last few months. Nevertheless, we can capture the effect of interest rate changes on the exchange rate in retrospect. This is because a change in interest rates that affects the exchange rate will be reflected in a change in exchange rate assumptions from one *Inflation Report* to the next.

5 Summary

Norges Bank uses a number of different tools in making projections for developments in the economy. In this article, we have provided insight into some of the key mechanisms in the macroeconomic model RIMINI and commented on our use of this model in connection with economic analyses. Norges Bank's economic projections are based on the model's relationships supplemented by assessments and judgement. Therefore, projections in the *Inflation Report* are not only based on the

⁷ See, for example, Akram (2000).

⁸ See Bernhardsen and Røisland (2000).

model's properties, but also on a systematic evaluation of all the estimated equations in the model and their historical contribution to forecast errors. The model's properties and results are thoroughly assessed. In the *Inflation Report*, we are careful about providing an account of this judgement. As model users, we continuously take into account current developments in the economy as well as use information of a temporary or permanent nature that we believe is not incorporated in the model's equations. Evaluation of the projections and a constant stream of new information will contribute over time to improving both the modelling tool and the use of the model so that we can interpret trends in the Norwegian economy and make projections about future developments on a more sound basis.

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Annex

Below we present a number of details regarding the estimated dynamic wage and consumer price relationship. The equation is estimated using least-squares regression. Lower case letters indicate that the variables are expressed in logarithmic form so that the estimates may be interpreted as elasticities. The figures in parentheses show the statistical significance (t value) related to the parameter estimate above. The variables are defined below.

Wage equation

$$\begin{aligned} \Delta_4 wc_t = & 0.087 + 0.851 \Delta_3 wc_{t-1} + 0.306 \Delta_3 cpi_{t-1} + 0.127 \Delta_3 zy_{t-3} + 0.042 \Delta_3 pb_t - 0.013 \Delta u_{t-3} - 0.013 \Delta u_{t-1} \\ & (3.97) \quad (20.25) \quad (5.92) \quad (3.35) \quad (3.24) \quad (3.40) \quad (4.32) \\ & + 0.053 \Delta almp - 0.972 \Delta nh_t - 0.124 [wc - zy - py]_{t-4} + 0.072 [cpi - py]_{t-4} + dummies + J.wc_t \\ & (4.59) \quad (7.99) \quad (5.9) \quad (3.24) \end{aligned}$$

Estimation period: 1968Q1–1998Q4

R² = 0.96

Durbin-Watson = 2.24

ARCH 4: F(4.100) = 0.6089 [0.6572]

F(26.81) = 1.01 [0.4658]

T = 124

Standard deviation in per cent = 0.96

AR 1–5: F(5.103) = 0.63961 [0.6700]

Normality: $\chi^2(2) = 1.03 [0.5975]$

RESET F(1.107) = 0.011768 [0.9138]

Note: Figures in parentheses are significance probabilities.

Consumer price equation

$$\Delta cpi_t = 0.014 + 0.058 \Delta cpi_{t-2} + 0.064 \Delta_3 wc_t + 0.153 \Delta wc_{t-3} + 0.024 \Delta pb_t - 0.060 \Delta_2 T3_{t-3} - 0.266 \Delta uei_t$$

(10.01) (1.30) (4.66) (7.09) (2.39) (3.06) (4.54)

$$+ 0.049 gap_{t-1} - 0.069 [cpi_{t-3} - 0.6(wc - zy)_{t-1} - 0.4pb_{t-1} - 0.5T3_{t-5}] + dummies + J.kpi$$

(2.83) (9.69)

Estimation period: 1969Q2–1998Q4
 R² = 0.89
 Durbin-Watson = 1.69
 ARCH 4: F(4.99) = 1.9136 [0.1141]
 F(21.85) = 1.0433 [0.4237]

T = 119
 Standard deviation in per cent = 0.37
 AR 1–5: F(5.103) = 2.1531 [0.0651]
 Normality: $\chi^2(2) = 2.5119$ [0.2848]
 RESET: F(1.106) = 1.4641 [0.2290]

Note: The figures in parentheses are significance probabilities.

List of variables

<i>ALMP</i>	Scope of labour market programmes	<i>U</i>	Unemployment rate including participants in ordinary labour market programmes
<i>GAP</i>	Output gap for mainland Norway. Observed value added as a percentage of potential output	<i>UEI</i>	World trade index
<i>CPI</i>	Consumer price index	<i>WC</i>	Labour cost per hour in manufacturing, building and construction
<i>NH</i>	Normal working hours per week	<i>ZY</i>	Person-hour productivity in manufacturing, building and construction
<i>PB</i>	Import price index in NOK	<i>J.WC</i>	Add factors in the wage equation
<i>PY</i>	Value added deflator in manufacturing, building and construction	<i>J.CPI</i>	Add factors in the consumer price equation
<i>T3</i>	Indirect tax rate		