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Contents

RAMSES – a new general equilibrium model for monetary policy analysis

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Introduction

For little more than one year now a new macroeconomic general equilibrium model of the Swedish economy is being used at the Riksbank for producing forecasts, interpreting economic developments and calculating effects of monetary policy interventions, for example. The model, called RAMSES (the Riksbank Aggregate Macromodel for Studies of the Economy of Sweden), is tailored to describe the development of a number of central macroeconomic time series with the aid of the best available econometric methods. In its methodology the model is in the scientific front line. The model is general in the sense that in principle it aims to explain the entire economy, not just a particular component such as private consumption or the labour market. But that does not mean that RAMSES describes every major aspect of the Swedish economy equally well.[2]

Before looking at the model in more detail, it may be appropriate to consider why the Riksbank uses formal models in monetary policy analyses. Reality is so complex that a model, be it ever so extensive, is bound to be just a simplified version of how the economy actually functions. Even so, using formal models that draw on lessons from economic theory and practical experience has great advantages. The interdependent relationships between different economic components and sectors are so numerous that it is difficult, not to say impossible, to forecast the economic future or analyse effects of a shock by studying individual relationships separately. With a model, a consistent framework can be constructed to

[1] The authors have had fruitful discussions with and received valuable comments from Kerstin Mitlid, Stefan Palmqvist, Staffan Viotti and Anders Vredin but are solely responsible for any remaining errors and obscurities.

[2] The modelling of fiscal policy and the credit market, for example, is not particularly sophisticated in RAMSES. Forecasting work therefore also uses partial models – based on economic theory or mainly on statistical correlations –that focus on a particular variable or sector.

obtain a comprehensive picture of the economy's components, instead of having to rely on fragmentary analyses that may not be entirely compatible. Thus, a model makes it easier to produce a consistent assessment of the future path of the economy's various components. That is particularly important when it comes to analysing alternative assumptions for the formulation of monetary policy. The effect of an interest rate adjustment on inflation depends not only on the reaction of aggregate demand, for example, but also on how the exchange rate reacts and what consequences that has for, say, patterns of consumption and imported inflation. Another advantage is that the model can serve as a tool for understanding the current economic situation and its future development. The observation of a current easing of inflationary pressure, for example, does not necessarily mean that an immediate policy rate reduction is the appropriate reaction because this depends on what is causing the lower inflation. If the cause is, say, supply factors and is thereby associated with rising GDP growth, the policy rate response would naturally be slighter and more gradual than if inflation is slowing on account of demand and is associated with a sharp drop in GDP growth. Another example concerns an upward development of wages: the policy rate should be raised only if wage increases are expected to exceed the rate that is judged to be in line with the development of productivity. With strong productivity growth, higher wage increases may be compatible with the inflation target and hence not require an increased policy rate. Further advantages are that using models to obtain more structured analyses makes it easier to explain forecasts and that a model can serve as a communication tool whereby internal analyses and discussions are held together. In addition, the systematic approach facilitates the evaluation of the forecast errors.

We now provide a somewhat more detailed description of the model. A general equilibrium model is a model which assumes that market mechanisms create a balance between supply and demand in every market in the economy. There are forecasting models which are general in the sense that they describe relationships between a number of sectors in the economy without being equilibrium models. An example is models consisting of a system of statistical relationships with limited support in economic theory, for instance unidentified vector autoregressive (VAR) models.[3] Modern general equilibrium models, on the other hand, normally incorporate some specific assumptions about the behaviour of individuals and organisations.[4] Individuals and households are assumed to maximise "utility" over the life cycle and firms are assumed to maximise the discounted present value of all future profits. This rational behaviour

[3] See, for example, Sims (1980).
[4] See Kydland & Prescott (1982).

also means that individuals and firms base their conduct on the best possible forecasts of the future they are able to obtain. Their expectations are rational. Thus, when RAMSES is used to forecast private sector behaviour, it is assumed that, for example, the effects of monetary policy interventions will be influenced by the private sector's forecasts of how the Riksbank normally will act.

Prior to the 1980s, the approach to analysing and forecasting inflation and the business cycle was dominated, not by general equilibrium models but by Keynesian models. Models of the latter type assume that players in the economy are governed by various rules of thumb. Neither do such models usually assume that expectations of the future are formed rationally; simple projections of earlier patterns in the data are used instead. One reason for choosing this way of describing the economy was the lack of technical tools (theories and computers) that are essential for solving complex systems of equations with forward-looking expectations. But another reason was that the earliest versions of general equilibrium models for studying macroeconomic developments seemed to be at odds with the data. Kydland & Prescott's (1982) fundamental model of the real business cycle, for instance, which emphasised the supply side's importance for understanding macroeconomic developments, was criticised for a lack of empirical realism.[5] The economy seemed to be characterised by much greater rigidities than might be expected if it were governed by market mechanisms and rational households and firms. However, the Keynesian models, which instead emphasised the importance of demand for understanding business cycles, ceased to describe data as well as before from the 1970s onwards, when stagflation (low growth combined with high inflation) showed up in the western world and these models failed to catch a number of structural shifts.[6] In the past decade, extensive academic research, using technical innovations, has developed a new generation of macroeconomic general equilibrium models where the emphasis in economic description is on the supply side but where demand in the short run also plays a role through the existence of various market imperfections combined with nominal and real rigidities. Due to the market imperfections and rigidities, the responses to various disturbances occur more gradually in the model. These second generation macroeconomic general equilibrium models are commonly referred to as New-Keynesian models and have sound, well-documented empirical properties.[7] The Riksbank's new model, RAMSES, belongs to this category.

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5 See, for example, Cogely & Nason (1995).
6 See, for example, Lucas (1976).
7 See, for example, Christiano, Eichenbaum & Evans (2005) and Smets & Wouters (2003).

The purpose of this article is to provide a thorough yet simple description of RAMSES' theoretical structure and empirical characteristics, together with a couple of examples of how the model is used in the regular monetary policy analysis.[8] The article is arranged as follows. RAMSES' cornerstones and theoretical properties in both the long and the short run are presented in the next section, with particular emphasis on the Riksbank's behaviour in the model. We then exemplify the uses of the model in two ways. First we describe how the model could be used to study effects of two alternative scenarios with higher wages. Then we use the model to interpret the path of inflation in 2003–06 with a view to understanding the underlying causes of the low inflation outcome in that period. We also examine the role monetary policy played in stabilising inflation and establishing a lower level in the 1990s. This is followed by a section that explains how the model is estimated on data for Sweden and compares RAMSES' forecasting performance with the performances of some alternative forecasting tools as well as with the Riksbank's historical assessments. Some final reflections conclude.

The model's theoretical properties

This section describes the model's theoretical structure and the mechanisms that determine how monetary policy affects resource utilisation and inflation in the short and long run.

RAMSES' CORNERSTONES

RAMSES consists of numerous different households and firms that interact in markets for goods, capital and labour. As in many other modern New-Keynesian general equilibrium models, markets for goods and labour are assumed to be characterised by monopolistic competition. This means that firms and employees, instead of taking prices and wages as given, are aware that they can influence them by their behaviour. However, as price and wage stickiness is assumed to exist, monetary policy is able to affect the real economy (output and labour supply, for example) in the short run because nominal prices and wages do not freely adjust to a change in the nominal interest rate.

The model also includes a central bank that sets the short-term interest rate and a government sector that is assumed to finance its consumption expenditure by taxing labour and consumption. There is also a foreign economy that, since Sweden is a small open economy, is assumed

[8] A detailed description of the model's theoretical structure is given in Adolfson, Laséen, Lindé & Villani (2005). A fuller empirical evaluation is presented in an article by the same authors (Adolfson, Laséen, Lindé & Villani, 2007).

to be unaffected by domestic economic developments in Sweden. In the model, consumer and investment goods are partly imported from the rest of the world and a part of domestic output is exported.

Without the nominal stickiness, RAMSES would closely resemble the first generation of macroeconomic general equilibrium models, for instance the real business cycle model presented by Nobel laureates Kydland & Prescott (1982). The formulation of monetary policy would then be irrelevant for business cycle analysis because monetary policy's impact on the real economy is very limited when prices and wages are entirely flexible; monetary policy would then be reduced to a tool for influencing the level of inflation only. An instructive introduction to a simple model of the real business cycle and how New-Keynesian aspects can be incorporated in it is to be found in Goodfriend (2002) and is recommended for a fuller understanding of the fundamental mechanisms contained in general equilibrium models. The description below is confined to RAMSES' most important aspects.

Households

Let us begin with households' behaviour in the model. Households are assumed to maximise their utility consumption and leisure over time, given a limited budget with earned as well as capital incomes. Households have access to an international credit market for investment or borrowing at the short-term nominal interest rates set by the domestic and foreign central banks. Households decide how much they consume today compared with tomorrow and how they divide their time between work and leisure. Leisure is determined by deciding the wage they are prepared to work for, assuming wage stickiness.[9] Given the wage, firms then decide labour demand. As holders of capital, households also decide how much to invest in the capital stock, which is then lent to firms.[10]

The nominal rigidities in the economy are accompanied by real rigidities. Households are averse to rapid changes in their pattern of consumption and for firms it is costly to change their investments. In this way, frictions that are supported in the data can be taken into account in the model while still assuming that rational behaviour and market mechanisms determine the economy's long-term path. It should, however, be borne in mind that it is not the real frictions as such, only the nominal

[9] Individual households are not free to choose their wage in every period, so overall wage development is sticky. This is modelled with the aid of Calco probabilities (see Calvo, 1983), which means that while certain individuals are able to choose their desired wage, others have their earlier wage indexed in a standard way that does not allow for new shocks in the economy.

[10] It does not seem unreasonable that households own firms as direct shareholders or via pension funds or other mutual funds. This is not modelled explicitly but the simplified assumption is of little consequence for the analyses that are made with the model.

frictions, that enable monetary policy to have short-run effects. Nevertheless, the real rigidness are important because they influence how interest rate changes affect the economy.

The fact that Sweden is a small open economy with relatively extensive foreign trade has to be incorporated in the model. We assume that households' basket of goods consists of domestic as well as imported items. The rate of core (UNDIX) inflation in RAMSES therefore comprises a domestically generated component, inflation from domestic products, π_t^d, and a component connected with the rest of the world, inflation from imported consumer goods, $\pi_t^{m,c}$. UNDIX inflation (π_t) can then be written in log-linearised form:

$$\hat{\pi}_t = (1-\tilde{\omega}_c)\hat{\pi}_t^d + \tilde{\omega}_c\hat{\pi}_t^{m,c}, \quad (1)$$

where $\tilde{\omega}_c$ is the weight for imported goods. Statistics Sweden usually assigns approximately 35 per cent of the items in the UNDIX basket to the imported category. However, pries for these products partly mirror domestically generated processing costs, for example distribution costs for transportation and retailing. In RAMSES the weight is therefore set to about 27 per cent. We shall return to the determination of π_t^d and $\pi_t^{m,c}$ after explaining the behaviour of firms in the model.

As a model for a small open economy, RAMSES also needs to describe how the nominal exchange rate is determined. The starting point here is an interest rate parity condition that assumes a freely floating currency. As mentioned earlier, households have access to an international credit market that enables them to invest in both domestic and foreign bonds, though domestic households that borrow capital abroad have to pay a risk premium on top of the foreign short-term interest rate. It seems reasonable to assume that the exchange rate adapts so that the expected yield in the domestic currency is the same regardless of the type of asset in which households invest. However, as this condition – uncovered interest rate parity – has relatively limited empirical support, we have modified it to include the correlations between the risk premium and the exchange rate's expected path that are supported in the data.[11,12]

Firms

We shall now describe how firms act in RAMSES. The goods market is characterised by monopolistic competition, with each domestic firm pro-

[11] For a test of uncovered interest rate parity see, for example, Fama (1984) and Duarte & Stockman (2005).

[12] For a fuller description of the modified interest rate parity condition and how it affects the determination of the exchange rate and the model's empirical characteristics, see Adolfson, Laséen, Lindé & Villani (2007).

ducing a particular kind of good with the aid of labour and capital rented from households. Thus, each firm has a certain degree of monopoly power and can therefore set its price as a mark-up on its nominal marginal costs.[13] The size of the mark-up depends in the long run on households' propensity to substitute one firm's type of product for others. The greater this propensity, the smaller will be firms' profit margins in the long run. When firms have reason to alter the mark-up, this affects inflation gradually and with some time lag because prices are rigid in RAMSES. The underlying reasons for price stickiness are menu costs, the cost to firms for obtaining new information about the demand situation and the structure of costs for a particular product, and firms' reluctance to disturb customer relations by adjusting prices frequently.[14] So in the event of a change in the economy, nominal prices are adjusted to a new long-term and stable equilibrium, not immediately but gradually. The difference is absorbed by the mark-up, which fluctuates when conditions change.

Firms are assumed to maximise the discounted present value of all future profits under the assumption that prices can not adjust freely.[15] The existence of price stickiness means that expectations of future inflation are taken into account when firms set prices today. As future inflation mirrors the likely future path of marginal costs, firms base their pricing on these expectations. Profit maximisation leads to the New-Keynesian Phillips curve, which can be written in a simplified (log-linearised) form as:

$$(2) \qquad \hat{\pi}_t^d = E_t(\hat{\pi}_{t+1}^d) + \gamma(mc_t + \hat{\lambda}_t^d),$$

where inflation, $\hat{\pi}_t^d$, is dependent on expected future inflation, $E_t(\hat{\pi}_{t+1}^d)$, firms' real marginal costs, mc_t, which are equivalent to the wage share of production costs (that is, to real unit labour costs,), with $\hat{\lambda}_t^d$ interpreted as a shock to the desired price mark-up, for example a change in competition. The parameter γ regulates the degree of stickiness in firms' price setting: the longer the interval between price adjustments, the lower the value of γ and hence the smaller the impact on inflation from changes in costs and mark-ups. Equation (2) can also be written so that the rate of inflation today $\hat{\pi}_t$ is a discounted sum of all future real marginal costs. This means that if firms foresee a future increase in real marginal costs (for instance because nominal wages are rising faster than productivity), they will ensure partial compensation for this by raising prices today. As

[13] This can be expressed mathematically as $P_t = \lambda_t^d MC_t$, where λ_t^d is the mark-up and MC_t the firm's nominal marginal costs.

[14] Evidence of price and wage rigidities is also to be found in empirical studies of the price-setting behaviour of Swedish firms; see, for example, Apel, Friberg & Hallsten (2005).

[15] This is modelled with the Calvo model, see Calvo (1983).

a result, real marginal costs return in time to the equilibrium level and so does inflation. Thus, the price-setting behaviour of firms is forward-looking, whereas with the Phillips curves in the early Keynesian models, firms were assumed to be mostly backward-looking.

Another assumption in RAMSES is that a separate category of firms import consumer and investment goods. They purchase intermediate products in the world market for subsequent processing and sale to households. The marginal cost is accordingly equivalent to the procurement cost expressed in Swedish kronor. Possible examples of the goods are textile garments and food products that are repackaged for distribution to retailers. The import firms are able to produce goods that differ from the ones produced by their competitors and accordingly have some degree of monopoly power that enables them to set the price as a mark-up on the marginal costs. In a world with flexible prices, the optimal price of imported products would therefore be given by:

$$(3) \qquad P_t^m = \lambda_t^m P_t^* S_t ,$$

where λ_t^m is the mark-up (profit margin), P_t^* is the world market price and S_t is the nominal exchange rate expressed as the cost in Swedish kronor of purchasing one unit of foreign currency. However, as import price stickiness is assumed, too, price formation is also influenced by expectations of future inflation. Moreover, the stickiness prevents import firms from adjusting prices fully when, for instance, a weaker exchange rate causes an increase in procurement costs. In the short run the model accordingly captures what is usually called an incomplete exchange rate pass-through: instead of immediately passing exchange rate movements on in prices in a one-to-one relationship, firms absorb a part of the change in profit margins. One reason for doing so may be that the exchange rate movement is expected to be transient and recurrent price adjustments might disturb customer relations. Another may be that a firm prefers to defend its market share from other producers that do not have the same structure of costs and are therefore not exposed to the same effect of exchange rate movements.

Domestic goods are exported in the same way in the model; that is, by a separate category of firms which produce domestic goods and distribute them to households abroad. Price-setting by export firms resembles that by import firms. Stickiness is likewise assumed to prevent the free adjustment of export prices in foreign currency, so an incomplete exchange rate pass-through also applies in the export sector (this means, for instance, that the price of Volvo cars in the United States does not rise immediately when the dollar depreciates against the krona).

The central bank

In RAMSES the Riksbank is assumed to determine the level of the policy rate in the light of how inflation and GDP are developing. This is a relevant description of monetary policy in most inflation-targeting regimes, though of course it is a simplification of reality.[16] The interest rate rule in the model has the following form:

$$(4) \qquad R_t = f\left(\pi_t - \bar{\pi}_t, y_t, \Delta\pi_t, \Delta y_t, x_t, R_{t-1}\right) + \varepsilon_{R,t}$$

where *f* is a function that describes how the policy rate (R_t) is set in relation to the gap between actual underlying inflation and the inflation target ($\pi_t - \bar{\pi}_t$), the level of the GDP gap (y_t)[17], the change in the rate of underlying inflation ($\Delta\pi_t$), the change in the GDP gap (Δy_t), the real exchange rate gap (x_t)[18] and the policy rate in the preceding period. The inclusion of the earlier policy rate allows for lags in the interpretation of new information and also mirrors the aversion to unduly rapid interest rate changes. The Riksbank accordingly acts gradually, a behaviour that is usually called interest rate smoothing (see, for example, Woodford, 1999).

The parameters in the monetary policy rule presented above are estimated to give a relatively close approximation to the Riksbank's real-life policy rate decisions over the years. This means, for instance, that the policy rate has been increased/decreased when underlying inflation has been above/below the inflation target or when the GDP gap has been positive/negative. The discrepancies between the historical policy rate decisions and the decisions that would have resulted from a strict application of the model's interest rate rule can be seen as a measure of the element of monetary policy surprises. The surprises are embodied in the variable $\varepsilon_{R,t}$ which is assumed to be random and independent over time. Some surprises can be said to represent temporary changes on the monetary policy strategy; others may be due to the Riksbank's practice of raising the policy rate in discrete steps of, say, 25 or 50 basis points, whereas the monetary policy rule in the model does not have such a stepwise appearance.

The specification of the reaction function raises at least two important questions. One is why the Riksbank is not assumed to react to the

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[16] In many economic models, including RAMSES, monetary policy is described with the aid of a Taylor rule; see Taylor (1993).

[17] The GDP gap, y_t, is defined as the percentage deviation of actual GDP, Y_t, from the long-term sustainable (steady-state) level of output, $\bar{Y}_t$, i.e. $y_t = \ln Y_t - \ln \bar{Y}_t$.

[18] The real exchange rate gap, *x*, is calculated as the percentage deviation of the actual real exchange rate from an assumed equilibrium level that is constant in Adolfson et al. (2005, 2007) but varies over time in the version of the model that is used for forecasts.

prospects for future inflation. The answer is that the reaction function should be regarded as a reduced form that contains most of the relevant information that determines the outlook for future inflation. Another question is why the Riksbank does not consider more variables than are included in equation (4), for example house prices and other indicators. The answer is that the Riksbank is assumed to consider other factors only insofar as they affect the Bank's assessment of resource utilisation and inflation prospects. Thus, it is assumed that the Riksbank does not react directly to factors such as a stronger development of house prices or credit growth.

Other components

As RAMSES describes a small open economy, the domestic economy does not influence either GDP, inflation or interest rates abroad. In their decisions, domestic households and firms accordingly take these foreign variables as given. The interaction of these three variables is therefore described in a separate set of equations.

The government sector is likewise modelled with the aid of a separate set of equations for public expenditures, income tax, value-added tax and employers' contributions. The government sector's budget can run a surplus or a deficit but in both cases this is transferred directly to households. In other words, households behave in such a way that a budget deficit, for example, is balanced by increased saving; this means that fiscal policy interventions are of little consequence in the model.[19]

A financial sector is included in RAMSES, albeit as a very simplified version of reality. As mentioned earlier, households have access to an international credit market for borrowing and investment. The model also has a domestic financial intermediary that accepts households' deposits of financial capital and lends capital to firms for funding borrowing costs. It follows that interest rate changes have a direct impact on firms' marginal costs. This is a simple way of representing that monetary policy has certain effects on supply in that firms tend to borrow for their operations.[20]

As in the seminal work of Kydland and Prescott (1982), fluctuations in aggregate quantities and prices are partly driven by changes in foreign conditions and fiscal policy discussed above, but also other stochastic variables (shocks) with different probability distributions. These probability distributions are the starting point for estimations of the model. The

[19] This household behaviour is usually described as conforming to Ricardian equivalence: households plan consumption on the basis of their expected total lifetime income rather than actual current income.

[20] A more realistic model of monetary policy's interaction with the financial sector is presented in Christiano, Rostagno & Motto (2007).

size and time path of the shocks are determined when the model is estimated on its links to the variables that can be observed in the data (see the Appendix). As each shock enters the model's structure in a particular way that is predetermined, it can be given a definite interpretation. The shocks, which are exogenous in the model, represent such things as changes in productivity, preferences and firms' competitive situation.[21]

The model can be formulated as a number of mathematical conditions that describe how households and firms act, given the assumption of an optimising behaviour with rational expectations and with the short-term nominal interest rate controlled by the Riksbank. RAMSES contains 24 equations for this. Together with the equations for conditions abroad, the conduct of fiscal policy and the course of shocks to the economy, they constitute a consistent mathematical system of non-linear differential equations that produces a fairly acceptable picture of how the economy develops over time.

THE MODEL'S LONG-TERM DYNAMICS

An established opinion among most academic economists, as well as in the central bank world, is that in the long run the levels of output and employment are not influenced by monetary policy, being determined instead by labour supply and technology. This view characterises RAMSES; in keeping with the mainstream literature in the field (see, for example Woodford, 2003), it is assumed that monetary policy is incapable of permanently affecting either output or employment in the long run, that is, in the steady state.[22] If the Riksbank were to decide to implement a more expansionary policy, the end result would simply be higher inflation.

Denoting the sustainable rate of productivity growth as μ_Y, per-capital GDP growth in steady state is given by

$$\frac{\overline{Y}_t - \overline{Y}_{t-1}}{\overline{Y}_{t-1}} \equiv \mu_Y , \tag{5}$$

where $\overline{Y}_t$ indicates that it is the long-term sustainable level of GDP per capita in period *t* that is intended.[23] Monetary policy cannot generate a permanently higher rate of output and thereby higher employment. In

[21] Note that this view of shocks differs from Keynesian models, where all residuals are regarded as "model errors". Here they can be given a structural interpretation instead.

[22] Steady state refers here to the state of the economy when all shocks have been fully incorporated into the economy and prices and wages are flexible.

[23] In the long run, the level of per-capita GDP is determined by the growth of labour productivity, which matches the growth of technology. The GDP growth rate is given in turn by the increase in the level of per-capita GDP plus the growth of labour supply.

this perspective, inflation is only a monetary phenomenon, which means that the Phillips curve (the relationship between inflation and some measure of resource utilisation) is vertical in the long run.

Thus, neither the level of GDP nor its growth rate in the long run can be influenced by the Riksbank changing its policy rate. But the central bank does determine the long-term rate of inflation. For a 2 per cent rate of inflation in the long run, the short-term nominal interest rate must in time equal the inflation target (2%) plus productivity's growth rate (say 2.25%), so that the following equation holds:

$$\bar{R} = \bar{\pi} + \mu_Y, \quad (6)$$

where the yield on the real capital stock (the real interest rate) approximately equals productivity's growth rate, μ_Y.[24] The thinking behind equation (6) is simple: for a household to hold a nominal bond, the nominal yield should be equivalent to what the household would have obtained by investing instead in the capital stock (μ_Y) plus a compensation for the reduction of the asset's nominal purchasing power ($\bar{\pi}$).

As RAMSES is a model for a small open economy, the long-term paths of the nominal and the real exchange rates are also endogenous in the model. In the version of RAMSES that is used for the Riksbank's internal analyses it is assumed that the domestic inflation target is the same as in the rest of the world and that domestic productivity in the long run is also the same in Sweden as elsewhere. Consequently, in the long run there is no appreciation or depreciation of either the real or the nominal exchange rate (see the box).

The nominal exchange rate S_t measures the cost in kronor of buying one unit of foreign currency. When S_t rises/falls, a unit of foreign currency costs more/less (the krona depreciates/appreciates). The exchange rate in the model is a weighted average of a variety of exchange rates (a TCW index). The real exchange rate Q_t is by definition given by $Q_t = S_t P_t^* / P_t$, where P_t^* and P_t are the foreign and the domestic CPI, respectively. In the same way as for the nominal exchange rate, the real exchange rate is said to depreciate/appreciate when Q_t rises/falls. So a higher/lower value of *Q* implies that the cost in kronor of buying a foreign basket of goods increases/decreases relative to the cost of buying a basket of Swedish goods. Taking μ_Y^* to be foreign productivity growth, the long-term path of the nominal exchange rate is determined as follows:

[24] This relationship holds exactly in the absence of capital taxes and given a discounting factor of one.

(B.1) $$\ln \bar{S}_{t+1} - \ln \bar{S}_t = \bar{R} - \bar{R}^* = (\bar{\pi} + \mu_Y) - (\bar{\pi}^* + \mu_Y^*),$$

where the second equality follows from equation (6) and where $\bar{\pi}^*$ denotes the rate of foreign inflation and $\ln \bar{S}_{t+1} - \ln \bar{S}_t$ is the percentage change in the nominal exchange rate.[25] Countries with an exchange rate that depreciates in the long run should accordingly have higher nominal interest rates than the rest of the world. Another implication is that if the foreign and the domestic productivity growth rates are the same in the long run, the domestic currency will depreciate if the domestic inflation target is higher than the inflation target in the rest of the world.

The definition of the real exchange rate, together with the relationship between the nominal exchange rate, the inflation target and the productivity differential in equation (B.1), can be used to derive the following relationship, which determines the real exchange rate's long-term path:

(B.2) $$\ln \bar{Q}_{t+1} - \ln \bar{Q}_t = \mu_Y - \mu_Y^*,$$

This means that the path of the real exchange rate is ultimately determined by the productivity differential between the domestic economy and the rest of the world. If in the long run domestic productivity growth is higher than abroad, in the long run the real exchange will depreciate.[26]

This result – that a country's real exchange rate depreciates if its productivity growth is higher than abroad – flatly contradicts the Balassa-Samuelson hypothesis (see Balassa, 1964, and Samuelson, 1964). While the hypothesis does have some support when developing and industrialised economies are compared, it seems to have little support in a comparison of real exchange rates among developed economies; see, for example, Lee & Tang (2007) and the references there. As the exchange rates in the TCW index are mainly those of industrialised countries, there seems to be reasonably good agreement between RAMSES and data on the real exchange rate and productivity differentials.

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[25] An implicit assumption in this account is that the factors which determine the short-term dynamics of the risk premium do not affect the risk premium in the long run and therefore disappear in the long run. This means that the GDP share for total net wealth vis-à-vis the rest of the world is irrelevant for the exchange rate's long-term path.

[26] That the real exchange rate depreciates in such a notional situation is logical because otherwise the domestic economy would ultimately be the global economy. The economic reasoning behind a depreciation of the real exchange rate is that foreign currency prices for Swedish goods must fall to induce the rest of the world to buy the increased volume of export in such a case. An alternative way of looking at this is that in such a case, Swedish export firms are more productive than firms abroad and their production costs are therefore lower; this enables them to have lower selling prices than firms abroad without any loss of profit. As productivity is directly related to the real interest rate in RAMSES, equation (B.2) also implies that a higher real interest rate than abroad leads in the long run to a real exchange rate depreciation.

The description above indicates that in the long run, monetary policy acts mainly by stabilising firms' and households' inflation expectations around the stated inflation target. This is somewhat different from the everyday picture and the frequently-heard argument that monetary policy's influence on inflation comes from its impact on aggregated demand. Both arguments are correct in RAMSES, however, since monetary policy has effects on the real economy because prices and wages are sticky.[27] The notion that monetary policy cannot have a lasting effect on the level of employment or output is the prevailing view among economists but there is still broad agreement that the economy's cyclical path is driven not only by changes in labour supply or production technology, for example, but also by monetary policy.[28]

Besides the nominal rigidities in RAMSES (price and wage stickiness), which are necessary if monetary policy is to affect resource utilisation, the path of the economy in the model is affected by real rigidities. The two most important real rigidities are habit formation in households' consumption behaviour and adjustment costs for changing the degree of investment.[29] With these two frictions, the economic impact of a monetary policy tightening occurs more gradually than it would without them. Thus, it is a combination of nominal and real rigidities in RAMSES that gives rise to reasonable effects of interest rate adjustment's, commonly referred to as the monetary policy transmission mechanism.

In RAMSES, a *temporary* policy rate increase leads to falling demand for goods and services because the real interest rate rises when price and wage are sticky. A *temporary* increase refers here to an increase of, say, 0.25 per cent in $\varepsilon_{R,t}$, with a return to the long-term equilibrium level of 4.25 per cent that is determined by the systematic component of the interest rate rule (how the unexpected increase today affects the future paths of inflation and the GDP gap). That households lower their demand for consumer goods is rational because a higher interest rate makes saving for future consumption more profitable. Investment also falls because the higher interest rate increases borrowing costs. With lower demand, output declines and so, therefore, does demand for labour and capital. The price of factors of production then falls, which reduces firms' marginal costs. Lower marginal costs lead in time to price reductions, which lowers the rate of inflation. This is the traditional *interest rate channel*.

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27 The degree of price and wage stickiness is determined empirically, using the best available estimation techniques; see the section below on estimating the model with Bayesian methods.

28 Monetary policy has real effects in the short run, so the coefficients in the systematic component of the reaction function affect the way in which different shocks affect the economy. For a fuller discussion, see for example Giavazzi & Mishkin (2006).

29 The relevance of the two real rigidities has been determined by evaluating how the model fits the historical variation in the data.

As RAMSES is a model for an open economy, the interest rate increase also causes the krona to appreciate relative to other currencies and that in turn weakens the balance of trade. To some extent, this accentuates the fall in demand. Inflation is affected as well because a stronger exchange rate lowers the price of imported goods at the same time as decreased net exports leads to a weakening of domestic demand and thereby contributes to the slowdown in domestic prices. This mechanism for monetary policy's economic impact is commonly called the *exchange rate channel*.

In time, prices and nominal wages will be adjusted downwards more and more by firms and households as the interest rate increase results in a contraction of the nominal money supply. Monetary policy's effect on the level of economic activity accordingly diminishes. When prices and wages have finally been fully adjusted by firms and households, the economy will return to the path that would have been forecast without the policy rate increase. Inflation finally returns to the targeted rate, the level of GDP returns to the steady-sate equilibrium path $\overline{Y}_t$ and the interest rate is back at its initial level. Thus, the monetary policy tightening does not affect either the level of GDP or its growth rate in the long run, in accordance with equation (5) above. An alternative way of putting this is that in the long run the level of GDP is determined solely by supply and monetary policy acts like a demand shock that only affects the GDP gap in the short and medium run.

The model's applications

An important part of the Riksbank's analysis of future economic developments is the analysis of scenarios concerning possible future paths for wages, interest rates or a different economic development abroad, for example. RAMSES can be used to analyse the combined consequences of a proposed alternative scenario. This is done by letting one or more exogenous shocks in the model, for instance a change in productivity or in price mark-ups, generate an alternative economic development. The model's other forecasts are then conditioned upon the predetermined development of these variables.[30] Similarly, one can study how the model's dynamic course in the various alternative scenarios is affected by alternative assumptions about, for example, the degree of nominal stickiness or the conduct of economic policy. In the following subsections we exemplify how two alternative scenarios can be analysed in the framework for RAMSES and how such an analysis can be structured by

[30] As mentioned earlier, the shocks in RAMSES describe conditions that cannot be explained within the model (see the section on RAMSES' cornerstones). The shocks can therefore be revised so that the model replicates the desired path for a particular variable.

the model. The first scenario involves households obtaining real wage increases that exceed what prevailing productivity allows; in the second, increases in productivity that are lasting but not permanent motivate higher real wage increases than normal. Thus, both scenarios concern real wage increases but the shocks that cause them differ.

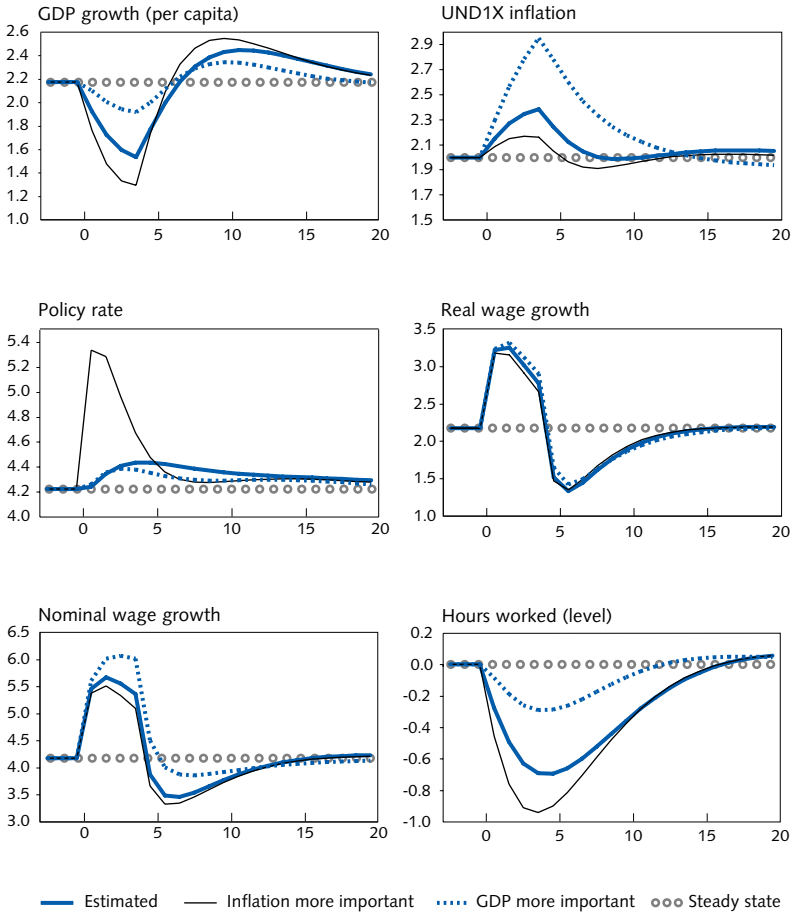
Besides using RAMSES for forecasting and scenarios, the Riksbank needs to understand the current economic situation and what the main driving forces have been in the recent past. This information is, of course, also useful for assessments of the economic future. A model can be used to analyse a particular economic development's underlying causes. As the shocks in RAMSES can be interpreted in economic terms (shocks that represent progress in productivity is one example), an opinion about which shocks have been important for the economy's historical development can be formed by excluding the shocks from the model one at a time. This can provide an indication of what would have happened in the economy if various shocks had not occurred. For instance, what part has the high productivity played for the low inflation in the 2000s and how would inflation have developed without the unexpectedly high productivity? The third subsection presents examples of such an exercise in which the model interprets the causes of the low inflation in the past three years.

AN ALTERNATIVE SCENARIO WITH HIGHER WAGES

Chart 1 presents an example of an alternative scenario with higher wages. The assumption is a temporary upward shift of about one percentage point in the rate of real wage increases, from the long-term stable rate of 2.2 per cent to about 3 per cent.[31] The chart shows how inflation, GDP, nominal wages and hours worked change in such a scenario. The higher rate of wage increases weakens firms' demand for labour and GDP growth falls below the long-term stable rate. As the real wage rise is not matched by increased productivity, labour demand decreases and the number of hours worked falls. The higher wage increases also lead to higher marginal costs for firms, which strengthens inflationary pressure. How much and how quickly inflation rises depends on the conduct of monetary policy. The solid curve represents what happens when the Riksbank sets the policy rate more or less in accordance with its historical decisions, that is, in line with the estimated interest rate rule. This causes

[31] This is generated in the model with the aid of a shock that reduces labour supply. The magnitude of the shock that is fed into the model is set to 0.59 per cent, which is equivalent to the estimated standard deviation. The real wage response is then determined endogenously in the model in relation to how other determinants of real wages are affected by, for instance, the monetary policy reaction to this shock. We start here from steady state but the scenario can of course be arranged around a specific main scenario.

Chart 1. Average economic growth with higher wages and alternative monetary policy tightenings.
Percentage annual changes



the Riksbank to raise the policy rate about 20 basis points to return inflation to its long-term equilibrium approximately two years ahead. The higher interest rate also contributes to the slowing of GDP growth. To illustrate the monetary policy deliberations such a scenario evokes, the chart also includes two alternative monetary policy responses. The thin black curve is what happens when the Riksbank attaches most importance to the inflation target and pays little consideration to the real economy, while the dotted curve is when the Riksbank attaches greater weight to real stability.[32] We see that when the real economy is hardly

[32] The scenario with inflation as most important (dashed curve) is generated from the interest rate rule where the response coefficients to inflation's deviation from the target and to changes in inflation are set to 5 and 2.5, respectively and the change in the GDP gap is set to 0. The scenario with GDP as most important (dotted curve) is generated with the coefficients for the GDP gap and the change in the GDP gap uprated to 1 and 0.5, respectively. This is to be compared with the solid curve, which is generated with the model's estimated interest rate rule, with coefficients of 1.7 and 0.3 for inflation and changes in inflation, respectively, and 0.04 and 0.1 for the GDP gap and changes in the GDP gap.

considered at all, the Riksbank raises the policy rate sharply to over 5 per cent to dampen inflationary pressure. GDP growth then weakens somewhat more than in the main case (solid curve). If, instead, the Riksbank attaches greater importance to real stability than to the inflation target, the increased inflationary pressure elicits just a marginal adjustment of the policy rate. Thus, to avoid a marked weakening of real growth, inflation is allowed to shoot up and thereby counter the real wage increases. In the somewhat longer run, the rate of real wage increases will slacken temporarily to below what is sustainable in the long-term so that the real wage level can return to its long-term path. As the shock is transient, GDP also returns to its long-term sustainable level. Thus, the chart shows that in such a scenario the Riksbank cannot simultaneously stabilise inflation and GDP. A trade-off between nominal and real volatility is called for.

AN ALTERNATIVE SCENARIO WITH HIGHER PRODUCTIVITY

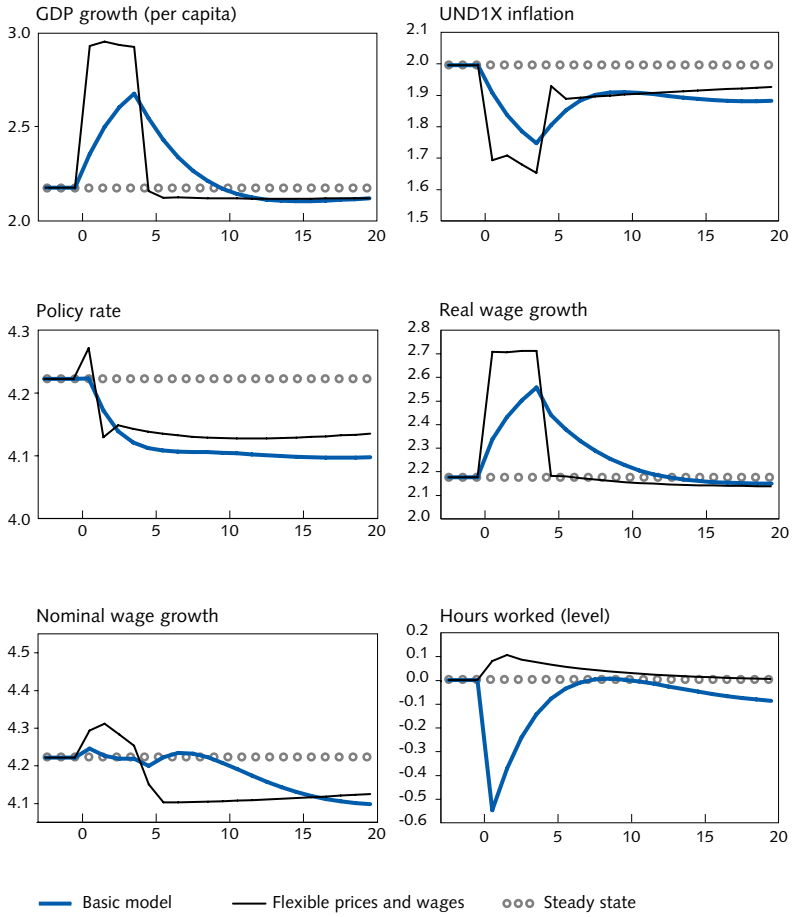
In the second exercise the assumption instead is that real wages rise on account of a lasting but not a permanent increase in total factor productivity (TFP). The duration of the increase is given by the model's estimates and is thus a guess with a firm foundation in the currently available information about the average duration of technological improvements in productivity.

Here, too, results are presented for variants of the model (see Chart 2). First there is the basic model, that is, the model that is actually used for Riksbank analyses. Then there is a variant of RAMSES that does not include the nominal and real rigidities, making this a real business cycle model, similar to Kydland & Prescott's (1982), for a small open economy.

As Chart 2 shows, a positive shock to TFP gives a strong real wage rise. But in contrast to Chart 1, inflation falls because with wage stickiness, the real wage increases are exceeded by underlying productivity growth and firms' marginal costs decline. As prices and real wages move in opposite directions, the nominal wage changes only slightly in relation to its long-term path. Notwithstanding a fall in the number of hours worked, per-capita GDP growth rises. Even so, the Riksbank lowers the policy rate because the monetary policy reaction function in the model attaches greater importance to the slackening of inflation. Due to the long duration of the shock, the adjustment back to the long-term steady state is relatively gradual.[33]

[33] The duration of the TFP increase is such that 60 per cent of it remains after 5 years, that is, the root in the underlying AR(1) process for the non-permanent increase in TFP is 0.975.

Chart 2. Average economic development with higher productivity with and without nominal and real frictions.
Percentage annual changes



Compared with the responses in the basic model, excluding the nominal and real rigidities from the model gives effects that appear and disappear considerably faster. In the real business cycle model, the real wage increases are so rapid that nominal wages also rise initially. As the shock is not permanent, the economy will be brought back to the early forecast paths for the levels of real variables (per-capita GDP, for instance) and growth will therefore be below the rate in the long-term steady state for a long time to come.

A notable difference between the two models concerns the response in hours worked. Without nominal and real wage stickiness, labour supply rises, whereas it falls sharply in the basic model. Rising labour supply after a productivity shock is in line with the predictions from simple real business cycle models (Goodfriend, 2002; Kydland & Prescott, 1982), where households and firms benefit from a period of being more produc-

tive. In the model with nominal and real frictions, households find that it does not pay to work more. So in RAMSES such an increase in productivity can generate GDP growth combined with a fall in the number employed and hours worked, which resembles what happened in the Swedish economy in the period 2003–05.

These exercises and alternative scenarios show that a model like RAMSES can provide very valuable information about topical monetary policy problems. We have analysed the consequences of high productivity growth, a phenomenon that has characterised the Swedish economy in recent years, and of strong wage increases, a risk scenario that many have in mind when looking ahead a couple of years.

WHY WAS INFLATION SO LOW 2003–06?

By decomposing the results, RAMSES can also be used to throw light on the driving forces behind earlier economic developments. To illustrate this, we use the model to filter out the factors behind the low inflation in recent years.

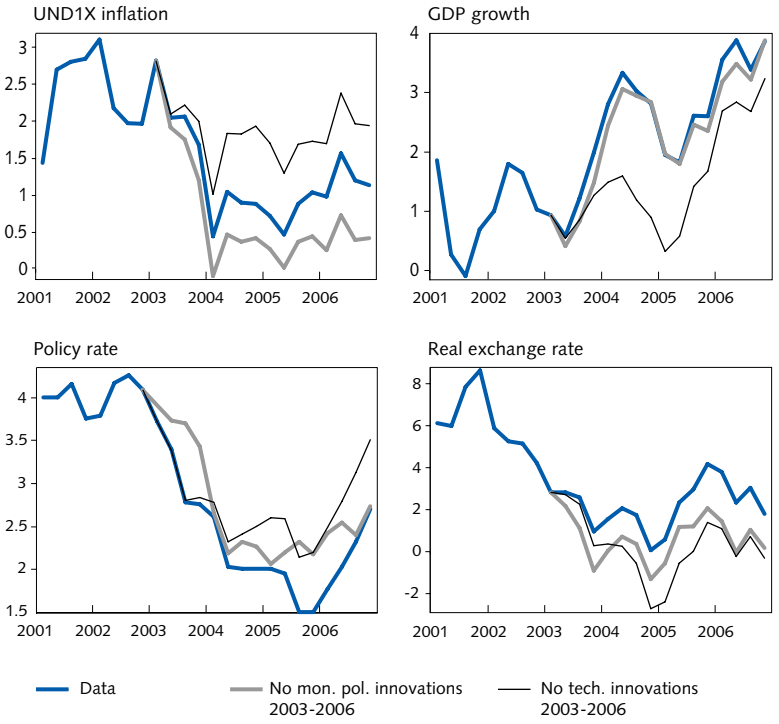
Chart 3 presents outcomes and model forecasts of inflation, GDP growth and the policy rate in the period 2003–06. The blue curves represent outcome data and the black curves show the model's forecasts of e.g. inflation given that no new shocks to productivity had occurred in the period. The latter implies that there were no technological improvements (or deteriorations) apart from the annual rate of 2.2 per cent. The grey curves show in turn what the model forecasts (including the productivity improvements) would have been if the Riksbank had strictly adhered to the estimated policy rate rule.

The chart shows that GDP growth exceeded what the model would have predicted in the absence of productivity shocks. Thus, the model interprets the difference between the blue and the black curves as a consequence of technological innovations that improved productivity in 2003–06 and led to high GDP growth and high real wage increases. Moreover, as the higher productivity also led to lower marginal costs for firms, inflation was below the rate that would have been expected without the reinforcement of productivity. In other words, the policy rate could be lower than would otherwise have been the case (the difference between the blue and the black curves).

The chart also shows that monetary policy in this period was unusually expansionary. The interpretation of the grey path of the policy rate being above the outcome data is that according to the model, in this period there were a number of expansionary "policy rate surprises" compared with the average historical pattern. Thus, inflation would have been even lower if the Riksbank's policy rate cuts in 2003–06 had not

continuously been somewhat larger than the estimated policy rate rule predicted. That in turn meant that the real exchange rate's depreciation was somewhat more marked than would otherwise have been the case. However, the combined effect of all this on GDP growth in the period would have been rather small.

Chart 3. Outcome and model predictions 2003-06 with alternative assumptions about economic shocks.
Per cent

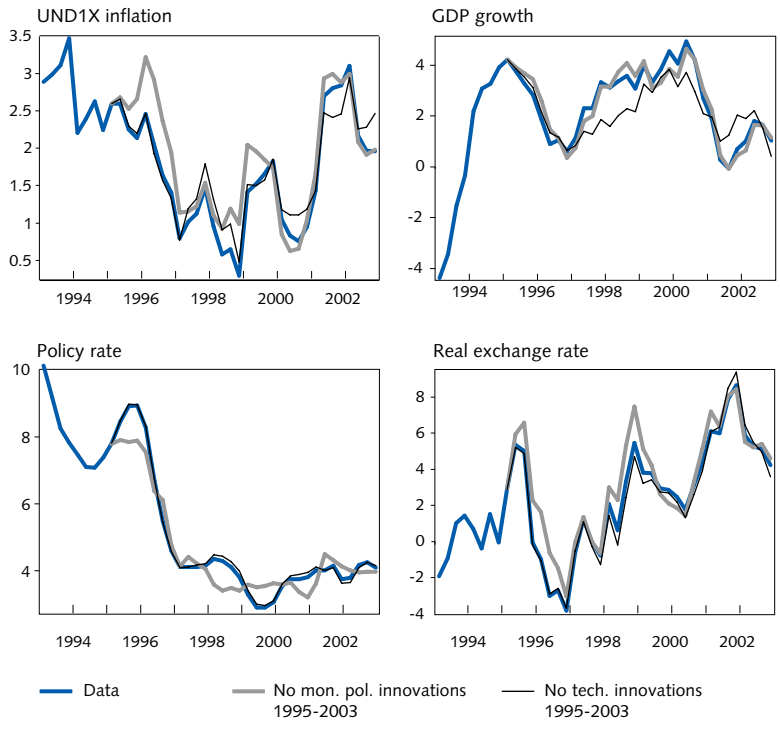


The model's interpretation of the course of events 2003–06 is accordingly that inflation was pressed down in these years by higher productivity, but also that it could have been even lower if monetary policy had not been more expansionary than normal. Is it the case that RAMSES always equates low inflation with improvements in productivity? To answer this, Chart 4 presents results of a similar analysis in which the model's predictions are decomposed into the same two components (productivity and monetary policy) ever since 1995. It will be seen that in 1997–98, for example, the model's prediction of inflation without technological innovations (black curve) is not all that different from the actual outcome (blue curve). So according to RAMSES, on that occasion it was not changes in productivity that led to the low inflation.

The chart also shows that part of the policy rate increase during 1995 represented a monetary policy tightening. The outcome was above

the policy rate the model would have predicted with the estimated interest rate rule (without any monetary policy "surprises"). It is worth noting, however, that without this relatively restrictive monetary policy, underlying inflation according to the model would have been above 3 per cent at the beginning of 1996 (grey curve). At the same time, the model indicates that the monetary policy tightening came a little late, so that this intervention contributed to inflationary pressure being somewhat low during 1998 in particular.

Chart 4. Outcome and model predictions 1995–2003 with alternative assumptions about economic shocks.
Per cent



The model's empirical properties

This section describes the empirical properties of the model and how its parameters have been estimated on data for Sweden. In line with Adolfson et al. (2006), we think it is important to evaluate RAMSES' empirical performance because it says something about the extent to which the model's predictions deserve to be taken seriously. As RAMSES is used in a forecasting environment, it seems natural to evaluate forecasting performance rather than the model's ability to conform to historical data. In order to judge whether RAMSES' predictive performance is satisfac-

tory or not, the forecasts in the model are compared with the Riksbank's assessment as well as with a number of statistical forecasting instruments with good documented forecasting properties. This is the same approach as in Adolfson et al. (2006).

MODEL ESTIMATIONS WITH BAYESIAN METHODS

The goal in the estimation phase of model work is to arrive at values of the parameters whereby RAMSES gives the best approximation to the historical paths of a number of macroeconomic time series. The theoretical *model variables* in RAMSES are linked with *measurement equations* to statistical observations of, for example, output, prices and interest rates (see also the Appendix). It is not necessary to include observed variables for every one of the model variables. There is in principle no empirical counterpart to some model variables (some of the shocks, for instance) and there is no satisfactory way of measuring others.[34] The estimation procedure involves using RAMSES' modelling structure together with the selected observed variables to form a picture of model variables for which measurements are not available.[35] It is, however, important that the set of observed variables is sufficiently informative for *identifying* the model's parameters and the underlying unobservable model variables, for instance the capital stock. Estimations of RAMSES are currently performed with the following 15 macroeconomic variables: GDP deflator, consumption, investment, real wages, real exchange rate, policy rate, hours worked, GDP, exports, imports, UND1X, investment deflator, foreign GDP, foreign inflation and foreign interest rate.

RAMSES is estimated on data from 1986 Q1 up to the present.[36] The choice of estimation period has to weigh quantity against quality: plenty of data is needed for the accuracy of the parameter estimates but the data should also refer to a period without sizeable structural changes. It can be argued that the major part of the financial market deregulations had been implemented by the beginning of 1986, making this a reasonable starting date for the estimation period. The next major structural change in the Swedish economy can be dated to the end of 1992, when the fixed exchange rate was abandoned, followed soon after by the Riksbank's announcement of a shift to an inflation-targeting regime. However, instead of making do with a smaller amount of data by choosing

[34] Examples of the latter type of variable are capacity utilisation and the capital stock. The measurement errors for these two variables are large because of the difficulties in valuing an effective capital stock and in telling from survey data what firms actually mean by capacity utilisation.

[35] The technical description of the model is presented in *state-space form* and the model variables that lack equivalents in the measurement equations are estimated with the *Kalman filter*.

[36] An additional five years of data from the period 1980–85 is used initially to form an opinion about the state of the economy at 1986 Q1, when the estimation period starts.

just the period after 1992, this structural change is modelled by having one monetary policy rule for the period 1986–92 and another for 1992 to the present.

For RAMSES estimations the Riksbank has used *Bayesian methods*, which combine the information in the measured variables with *prior information* about the model's parameters.[37] Prior information is knowledge derived from sources other than the chosen measured variables, for example studies of similar models for other countries, various types of micro data or even information of an institutional nature such as data on the duration of negotiated wages agreements.[38] Bayesian methods use *Bayes' theorem* to achieve an optimal combination of the information in data and the prior information. Besides the possibility of supplementing the information in data with other information, the Bayesian approach results in a more satisfactory empirical evaluation of the model and also means that the uncertainty in the estimation can be incorporated in a natural way in, for example, the forecast interval.

FORECASTING PROPERTIES OF THE ESTIMATED MODEL

As mentioned earlier, RAMSES can be used to forecast future economic developments in a consistent manner, as well as to interpret and understand the developments. In order to illustrate the model's forecasting properties, in this section forecasts using RAMSES are compared with those from other forecasting models as well as with the Riksbank's official inflation assessments in the *Inflation Report.* In addition, the accuracy of the different forecasting instruments is compared by evaluating their average forecasting performances.

In Chart 5, the outcome for yearly UND1X inflation is compared with forecasts 8 quarters ahead produced on a score of occasions between 1999 Q1 and 2006 Q2. The RAMSES forecasts are presented in the uppermost chart, followed by forecasts from a Bayesian VAR (BVAR) model[39] and finally the Riksbank's historical inflation forecasts.[40]

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[37] Koop (2003) is recommended as an introduction to Bayesian analysis. An introduction to Bayesian estimation of general equilibrium models is presented in An & Schorfheide (2007).

[38] A good example of the use of a priori information is the survey by Apel, Friberg & Hallsten (2005) of how frequently firms adjust prices. These micro data serve as a guide to the appropriate degree of price stickiness in the model.

[39] The BVAR model comprises seven variables: the rates of UND1X inflation and GDP growth, the policy rate, the real exchange rate and the foreign 3-month interest rate and rates of (TCW-weighted) CPI inflation and GDP growth. It is a direct time-series model that captures historical correlations in data without a closer foundation in economic theory. The parameters of the BVAR model are estimated with Bayesian methods, using prior information about the variables' long-term means (see Villani, 2005).

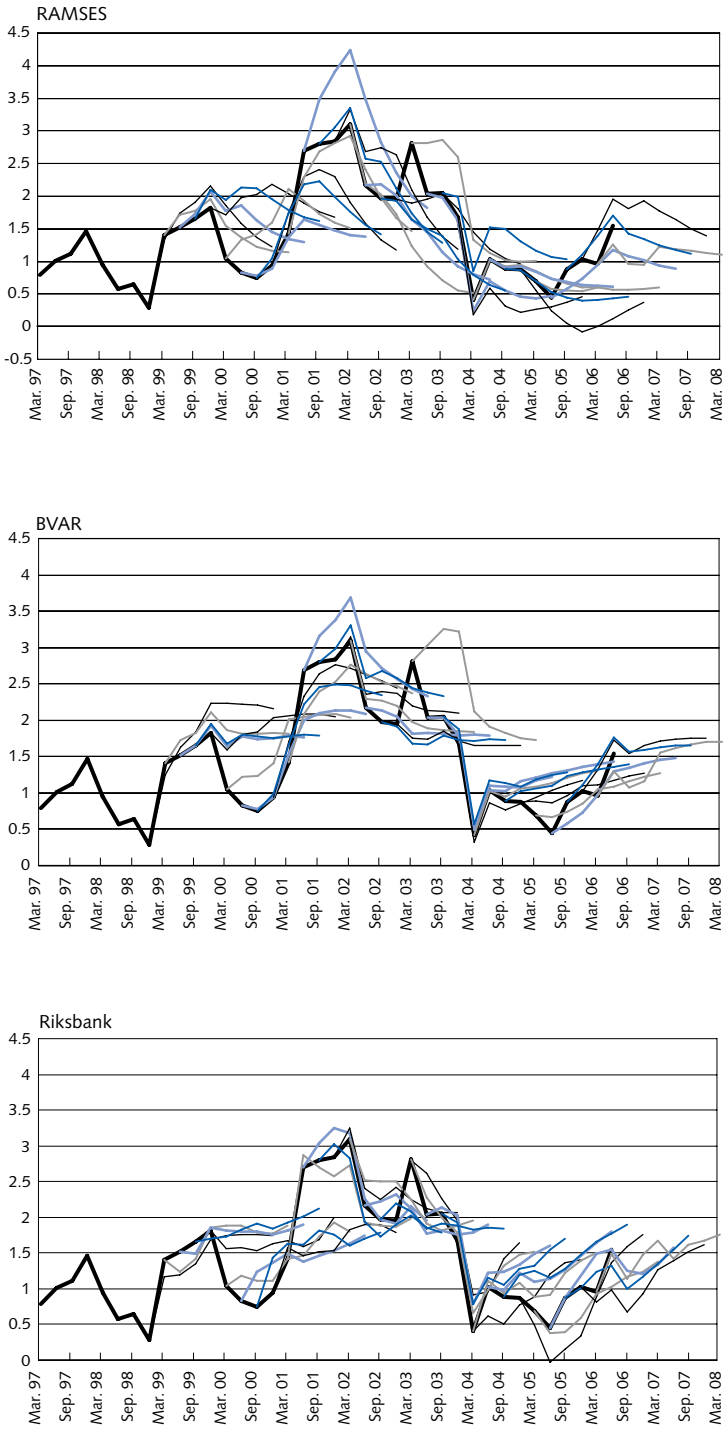
[40] The BVAR and RAMSES were introduced in the Riksbank's forecasting work at different times in 2005. There is a sense in which the comparison between the Riksbank's official forecasts and the model forecasts is somewhat difficult to interpret in the final quarters of the sample because in those quarters the latter were partly incorporated in the former. But as judgements make a large contribution to the Riksbank's official forecasts, we nevertheless chose to include 2006 in the analysis.

It can be seen that the methods give somewhat different patterns in the forecasts.[41] RAMSES forecasts have a dispersion that is relatively large compared with inflation's outcome over time. The inflation forecasts with the BVAR model, on the other hand, seem to be generally sound but as they tend to be simple projections of the current quarter's inflation they are not very informative about inflation's future path. It is noteworthy, however, that in the event of a forecast error, the time series model soon incorporates changes in the pattern of inflation (see, for example, 2003 Q1 and Q2). Finally, the Riksbank's inflation forecasts seem to return to the 2 per cent target somewhat sooner than the forecasts with the two models. It should, however, be kept in mind that up to 2005 Q3 the Riksbank conditioned its forecasts on an unchanged policy rate, whereas we have not conditioned the model forecasts on a constant policy rate, so the two are not entirely comparable. But considering the large element of judgements behind the Riksbank's official forecasts, it seems fairly reasonable to assume that they have actually been closer to an unconditioned forecast than a conditioned.[42]

[41] Note that to assist comparisons of the models, the forecasts for a particular quarter are all plotted in the same colour.

[42] If one supposes that the Riksbank's forecasts were in fact conditioned on a constant policy rate (which in 2003–05 would have been higher than the policy rate in practice), the overestimation of inflation in this period would presumably have been even greater because the outcome was below the paths for constant interest rates. In other words, a constant policy rate path in this period would have been restrictive rather than expansionary.

Chart 5. Outcome for UND1X inflation and sequential forecasts with alternative forecasting models.
Percentage 4-quarter change



In order to evaluate the models' average forecasting performance, we use the root mean squared forecast errors for yearly UND1X inflation, yearly GDP growth and the policy rate.[43] This is done for forecasts of one to eight quarters ahead in the period 1999 Q1–2006 Q2 for inflation and the policy rate and in the period 2000 Q1–2006 Q2 for GDP growth. Only information that was available at the time of each forecast is used.[44] Note that in the absence of a real-time data base, the Riksbank's GDP growth forecasts are likely to be less accurate than the models' because revised GDP data were fed into the latter. However, we do evaluate the Riksbank's GDP forecasts against both real-time data and the latest revision (2006 Q2) of GDP outcomes. As the series on inflation are not revised over time, real time data are less of a problem when comparing inflation forecasts by the models with the Riksbank's assessments. It may even be the case that when the *Inflation Report* has been published at quarter ends, the Riksbank may have a slight advantage over the models because data on inflation and interest rates, for example, are then available for the first two quarters.

Chart 6 presents the annual percentage root mean squared errors for forecasts 1–8 quarters ahead for UND1X inflation, GDP growth and the policy rate for RAMSES, the BVAR model and the Riksbank. The chart also includes the accuracy of forecasts using a simple statistical correlation, an autoregression (AR(1)).[45] Once again, as the Riksbank conditioned its forecasts in this period on an unchanged policy rate (rather than publishing a path for the policy rate), we compare the models' policy rate forecasts with the implied forward interest rate. Thus, the models are not conditioned on an unchanged policy rate. That could, of course, affect the accuracy of the inflation forecasts, for example, though it is hard to say in which direction. It should be borne in mind that the unchanged policy rate applies only up to the forecast horizon.

The charts illustrate that the reliability of the alternative forecasting tools differs somewhat across the forecast variables. For underlying inflation, the forecast errors for RAMSES and the BVAR at short horizons are somewhat larger than for the Riksbank's assessments. The high degree of accuracy in the Riksbank's inflation forecasts for the first quarter is

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43 The root mean squared error (RMSE) is calculated for variable *i* and horizon *h* as $RMKF_i(h) = \sqrt{(1/N_h)\sum_{t=T}^{T+N_h-1}(x_{i,t+h} - \hat{x}_{i,t+h|t})^2}$, where N_h is the number of forecasting occasions, x_i the actual outcome for variable *i* and $\hat{x}_i$ the forecast given the information available up to and including the time of the forecast *t*.

44 The first quarterly forecast is accordingly calculated with the information available up to 1998 Q4 (1999 Q4 for GDP). One additional observation 1999 Q1 (2000Q1) is then added to the data and the forecast for one to eight quarters ahead is calculated again. The parameters of the BVAR model are re-estimated every quarter, while for this exercise the parameters of the RAMSES model have been updated only annually because the estimation of RAMSES is more time-consuming.

45 The autoregressive processes have been estimated separately for each variable in first differences for GDP and CPI. The repo rate was modelled in level. The forecasts were then converted to yearly growth rates.

not surprising because in many cases the Riksbank already has data for two-thirds of that quarter. At longer horizons (6–8 quarters), on the other hand, the models appear to perform better than the Riksbank's assessments. On the whole, we consider that the models' forecasting performance for underlying inflation compares remarkably well with the Riksbank's capacity in this respect. Compared with the BVAR, the reliability of RAMSES' inflation forecasts in the evaluation period is generally somewhat poorer. The forecast errors differ at most by approximately 15 basis points. Considering that RAMSES includes almost twice as many variables as the BVAR model, its slightly lower reliability is not particularly surprising. Compared with the BVAR model we have chosen to use here, RAMSES is accordingly capable of forecasting a much larger set of macroeconomic variables.

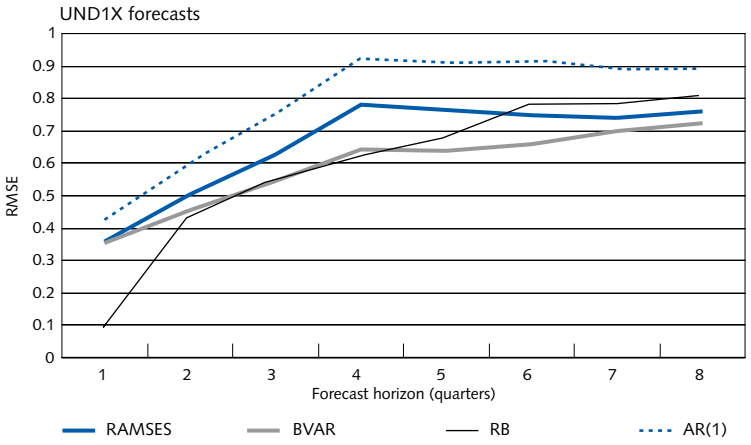
Chart 6 also presents the reliability of the GDP growth forecasts. The reliability of RAMSES GDP forecasts seems to compare relatively well in general with the BVAR forecasts, the Riksbank's assessments and, for that matter, an autoregression for GDP growth. The Riksbank's GDP assessments are actually not entirely comparable because the Riksbank did not have the revised GDP data when its inflation reports were published; an evaluation for real-time data indicates fairly satisfactory reliability for the Riksbank's GDP assessments.[46] At somewhat longer horizons, say two years ahead, however, the alternative forecasting tools do not seem to differ all that much in terms of reliability.

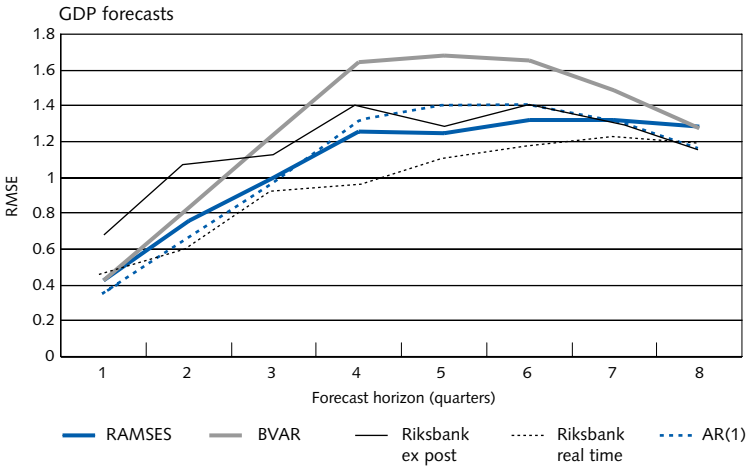
As the Riksbank did not publish policy rate forecasts prior to January 2007, the forecast error presented in Chart 6 concerns the implied forward interest rate curve based on market expectations.[47] It is worth noting that RAMSES' policy rate forecasts are somewhat less accurate than those of the BVAR model. At horizons up to one year the path of the implied forward interest rate performs somewhat better in forecasting the policy rate's future path, whereas the average reliability of the models appears to be better at somewhat longer horizons (5–8 quarters ahead).

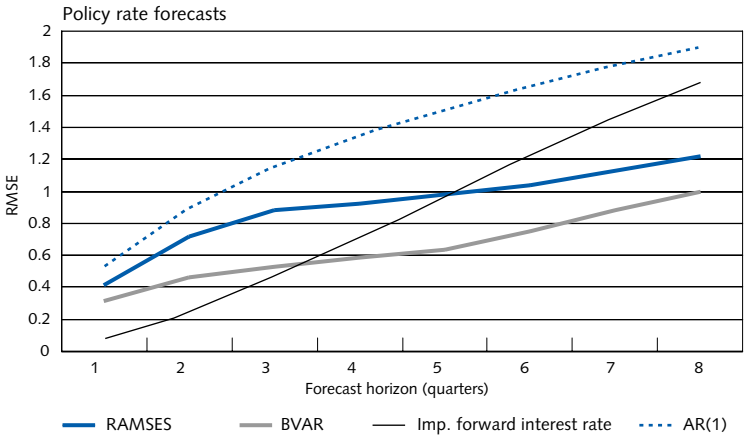
[46] Another point worth noting is that the models use seasonally-adjusted GDP per capita, whereas the Riksbank forecasts total (annual) GDP growth.

[47] The implied forward interest rate curve is calculated from quarterly averages of the daily observations for a spectrum of government securities with different maturities. Bear in mind that as this curve includes maturity and risk premia, for example, it is not a perfect representation of market expectations of future monetary policy.

Chart 6. Accuracy of alternative models' forecasts of UND1X inflation, GDP growth and the policy rate.
Per cent







Note. RMSE = root mean squared error.

Conclusions

This article aims to present a relatively simple description of the principal characteristics of the RAMSES model, which is an important tool today for the Riksbank's monetary policy analysis. Moreover, RAMSES' empirical properties are compared with those of other, more statistical models as well as with the Riksbank's assessments in the period 1999–2006. We argue that empirical evaluations of models play a major part in elucidating the extent to which the models' predictions in other contexts deserve to be taken seriously.

All models are simplified representations of reality, so their analyses have to be combined with assessments of economic developments that models do not pick up satisfactorily. In this respect, RAMSES is no exception. We have therefore included a couple of examples to show how alternative scenarios can be analysed by combining the model with sector experts' more detailed knowledge.

As many aspects of the economy are modelled far too simple in RAMSES, this model is not appropriate for a number of purposes. One important example is that RAMSES does not include financial frictions, the importance of which for understanding the monetary policy transmission mechanism is discussed extensively in the literature. Another example is fiscal policy's very limited role in RAMSES. However, the work of developing models is a continuous process at the Riksbank and aims to learn from the shortcomings that are an inevitable feature of this field. In this work it is, of course, also important to document the models' empirical properties.

Finally, we wish to emphasise that while we do not believe that formal models such as RAMSES can replace the extensive analytical work of sector experts and others, the development of the new generation of general equilibrium models has now proved so successful in various ways that these models have earned a prominent place in a central bank's toolbox.

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Appendix

ESTIMATING RAMSES – STEP BY STEP

The mathematical form

RAMSES can be formulated mathematically as a system of non-linear differential equations with rational expectations. To simplify the estimation of the model's parameters, these equations are log-linearised around the model's steady state. A simplified example of such a linearised equation is the New-Keynesian Phillips curve for domestic inflation in equation (2). The parameter γ in the New-Keynesian Phillips curve is a function of β (the discounting factor) and ξ_d (the degree of price stickiness), which are two of the fifty or so structural parameters in RAMSES.

The goal of the estimation phase of model work is to identify the values of the structural parameters whereby RAMSES gives the best fit to the historical paths of a number of macroeconomic time series. Consequently, the theoretical model has to be linked to statistical measurements of, for example, output, prices, wages and interest rates. This in done in steps, as described below.

The reduced form

In the first step the above-mentioned system of equations is solved for a given set of parameters to obtain a *reduced form* of RAMSES.[48] This form is a description of the model's endogenous variables as a function of exogenous variables and shocks. The following system is a simplified example of a reduced form of two arbitrarily chosen endogenous variables, π and R:

$$\begin{aligned} \pi_t &= a_{11}\pi_{t-1} + a_{12}R_{t-1} + b_1 x_t + c_1\varepsilon_t \\ R_t &= a_{21}\pi_{t-1} + a_{22}R_{t-1} + b_2 x_t + c_2\varepsilon_t \end{aligned} \qquad \text{(A.1)}$$

where x_t is an exogenous variable (for example external demand or external interest rate), and ε_t is an exogenous random variable, for example the λ_t^d shock in equation (2). All the parameters in the reduced form are (non–linear) functions of the model's structural parameters (for example β and ξ_d in equation (2). With given values of these structural parameters, the reduced form can be used to, for instance, simulate the future development of the model economy. If π_t and R_t are taken to represent inflation and the policy rate, with ε_t as a cost shock, the system of equations in (A.1) results in the Riksbank raising the policy rate in the event of a lasting (but non-permanent) increase in costs. This makes it

[48] The log-linearised system of equations is solved numerically with the AIM algorithm, developed by economists at the US Federal Reserve (Anderson & Moore, 1985).

reasonable that both the coefficients in front of ε_t are positive. The path back to the stable equilibrium is determined by the *a* coefficients, which in turn are (non-linear) combinations of the Riksbank's actions and the workings of the economy.

The measurement equations

The variables π_t and R_t in equation (A.1) are theoretical constructions for the model. The second and final step in connecting RAMSES with reality amounts to using *measurement equations* to link these *model variables* to *measured variables*, such as GDP and inflation. There does not have to be a measured variable for each model variable. For some model variables there is in principle no empirical equivalent; for others there are no satisfactory measurements.[49] In these cases the estimation procedure uses the model structure in RAMSES together with the chosen measured variables to arrive at a picture of model variables for which measurements are not available.[50] It is important, however, that the set of measured variables is sufficiently informative to make it possible to *identify* the model's parameters and the underlying non-observable model variables, for example the capital stock. At present, 15 macroeconomic variables are used for estimations of RAMSES.

Likelihood

The reduced form, combined with the measurement equations and probability distributions for shocks, specify a simultaneous probability distribution for the measured variables. The probabilities the model assigns to different paths of the chosen measured variables can then be calculated for chosen values of the structural parameters. A reasonable estimation of the model's parameters maximises the probability the model assigns to the observed historical path of the measured variables. This estimation is thus the set of parameters that maximises the model's *likelihood function* $p(y \mid \theta)$, where *y* denotes all the chosen measured variables over the chosen observation period, θ contains all the model's parameters and $p(y \mid \theta)$ is the probability distribution (density) for *y* given θ. Note that the likelihood function is regarded as a function of the parameter θ and data (y) are known values. Assuming that the model contains only one parameter, an example of the appearance of the likelihood function is the black curve in Chart A.1. There the likelihood function shows that a value around 0.75 for θ gives the model with the best fit to historical data.

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[49] Examples of variables of the latter type are capacity utilisation and the capital stock.

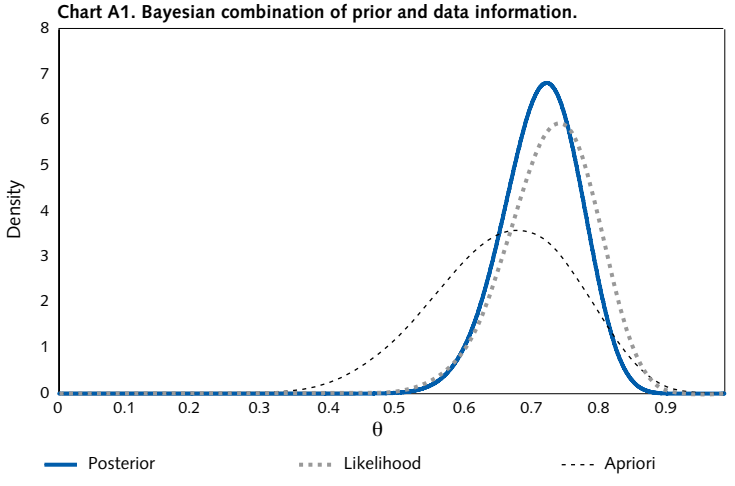
[50] In technical terms, the model is set up in *state-space form* and the *Kalman filter* is used to estimate the model variables for which there are no equivalents in the measurement equations.

Moreover, a value of θ outside the interval from 0.5 till 0.9 gives a model that is not compatible with data.

Bayesian methods

The Riksbank has used *Bayesian methods* for estimations of RAMSES. These methods also make use of the likelihood function but combine this information with *prior information* about the model's parameters. Prior information is knowledge about the model's parameters that is derived from sources other than the chosen measured variables. Examples are information from other studies of similar models for other countries, various kinds of micro data, or even information of an institutional nature such as the duration of negotiated wage agreements. As the reliability of this type of information varies, it is summarised in probability distributions for the respective parameters, *prior distributions*. The Riksbank can therefore specify the most probable value of each parameter as well as the uncertainty around this value in terms of a probability distribution. This does not mean that the Riksbank perceives the model's parameters as random in the traditional sense; it simply mirrors the fact that the Riksbank's information about the parameter is incomplete. An example of a prior distribution is the blue curve in Chart A.1. Bayesian method uses *Bayes' theorem* to arrive at an optimal combination of the information in the likelihood function and prior information. The combined distribution, which summarises prior and data information, is called the *posterior distribution*. The red curve in the chart represents the posterior distribution for parameter θ. In this example the data information is stronger than the prior information, which means that the posterior distribution is closer to the likelihood function.

Chart A1. Bayesian combination of prior and data information.



Increased competition and inflation

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Inflation has been low in the past decade, in Sweden as well as internationally. It is commonly believed that one reason for this is increased competition. In this study, a dynamic general equilibrium model estimated on data for Sweden is used to show how increased competition affects inflation.

Inflation in Sweden dropped from around 6 per cent in the early 1990s to around 2 per cent a decade later (see Table 1). Inflation also fell in many other countries. The global rate of inflation decreased in this period from 30 to 4 per cent. This was mostly due to inflation in developing countries, where the rate plummeted from 53 to 6 per cent. In the industrialised countries the rate slowed from 4 to 2 per cent.

Table 1. CPI in Sweden and globally.
Percentage annual rate

	1980–84	1985–89	1990–94	1995–99	2000–04
Sweden	10.3	5.6	5.8	0.8	1.6
Global average	14.1	15.5	30.4	8.4	3.9
Industrialised countries	8.7	3.9	3.8	2.0	1.8
Developing countries	31.4	48.0	53.2	13.1	5.6

Sources: Rogoff (2003) and the Riksbank.

How is this remarkable slowdown of inflation in the 1990s to be explained? One reason that is often mentioned is increased competition. The globalisation process, with the expansion of trade and greater openness, is presumed to lead to more competition in product and labour markets. Firms react to stronger competition by cutting profit margins and price mark-ups, which leads to lower prices.

This view was aptly summarised in a speech in 2004 by Riksbank Deputy Governor Kristina Persson: "… the slackening in price trends is a result of many factors that are partly connected with globalisation:

- Increased world trade and more operators lead to greater competition
- Deregulation and privatisation will also mean that competition increases

[1] The author is grateful for comments on earlier drafts of this article from Jesper Lindé, Kerstin Mitlid, Marianne Sterner, Staffan Viotti and Peter Welz.

- A greater degree of specialisation and utilisation of comparative advantages (which is known as global labour reallocation) lead to increased productivity and efficiency
- More production in typically low-wage countries leads to lower costs

All of this indicates that international price pressure should be lower during the coming years at a given point in the economic cycle".

Among academic economists, Rogoff (2003) has argued that increased competition is a major reason of inflation's slowdown: "… the mutually reinforcing effects of globalization, deregulation, and widespread reduction of the role of government have no doubt sharply increased competition and lowered 'quasi-rents' to monopolistic firms and unions throughout much of the world." He stresses that besides having a direct impact on inflation, a smaller mark-up exerts an indirect effect that leads to greater price and wage flexibility. With smaller mark-ups, firms are more prone to adjust prices in the event of shocks. To the extent that the real economic effects of monetary policy have to do with price and wage rigidities, the effects will be less marked if prices are adjusted more quickly. That leaves central banks with less incentive for and possibilities of stabilising GDP, which should result in a less activist monetary policy and a stronger focus on stabilising inflation.

It should be borne in mind that increased competition is not the only explanation that is put forward for the slowdown in inflation. Another example is improvements in monetary policy. A number of monetary policy reforms in the 1990s led, for example, to greater central bank independence. Many countries introduced a specific target for inflation. These developments also induced central banks to become more transparent, which calls for clearer communication and better analyses.

Another common explanation is sounder fiscal policies. In Sweden, for instance, large public sector deficits in the early 1990s were transformed into surpluses in the early 2000s. While it is true that an improvement in the public finances was not a global phenomenon in the 1990s, it may have contributed in some countries. Finally there is stronger productivity growth, which serves as an explanation for the United States but less so for Europe and other regions. For a fuller discussion of these alternative explanations, see Rogoff (2003) and the references there.

The focus of this study is, however, on the relationship between increased competition and inflation. The purpose is to clarify how inflation is affected by increased competition in product and labour markets. The degree of competition is measured in terms of price and wage mark-ups. Decreased mark-ups lead more or less by definition to a lower price level. In the period during which prices are adjusted to a lower level, price

movements (inflation) also decrease. So the impact of increased competition on inflation is transient. But due to the number of factors that are involved, it is hard to tell how large the impact will be and how long the adjustment will take. The following factors are considered in this study: [2]

- *The type of market that is exposed to competition*. The quantitative effects differ according to whether competition increases in the product as opposed to the labour market. In the product market, moreover, a distinction is made between the markets for domestic and imported consumer goods, respectively.[3,4] As we shall see, the effects on inflation also differ depending on which of these two markets is exposed to competition.
- *The degree of price and wage rigidities in the economy.*
- *Monetary policy.* As inflation is a monetary phenomenon, the central bank can, in principle, keep inflation completely stable in the event of increased competition. However, that would entail costs in the form of large fluctuations in interest rates and GDP.

EMPIRICAL STUDIES POINT TO THE IMPORTANCE OF DEREGULATIONS

This study's results are largely theoretical. There is, however, an interesting body of empirical literature on estimating how the degree of competition changes over time. The OECD, for example, has presented a number of studies in this field. In a recent publication (OECD 2006), survey data are used to calculate a variety of indicators of the degree of competition. The indicators, for instance of state control, barriers to entrepreneurship and barriers to trade and investments, are combined into a weighted aggregate measure. Chart 1 presents the degree of competition in product markets in a number of countries in 1998 and 2003. The value of the indicator ranges from 0 to 6 and the lower the value, the greater is the degree of competition. Product market regulation in 1998 was higher than in 2003 in every country, which points to deregulation being a global phenomenon.

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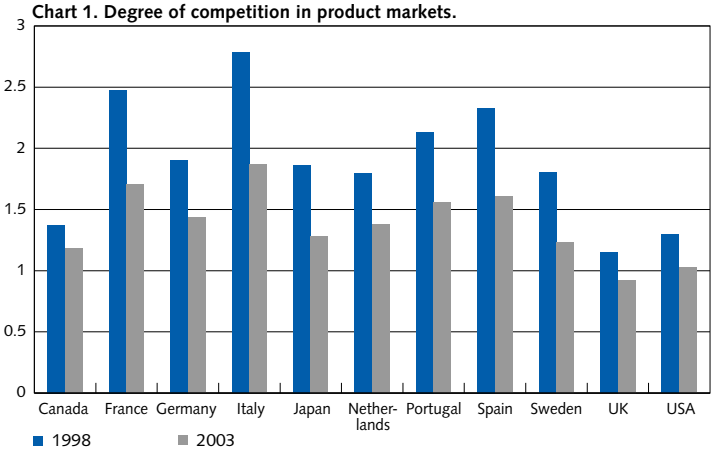
[2] One important factor that is not considered here but is discussed in Asplund & Friberg (1998) is the type of competition.

[3] The model also includes markets for imported investment goods and export goods but increased competition's effects on these markets are not analysed here.

[4] The analysis is simplified by making no distinction between goods and services. In practice, domestic goods consist predominantly of services.

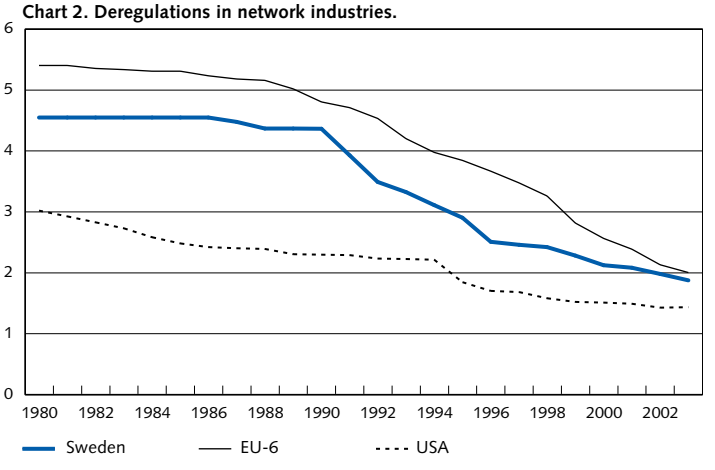
Chart 1. Degree of competition in product markets.



Sources: OECD and the Riksbank.

The broad indicator of product market reforms that is reproduced in Chart 1 has been calculated only for 1998 and 2003. To obtain a picture of developments over a longer period, the OECD has calculated an indicator of regulation in energy, transport and communications. This indicator summarises regulatory provisions in seven sectors: telecoms, electricity, gas, post, rail, air passenger transport, and road. The period from 1980 to 2003 is presented in Chart 2 for Sweden, EU-6 and the United States.[5] Here, too, the indicator's value ranges from 0 to 6, with 0 as the most liberal situation. This indicator shows that the process of deregulation began in earnest in the early 1990s in Sweden and EU-6 and some years later in the United States.

Chart 2. Deregulations in network industries.



Sources: OECD and the Riksbank.

[5] EU-6 comprises the EU member states that are most important economically: the United Kingdom, France, Germany, Spain, Italy and the Netherlands.

It is worth noting that explicit attempts to measure price mark-ups tend to find little evidence of increased competition in the past decade and a half. In one such study (Bowman 2003), of the 20 OECD countries that were included, only four (Portugal, Japan, Greece and Norway) had a price mark-up in the early 2000s that was lower than a decade earlier. In Sweden, for example, the mark-up was somewhat higher at the beginning of the 2000s. However, studies of this type produce results that are rather uncertain. Data on production costs, for example, are difficult to come by. Instead, the inverse of real unit labour costs is often used to measure the price mark-up, which is correct only under certain special circumstances.

LABOUR MARKET REFORMS ARE LIKELY

Labour markets have been subject to relatively fewer reforms than product markets. But there is reason to suppose that such reforms will occur as globalisation continues. Persson & Radetzki (2006) argue that the global economy can expect a huge supply shock when China, India and Eastern Europe enter the world market. Major wage cuts will be needed, for example, to keep labour markets intact. Moreover, according to Calmfors (2006, translated here): "In the first place we should adjust by means of structural changes and increased productivity. But greater wage flexibility may be called for, too. Possible ways of achieving this are more decentralised wage formation, longer working hours, lower compensation for unemployment, tax rebates on low-pay income and a shift in the balance of strength between the parties in the labour market." Under these circumstances it is also relevant to look at the consequences for inflation of increased competition in the labour market.

This study continues as follows. The theory and model that are used to illustrate the relationship between increased competition and inflation are presented in the next section, followed by an account of how inflation is affected by increased competition in product and labour markets. The article ends with some concluding comments.

The dynamic general equilibrium model

Analysing how increased competition affects inflation calls for a theoretical framework or model. The purpose of the model is to illustrate, in simple but consistent terms, the basic mechanisms that determine how inflation is affected by increased competition in product and labour markets. This study starts from a dynamic general equilibrium model based on New-Keynesian theory and estimated on data for Sweden. The model is consistent with a number of well-known facts about long-term

growth and has proved capable of explaining a large part of the short-run fluctuations in the main macro variables. The model is, moreover, used regularly in the Riksbank's forecasting work. For a fuller description of the model, see Adolfson et al. (2005, 2007).

The model is constructed to describe a small, open economy, which means that the domestic economy does not influence either interest rates, GDP or inflation in other countries. Households and firms therefore take these variables as given in their decisions. In a dynamic general equilibrium model, households strive to maximise utility over the life cycle and firms aim to maximise profits over time. Prices are the mechanism that generates an equilibrium where supply balances demand in every market.

An important feature of the model is that prices and wages are characterised by rigidity. This means that in the event of a change in the economy, for instance an increase in competition, prices and wages adjust gradually, not immediately. According to Apel et al. (2004), firms in Sweden alter their prices approximately once a year on average. In order to reproduce this behaviour, the model assumes that those who set prices and wages can do so only at certain (randomly given) points in time. The frequency of the adjustments has been estimated with Bayesian methods and turns out to differ between markets. In the market for domestic products, prices are changed once a year on average, which agrees with the findings in Apel et al. (2004). The frequency is the same in the labour market, that is, wages are altered once a year on average. In the market for imported products, on the other hand, prices are considerably more rigid and are changed every second year on average.

Monetary policy is described by a Taylor rule, which means that the central bank reacts to changes in the rates of inflation and GDP. An increase in prices and/or GDP causes the central bank to react by raising its policy rate to stabilise the fluctuations in these variables. In this way, the central bank takes the real economy into consideration in its policy rate decisions.

COMPETITION AND INFLATION IN THE MODEL

Product and labour markets are characterised by monopolistic competition. In product markets this means that there is a large number of firms which compete with each other by turning out similar but not identical products. Due to this product differentiation, the products are close but not perfect substitutes for each other. With many firms in the market, each one produces just a small share of the total supply, which means that the prices charged by one firm do not affect the pricing strategies

of other firms. Moreover, each firm faces a negatively sloped demand curve and can therefore choose the price that maximises profit, given this demand curve.

Monopolistic competition is a market structure with perfect competition and monopoly as the polar cases. Perfect competition obtains if the products are perfect substitutes; a market with only one firm is a monopoly. Oligopolistic competition, a market structure characterised by strategic interaction between firms, is not included in the model. Due to the complications involved in modelling the strategic interaction, oligopolistic competition tends to be disregarded in macro models of this type.

In a model with monopolistic competition, firms maximise profits by setting the price, P, as a mark-up, λ, on the marginal cost, MC:[6]

$$P = (1 + \lambda) \cdot MC \quad (1)$$

The mark-up in turn is a function of the elasticity of product substitution. A high substitution propensity gives a low mark-up. As the substitution propensity approaches infinity, the mark-up approaches zero per cent, $\lambda = 0$, and the market is then in a state of perfect competition. Note that a permanent reduction of the mark-up gives a permanently lower price level. In other words, a reduced mark-up's impact on changes in the price level (i.e. inflation) is only transient. A permanent effect on inflation from increased competition would therefore require a continuous reduction of mark-ups. As mark-ups cannot be less than zero per cent, that is clearly not possible.

Two types of firm are included in the model, domestic firms that supply domestic products and import firms that supply foreign products. Marginal costs differ between these two types of firm. Domestic firms produce products with the aid of labour and capital, so their marginal costs depend on wages and interest rates. Higher wages and interest rates entail higher marginal costs. Import firms purchase products from abroad and sell them on to households. Their marginal costs accordingly depend on prices abroad and exchange rates. Higher prices abroad and a weaker exchange rate leader to higher marginal costs.

As Sweden is a small open economy, it is reasonable to assume that prices abroad are not affected by changes in competition in Sweden. In the scenarios presented in the next section, the price of imported products is therefore determined primarily by exchange rate movements. The exchange rate is, among other things, determined by conditions for interest rate parity, with the interest rate differential with the rest of the

[6] The marginal cost is the additional cost of adding one unit to output; in general, this does not equal the cost of producing the last unit.

world as the main driving force. A high interest rate in Sweden compared with abroad entails an expected weakening of the exchange rate; that is, the future exchange rate must be weaker than at present. The weakening can, in principle, occur in one of two ways or as a combination of them: a stronger current level with the future level unchanged or an unchanged current level with a weaker future level. Conversely, of course, a low domestic interest rate compared with abroad entails an expected strengthening of the exchange rate.

The division of products into domestic and imported items follows the method Statistics Sweden uses to calculate CPI inflation. This is done as a weighted combination of price movements for domestic and imported products. Taking π^{dom} and π^{imp} to denote domestic and imported product price movements, respectively, CPI inflation, π^{cpi}, is written:

$$(2) \qquad \pi^{cpi} = (1-\omega)\cdot\pi^{dom} + \omega\cdot\pi^{imp}$$

where ω is the weight for price movements for imported products and is set to 0.27. Thus, for domestic products a reduced domestic mark-up mainly affects π^{dom} and a reduced mark-up on imported products mainly affects π^{imp}.

The labour market is likewise represented by a model of monopolistic competition, which means that there is a large number of households whose services are close but not perfect substitutes. The market power of households accordingly resembles what they would have if they were organised in trade unions. In other words, households are wage-setters. In this capacity they weigh the marginal utility of leisure time against the marginal utility of the income they can earn, given the demand for labour.[7] The strength of households' wage-setting power is expressed as a wage mark-up.

With monopolistic competition, households/trade unions maximise utility by setting the wage, W, as a mark-up on the marginal rate of substitution for leisure time in terms of consumption, MRS:

$$(3) \qquad W = (1+\lambda^{w})\cdot MRS$$

The marginal rate of substitution represents the amount of consumption households are prepared to abstain from in order to obtain an additional unit of leisure time. In the special case of perfect competition in the labour market, $\lambda^{w} = 0$, households choose the combination of consumption and leisure time that gives equality between the marginal rate of

[7] Marginal utility measures the change in total utility that results from consuming one additional unit of a product.

substitution and the wage. This means that households' preference for increased leisure time in exchange for decreased consumption equals the alternative cost, that is, the wage.[8] The market power of households enables them to obtain a wage that is higher than the value they assign to leisure time.

The wage mark-up affects prices in the economy via its impact on wages and thereby the firm's marginal cost. A reduced mark-up leads to a lower wage, given that the marginal rate of substitution does not increase. The firm then has a lower marginal cost and cuts its prices. In general, however, there tends to be some increase in the marginal rate of substitution, which means that the wage does not fall as much as would otherwise have been the case. A lower wage strengthens labour demand and that leads to an increased labour supply, which reduces leisure time. With less leisure time, the value households assign to leisure time rises, giving an increase in the marginal rate of substitution.

ESTIMATING PRICE AND WAGE MARK-UPS

Price and wage mark-ups are commonly used in economic literature to measure the degree of competition. They have been estimated for the markets considered here with Bayesian methods. This gave price mark-ups of 22 per cent for domestic products and 8 per cent for imported products. Typical estimates for Europe and the United States are around 35 and 23 per cent, respectively, see Bayoumi et al. (2004). This indicates that competition in product markets in Sweden is higher than in Europe but much the same as in the United States. The wage mark-up is set in the model to 30 per cent, which is a typical value for European economies according to Bayoumi et al. (2004).

WHAT DETERMINES INCREASED COMPETITION'S IMPACT ON INFLATION?

To what extent is a reduction of the price or wage mark-up likely to affect inflation? Equations (1) and (3) suggest that a 1 per cent reduction in either case would lower the price level 1 per cent. However, this need not be the case, for a number of reasons. The pass-through will be smaller as a rule, as explained in the next section, where the following reasons are discussed:

[8] The wage measures what households lose by choosing more leisure time, that is, it measures leisure time's alternative cost. Alternative cost is the yield obtainable from the best alternative utilisation of a particular resource; in other words, the yield that is lost by choosing some other alternative.

- The marginal cost for domestic firms consists of wage and interest expenditures. A price cut for domestic products leads to increased demand from households. Output then rises and with it firms' demand for labour and capital. That pulls wages and interest rates up. A reduced price mark-up on imported products tends to push up the marginal cost for import firms because the exchange rate weakens. Finally, a lower wage mark-up tends to push up the marginal rate of substitution for leisure time relative to consumption. It follows that the quantitative effects on inflation vary with the type of market that is exposed to competition. The quantitative effects on inflation of increased competition in product markets differ from those associated with increased competition in the labour market. Neither are the quantitative effects of increased competition necessarily the same in markets for domestic compared with imported products.
- Due to rigidities, prices and wages do not immediately adjust to a shock in the economy. There is therefore less than a full pass-through to prices from a reduction of price and wage mark-ups.
- Monetary policy. Inflation is a monetary phenomenon and its development is accordingly determined by the central bank. In principle, a price fall generated by increased competition can be countered by the central bank cutting its policy rate. However, sizeable interest rate cuts are liable to lead to large fluctuations in GDP.

Quantitative analysis of increased competition

This section presents inflation's dynamic adjustment to increased competition in product and labour markets. The focus is on inflation but the account also includes the adjustment of the interest rate and GDP. For simplicity's sake, the price and wage mark-ups are assumed to decrease 1 percentage point in period 1 and then gradually return at a uniform rate that brings them back to the long-term (initial) value after 6–7 years. The duration of the reduction determines how long it takes for inflation to adjust: the longer the duration, the more protracted the adjustment. The paths are plotted in the charts as deviations from the long-term levels. For the three meausures of inflation, π^{cpi}, π^{dom} and π^{imp}, and the interest rate, the deviations are plotted in percentage points (at quarterly rates) and for GDP as the percentage deviation from steady state (at an annual rate). The results are shown for 12 quarters (3 years) ahead.

Three different scenarios are studied. The price mark-up is reduced by domestic firms in the first scenario and by import firms in the second. The third scenario is a reduction of the trade unions' wage mark-up. The purpose of the scenarios is to estimate increased competition's quantita-

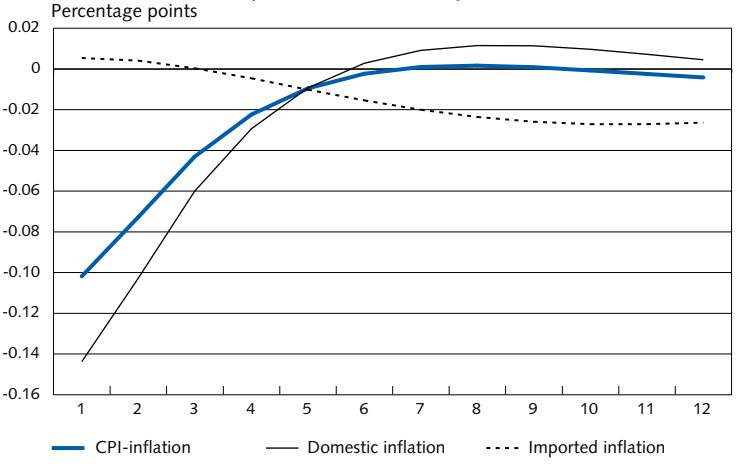
tive impact on inflation and also discuss the economic relationships that drive the adjustment.

INCREASED COMPETITION IN THE DOMESTIC PRODUCT MARKET

The first scenario – the impact on inflation from domestic firms reducing their price mark-up – is intended to illustrate a situation where foreign firms, in China and India for example, that have lower costs start to sell their products in the domestic market. This forces domestic firms to lower price mark-ups in order to stay in the market. The mark-up is assumed to fall from 22 to 21 per cent, that is, by one percentage point.

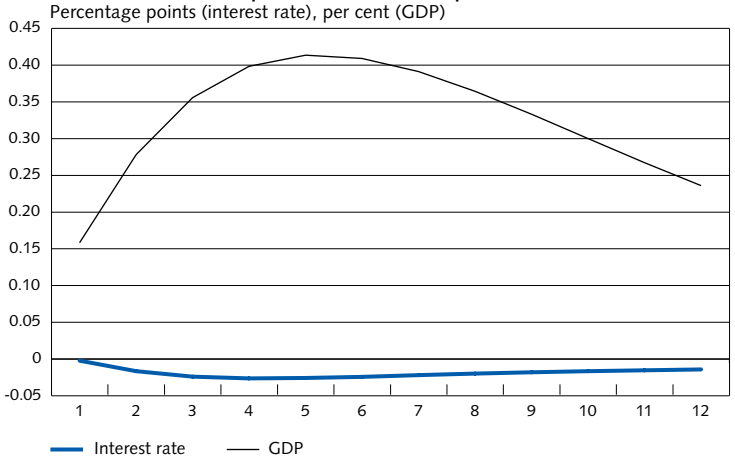
The dynamic paths for inflation, the interest rate and GDP are shown in Charts 3a and 3b. Domestic inflation slows by around 0.15 percentage points initially. A larger pass-through is essentially precluded by the factors that were discussed in the preceding section. Due to price and wage rigidities, the adjustment to a change in competition is only gradual. Firms' marginal cost tends to rise. The central bank, finally, lowers the policy rate to avoid an excessive deviation from the inflation target. As the central bank takes the real economy into consideration, the interest rate cut is relatively moderate, 0.03 percentage points at the most.

Chart 3a. Increased competition in the domestic product market.
Percentage points



Source: The Riksbank.

Chart 3b. Increased competition in the domestic product market.
Percentage points (interest rate), per cent (GDP)



Source: The Riksbank.

The price of imported products tends to rise initially and then falls. A lower interest rate leads to a weakening of the exchange rate, which makes imported products somewhat more costly. The CPI accordingly fall 0.10 percentage points initially.

The lower prices stimulate demand and after a year or so GDP has risen approximately 0.40 per cent. This illustrates the tendency for increased competition to enhance welfare, for households as well as firms. The welfare benefits consist as a rule of a more efficient allocation of the economy's resources and an increase in the cost efficiency of firms. Increased competition also generates gains in efficiency as the utilisation of technology benefits from innovations and less efficient firms are closed. However, the model used in this study only accounts for the allocation of resources becoming more efficient. An optimal resource allocation requires, among other things, that the price equals the marginal cost and the wage equals the marginal rate of substitution between leisure time and consumption. In other words, it requires perfect competition in product and labour markets.

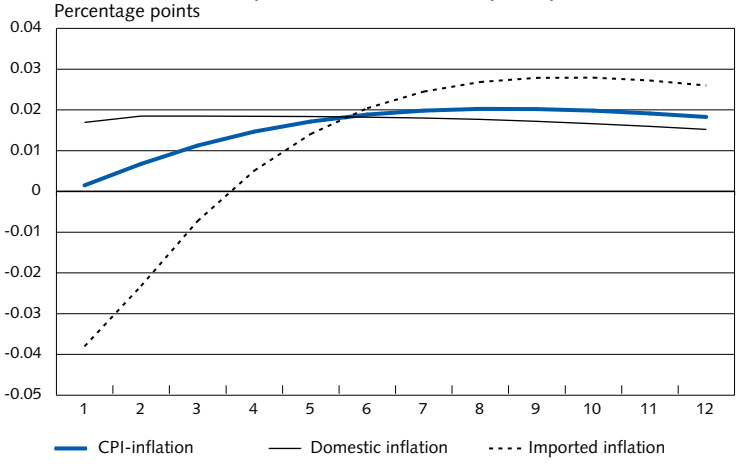
INCREASED COMPETITION IN THE MARKET FOR IMPORTED PRODUCTS

The second scenario – the impact of a reduced price mark-up on imported products – illustrates a situation where increased competition in the rest of the world leads to a price fall for imported products. Note that the state of competition among firms producing domestic products is not affected; in other words, the price mark-up on domestic products is unchanged. Domestic firms adjust prices only insofar as their marginal cost changes. This scenario may seem less plausible. It would probably

be more reasonable to combine a decreased price mark-up on imported products with a resultant reduction of the price mark-up on domestic products. Here, however, these two types of price mark-up are studied separately because this provides information about which of them is most important for the development of inflation.

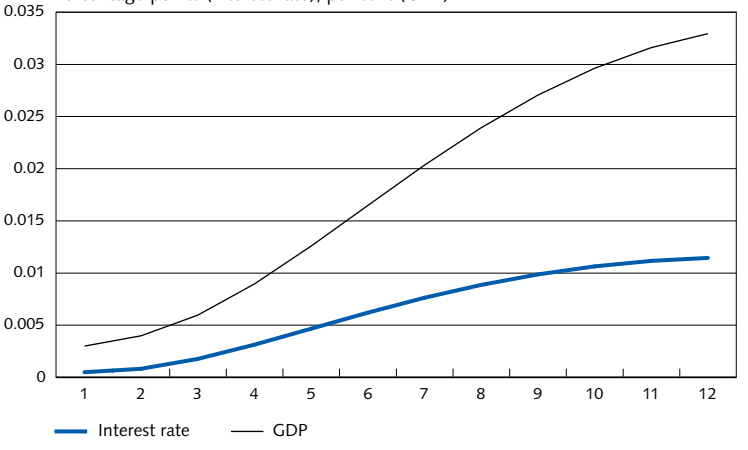
In this scenario the price mark-up on imported products is lowered 1 percentage point, from 8 to 7 per cent. As a result, the price of imported products falls 0.04 percentage points (see Charts 4a and 4b). The low pass-through is mainly due to prices in this part of the economy being relatively rigid. On average, consumer prices for imported products are adjusted only every second year. Another reason for the low pass-through is that a weakening of the exchange rate increases import firms' marginal cost.

Chart 4a. Increased competition in the market for imported products.
Percentage points



Source: The Riksbank.

Chart 4b. Increased competition in the market for imported products.
Percentage points (interest rate), per cent (GDP)



Source: The Riksbank.

A weaker exchange rate leads to increased exports and thereby to higher output and stronger demand for labour. That fuels wage demands and raises the marginal cost of domestic firms. However, the addition to costs is virtually negligible and the domestic price rise stops at under 0.02 percentage points. This leads to some increase in the CPI, where domestic products weigh much more heavily than imported products. The CPI increase reaches a high of 0.02 percentage points after about two years. Higher inflation and GDP growth lead to some increase in the interest rate.

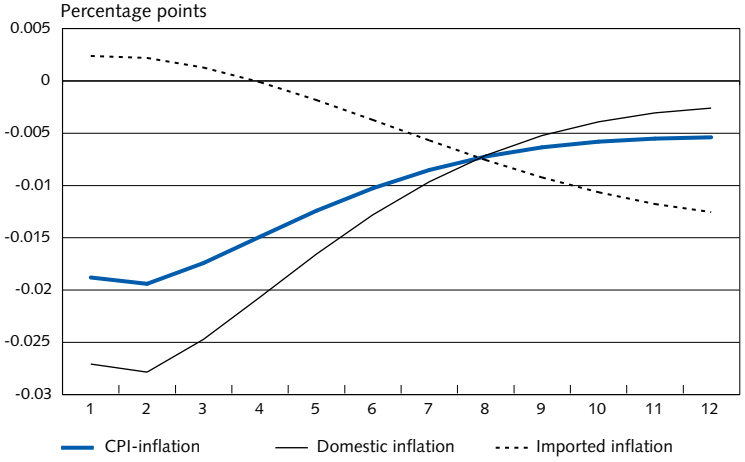
These two scenarios illustrate an important point. The CPI effect of increased competition in the rest of the world depends above all on how the competitive situation for domestic firms is affected. If the lower price mark-up applies only to imported products, the effect on inflation will be marginal. Indeed, as we have just seen, in such a scenario inflation may even rise. If price mark-ups fall for domestic products, too, on the other hand, the effect will be stronger, though in quantitative terms it is still relatively small.

INCREASED COMPETITION IN THE LABOUR MARKET

The third and last scenario shows how inflation is affected by increased competition in the labour market (see Charts 5a and 5b). The wage mark-up is assumed to fall from 30 to 29 per cent. This tends to push wages down. Due to wage rigidities, the pass-through is only partial in the short run. The weaker development of wages reduces the marginal cost for domestic firms and thereby lowers prices. As there are also price rigidities, the pass-through from the lower marginal cost is likewise only partial. The final result is a domestic price fall of less than 0.03 percentage points.

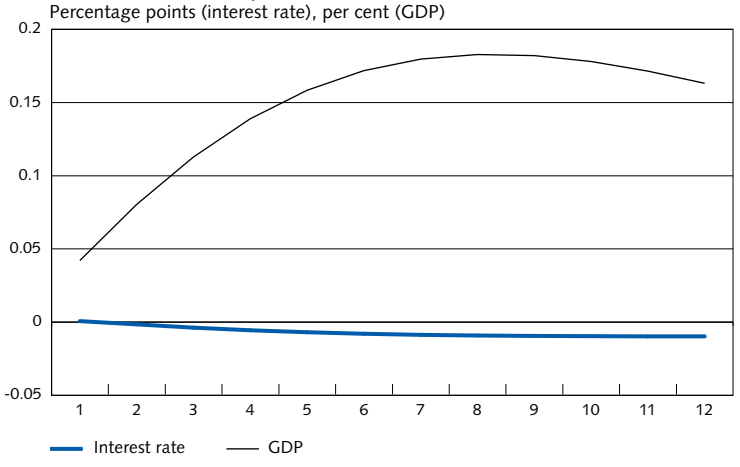
Low wages reduce the cost of hiring labour, which enables firms to expand production. The increase in GDP amounts at the most to 0.20 per cent. As prices fall, the central bank lowers the interest rate even though GDP increases. A lower interest rate leads to a weaker exchange rate, which entails some initial increase in the price of imported products. The CPI falls around 0.02 percentage points. Increased competition in the labour market accordingly has little quantitative effect on inflation.

Chart 5a. Increased competition in the labour market.
Percentage points



Source: The Riksbank.

Chart 5b. Increased competition in the labour market.
Percentage points (interest rate), per cent (GDP)



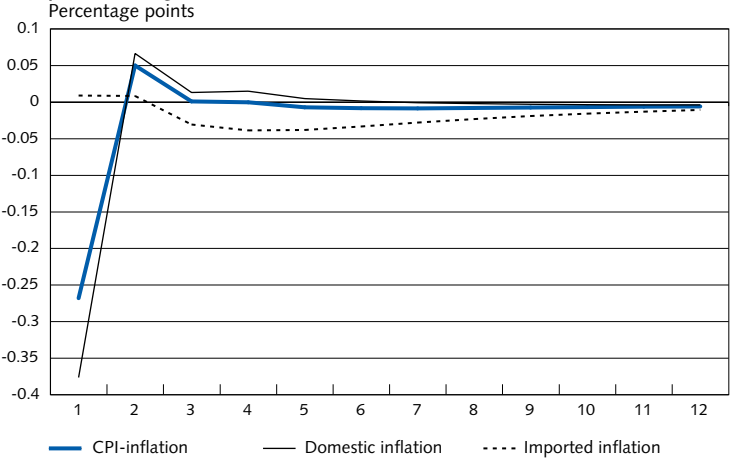
Source: The Riksbank.

INCREASED COMPETITION WITH FLEXIBLE PRICES AND WAGES

We have just seen that, as a rule, increased competition has effects on inflation that are small. An important reason for this is that prices and wages are relatively rigid. In a much-quoted article, Rogoff (2003) argues that increased competition should lead to less price and wage rigidity. In the model that is used in this study, however, changes in competition do not affect the degree of price and wage rigidity. But in order to illustrate Rogoff's point, we shall now look at how the results differ when prices and wages are less rigid. For the sake of simplicity we assume that prices and wages are completely flexible. That gives an upper limit for the quantitative importance of price and wage rigidities.

Chart 6 shows how inflation is affected when the price mark-up on domestic products is lowered 1 percentage point and prices and wages are entirely flexible. The price of domestic products falls 0.40 percentage points initially compared with 0.15 percentage points with price and wage rigidities. The pass-through to the CPI is approximately 0.25 percentage points as against 0.10 percentage points with rigid prices and wages.

Chart 6. Increased competition in the domestic product market with fully flexible prices and wages.
Percentage points

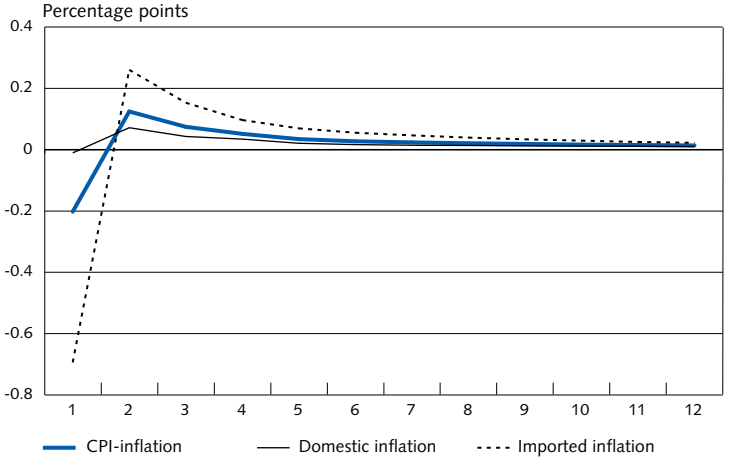


Source: The Riksbank.

Chart 7 shows the effect on inflation when import firms lower their price mark-up 1 percentage point. The price of imported products then falls as much as 0.70 percentage points compared with the marginal price fall of 0.04 percentage points with price and wage rigidities. As mentioned earlier, the large difference has to do with price rigidities being relatively strong in this sector. Another point to note is that in this case the CPI falls, in quantitative terms by 0.20 percentage points.

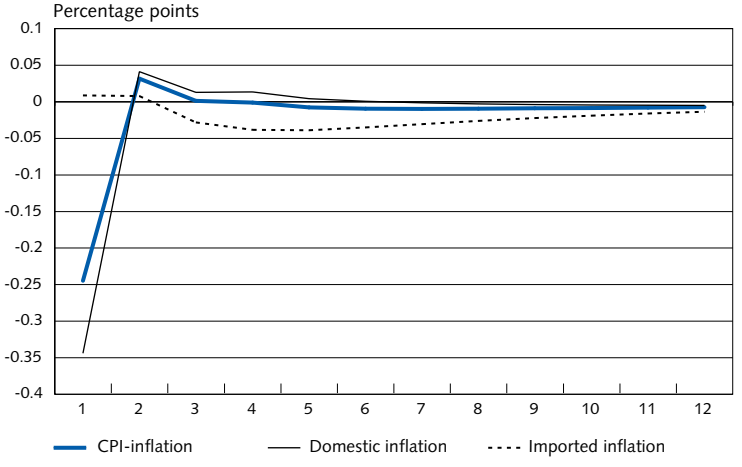
The extent to which prices are affected by increased competition in the labour market is largely dependent on the degree of wage flexibility. The pass-through from a lower wage mark-up to wages increases as wages become more flexible. Price rigidities are important, too, because they affect the extent to which the change in the marginal cost is passed on to prices. With fully flexible prices and wages, the pass-through to domestic prices is 0.35 percentage points (see Chart 8). As we saw in the preceding section, with price and wage rigidities the pass-through is less than 0.03 percentage points. The pass-through to the CPI is 0.25 percentage point as against 0.02 percentage points with price and wage rigidities.

Chart 7. Increased competition in the market for imported products with fully flexible prices and wages.
Percentage points



Source: The Riksbank.

Chart 8. Increased competition in the labour market with fully flexible prices and wages.
Percentage points



Source: The Riksbank.

To sum up, this section shows that price and wage rigidities are of major importance for the quantitative outcome. They are particularly important for the result of a lower wage mark-up and a lower price mark-up on imported products.

INCREASED COMPETITION AND MONETARY POLICY'S RESPONSE

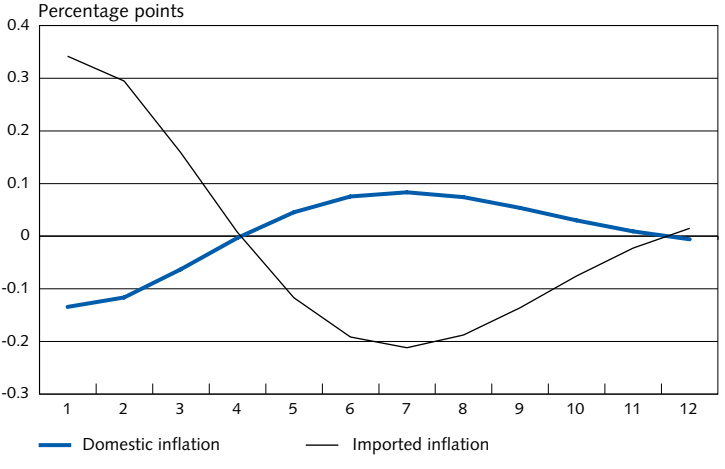
In the results presented above, the central bank chose to refrain from stabilising inflation completely when competition increased. Consideration was paid to the real economy; the fluctuations in GDP were stabilised in addition to the development of inflation. As it is possible in principle for a central bank to keep inflation completely stable, it is of interest to study what the effects of such a policy would be. There would, of course,

be no fluctuations in inflation but considerably larger fluctuations in the interest rate and thereby in GDP. The purpose of this section is to present the magnitude of these fluctuations. The focus is on the result of a lower price mark-up on domestic products. As we have seen, the CPI effects of a lower price mark-up on imported products and a lower wage mark-up are virtually negligible.

Chart 9 presents a scenario where the price mark-up on domestic products falls 1 percentage point and the central bank chooses to keep the CPI completely stable. Under these circumstances, the domestic price level falls approximately 0.15 percentage points initially. An unchanged CPI then requires an increase in imported prices. In quantitative terms, the increase needs to be approximately 0.35 percentage points. To achieve this, the central bank lowers the interest rate approximately 1 percentage point, which weakens the exchange rate and makes imported products more costly. The marked interest rate cut leads to large fluctuations in GDP, with an increase that reaches as much as 1.2 per cent. An increase in GDP may seem positive but a central bank that takes the real economy into consideration is intent on reducing the fluctuations around some "normal" level of GDP, in this case the steady state.[9] In other words, the central bank tries to avoid positive as well as negative deviations.

Briefly, then, this scenario shows that it is relatively costly for the central bank to keep the CPI completely stable. Large fluctuations occur in the interest rate as well as in GDP. It is therefore reasonable to expect that the central bank allows changes in competition to affect inflation. As we have seen, even when the central bank takes the real economy into consideration, the fluctuations in the CPI are relatively moderate.

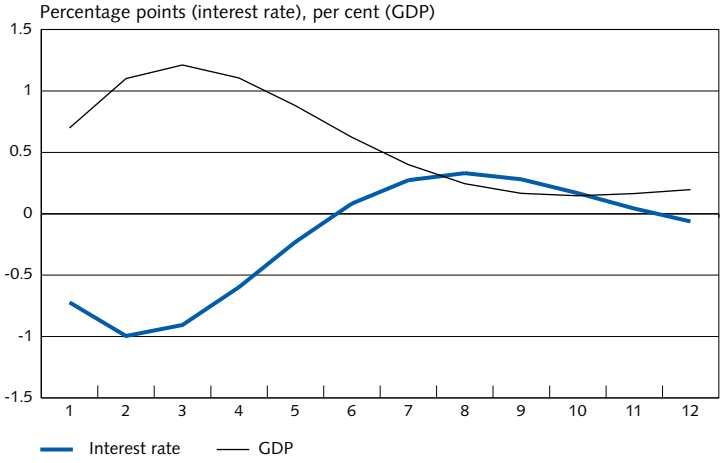
Chart 9a. Increased competition in the domestic product market with complete central bank stabilisation of the CPI.



Source: The Riksbank.

[9] There are a number of different ways to define the "normal" level, see Palmqvist (2007) for a discussion.

Chart 9b. Increased competition in the domestic product market with complete central bank stabilisation of the CPI.
Percentage points (interest rate), per cent (GDP)



Source: The Riksbank.

Concluding comments

This study aims at quantifying how increased competition affects inflation. It looks at the effects when price and wage mark-ups are lowered 1 percentage point in period 1, followed by a return at a uniform rate to the initial levels. The return is assumed to take approximately 6–7 years.

Increased competition turns out to have quantitative effects on the CPI that are small. A 1 percentage point reduction of the price mark-up on domestic products has an initial impact of 0.10 percentage points on the CPI. The CPI effects of increased competition in the imported products market and the labour market are virtually negligible.

A major reason why increased competition's impact on inflation is relatively small is that prices and wages in Sweden are relatively rigid. As we have seen, if prices and wages were fully flexible, the quantitative effects would be considerably larger. In a much-quoted study, Rogoff (2003) argues that price and wage rigidities are dependent on the degree of competition; increased competition leads to more flexible prices and wages. In that case, this model may underestimate increased competition's quantitative impact on prices. There are, however, other theories that point to increased competition leading to greater price and wage rigidities. Briefly, one such theory, presented by Woodford (2003), envisages that the risk of losing market share makes firms averse to their prices differing too much from the average price level. Increased competition accentuates the risk of losing market share and makes firms less prone to alter prices. So in theory there is no clear foundation for how price and wage rigidities are affected by increased competition. It may therefore be reasonable to assume, as we have done in the present model, that price and wage rigidities are independent of the degree of competition.

Finally, what conclusions can be drawn from this study of increased competition and its importance for inflation? The aim has been to discuss and quantify the relationship with the aid of a specific model. The account shows that the relationship between competition and inflation is complex, which rules out any simple conclusions. Still, the general picture presented here does suggest that increased competition's quantitative effects on inflation are relatively moderate. This also agrees with the conclusion in Asplund & Friberg (1998): "Having completed this survey, our reading of the evidence is that the primary explanation of low inflation rates in many countries in the last decade is not intensified competition." Instead, one of the primary reasons of the low inflation in Sweden in 2004–06 is presumably increased productivity; for an analysis of this, see Adolfson et al. (2007)

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Flexible inflation targeting – how should central banks take the real economy into consideration?

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Inflation targeting central banks frequently express that their policy is flexible. This means that when setting the policy rate they not only try to attain the inflation target, but also strive to stabilise real economic developments. To date, however, central banks have found it hard in practice to be precise about what stabilising the real economy means. One of the difficulties lies in defining and estimating the relevant measure of "potential output". This article describes alternative ways of defining potential output and discusses which definition is most appropriate from a monetary policy perspective.

Today, there are more than 20 central banks that conduct monetary policy with an inflation target. These central banks formulate their targets similarly in many respects, though there are, of course, differences in the details. All inflation targeting countries have, for instance, chosen to announce a quantitative objective for inflation, for example 2 per cent. They are also explicit about how to measure inflation for this purpose, for example as the annual percentage change in the consumer price index (CPI). Another common denominator is the practice of publishing forecasts and assessments on which monetary policy decisions are based. Moreover, all inflation targeting central banks conduct what is now commonly known as flexible inflation targeting. [2, 3]

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[2] The term "flexible inflation targeting" was introduced by Svensson (1999). It was defined as a situation where the central bank was minimising a quadratic loss function consisting of inflation's deviation from its target as well as output's deviation from its potential level. A central bank that focused solely on inflation's deviation from its target was said to be conducting strict inflation targeting.

[3] See Kuttner (2004) for an account of how countries with an inflation target formulate these targets.

Inflation targeting equals flexible inflation targeting in practice.

In simple terms, flexible inflation targeting means that the central bank sets its policy rate so as to stabilise inflation around the targeted rate and also stabilise the real economy. In practice, however, there are different ways of expressing this flexibility.

Some countries have chosen to define the inflation target in terms of a measure of core inflation, usually calculated as CPI inflation excluding price movements for certain goods and services. The purpose of excluding certain components of the CPI is to get an inflation measure that is less affected by short-run changes on the supply side of the economy. Supply shocks in oil-producing countries, for example, can lead to temporarily higher oil prices and thereby to a temporary increase in CPI inflation. By basing monetary policy deliberations on a measure of core inflation that excludes oil prices, the central bank reduces the risk of its policy accentuating real economic fluctuations, for instance in output, employment or unemployment. Formulating the inflation target in terms of core inflation can therefore be seen as a way of paying consideration to real economic developments, that is, it can be interpreted as flexible inflation targeting.

Another way of expressing that inflation targeting is flexible concerns the target horizon and how quickly the central bank tries to bring inflation back to the targeted rate after a deviation. Central banks usually state that under normal circumstances, inflation is to be brought back to target within a specified period, for example two years. They may also state that a slower return than normal may be reasonable in the event of a shock that is unusually large. The reason for this is that a policy for a rapid return to the target could generate unnecessary fluctuations in the real economy. Escape clauses of this type mean that the central bank does not focus solely on inflation when setting its policy rate and can thereby be seen as another way of expressing what we think of as flexible inflation targeting.

There is, however, a discrepancy between flexibility's manifestation in practice and what the scientific literature recommends. Theory requires that under flexible inflation targeting, each monetary policy decision shall entail a trade-off between inflation's deviation from the target and real economic stability. The academic literature on monetary policy recommends that this is done explicitly in order to clarify the central bank's view of both sides of the trade-off. In practice, the real economy is taken into consideration rather indirectly. So the discrepancy primarily concerns the appraisal of real economic stability and how it should be measured. Given the lack of agreement about and the difficulties involved in

measuring real economic stability, most central banks have not yet been particularly clear about what they mean by it.

Norges Bank is currently the central bank that comes closest to working in accordance with the theoretical notion of flexible inflation targeting. Norges Bank publishes forecasts for the policy rate, inflation and a measure of the output gap as a proxy for real economic stability. Moreover, monetary policy decisions are motivated with reference to an explicit trade-off between inflation's target deviation and real economic stability. This begs the question why other central banks have not followed this example. A probable explanation is that a numerical forecast of real economic stability is far more difficult to produce than a number for future inflation. So let us look at what the concept of real economic stability stands for and why it has become such a central issue in the academic literature.

Potential output can be defined in various ways

Real economic development is obviously crucial for a country's prosperity. Higher growth creates possibilities of greater welfare. Low unemployment is preferable to high, et cetera. However, monetary policy cannot effect the real economy in the long run. Research and experience both show that attempts to achieve permanently lower unemployment or higher growth are bound to fail. This is because monetary policy can create higher economic activity only by generating unexpectedly high inflation. So a monetary policy for permanently higher activity has to take economic agents continuously by surprise. When people realise that the central bank is intent on an increasingly expansionary policy, they will adjust their expectations to higher and higher inflation. As a result, actual and expected inflation will both rise but there will be no effect on economic activity. It is simply not possible to delude economic agents systematically. So today there is fairly general agreement about monetary policy being neutral in the long run, that is to say, it cannot exert a permanent effect on real economic developments. What monetary policy can do, on the other hand, apart from stabilising inflation, is to reduce fluctuations in real economic activity around a "potential" level, that is, to stabilise the real economy.

So what does the concept potential level stand for? There is actually no single generally accepted definition of this concept, as regards either output or other variables, for example unemployment and employment.[4]

[4] Rogerson (1997) exemplifies the confusion that exists about concepts such as the NAIRU, natural unemployment, equilibrium unemployment, et cetera, and considers that just a few of these concepts are adequately defined in modern research. However, as the article starts from an entirely real model, it is not particularly relevant when discussing what measure of potential output is appropriate for monetary policy.

Some economists appear to equate potential output with efficient output, that is, the hypothetical level output would reach if all factors of production were fully utilised and there were no imperfections in the form of, for example, distortionary taxes, imperfect competition or price and wage rigidities.[5] Others seem to envisage some form of average or trend output. It is not hard to see that these are two different notions. The first, potential output as the hypothetically efficient level, means that in practice the economy will presumably always be below its potential output. The other, trend output, equates potential output with the average level.

A third definition sees potential output as the hypothetical level that would be reached if all prices and wages were entirely flexible but there were still real distortions, such as taxes and imperfect competition. This notion of potential output is known as flexprice output.[6]

The difference between actual and potential output is commonly known as the output gap. Estimations of the output gap will differ, depending on whether potential output is defined as efficient output, trend output or flexprice output. So which definition of potential output is most appropriate in the context of monetary policy?

General equilibrium

Modern macro economics is increasingly based on general equilibrium and that is the starting point for this article. What, then, do we mean by general equilibrium theory or general equilibrium models?[7] Simplifying somewhat, general equilibrium implies that if we have a theory for explaining or understanding a number of economic parameters or variables (consumption and income, for example), then all these variables must be determined within the framework for the theory in question. In the case of partial equilibrium, we can, for instance, have a given development of income and a theory for how households then determine their consumption. With a general equilibrium model, on the other hand, the development of income is also determined within the model's framework. In general equilibrium, moreover, prices and quantities invariably adjust so that supply equals demand in every market (financial markets as well

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5 The term "full utilisation of factors of production" may not be entirely clear because the supply of labour and capital, for example, vary. Instead of delving deeper into this problem, we can interpret the full utilisation of factors of production as a situation with no unemployment and fully utilised capital stocks.

6 Potential level is sometimes also defined as the level that is compatible with a stable rate of inflation, that is, a level at which inflation neither rises nor falls. For unemployment, the potential level according to this definition is often referred to as the NAIRU or the "Non-Accelerating Inflation Rate of Unemployment". But as this definition of potential output has not left much mark on monetary policy research, it is not considered in this article.

7 The words "theory" and "model" are used synonymously in this article because all economic models are based on some economic theory and modern economic theory can mostly be described in the form of an economic model.

as factor and product markets). That is, in fact, what general equilibrium implies.

General equilibrium theory has existed and been used for a long time. The original general equilibrium models required a number of simplifying assumptions because otherwise they would have been excessively extensive and complex. Common assumptions were that all prices and wages are entirely flexible and that perfect competition reigns in every market. With the theory's application to a growing variety of issues, however, the basic assumptions had to be changed to get a better fit between the models and actual economic developments. Price or wage rigidities and some form of imperfect competition, for example, are now the rule rather than the exception in general equilibrium models. Models that incorporate such rigidities have proved to possess sound forecasting properties.[8]

The growing prevalence of general equilibrium as a foundation for macro economic theory also has consequences for terminology. In general equilibrium theory there is, for instance, no mention of disequilibria. The notion of general equilibrium embodies an endeavour to understand observed phenomena in a model within which all the variables are determined and where supply equals demand in every market. Actual output, like every other variable, can be seen as the outcome of an equilibrium that arises through the interaction of all the agents in the economy – households, firms, the central bank and the government. So in general equilibrium theory, "equilibrium output" is synonymous with "actual output".

Equilibrium output is, in fact, a term that is sometimes used to denote potential output. Similarly, equilibrium unemployment is sometimes used for the level of unemployment that is compatible with a stable rate of inflation. That is a terminology which I deplore: in general equilibrium, equilibrium output is equivalent to actual output, just as equilibrium unemployment is the same as actual unemployment. Denoting potential output as output's equilibrium level does not help us to arrive at the level of output which a central bank should aim for when stabilising actual output. So let us take a look at some other concepts that, unlike equilibrium output, can promote an understanding of which definition of potential output is relevant for monetary policy.

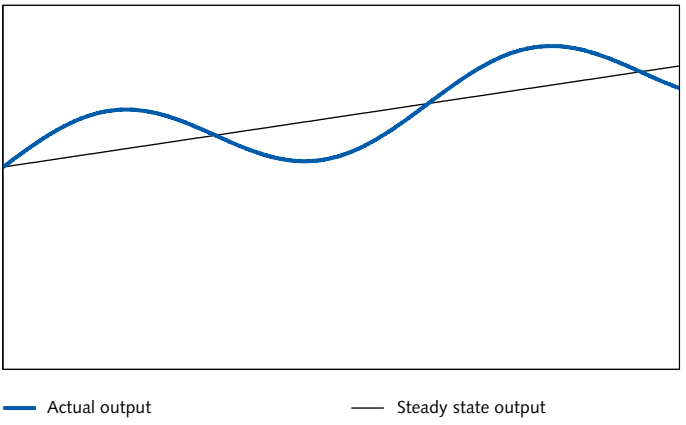
Steady state as a measure of potential output

Steady state, a concept that frequently features in general equilibrium theory, for example, refers to the state of the economy in the absence of new shocks when effects of all earlier shocks have faded away. Steady

[8] See Christiano, Eichenbaum, & Evans (2005), Smets & Wouters (2003), and Adolfson et. al (2005).

state is a hypothetical state that does not occur in practice because new shocks occur all the time. An alternative term for steady state, long-run equilibrium, is unsatisfactory for two reasons. One is that, as mentioned earlier, there are no disequilibria in general equilibrium theory (all outcomes are assumed to represent equilibria), so a reference to equilibrium does not add anything. The other reason is that the epithet long run is misleading because it suggests that the state will occur sooner or later, whereas steady state is, as mentioned, a hypothetical construct that does not arise in practice in either the short or the long run. Steady state is therefore the preferred term. Enough of terminology; Chart 1 presents a schematic picture of actual and steady state output.

Chart 1. Schematic representation of actual and steady state output.

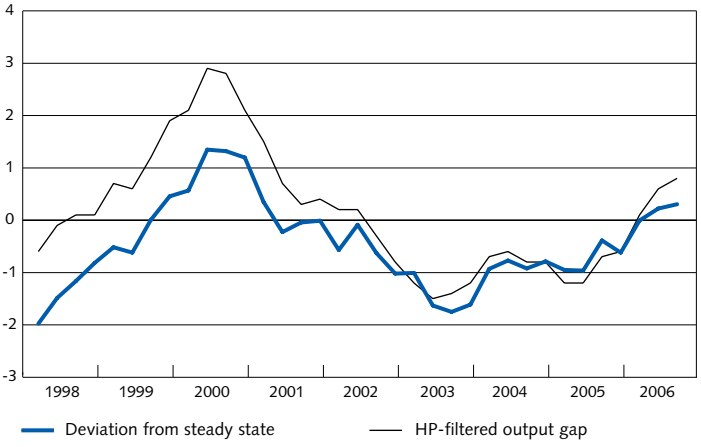


As we see, actual output fluctuates around the trend that represents output in the steady state. A common everyday term for the gap between actual and trend output is the business cycle. In practice, steady state output is not necessarily represented by an exactly linear trend. There are, however, just a few factors that can permanently alter the average growth of output, for instance research and development, education, and changes of a demographic and institutional nature (see for example Barro & Sala-i-Martin, 1995).

As it is a hypothetical concept, steady state output is not directly observable. Econometric methods are therefore commonly used to decompose actual output into a cyclical component and a trend that is derived by estimating output in the steady state. One method involves fitting a trend to data with an HP-filter. Alternatively, steady state output can be estimated with the aid of a general equilibrium model. Estimated business cycles (the gap between actual and steady state output), calculated with

an HP-filter and as deviations from the steady state in the Riksbank's macro model, RAMSES, are presented in Chart 2.[9]

Chart 2. Output gap calculated with an HP-filter and as the deviations from the steady state in the Riksbank's macro model, RAMSES.
Per cent



Sources: Statistics Sweden and the Riksbank.

The pictures provided by these alternative ways of calculating the business cycle are fairly similar: the timing of the peaks and troughs is more or less the same, though the levels differ now and then. The similarity is not surprising because these are basically just two different ways of trying to estimate the same thing. In many respects, both ways of calculating trend output resemble the process of fitting a linear trend. With the HP-filter the trend is not entirely linear; instead, a smooth trend is fitted that partly follows actual output. In RAMSES the steady state also follows a smooth trend. Output in the steady state is driven by a permanent productivity shock, that is, a productivity shock with permanent effects on productive capacity. As the permanent productivity shock is relatively stable in practice, the steady state in RAMSES also resembles a linear trend.

As mentioned in the introduction, there is no single, generally accepted definition of potential output. One possibility would be to define potential output as output in the steady state, which in practice is roughly tantamount to calculating the business cycle as the difference between actual and trend output. Does this mean that central banks ought to focus policy on stabilising such business cycles?

[9] For a decription of RAMSES, see Adolfson *et. al* (2007).

Stabilisation policy should not eliminate business cycles

A common argument in the debate on stabilisation policy is that the role of this policy is to eliminate business cycles, calculated as actual output's deviation from the steady state. The argument is frequently based on the notion of consumption smoothing, which refers to households' preference for a smooth as opposed to a fluctuating development of consumption. This suggests that besides stabilising inflation around the target, a central bank should try to eliminate the cyclical variations. To understand why this argument is misleading, we need to analyse the causes of variations in consumption.

One reason why consumption varies over time has to do with the variations in productivity. In this case, consumption smoothing can be illustrated by giving households a choice between two paths for productivity: one that sticks to the trend and another that fluctuates around this trend. Households would choose the stable development of productivity because that gives rise to a smoother development of consumption. From this it follows that it would be desirable to eliminate the cause of the variation in consumption, in this case the fluctuations in productivity.

But even if it is desirable to eliminate all variations in either productivity or other causes of business cycles, that cannot be achieved with either monetary or fiscal policy. Stabilisation policy simply cannot bring about a stable development of productivity. Instead, the question stabilisation policy faces is as follows: Given that productivity, for example, varies over time, should or should not policy focus on eliminating the consequences of these variations?

According to the academic literature, it would not be optimal for stabilisation policy to aim for the total elimination of all cyclical variations. The reason for this is easiest to understand by studying a neoclassical general equilibrium model, that is, a model with perfect competition in every market and no rigidities or other imperfections. In such a model, business cycles arise as efficient responses to the occurrence of shocks, for example productivity shocks.[10] As all responses are efficient, in terms of welfare there is nothing a central bank or a government can do to improve the outcome for consumers and consequently there is no point in trying to eliminate business cycles.

Even when price or wage rigidities are included in the model, business cycles can arise in the same way. With such nominal rigidities, however, prices do not adjust to the same extent as in the neoclassical model. With price rigidities, output's response to a productivity shock,

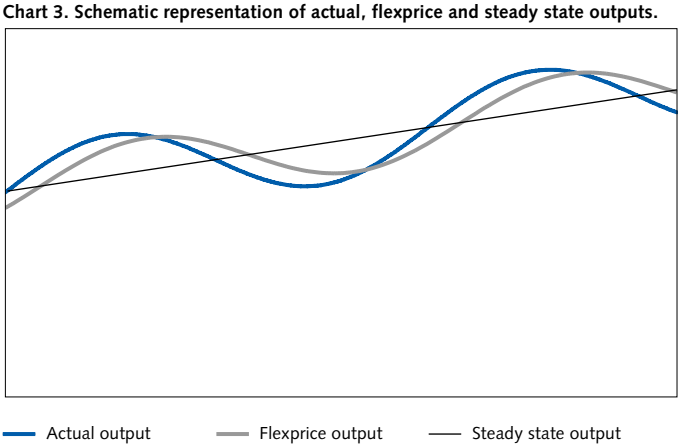
[10] See Kydland & Prescott (1982).

for instance, will not be efficient and as the responses are inefficient, there is room for welfare improvements. That is why monetary policy research indicates that central banks ought to pay *some* consideration to the real economy when setting the policy rate. How is this to be done? As the *total* elimination of business cycles is not optimal in a model with fully flexible prices, neither is it optimal in a model with price rigidities. So instead of eliminating business cycles, the best thing a central bank can do in a model with price rigidities is rather to aim for a cyclical path that resembles what would have occurred if prices had been flexible, which brings us to the concept of flexprice output.

Flexprice output is the most relevant measure of potential output

As mentioned earlier, it is becoming increasingly common for general equilibrium models to incorporate rigidities in prices and wages, for example. This has led to the introduction of the concept of flexprice output, which represents the output that would have occurred, given that all prices (including wages) are fully flexible. This is a hypothetical measure and a deviation from flexprice output is called the flexprice gap. A schematic representation of flexprice output is shown in Chart 3 together with actual and steady state outputs.

Chart 3. Schematic representation of actual, flexprice and steady state outputs.



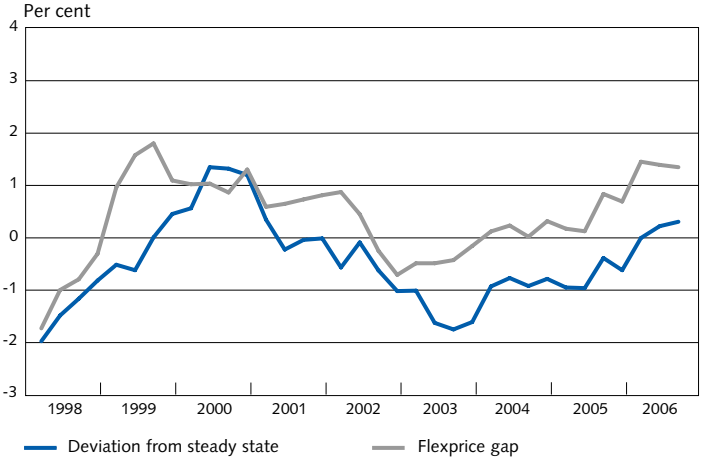
As we see, actual and flexprice output both fluctuate around the same steady state. The driving forces on flexprice output are in principle the same as those on actual output, for instance productivity shocks. This is very different from steady state output, which is affected by just a few matters. The similarity between the influences on flexprice and actual

output has to do with how the two are defined: the only difference is that flexible prices are assumed for flexprice output and price rigidities for actual output. If price rigidities are very small, flexprice output will not differ greatly from actual output; an increase in productivity, for example, will raise both flexprice and actual output to much the same extent. With very rigid prices, on the other hand, increased productivity will result in a larger difference. As flexprice and actual output are influenced in a similar manner, one of them cannot be studied or forecast independently of the other. They are closely inter-related and have to be estimated within the framework of one and the same model.

Flexprice output has recently been attracting more and more attention in monetary policy research. Woodford (1999) argues that it is precisely flexprice output which is the relevant measure of potential output for monetary policy. In other words, a central bank ought to aim to minimise actual output's fluctuations around this varying flexprice output. Svensson (2006) voices a similar opinion. One of the underlying reasons is the presumed desirability of monetary policy reducing or eliminating the consequences of price and wage rigidities.

The Riksbank's macro model, RAMSES, mentioned above, can also be used to calculate flexprice output.[11] Output gaps calculated as the flexprice gap and the deviation from steady state, respectively, are presented in Chart 4.

Chart 4. Deviations from steady state and flexprice gap according to the Riksbank's macro model, RAMSES.
Per cent



Sources: Statistics Sweden and the Riksbank.

[11] The version of RAMSES that is normally used includes both price and wage rigidities; this version is estimated on real-life data and one of its results is an output gap that measures output's deviation from the steady state. Flexprice output is obtained with the same model and parameter estimates except that price and wage rigidities are set to zero; flexprice output is then obtained by introducing the shocks, for instance from productivity, that have been identified in the version with price and wage rigidities.

When we compared an HP-filtered output gap with an output gap calculated as the deviation from steady state, the main difference was in the output gap's level, while the timing of peaks and troughs was relatively similar. The flexprice gap gives a somewhat different picture, as one might expect since the two measures are based on different definitions of potential output. The flexprice gap indicates, for instance, that flexprice output was already exceeded by actual output early in 1999, whereas the latter did not exceed steady state output until almost a year later. The two ways of defining potential output give a similar discrepancy in the picture of the current situation: actual output has been above flexprice output ever since the beginning of 2004 whereas it did not exceed steady state output until the summer of 2006.

Flexprice output accordingly indicates what output would be if prices and wages were fully flexible. If price and wage rigidities were the only imperfections in the economy, the central bank should take the real economy into consideration by stabilising the flexprice gap as well as inflation's deviation from the target. In practice, however, other imperfections are at work, for instance in product markets. So what are the implications of these and other imperfections for the measure of potential output that is relevant for monetary policy?

Other imperfections also exist in practice

The case for taking the real economy into consideration by stabilising the flexprice gap is valid only if price or wage rigidities are the economy's only imperfections. Given imperfect competition in product markets, firms will set prices as a mark-up over marginal costs. Prices will then be higher and the volume of output lower than with perfect competition. So even if all prices and wages were fully flexible, average output would be unduly low. Thus, flexprice output is inefficient under imperfect competition. So a central bank that aims to stabilise the flexprice gap will not produce the best possible outcome for consumers.

A common assumption in general equilibrium models such as RAMSES is that the price mark-up varies over time, which means that flexprice output varies over time as a direct consequence of mark-up changes.[12] Under perfect competition, on the other hand, price mark-ups are constant over time. So in order to approximate efficient output under perfect competition, the variations in price mark-ups must be turned off in the model, as well as the price and wage rigidities.[13]

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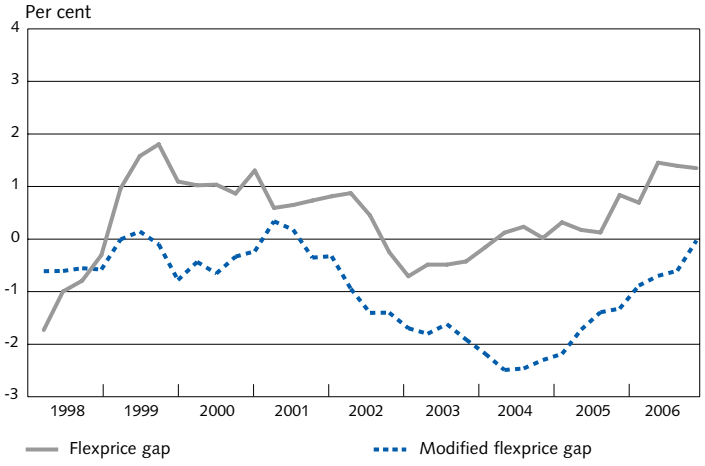
[12] For a study of the effects of mark-ups on inflation, see Jonsson (2007).

[13] Just shutting off the variations in price mark-ups is not sufficient in practice. The model is calibrated around a steady state with an average price mark-up that is greater than one, that is, output in the steady state is too low. Benigno & Woodford (2005) demonstrate how a welfare-relevant measure of potential output can be calculated when the steady state is inefficient due to imperfect competition in product markets.

In RAMSES it is not only price mark-up variations that give rise to a difference between flexprice output and efficient output. There is, for example, the assumption that monetary policy follows a Taylor rule, which simplifying somewhat means that the policy rate is set as a function of inflation's deviation from the target and a measure of the output gap.[14] The monetary policy rule also includes a monetary policy shock: a measure of how well the rule manages to predict actual policy rate adjustments. Such monetary policy shocks have some effect on flexprice output but not on efficient output. Chart 5 presents a modified flexprice gap when some of these factors have been turned off and price and wage rigidities are set to zero.

Chart 5. Pure and modified flexprice gaps according to the Riksbank's macro model, RAMSES.



Note. Calculating the modified flexprice gap involves setting all price and wage rigidities to zero and shutting off all variations in price mark-ups, monetary policy shocks, deviations from UIP and shocks to the inflation target.

Sources: Statistics Sweden and the Riksbank.

As Chart 5 shows, these two ways of defining potential output also give different estimates of the output gap. We are accustomed to the uncertainty in forecasts of future inflation, whereas current inflation is a more definite quantity. The uncertainty about the output gap is of a different kind. It concerns the most correct way of the defining the measure of potential output that is relevant for monetary policy and the choice results in relatively large differences in the picture of the current situation. Arriving at numerical forecasts for the measure of the output gap that is relevant for monetary policy is therefore an order of magnitude more difficult than forecasting a number for inflation.

[14] In practice, the monetary policy rule also includes the previous period's interest rate and the changes in inflation and the output gap as well as the real exchange rate.

Real economic stability in the future

Of the more than 20 countries that target inflation, a majority can be seen as examples of flexible inflation targeting. But it is only Norges Bank that publishes output gap forecasts and motivates its decisions with an explicit trade-off between inflation's deviation from the target and the path of the output gap. It is noteworthy, however, that Norges Bank recently attracted some criticism for not being clear enough in its opinion about potential output and that the latter should not be represented by output's trend level.[15]

In order to conduct a policy in line with the theoretical definition of flexible inflation targeting and present a clearer view of real economic stability, it is necessary to form an opinion about the measure of potential output that is relevant for monetary policy. This measure clearly cannot be obtained with simple traditional methods for fitting a trend to data. Neither does it seem possible to calculate without a model that includes all the main markets, rigidities and imperfections. In the absence of such a model, one can hardly form an opinion about what output would be if, for example, prices were fully flexible. General equilibrium models can admittedly serve to calculate a flexprice gap and other welfare-relevant measures of the output gap. But not even with such models is it a simple matter to define and calculate the measure of potential output that is relevant for monetary policy. The treatment of capital stocks in a calculation of flexprice output is, for example, not self-evident. Should flexprice output be seen as the level of output that would be reached if prices and wages are flexible in the future but the existing capital stock is taken as given? Or should the capital stock be calculated as the hypothetical stock that would exist today if prices and wages had been flexible since the beginning of time?

Even if general equilibrium models are included in forecasting work by more and more central banks, they are only one of many ingredients in the final forecast. They do not comprise all the available information about economic developments; assessments by sector specialists and forecasts from time series models also contribute to the final result. Central banks' overall "model" of the economy in a wider sense is obtained as a weighted mix of all these ingredients. So how should a welfare-relevant measure of potential output be calculated when the final forecast consists of an implicit mixture of all the various ingredients? No central bank has yet fully integrated a general equilibrium model in its forecasting work, so it is perhaps hardly surprising that most central banks are not particularly precise about their view of real economic stability. It is reasonable to suppose that in future these models will continued to be

[15] See Goodfriend et al. (2007)

developed and integrated in monetary policy analyses by more and more central banks. As the picture of the measure of potential output that is relevant for monetary policy becomes clearer, it is also reasonable to suppose that central banks will become clearer in their view of the part that real economic stability plays in monetary policy decisions.

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Aspects of the relationship between monetary policy and unemployment

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For fifteen years now, unemployment in Sweden has been historically high. Monetary policy is sometimes blamed for this, particularly in recent years when inflation has been below the Riksbank's targeted rate. The article considers the relevance of this criticism in the light of the conditions in which monetary policy is conducted. With hindsight it can be said that monetary policy could have been somewhat more expansive, above all in the period 2002–03. But to conclude from this that much of the responsibility for the high unemployment in recent years rests with the Riksbank is to have unreasonable expectations of what monetary policy can accomplish.[1]

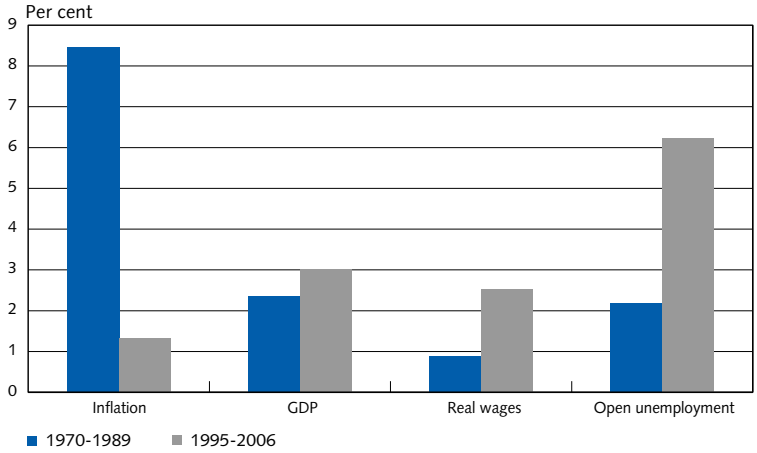
Since the change in Sweden's economic policy regime in the early 1990s, real incomes and GDP have grown more rapidly than in the preceding decades but unemployment has developed less favourably (see Chart 1). There has been a lively discussion of the reasons for this. Some see it as a result of a new economic phenomenon, jobless growth; others suggest that it was only after the regime shift that the Swedish labour market's structural problems became visible. There is, however, a third view to the effect that much of the unemployment has been due to inflation being below the Riksbank's targeted rate and that this in turn is a consequence of monetary policy misjudgements. It is the latter argument that is our primary concern here.

[1] Valuable opinions have been contributed by participants in the Riksbank's monetary policy group. We also wish to thank Johanna Stenkula von Rosen and Gustav Karlsson for assistance with statistics and charts.

The discussion about monetary policy's role for unemployment flared up in 2004, when inflation was markedly below the Riksbank's target. It was argued that monetary policy had been instrumental in adding between 50,000 and 70,000 to the number of unemployed persons.[2] The Riksbank's opinion about this, presented in speeches and articles, is that the calculations do not, for example, take the conditions under which monetary policy operates into account.[3]

New fuel was recently added to this debate with the publication of Giavazzi & Mishkin's (2006) monetary policy evaluation, which notes on page 77 that inflation has undershot the target in recent years and that "this has been associated with a loss in output and higher unemployment", a formulation that was manna to the Riksbank's critics.[4]

Chart 1. Inflation, GDP growth, change in real wage income and open unemployment 1970–2006.



Note. The bars represent the average for each period. Real wages are for the total economy.

Sources: National Mediation Office, Statistics Sweden and the Riksbank.

An open debate about monetary policy and its effects is self-evidently welcome. It is a necessary condition for the legitimacy of the Riksbank's independence as Sweden's central bank. But it is also important that the debate is based on what we now know about the relationship between inflation and unemployment, as well as on a realistic view of what monetary policy can accomplish. The renewed debate about monetary policy and unemployment in the wake of Giavazzi & Mishkin's report shows that a reminder is needed of the conditions under which monetary policy is conducted and acts.

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2 See, for example, Edin *et al.* (2004) and Lundborg (2004).

3 See, for example, Bergström & Boije (2005), Heikensten (2005) and *Inflation Report* 2005:1, 55–64, Sveriges Riksbank.

4 See, for example, the leading article in *Aftonbladet*, 2 December 2006, and Johansson & Sommestad (2006). For rejoinders, see Persson (2007) and Rosenberg & Vredin (2006).

This article begins by considering what is the primary aim of the Riksbank's monetary policy because that is fundamental for an understanding and evaluation of monetary policy decisions. We then look at what research and practical experience have to say about the relationship between monetary policy, inflation and unemployment. We also discuss what the necessity of basing monetary policy on forecasts implies for what monetary policy can be expected to achieve. In the light of all this we scrutinise the argument that much of the high unemployment in recent years is the Riksbank's fault. In conclusion, we briefly consider other possible reasons why unemployment today is higher than in the decades before the crisis in the early 1900s.

1. Monetary policy's objective

From the public debate about monetary policy and unemployment it sometimes seems that, following the regime shift in economic policy in the early 1990s, responsibility for stabilisation policy in a wide sense has been assigned to the Riksbank. In reality, however, the primary reason for the change of regime was to put an end to the earlier decades' unsuccessful attempts to fine-tune the economy. Economic policy would now be based instead on firm rules; monetary policy would be responsible for price stability and fiscal policy was to be based on long-term sustainability.

The Riksbank Act stipulates that the objective of the Riksbank's activities is to maintain price stability, without any qualifications such as a goal for employment. The Act's prefatory documents do state, however, that without prejudice to the objective of price stability, the Riksbank is to support the goals of general economic policy with a view to achieving sustainable growth and high employment. In recent years the Riksbank has been increasingly explicit about how it takes the real economy into account. This is done by not invariably aiming to restore the rate of inflation to the 2 per cent target as soon as possible in the event of a deviation. Monetary policy normally aims to bring inflation into line with the target within two years after a deviation has occurred. This means that at times the Riksbank deliberately accepts a shorter period during which inflation is above or below the target.[5] This is what is known as a flexible inflation-targeting policy.

[5] For a fuller account of how monetary policy is conducted, see *Monetary policy in Sweden* (Sveriges Riksbank 2006a), which can be downloaded from the Riksbank's website, www.riksbank.se.

2. The relationship between inflation and unemployment

The beginning of the marked increase in unemployment more or less coincided with the introduction of the low-inflation regime in the early 1990s. This might be taken to indicate that the high unemployment is at least partly a consequence of the low-inflation policy as such. So how are inflation and unemployment inter-related?

The standard starting point for illuminating the relationship between inflation and unemployment is the Phillips curve, which postulates a negative relationship in the short run. If demand is stimulated with an expansionary monetary policy, firms will employ more labour in order to increase their output. This will be accompanied by a faster increase in product prices – higher inflation. Sooner or later, however, employees will demand higher wages to compensate for the increased inflation. The price and wage increases will then counteract monetary policy's stimulatory effect, leading to slacker demand and declining employment. In the long run, unemployment will return to an equilibrium level (NAIRU) where actual inflation is at the expected rate.[6] This is sometimes described as the Phillips curve being vertical in the long run.[7]

Some studies do suggest that the Phillips curve could become vertical at a rate of inflation that is somewhat higher than the levels around 2 per cent that most central banks have chosen (see Akerlof et al. 1996, 2000; Lundborg & Sacklén 2002, 2006). In that case, the Riksbank's choice of inflation target may contribute to unnecessarily high unemployment. While space does not permit a closer look at this literature, it should be noted that these studies have elicited theoretical as well as empirical objections (see e.g. Blinder 2000, Holden 2004 and Bergström & Boije 2005). There are currently no convincing arguments or empirical evidence that the choice of inflation target has contributed to higher unemployment. Neither did Giavazzi & Mishkin (2006) find any strong reasons for adjusting the level of the Riksbank's inflation target.

Although the traditional Phillips curve simplifies the relationship between inflation and unemployment, it is an illustrative representation of the basic insight that monetary policy cannot achieve a permanent increase in employment: if an expansionary monetary policy is used systematically to bring unemployment down below the natural level, the end result will simply be higher inflation and inflation expectations.

It is more of a problem to use simple models of this type to form an opinion about how monetary policy ought to be conducted or how

[6] NAIRU stands for Non Accelerating Inflation Rate of Unemployment.

[7] See Lundborg et al. (2007) for a discussion of factors that can be assumed to affect the level of NAIRU.

it affects unemployment. The simple Phillips curve is sometimes used to argue that provided the Riksbank maintains an inflation rate of two percent, unemployment will be constant and equal the NAIRU. From this point of view, NAIRU is the level of unemployment that is assumed to be compatible with stable inflation in line with the Riksbank's target. Estimations of the NAIRU have been used by Edin et al. (2004), for example, to arrive at monetary policy's contribution to the number of unemployed persons. In 2004 the labour force totalled approximately 4,460,000 persons and the registered rate of unemployment was 5.5 per cent; assuming that the NAIRU was 4 per cent, this line of reasoning gives a loss of jobs for 67,000 persons [(0.055–0.04)*4,460,000 = 67,000].[8]

There are several objections to calculations of this type. One concerns the assumption that inflation and open unemployment are, in fact, related in the sense that the targeted rate of inflation leads to actual unemployment at the NAIRU level. Reality is far more complicated and the NAIRU is a concept with little foundation in modern monetary policy research. Numerous factors influence unemployment in practice and most of them are unconnected with monetary policy and inflation. In modern labour market models, unemployment is affected by, for instance, the development of productivity, rule changes and other shocks to which the economy is constantly exposed.[9] From the macro models that are used in research nowadays and, to a growing extent, by central banks, it is clear that inflation likewise fluctuates as a result of many factors.[10] In other words, the driving forces behind inflation cannot be understood simply by studying developments in the labour market. In order to explain a particular development of inflation or unemployment, one needs a picture of all the various disturbances that are currently at work in the economy.

Against this background it is hardly surprising that most empirical studies have not been able to demonstrate a simple and stable relationship between the levels of unemployment and inflation. American studies have found that changes in unemployment explain approximately 20 per cent of the variation in inflation.[11] According to Stiglitz (1997), this points to unemployment being an important factor for monetary policy, an opinion that we share. The Riksbank does, in fact, closely follow how the degree of resource utilisation in the labour market develops.[12] But it is also the case that the American studies show that 80 per cent of the variation in inflation is due to factors other than unemployment. It fol-

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8 Note that the calculation is highly sensitive to the assumption about the NAIRU; with an estimate of 5 instead of 4 per cent, the job loss would amount to 22,000.

9 See, for example, Rogerson et al. (2005).

10 See, for example, Smets and Wouters (2003).

11 See, for example, Stiglitz (1997).

12 See, for example, *Inflation Report* 2006:3, 42–50, Sveriges Riksbank (2006c).

lows that actual unemployment's deviation from the NAIRU should be of relatively limited value as information about future inflation. Jansson & Palmqvist (2005) show that in the past decade, the relationship between labour-market resource utilisation and inflation has been very weak. For the Riksbank's inflation forecasts, the consequences of assuming that the NAIRU is, say, 5 rather than 4 per cent are therefore very slight.[13] Staiger et al. (1997) consider that NAIRU estimations for the US economy are so uncertain that they add nothing to the discussion of monetary policy.

Our conclusions so far can be summarised as follows: There is a short-run relationship between inflation and unemployment but it is neither simple nor stable. In the long run, a permanent reduction of unemployment cannot be achieved via an expansionary monetary policy. The existence of a short-run link between inflation and unemployment is, however, a reason for the Riksbank to take the real economy into consideration. We have also argued that the NAIRU can be used for an instructive explanation of why a continuously expansionary monetary policy, aimed at bringing unemployment down below the natural level, simply leads to higher inflation and higher inflation expectations. With reference to how monetary policy ought to be conducted, however, the NAIRU has little to contribute. Actual unemployment's deviation from the NAIRU is a poor indicator of inflation for the simple reason that inflation is also determined by many other factors. Modern research suggests that for a judicious monetary policy it is considerably more important to employ a general equilibrium approach and identify the type of disturbance that is affecting the economy.[14]

3. Monetary policy's impact on unemployment

Monetary policy is accordingly not to blame for every fluctuation in unemployment. It is still possible, however, that monetary policy misjudgements can render the labour market unnecessarily weak in the short run. At the same time, an assessment of monetary policy in recent years, when inflation has undershot the target, calls for an understanding of the conditions under which monetary policy is conducted. It is also important to understand the reasons why inflation has been so low and how unemployment has been affected by them, over and above any effects connected with the formulation of monetary policy.

[13] See also Flodén (2005).
[14] See, for example, Rogerson (1999) and Hall (2005).

MONETARY POLICY IS BASED ON FORECASTS

The first thing to note is that, because of the time lag before its full effects materialise, monetary policy has to be based on forecasts, which are inherently uncertain. Future economic developments cannot be predicted exactly by either the Riksbank or other observers. Moreover, if inflation has strayed from the targeted rate, it cannot be brought into line again at short notice, except possibly with very large interest rate adjustments. It is therefore not reasonable to base an assessment on the notion that the Riksbank must always have an exact perception of future economic developments and that inflation shall be constantly on target. But one can require the Riksbank to produce the best possible forecasts. Given that the Riksbank's forecasts are no worse than others, an assessment must focus on whether monetary policy decisions have been reasonable in the light of the concurrent forecasts.

Giavazzi & Mishkin's (2006, p. 77) conclusion that inflation in recent years has "persistently undershot the Riksbank's target; this has been associated with a loss in output and higher unemployment" is unobjectionable. Declining inflation coincided with rising unemployment. The relevant issue here, however, is the extent to which this was a consequence of shortcomings in the Riksbank's forecasts. Giavazzi & Mishkin note that these forecasts stand up well compared with those from other observers but leave "room for improvements" (p. 77). At the same time, they stress that the forecasting errors were presumably difficult to avoid (p. 56).

BELOW-TARGET INFLATION AND ITS IMPORTANCE FOR UNEMPLOYMENT

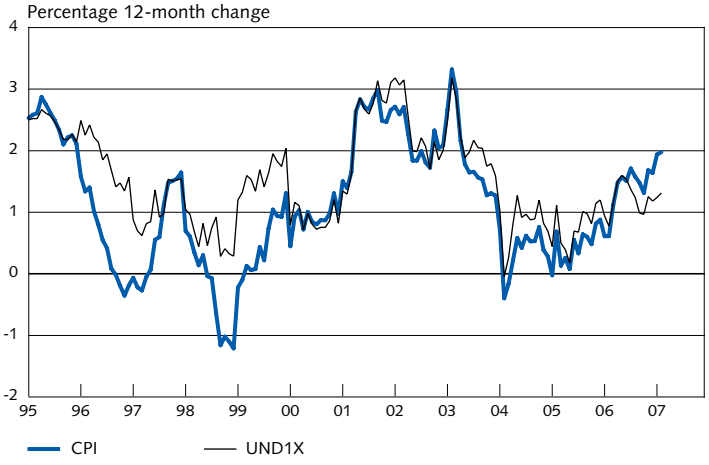
Between 1995 (when the inflation target was adopted in full) and 2006, annual CPI inflation averaged 1.3 per cent and UND1X inflation 1.7 per cent (the latter calculated with Statistics Sweden's earlier method before 2005 and then with the new method).[15] Although the average level differed somewhat from the Riksbank's chosen target, it must be said that the statutory objective of price stability was fulfilled. Moreover, inflation expectations have been anchored around 2 per cent since long, which suggests that despite the deviations, the inflation target has been perceived as credible.

A period when inflation deviated markedly from the Riksbank's target is 2004–05 (see Chart 2), making it relevant to take a closer look at the reasons for this. Was it a result of earlier monetary policy misjudgements? One way of finding an answer involves studying whether

[15] One reason why UND1X inflation was above CPI inflation in this period is the repo rate's downward trend and the impact of this on house mortgage rates.

the Riksbank's previous behaviour changed in the years before inflation undershot the target (for instance by beginning to pay particular consideration to the development of house prices, as has been asserted in the debate). The conclusion Giavazzi & Mishkin draw from such an analysis is that the actual policy rate was generally close to the rate the Riksbank would have chosen, given an estimated historical pattern of behaviour. So there are no grounds for asserting that it was monetary policy which *caused* the low inflation in recent years. Instead, the Riksbank *reacted* to the low inflation by reducing its policy rate to a level that was historically low.

Chart 2. Inflation (CPI and UND1X).
Percentage 12-month change



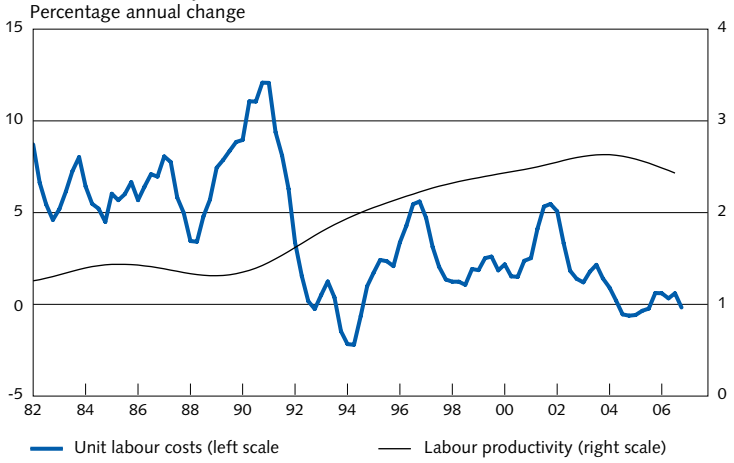
Source: SCB.

Instead, the low inflation was primarily a result of changes occurring on the supply side of the economy . One illustration of this is the combination of low inflation and strong economic growth. The Riksbank's analysis singles out the high productivity growth as the most important supply shock (see Chart 3).[16] Strong labour productivity, accompanied by moderate wage increases, left firms with less need to raise prices.

It has been argued in some quarters that inflation below the target has resulted in unduly high real wages (see, for example, Vartiainen 2005 and Lundborg 2004) and thereby subdued labour demand. However, considering that the strong productivity growth gave a very favourable development of unit labour costs in the years in question (see Chart 3), it is hard to see unit labour costs as a crucial factor behind the high unemployment.

[16] Simulations in RAMSES, the Riksbank's dynamic general equilibrium model, support the impression that supply shocks were the crucial factor behind the below-target inflation. See Adolfson et al. (2005).

Chart 3. Productivity and unit labour costs.
Percentage annual change



Note. Trendwise productivity for the total economy, calculated with a Hodrick-Prescott filter. Unit labour costs calculated as a moving four-quarter average.

Sources: Statistics Sweden and the Riksbank.

HOW WOULD A DIFFERENT MONETARY POLICY HAVE AFFECTED UNEMPLOYMENT?

We have noted that the below-target inflation and weak employment in recent years did not stem from slack growth and demand. On the contrary, the growth of output exceeded the Riksbank's expectations. Neither are there grounds for claiming that inflation below the target has led to notably high real labour costs. But of course one can assert, at least with hindsight, that if the Riksbank had chosen to stimulate demand even more by cutting the policy rate earlier on, employment could have been higher without a risk of inflation overshooting the target. As we pointed out earlier, however, the relevant question is whether the Riksbank's monetary policy decisions were reasonable, given the information and knowledge that were available at the time. Assessments have shown that the monetary policy decisions in the years 2002–03 were based on prospects for inflation and the business cycle that did not differ appreciably from the picture presented by other observers.[17] There were those who argued for a slightly different formulation of monetary policy. The Swedish National Institute of Economic Research, for instance, recommended an earlier reduction of the policy rate. However, compared with the policy rate's actual path in the years 2002–03, the Institute's recommended development represents an average difference of only 0.2 percentage points. It is hard to judge how the labour market would have developed if

[17] See Giavazzi & Mishkin (2006); also *Inflation Report* 2005:1, 55–64, Sveriges Riksbank (2005) and *Inflation Report* 2006:1, 48–61, Sveriges Riksbank (2006b).

the rate had been that much lower for a couple of years. The Riksbank's calculations suggest that the number unemployed might perhaps have been just over 5,000 fewer. According to earlier calculations from the National Institute, the effect would have been even smaller.[18]

In Inflation Report 2005:1 (Sveriges Riksbank 2005, p. 61) the Riksbank states that "the demands on monetary policy would have had to be considerable if 2004 inflation were to have turned out a lot closer to the target than was the case". For one thing, in the years 2002–03 the Riksbank would have needed to foresee a development that no other observer managed to predict and that differed greatly from the general view of prospects for the economy and inflation. For another, the high inflation at that time would have made it very difficult to motivate a policy rate that was a good bit below what the Riksbank actually chose.

Still, let us assume hypothetically that in that situation the Riksbank, unlike every other observer, had managed to foresee the permanently high growth of productivity. Let us also assume that the policy rate could then have been, say, 0.5 percentage points lower in 2002–03 without the Riksbank's credibility being seriously questioned in the prevailing situation with high inflation. What would that have meant for unemployment? The Riksbank's esimate is that this difference could have contributed to around 10,000–15,000 fewer persons in unemployment. That is not a negligible number but it needs to be seen in relation to the total number unemployed, which in 2004 and 2005 was around 350,000 persons (ILO's definition). This shows that the problems in the Swedish labour market do not have all that much to do with the formulation of monetary policy.

4. Factors behind the historically high unemployment

So what are the alternative explanations for unemployment now being higher than in the 1970s and 1980s?

In the decades before the crisis in the early 1990s, economic policy was accommodating – rising costs and falling export growth were countered with devaluations. Writing down the value of the currency safeguarded competitiveness for some years, whereupon another devaluation was called for. As a remedy for the problems with employment, however, this was a short-term solution. As time passed, more frequent and larger devaluations would have been required to restore competitiveness, with an appreciable risk of inflation getting out of hand. Another way of keeping unemployment down in the 1970s and 1980s was a gradual expansion of public sector jobs but neither could that continue. It can

[18] See Bergström & Boije (2005).

therefore be argued that in those decades unemployment was kept down with measures that were not sustainable.[19] So it is hardly surprising that open unemployment has not fallen back to the level of 2 per cent around which it had fluctuated prior to the 1990s crisis.

It is also possible that the strong productivity growth has contributed to unemployment being higher than would otherwise have been the case. High productivity growth should benefit households in the long run by generating real wage increases. It is more uncertain to what extent advances in technology lead to increased or decreased employment in the *short and medium term*. According to Galí (1999), improvements in technology enable firms to maintain output with fewer employees in a transitional period before labour demand rises. If so, that could explain why the high GDP growth has not been accompanied by rising employment (jobless growth). However, this is a controversial issue in economic research.[20]

Another reason why unemployment has remained historically high after the crisis in the early 1990s could be that it is characterised by persistence or labour-market hysteresis. Persistent unemployment is a phenomenon that entails a slow return to the equilibrium level after a shock. In the presence of hysteresis, unemployment's long-term level tends to be affected by fluctuations in actual unemployment.[21]

There are grounds for believing that the degree of hysteresis may have to do with the type of shock that hits the economy. Results presented by Jacobsson et al. (1997) suggest that in the Scandinavian countries, supply-side shocks, for instance changes in technology, are more important for hysteresis than demand shocks. One explanation may be that changes in labour demand of a more structural nature affect some industries more than others. There is then more of a risk that those who lose their jobs find it harder to get new work in the same industry or locality. When a tighter monetary policy leads to rising unemployment, on the other hand, smaller effects are spread over more industries and when policy becomes more expansionary again, the renewed labour demand is for the same type of labour as before. Ljungqvist & Sargent (1998, 2006) also argue that it is precisely structural changes, together with generous unemployment insurance, that can contribute to persistent unemployment. So the high unemployment today could be, at least in part, a residual effect of the mass unemployment in the early 1990s.

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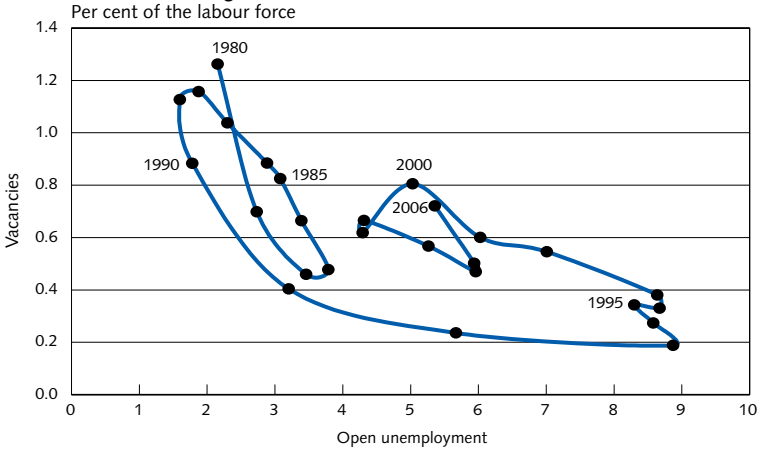
19 See also Lindbeck (2003) and Holmlund (2003).

20 See, for example, Basu et al. (1998) and Christiano et al. (2003).

21 The Swedish Trade Union Confederation (LO) has raised the issue of whether inflation below the target can have contributed, via hysteresis effects, to an increase in equilibrium unemployment (LO 2005). For a comment on this, see Bergström & Boije (2005).

Yet another possible reason why unemployment has remained high is that in the past decade the matching of unemployed persons and vacant jobs has functioned less well than before. This relationship is often illustrated with a Beveridge curve, which plots the number of vacant jobs against the number unemployed (see Chart 4). A shift along a notional downward-sloping curve is assumed to have cyclical causes, while an outward (inward) shift is assumed to indicate a deterioration (improvement) in the matching of labour supply and demand. As Chart 4 shows, in the years after the crisis in the early 1990s the curve tended to shift outwards.[22]

Chart 4. A Beveridge curve.
Per cent of the labour force



Note. To allow for methodological changes in the labour force surveys as of 2005, the chart is based on a chained data series. The number of vacancies is estimated on the basis of the number of unfilled vacancies according to statistics from the National Labour Market Board.

Sources: National Labour Market Board, Statistics Sweden and the Riksbank.

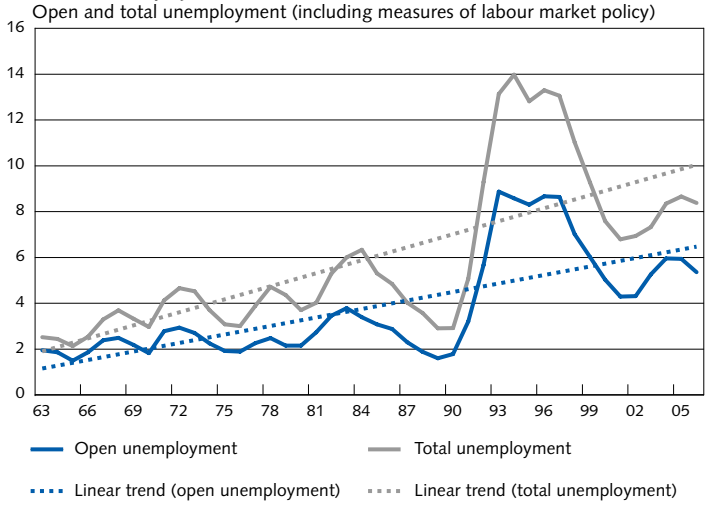
At the same time, however, there are grounds for supposing that various structural changes in the labour market in the past decade and a half have tended to make the labour market more efficient. According to Forslund & Holmlund (2003), factors such as less generous unemployment insurance, the emerging market for labour agencies, increased competition in product markets and tendencies to an increased coordination of wage formation may have contributed to a lower level of equilibrium unemployment.

The actual level of some form of long-term equilibrium unemployment is highly uncertain, however, partly because, as mentioned above, unemployment in the decades before the 1990s can hardly be used to derive a long-term equilibrium. In the latest cyclical upswing, in the

[22] Holmlund (2003) adjusts the Beveridge curve for cyclical labour-force inflows and outflows, which gives a less pronounced deterioration of the matching process.

early 2000s, open unemployment never fell below 4 per cent and total unemployment was never below 7 per cent. Seen over a longer period, unemployment displays a rising trend ever since the late 1960s (see Chart 5). Unemployment increased markedly in connection with the 1990s crisis and then returned to the slightly upward long-term trend. Even excluding the last fifteen years, there has been a rising trend for unemployment, particularly total unemployment. This points to the existence of structural problems in the Swedish labour market. Such problems cannot be remedied with monetary policy.

Chart 5. Unemployment 1960-2006.
Open and total unemployment (including measures of labour market policy)



Note. Due to statistical rearrangements, the chart is based on a chained data series.

Sources: Ljungqvist and Sargent (2006), National Labour Market Board, Statistics Sweden and the Riksbank.

5. Conclusions and some final reflections

It is important that monetary policy and its significance for employment and unemployment are debated. At the same time, the debate needs to start from reasonable expectations of what monetary policy should and can achieve. Monetary policy's objective is price stability. Monetary policy does not and should not have a goal for unemployment, partly because of the considerable uncertainty about unemployment's equilibrium level. Neither can monetary policy affect unemployment at all in the long run, only inflation. In the short run, however, the Riksbank can pay some consideration to developments in the labour market by not invariably aiming to return inflation to the targeted rate as quickly as possible.

As monetary policy has to be based on forecasts, it is not reasonable for assessments to assume that the Riksbank can always predict economic developments exactly. Consequently, the Riksbank is not to be

blamed for every short-run fluctuation in either inflation or unemployment. In recent years it is not unreasonable monetary policy decisions but unexpected supply shocks, above all in the form of strong productivity growth, that have contributed to inflation undershooting the target. The persistently high productivity growth may also be one reason why unemployment has not fallen at the same pace as the economy has expanded.

When the Riksbank is criticised for undershooting the inflation target by an average since 1995 of some tenths of a percentage point and this in turn is said to have contributed to high unemployment, historical comparisons may be relevant. In 1990 Sweden had two-digit inflation; economic policy as a whole had been unduly expansionary for many years and recurrent costs crises had necessitated a series of devaluations. That was the background to the cost crisis in the early 1990s and the shift to a new economic policy regime. If anyone had predicted that fifteen years later there would be an intense debate because the Riksbank had missed the inflation target by an average of some tenths of a percentage point, she or he would hardly have been believed.[23]

With hindsight, of course, it can still be asserted that monetary policy in recent years could have been a little more expansionary. What that would have meant in terms of increased employment is hard to tell because such assessments are bound to be rather uncertain. Judging from all that we know about the workings of the economy, it seems reasonable to suppose that the effects on unemployment would have been comparatively slight and of a very different order from what the public debate suggests. Instead, there are many indications that it is structural factors which are mainly responsible for unemployment today being considerably higher than in the 1970s and 1980s.

Assigning an unreasonably large share of the blame for unemployment to monetary policy is less serious, however, than the fact that the vital debate about unemployment is wrongly focused. Looking to monetary policy for a solution to the problem of unemployment is somewhat reminiscent of the story about the man who, after a hard evening, searched for his car keys under a street lamp; he had admittedly dropped the keys somewhere else but looking for them under a light was less trouble. The tendency to focus the debate about employment and unemployment on what monetary policy can achieve in the short run is liable to divert attention from other questions that in the longer run are more important for unemployment.

[23] Ses also Sundling (2007).

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