CZECH NATIONAL BANK

THE CZECH NATIONAL BANK'S FORECASTING AND POLICY ANALYSIS SYSTEM

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Edited by Warren Coats, Douglas Laxton, and David Rose

Czech National Bank

PRAGUE

TABLE OF CONTENTS

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PREFACE

The Czech National Bank (CNB) now has more than five years of experience with inflation targeting. Much has been achieved during this time. At present, the Czech Republic enjoys low inflation, and inflation expectations seem to be firmly anchored at low levels. Monetary policy decision-making is systematic and transparent, thereby enhancing the credibility of the CNB.

The Czech Republic was the first transition country to adopt inflation targeting, and as such had to face many challenges. The new regime was introduced soon after a period of currency turmoil in May 1997, which resulted in high inflation expectations. Moreover, the Czech Republic is a small and very open economy, subject to strong exogenous shocks. These factors have made the achievement of inflation targets more difficult than in some other countries.

The Czech experience with inflation targeting thus illustrates that the ultimate purpose of inflation targeting is not to announce inflation targets and then hit them mechanically. It is a mistake to confuse inflation targeting with inflation obsession. The aim is to design a rule-based monetary policy framework characterised by a high degree of transparency and accountability. Such a framework allows an independent central bank to commit credibly to its long-term goal of price stability, and at the same time preserves enough discretion for an active anti-cyclical monetary policy that takes into account not only inflation, but also other factors such as variability of output. The shift towards such a regime from a fixed exchange rate system, however, requires a radical change in the central bank's mentality. This is perhaps the biggest challenge that the CNB has faced in recent years.

All this said, it is not surprising that the Czech inflation-targeting regime has gone through an evolutionary process, during which many of its details have been adjusted in response to the changing needs, newly acquired experience and evolving thinking of the central bank. The most important changes have included the specification of inflation targets, the development of a communication strategy, co-operation with the government and the approach to dealing with high exchange rate volatility.

Inflation targeting requires us to assess all the available information in a systematic and complex way, and is thus more demanding from this point of view than the alternative monetary strategies such as exchange rate fixing or monetary targeting. Therefore, much work has been done at the CNB over the past five years to improve our analytical tools, leading to substantial development in our internal analytical processes. These changes culminated a year ago, when the CNB settled upon a new forecasting process. This integrates expert judgement and sectoral analyses – which were the key pillars of the CNB's forecasting tool-kit in the first years of inflation targeting – with a small-scale macroeconomic model developed by the CNB's staff with the assistance of the International Monetary Fund. By doing so, I believe the CNB has moved close to the state-of-the-art among the inflation-targeting central banks around the world.

It must always be borne in mind, of course, that even highly developed, technically advanced and institutionally well-organised forecasting procedures are not an automatic pilot. They are no more – but also no less – than an important input into the monetary policy process. Eventually, the decision is always based not only on the central forecast itself, but also on discussion of the associated risks by the Bank Board. Good analytical tools, however, can be helpful even in this respect, by enabling us to simulate the different alternative scenarios demanded by the Board in a consistent manner.

I am glad that the progress we have jointly achieved in developing the Czech National Bank's Forecasting and Policy Analysis System has been documented in a comprehensive way and is presented to all interested readers in this publication.

Zdeněk Tůma
Governor
Czech National Bank

February 2003

CHAPTER 1

Historical Perspective on the Development of the Forecasting and Policy Analysis System

By Aleš Čapek, Tibor Hlédik, Viktor Kotlán, Stanislav Polák and David Vávra [1]

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INTRODUCTION

In December 1997, following an exchange rate crisis, the Czech Republic adopted a series of end-year inflation targets for monetary policy. The new regime proved very effective in combating inflation and anchoring inflation expectations in the aftermath of the crisis and continued to evolve in the subsequent years toward a more transparent full-fledged inflation targeting regime where monetary policy is anchored by a medium-term perspective. Most recently, the character of the regime was further enhanced by publication of unconditional forecasts based on changing interest rates to move the Czech National Bank's forecast for inflation over time toward the mid-point of the target corridor.

This chapter describes the background to the regime and the internal system developments, while the rest of the volume concentrates on various elements of the forecasting and policy analysis system being put in place to support the new policy regime. No such system is ever completely finished, and this one is no exception. This publication describes the state of the Czech National Bank's Forecasting and Policy Analysis System as of the beginning of the year 2003. Indeed, we have adopted an explicitly evolutionary approach, wherein the components of the system are expected to change over time as experience grows and as time allows more complex structures and procedures to be designed and implemented.

The switch to an inflation targeting (IT) regime can be seen as the logical outcome of a process of gradual erosion of the fixed-exchange rate system with monetary targeting that was in place earlier in the 1990s, and of the exchange rate crisis of May 1997. In essence, the Czech National Bank (CNB) was unable to defend a fixed exchange rate, and the Czech Republic, like many other small open economies, was forced to move to a flexible exchange rate system. In an economy with a flexible exchange rate, the monetary authority can, and indeed must, select some domestic nominal anchor for the system. In an increasing number of countries, this choice is to make the role of the central bank that of ensuring that inflation stays anchored to some target rate. To implement such a policy, the central bank must use a policy instrument to respond to perceived problems, arising from shocks to the economy or other new information, that lead to a change of view of the likely outturn for future inflation. As in most other countries where IT provides the basis for monetary policy, the CNB uses its tools to influence short-term interest rates.

With the switch to a flexible exchange rate and the adoption of inflation targets came a need for a new kind of analytical and forecasting system. This system had to be more analytical than before, as it was supposed to provide a different kind of information to the policymaker on the basis of a new macroeconomic framework. First, of course, the system had to be capable of describing an economy with a flexible exchange rate. An exchange rate is perhaps the most endogenous variable, since it is influenced by virtually everything else in the macro economy. Thus the staff had to develop a framework to describe a dynamic general macro equilibrium system. Moreover, to support the policy decisions necessary to respect a target for inflation, the framework had to be forward-looking and capable of dealing with the process of controlling inflation.

There is no mechanism in a market economy for a central bank to set the inflation rate directly. Control over inflation requires the use of indirect channels through which something that can be controlled (or at least substantially influenced), a monetary instrument, influences the outcome for inflation. This means that at least two things are required for the new macroeconomic framework: a clear description of how monetary policy works to influence the macro economy (the transmission mechanism) and a clear description of the dynamics of inflation and especially the links between the real economy and inflation. Macroeconomic models have become very effective descriptions of such mechanisms and their dynamics.

In all countries where inflation targets have been adopted, the authorities have made it clear that inflation cannot be controlled precisely. Monetary instruments are seen as operating with important lags that make it impossible to offset current shocks and keep inflation always on target. The policy tasks are to set the instrument so that, in the absence of new shocks, inflation will move to respect the target within a reasonable period, and to take into account the major risks implicit in the uncertain environment. A forward-looking model of the transmission mechanism can play a useful role in providing information to help policymakers with these difficult tasks.

A BRIEF HISTORY OF MONETARY POLICY IN THE CZECH REPUBLIC

Fixed Exchange Rate and Monetary Targeting: Prelude to an Exchange Rate Crisis

From January 1993 through February 1996, monetary policy in the Czech Republic focused on supporting a fixed exchange rate and at the same time targeting monetary aggregates. As for the exchange rate, the goal was to peg the Czech koruna to a basket of foreign currencies, originally within a tight band (+/- 0.5 percent). The exchange rate expressed this way was indeed very stable over this period, despite important changes in the bilateral exchange rates between the two principal components of the basket: Deutschmark and US dollar (Figure 1 in the end of this Chapter). Especially in the early part of this period, there was relatively low capital mobility, in part owing to only gradually phasing-out capital controls, but also perhaps to a lack of credibility abroad of the sustainability of the fixed exchange rate. As a result, the CNB had little difficulty sterilizing the effects of capital flows in the early years. Indeed, this permitted the CNB to roughly respect a domestic money supply target (expressed in terms of M2) based on annual Monetary Programs, while successfully maintaining the exchange rate peg.

The ongoing privatization of the economy, liberalization of capital flows and a high rate of return on capital gradually attracted more and more foreign capital. As capital inflows—both short-term flows and foreign direct investment—intensified, the conflict between the sustainability of the two intermediate targets deepened. From the beginning of 1994, the CNB gradually lost its ability to sterilize the capital inflows. The money supply and domestic demand, fuelled by expansive fiscal policy, were accelerating. Except in 1995, actual M2 growth substantially exceeded announced targets during the 1994-96 period. Direct inflationary pressures of the fiscal driven expansion were most apparent in non-tradable goods, where inflation exceeded 10 percent for most of the period (Figure 2). In the tradable-goods sector, inflationary pressures were not as evident, as the fixed exchange rate continued to play its disciplinary role. Indeed, over the latter part of this period, appreciation with respect to the DEM (Figures 1 and 3) put downward pressure on import price inflation (Figures 2 and 3). However, signs of overheating and latent inflationary pressures were present in the form of a high current account deficit and growing excess demand (Figure 4).[2]

On the supply side, the economic growth was hardly sustainable mostly owing to a sluggish pace of corporate restructuring and a hold up of privatisation in the banking sector. Figure 4 shows the (log) level of GDP and of potential output (GDP at full employment, GDP_FE), and Figure 5 shows the resulting measure of the output gap. As we have noted, the economy faced considerable excess demand in the period leading up to the exchange rate crisis in 1997. This was also manifested in the developments in the labour market. During the period 1990-94, the rate of unemployment was very low owing to general labour hoarding, strong growth in the service sector (sufficient to absorb significant flows out of agriculture and industry), and declining labour force participation[3], especially for the post-working age population and for women. During 1995 and 1996 intersectoral employment flows were much lower, which reflected halted restructuring, and participation rates were more stable. All in all, by the beginning of 1997, the growth of GDP potential was showing signs of weakening.

[2] See Box 1 for a summary of the measures of excess demand and their usefulness in describing the inflation and the links between monetary conditions and these measures. We describe these measures in detail in Chapter 5.

[3] The decline in participation was, at least in part, the result of deliberate policy. To limit the impact of restructuring on unemployment, working pensioners were exposed to a punitive payroll tax to encourage them to leave the labour force.

This situation of excess demand and a slow-down in potential output growth developed for a number of reasons. Fiscal policy was looser than was prudent in such circumstances, which contributed to the risk premium and the capital inflows. The central bank was unable to sterilize the rising capital inflows, attracted, in part, by the high domestic interest rates. At the same time, there were tough precautionary standards in providing bank credit, and weak corporate governance generally. In short, money and credit were expanding too quickly, and the policy framework of two targets seemed to be constrained in its ability to respond efficiently. Monetary policy was in a difficult position; from a structural perspective, real rates were too high, but to deal with the pressures on inflation, short-term rates had to be increased.

The measures taken in this regard had begun to work in 1996. In the period leading up to the exchange rate crisis, the CNB had been tightening monetary conditions by pushing up short rates in an effort to ease demand pressures (Figures 6 and 7). With declining inflation, real interest rates were rising significantly, and this occurred during a period when German rates were easing somewhat (Figure 7). The economic developments lead the government to curb its spending by introducing a sequence of austerity packages throughout 1997. As a consequence of these demand-side measures and a weak supply side, GDP growth had begun to ease. The process of slow-down was initiated well before the exchange rate crisis. Indeed, by the first quarter of 1997, GDP *growth* was already below potential (Figure 6), although in level terms our best estimates suggest that there was still some excess demand (Figure 4).

The conflict between the two intermediate targets was largely resolved in February 1996, when the fluctuation band around the currency basket was widened to +/- 7.5 percent, effectively eliminating the peg. Net inflation (inflation in the Consumer Price Index, excluding regulated prices, the net CPI)[4] fell from about 10 percent at the beginning of 1995 to 5 percent at the beginning of 1997 (Figure 6), largely owing to the effect of an appreciating currency on imported-goods prices (Figure 3).

Exchange Rate Crisis: Abandoning the Peg

This gradual disinflation was interrupted by the exchange rate crisis of May 1997. Immediately following the Asian currency crisis, the koruna came under heavy pressure, much like many other currencies with no significant links to Asian markets. In terms of domestic conditions, the relatively strong appreciation over previous periods appears to have been overdone (Figure 7). Moreover, the growing current-account deficit and concerns about lack of progress on competitiveness contributed to doubts about the sustainability of the external value of the koruna. Relative to the DEM, the koruna depreciated by about 10 percent in May 1997; depreciation relative to the dollar was even greater (Figure 1). In response to the exchange rate pressures, the CNB raised short-term interest rates dramatically (Figures 6 and 7).

The effects of the sharp rise in interest rates and the government's austerity packages, coming at a time when the economy had already experienced significant slowing, were dramatic. GDP growth declined further and the economy entered into a severe and protracted recession. Growth rates remained negative until mid 1999 (Figure 6), and a large excess supply gap developed (Figure 4).

The short-term effect of the exchange rate crisis was to push inflation up, as higher imported goods prices passed quickly into broader measures of inflation. The earlier relaxation of the bands had been a first sign of removing the nominal anchor provided by the fixed exchange rate, and with no clearly announced replacement, inflation expectations were undoubtedly very uncertain and especially sensitive to developments. The depreciation during the exchange rate crisis appears to have been factored rapidly into expectations, which played a role in the rapid pass-through of the pressures on traded-goods prices into broader measures of inflation.

[4] We describe the net CPI in greater detail later in this chapter. It includes food prices; without food the targeted index would represent only about 50 percent of the total CPI.

In the period that followed the exchange rate crisis, discerning inflationary trends was complicated by very large increases in regulated prices (Figure 2). At the peak in early 1998, inflation in the regulated price component of the CPI was about 35 percent, year-over-year. At that time, the weight of regulated prices in the CPI was about 26 percent, and the effect on the overall CPI was notable (Figure 2).[5] This undoubtedly had a propelling effect on inflation expectations. For the more important of the regulated prices—rents and electricity, for example—there is little chance for consumers to find a cheaper substitute.

On the supply side, the period following the exchange rate crisis coincided with a renewed pace of restructuring, which temporarily lowered the growth rate of GDP potential. The ongoing privatisation of state-owned enterprises led to considerable shedding of employment at the same time as the recession was building. From a low of about 3 percent in mid-1996, the rate of unemployment ballooned to over 9 percent in the first quarter of 2000 (Figures 4 and 6).

Figure 4 provides our estimates of the decomposition of the rising unemployment into a full-employment component (non-accelerating-inflation rate of unemployment or NAIRU) and a cyclical component.[6] It is to be expected that in a period of major restructuring there will be a rise in the NAIRU. In part, this reflects the removal of what was previously hidden unemployment in the form of underemployment of workers in subsidized sectors and the delayed emergence, especially in the face of a major recession, of the new activities that will eventually absorb the surplus labour. It also reflects the difficulties in moving from one type of work to another, the time needed to replace job-specific skills, or simply to learn new skills appropriate for the expanding sectors. In part, it also reflects low labour mobility in a situation with significant differences in the regional rates of unemployment. Yet, it is clear that a significant part of the rise in unemployment must be attributed to cyclical rather than structural factors. Our estimates indicate that from its low in 1996, the NAIRU rose by about 3.5 percentage points by the first quarter of 2000, leaving about 3 percentage points of the rise in unemployment over the same period attributed to the purely cyclical aspects of the recession.[7]

Adoption of Inflation Targeting: Gaining Credibility

In the aftermath of the foreign-exchange crisis and the sharply rising inflation, the issue of what monetary policy the Czech Republic would adopt was a pressing concern. In December of 1997, a new policy of inflation targeting was announced. The CNB's medium-term inflation target was announced at the same time: the central bank committed itself to setting its monetary policy instruments so as to achieve annual net inflation within the range 3.5 to 5.5 percent by the end of 2000. To better anchor inflation expectations, the CNB also announced a short-term target range for net inflation of 5.5 to 6.5 percent for end of 1998. In November 1998, another short-term net inflation target range of 4 to 5 percent was set for the end of 1999. Setting of the targets in this manner clearly reflected the credibility concerns of the period: to fight immediate inflation and anchor inflation expectations.

Table 1: The CNB's inflation targets set in terms of net inflation

Year	Target range (percent)	Target month	Set in
1998	5.5 – 6.5	December 1998	December 1997
1999	4 – 5	December 1999	November 1998
2000	3.5 – 5.5	December 2000	December 1997
2001	2 – 4	December 2001	April 2000
2005	1 – 3	December 2005	April 1999

[5] After the rebasing of the CPI in the first quarter of 2001, the weight of regulated prices has fallen to about 18 percent.

[6] The methodology used to derive these estimates is discussed in Chapter 5.

[7] Unemployment typically lags output in a recovery, and we see that in these data. The rate of unemployment in the Czech Republic continued to rise, and by more than the NAIRU, opening up a larger unemployment gap, for at least two quarters after GDP growth resumed.

Nominal interest rates remained relatively high for much of the year 1998. Several factors have been identified for the delay in lowering rates. Domestic inflation measured by the GDP deflator (Figure 3) and unit labour costs (not shown directly, but see Figure 8) remained relatively high through 1998, much longer than CPI measures. The CNB's 1998 Annual Report identifies this as a reason for caution. Also noted were concerns about ongoing increases in regulated prices, increases in the VAT and some excise taxes, high inflation in some food prices, all generating the possibility of spillover into labour costs and other prices. Finally, there was uncertainty as to whether the pass-through effects from the depreciation had been completed. As for future inflationary risks, the CNB expressed concern regarding the impact of the fiscal deficit on demand, risks related to wage developments, especially in the private sector, expected exchange rate developments and unfavourable inflationary expectations.

The 1997-98 recession was indeed severe. In that respect the timing of the Asian crisis was unfortunate, because it forced a severe monetary and fiscal restriction at a time when, from a purely domestic perspective, less was needed. The level of GDP fell by about 6 percent from its pre-recession peak to the trough in 1999 Q2. As restructuring proceeded, and the NAIRU rose, potential GDP growth slowed (Figure 4). A negative output gap opened rapidly reaching just over 5 percent of potential output by the second quarter of 1999. While this gap has begun to close since 1999, we estimate there is still excess capacity in the economy as of the beginning of 2003. In late 2001 the excess supply began widening again, this time as a consequence of massive real exchange rate appreciation. In Figure 5, we see that the unemployment gap became negative (unemployment above the NAIRU) in the fourth quarter of 1997, and rose to about 2.5 percent by the first quarter of 2000. It has subsequently declined, but some excess supply still remains.

The effects of the higher interest rates and the recession, however, soon began to change the inflation picture in the new regime. In response to the positive interest rate differential vis-a-vis Germany, the exchange-rate depreciation of 1997 was, to a large extent, reversed through 1998 (Figures 1, 3 and 7). This, coupled with the weak domestic economy and fall in oil prices, put considerable downward pressure on inflation. As measured by the net CPI, inflation fell from about 8 percent at the start of 1998 to zero by the first quarter of 1999 (Figure 6), considerably undershooting all longer-term targets (Figure 10).[8]

Adoption of Inflation Targeting: Progress with Medium-Term Issues

The fast elimination of excess inflation enabled the CNB to focus more on a medium-term perspective. Launched in April 1999, *The CNB Monetary Strategy* document formulated a long-term objective of price stability (defined as net CPI inflation in the 1 to 3 percent range), this objective to be met by the end of 2005. The document also contained additional factors that the CNB would regard as not encompassed by the target commitment and hence not requiring a policy response (generally referred to as "caveats" or "escape clauses" to the commitment to specific numerical targets).[9] Nevertheless, the regime still respected end-of-year targets; a year later (in April 2000), a target was set for the end of 2001. At that time net inflation was moving up a bit in 2000, in part owing to the very large increases in energy import prices. However, although the rise in oil prices was indeed substantial, its final effects on CPI inflation were to a large extent neutralised by the appreciating exchange rate and latent downward pressure coming from the output gap. Hence the 2000 target was again undershot, albeit only by half a percentage point (Figure 10).

[8] Figure 6 permits a comparison of the course of the output gap and the evolution of inflation, measured by the net CPI. In the immediate aftermath of the exchange rate crisis, there was still some upward movement in inflation, in part owing to the rising prices of imported goods associated with the depreciation of the koruna and perhaps, some crossover effect on non-regulated prices of the massive increases in regulated prices through 1998 (Figure 3). Thereafter, however, inflation fell very rapidly, moving from over 8 percent to zero in a year.

[9] These factors are (plus two more included in April 2001): major deviations of world prices of raw materials, energy-producing materials and other commodities from the forecast; major deviations of the koruna's exchange rate from the forecast that are not connected with domestic economic fundamentals and domestic monetary policy; major changes in the conditions for agricultural production having an impact on agricultural producer prices; natural disasters and other extraordinary events having cost and demand impacts on prices. (Source: *CNB Monetary Strategy*)

Adoption of Inflation Targeting: A Move Closer Toward a More Transparent Full-Fledged IT Regime

In April 2001, a decision was made to move further towards a “full-fledged” form of an IT regime that is based more on a medium-term perspective. The new target range is specified in terms of a “headline” inflation rate (the rate of increase of the total CPI[10]) and the target trajectory for headline inflation is expressed by means of a continuous and gradually declining target band. The band was announced starting in January 2002 at 3-5 percent and ending in December 2005 at 2-4 percent[11]. The policy of IT was supported and agreed to by the government. The newly agreed headline-inflation target is conditional, to a certain degree, on price deregulation and other price related decisions of the government (for example, changes of indirect taxes).[12] The caveats defined previously were amended by two new ones and they jointly continue to affect the CNB’s interpretation of whether the targets will be respected unaltered or subject to defined exceptions.

Table 2: The CNB’s inflation targets set in terms of headline inflation

	Target range (percent)	Target month	Set in
Range starts	3 – 5	January 2002	April 2001
Range ends	2 – 4	December 2005	

NEW REQUIREMENTS OF THE FORECASTING AND ANALYTICAL SYSTEM

The switch to IT in the Czech Republic came as a reaction to the inherent contradiction between the fixed exchange rate and the increasing mobility of capital. Moreover, the change came at a difficult time of economic slow-down and major financial crises in Asia and Russia. Co-ordination of monetary and fiscal policy was also a problem, both before and immediately after the switch. The initial move to announce an inflation target came after a round of wage bargaining that had not helped to establish a commitment to reducing inflation. Then, among other things, a massive increase in regulated prices in the early stages of the effort to establish the new regime made it both hard to administer and hard to gain credibility for the new policy regime.

In the fixed exchange rate regime, the role of monetary policy was narrowly defined, and did not require a medium-term perspective on the macro economy. That changed completely with the new regime. However, while the first announced targets were for the medium term, there was very little in place to provide analysis of the medium term and, in practice, the CNB focused on the next 12 months. Indeed, the CNB soon announced intermediate targets for that horizon. Without the benefit of medium-term analysis, the CNB’ staff could hardly provide the policymakers with the structured and consistent policy advice required in the new regime. Without adequate development of the forecasting and policy analysis system, risks of systematic policy errors that could jeopardize the success of the new regime were high. Restrictive monetary policy of 1998, for instance, reflected in part understandable caution and the desire to establish credibility for the new regime under very difficult circumstances. But it can also be argued that there was perhaps an over-reliance on the short run and the power of the exchange rate channel.[13]

10 The CNB bases its assessment of the inflation trend on the statistical data published by the Central Statistical Office (CSO). The inflation outturns—which, within the IT regime, form the basis for both the conduct and retrospective assessment of monetary policy—are thus published by an institution independent of the CNB. This arrangement enhances the credibility of inflation targeting.

11 See, CNB, The Setting of the Inflation Target for 2002–2005, April 2001.

12 The contribution of the regulated price movements to the headline inflation is expected to be limited to 1 to 1.5 percentage points per annum, and the target is further abstracting from changes in indirect taxes.

13 An important question is whether the CNB could have done better in limiting the severity of the recession. There was little scope for alternative decisions during the exchange rate crisis, but could the subsequent easing have been faster, and would this framework have helped in that regard? It is difficult to know whether decisions would have been different had this type of information been available to policy makers at the time. It is also important to stress that the gap measures we show benefit substantially from hindsight. We attempt to deal with this issue in Chapter 5 by asking what our methodology would have produced, used live as the data emerged at the time. We argue that even without the benefits of hindsight, there would have been clear signals of the disinflation to come.

Experience with the IT regime has shown clearly that a forecasting and policy analysis support system that is capable of dealing effectively with medium-term issues is necessary. Policy decisions must be taken with a more explicitly forward-looking perspective, with systematic response to disturbances that would otherwise have lasting effects on inflation, but with less concern about purely transitory shocks.

The challenge for a forward-looking monetary policy is to establish clearly that neither inflationary nor deflationary disturbances will be allowed to persist. We believe that the forecasting and policy analysis system presented in this volume can make a contribution to better decision-making. Even the short experience of the CNB can provide evidence in support of this argument. Moreover, the publication of forecasts and reports explaining policy decisions, which are facilitated by a proper system, help improve the general understanding of the IT regime and to establish its credibility. To this end, the CNB has recently made a further new step by communicating with the public on the basis of unconditional forecasts, that is forecasts with a systematic reaction of monetary policy. Production of such a forecast, which is a subject of most chapters of this volume, would not have been possible without significant changes in the analytical and forecasting system in the Bank.

Box 1: System Estimates of Potential Output and the NAIRU [14]

Given the importance of the output gap and the NAIRU for monetary policy, it is important to have a reliable method to obtain good estimates of these variables. We use a multivariate filter to provide estimates from a small system that simultaneously determines these values using information on inflation, output, unemployment and monetary conditions. Filters of Hodrick-Prescott (HP) type use the information from a single macroeconomic variable to infer a trend; for example, real GDP alone is used to estimate potential output.[15] In reality, however, potential output is affected by the NAIRU, since the non-inflationary level of employment has an effect on how much can be produced on a sustainable basis. Moreover, since we want a measure of potential output that is useful to forecast inflation, it makes sense to use the historical information on inflation to condition estimates of potential output. For example, an observation that inflation is rising makes it more likely that there was excess demand at the time (or a bit earlier, given the lags in the system). This may not be true every time, since other things influence inflation, but from an estimation perspective it makes sense to allow the inflation data to influence the estimate of potential. Similarly, since we also need a clear model of how monetary conditions influence the economy, and since we have estimates of monetary conditions, it makes sense to exploit the structure of our model of the transmission mechanism in deriving our estimates of potential output. Finally, since we need a model that describes the interaction of all these variables in the macro economy, it is appealing to use information from the model on how the macro variables interact in conditioning estimates of the unobservable trend or equilibrium values. With this approach, our estimates of the unknowns have the best chance of helping explain the data within the framework of the model we will use for forecasting and policy analysis.

[14] The first draft of this Box was prepared by Emil Stavrev.

[15] Using a univariate approach to extract independent estimates of the output gap and the NAIRU can give biased results that may lead to inappropriate reaction by policymakers. We show this with an example in Chapter 5.

In our model, the main macroeconomic variables in the economy interact as follows: excess demand will put direct upward pressure on inflation and (as per Okun's law) will cause an increase in employment that is not sustainable, which will create upward pressure on wages and the conditions for the onset of a wage-price spiral. If this is allowed to continue, inflation expectations will respond increasingly, putting more pressure on the nominal spiral. A prompt reaction of the central bank is required in order to stabilize the economy and curb the inflationary pressures. The bank reacts with a nominal interest rate increase, which, owing to lags in expectations, translates into a real interest rate increase. This is part of what creates tighter monetary conditions, which, in turn, acts to cool down excess demand. At the initial stage, the higher interest rate attracts foreign capital, and through the operation of an uncovered-interest-parity arbitrage condition, causes nominal exchange rate appreciation. This provides relief from inflationary pressures both from the downward pressure on import prices and from the negative effect on excess demand.

To capture the interaction among the main macroeconomic variables, the multivariate filter uses three key behavioural equations from the model, equations that link real monetary conditions (Figure 9), the output gap, unemployment and inflation.[16] The effect of excess demand on inflation is captured through a forward-looking Phillips curve, wherein a positive output gap tends to push up inflation. Monetary policy influences the real economy through an equation for the output gap, where both higher real interest rates and real exchange rate appreciation act to lower the output gap, albeit with an important lag. Unemployment and output are linked through an Okun's law relationship that contains lags to take account of higher inertia in unemployment compared to output.

The filter system is completed with equations that describe statistical assumptions about the evolution of the NAIRU, potential output growth, and the links between the NAIRU and the level of potential output. Assumptions are made concerning the covariance structure of the disturbance terms in the system, and the entire system is estimated using the technique of Kalman filtering.[17]

The estimation results are shown in Figures 4 and 5. Figure 4 shows the levels. In the first chart in Figure 5, the estimated unemployment and output gaps are plotted. After a period of a moderate, but rising, excess demand in 1995 and 1996, the economy slows substantially to reach its lowest point at the beginning of 1999, and then starts slowly to recover. The unemployment gap lags the output gap, bottoming out approximately three quarters after the output gap, reflecting rigidities in the labour market. The second graph in Figure 5 depicts the impact of the output gap on net inflation. The sharp disinflation that starts in the second quarter of 1998 is led by the deepening excess supply in the economy.

Figure 7 shows our estimates of the main components of real monetary conditions,[18] expressed as gaps for the real exchange rate and the real interest rate from their neutral values.[19] Clearly the sizeable increase in the real interest rates during the first quarter of 1997, initially in response to the exchange rate crisis in May, but held until the second quarter of 1998, contributed to the sharp slowdown of the economy and the rapid disinflation. During the second half of 1998, there was a significant appreciation of the real exchange rate, which tightened monetary conditions further and extended the recession.

[16] These equations are described fully in Chapter 4.

[17] For an in-depth description of the multivariate filter and the estimation procedure, see Chapter 5.

[18] The full specification includes another component, the state of the interest-rate gap in the German economy.

[19] See Chapter 5 for a description of how these measures are derived. In short, another filtering methodology is used to define these measures prior to the estimation of potential output and the NAIRU using the multivariate filter, where the monetary conditions measures are treated as exogenously given.

Figure 1: Nominal Exchange Rate Index

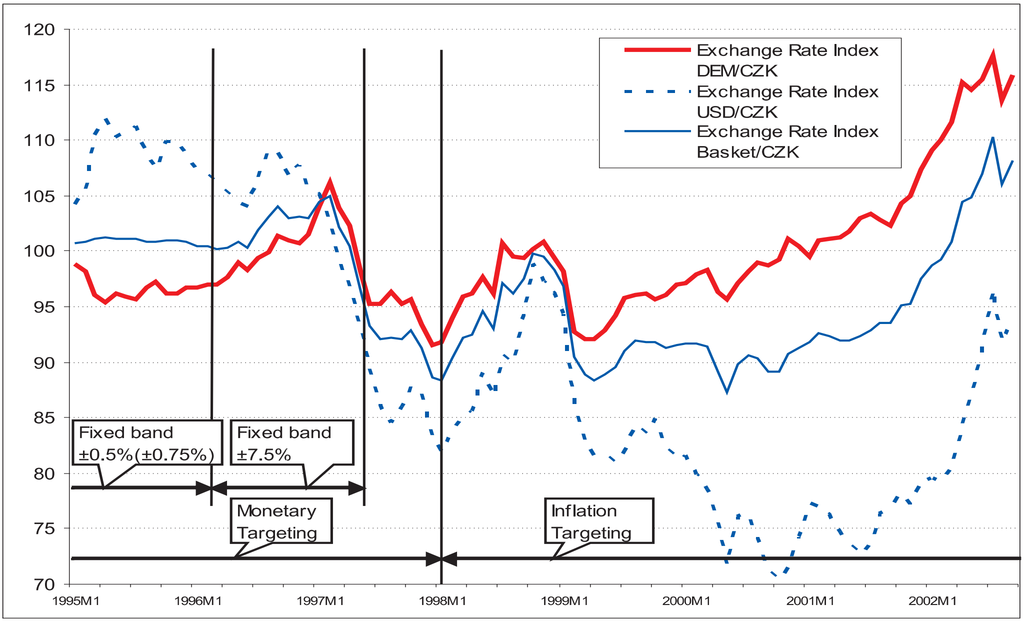


Figure 2: CPI-Based Measures of Inflation

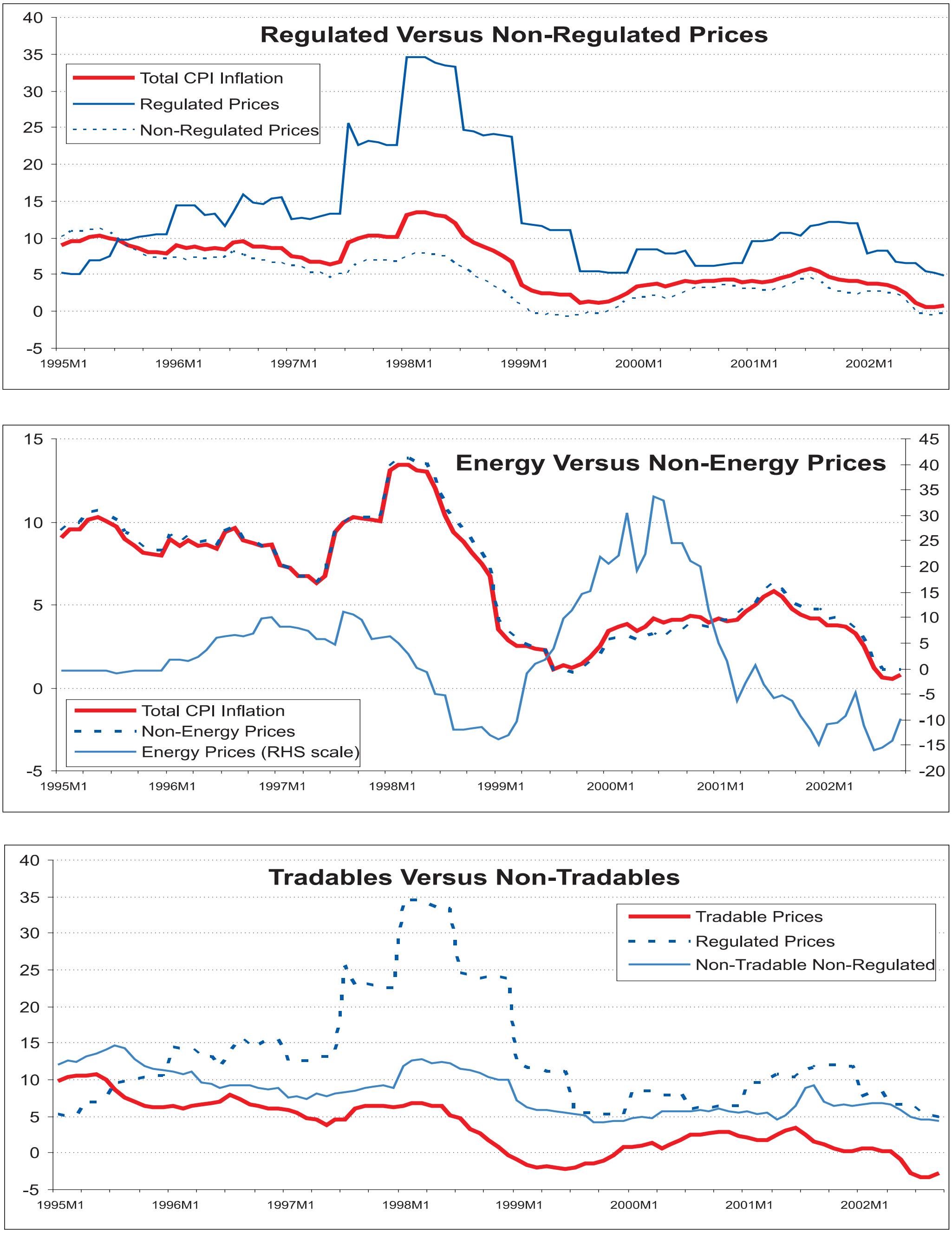


Figure 3: Alternative Measures of Core Inflation and Import Price Inflation

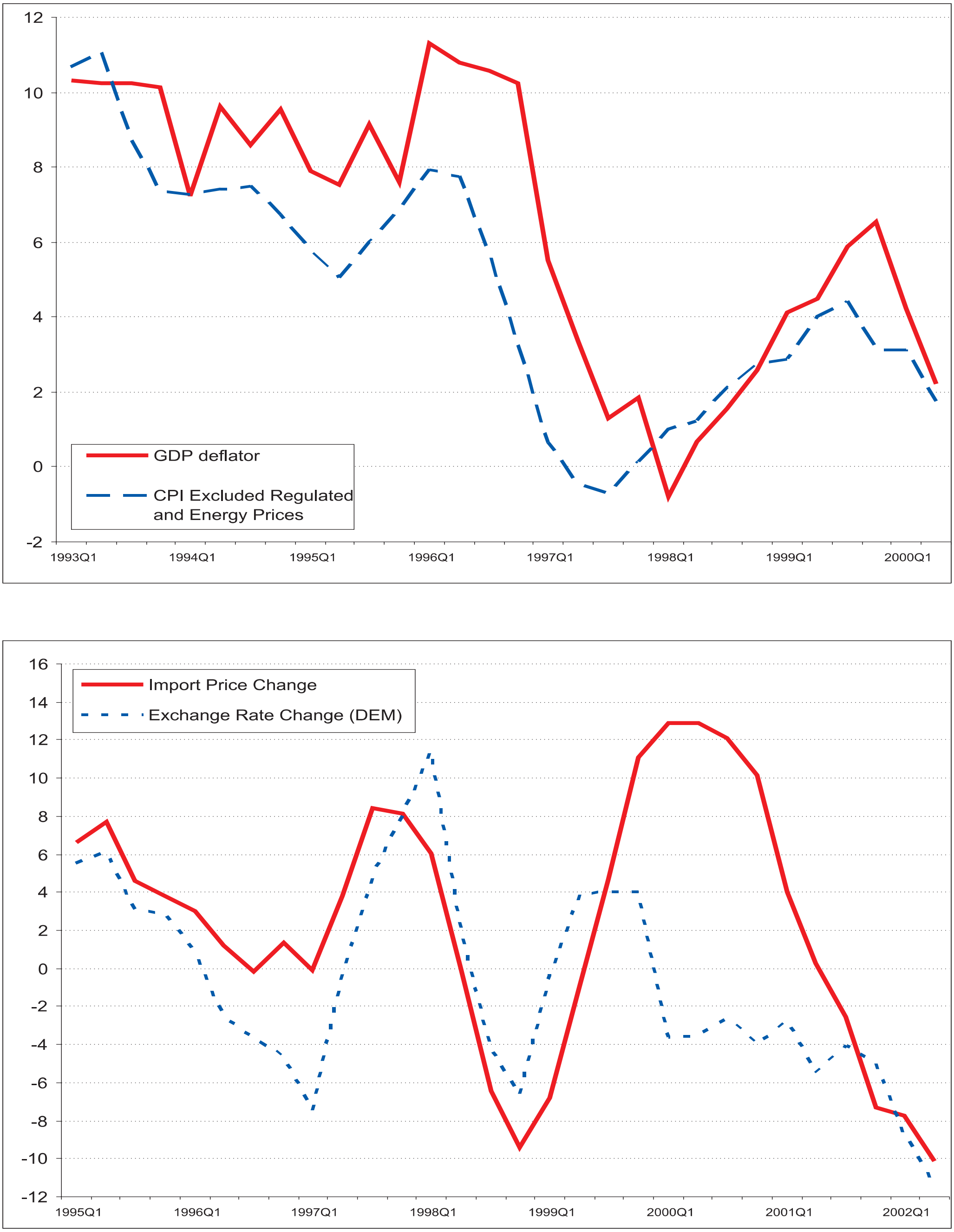
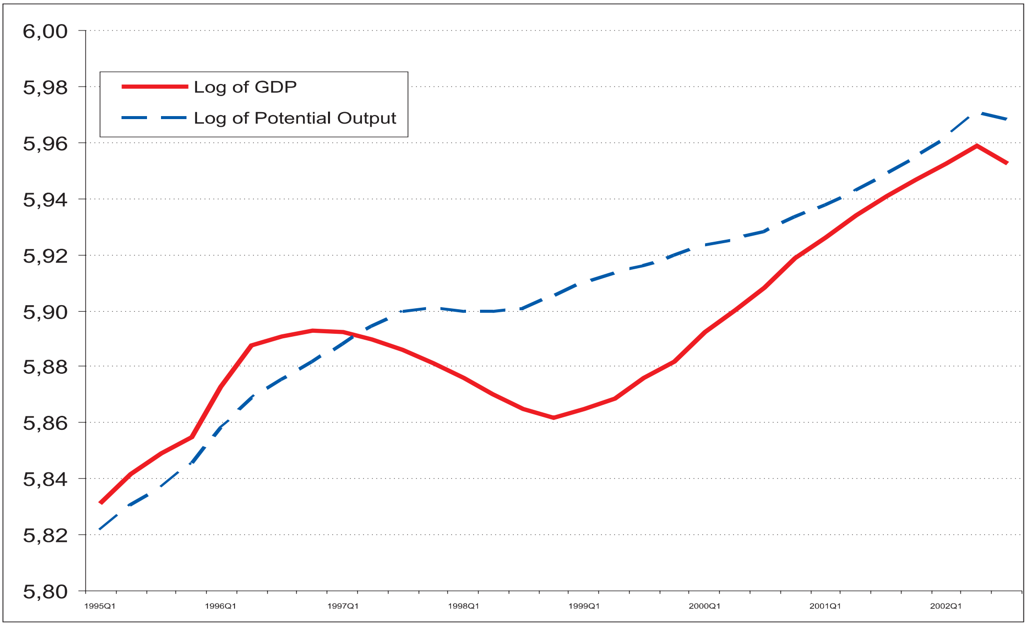


Figure 4: Estimates of the NAIRU and Potential Output



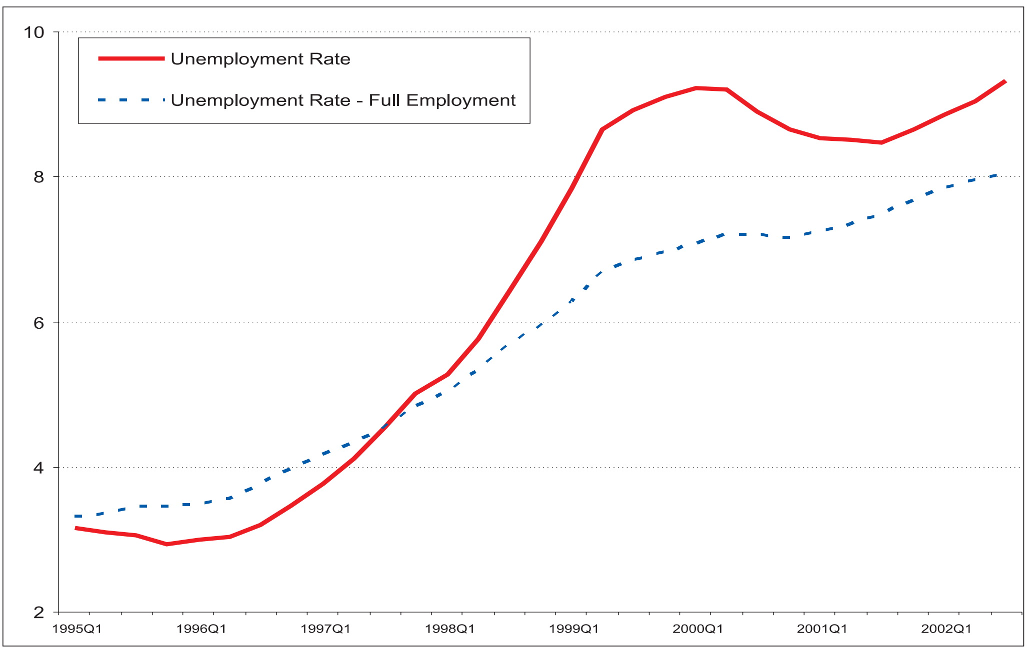
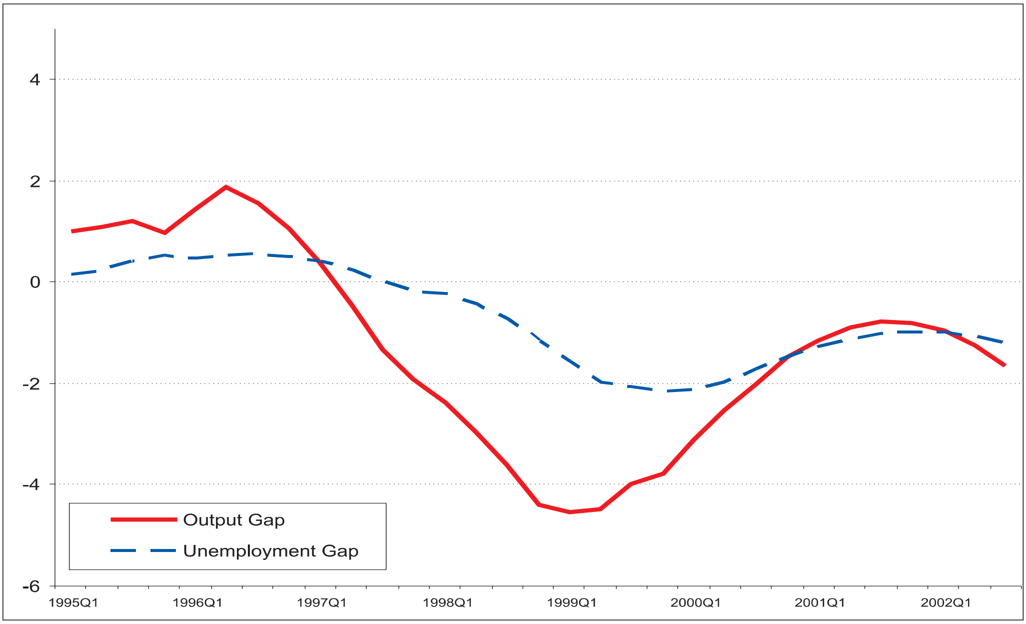


Figure 5: Output, Unemployment and Inflation



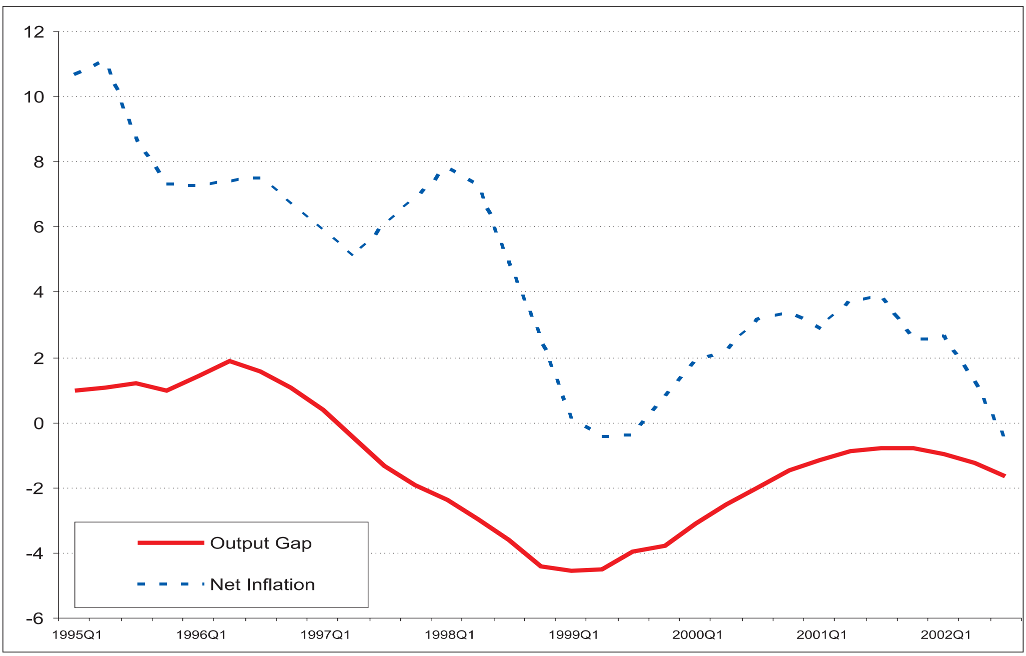
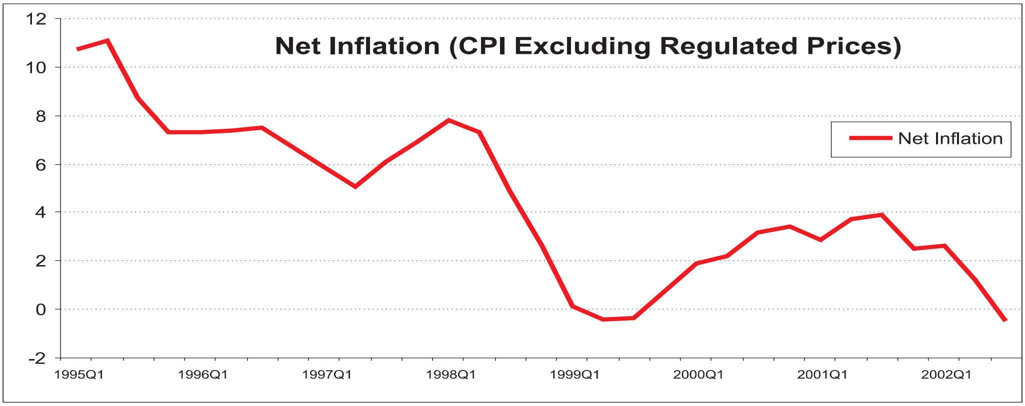
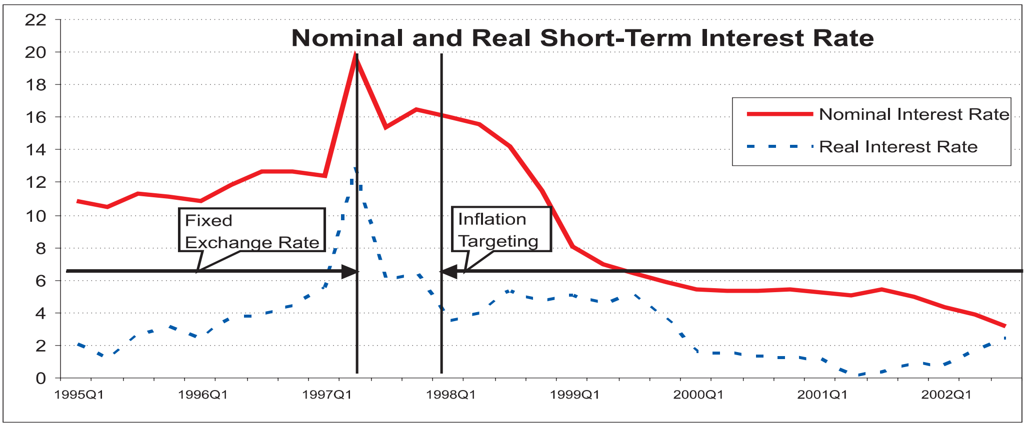


Figure 6: Key Macroeconomic Indicators for the Czech Republic





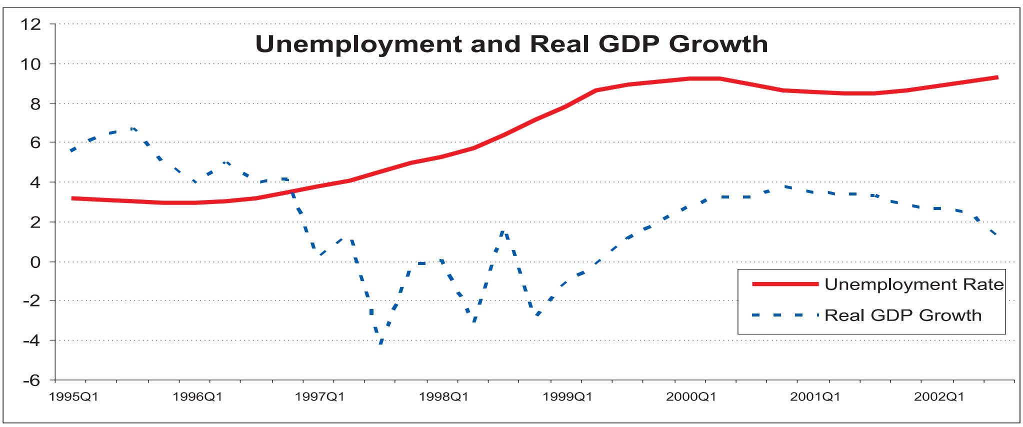


Figure 7: Measures of Real Monetary Conditions

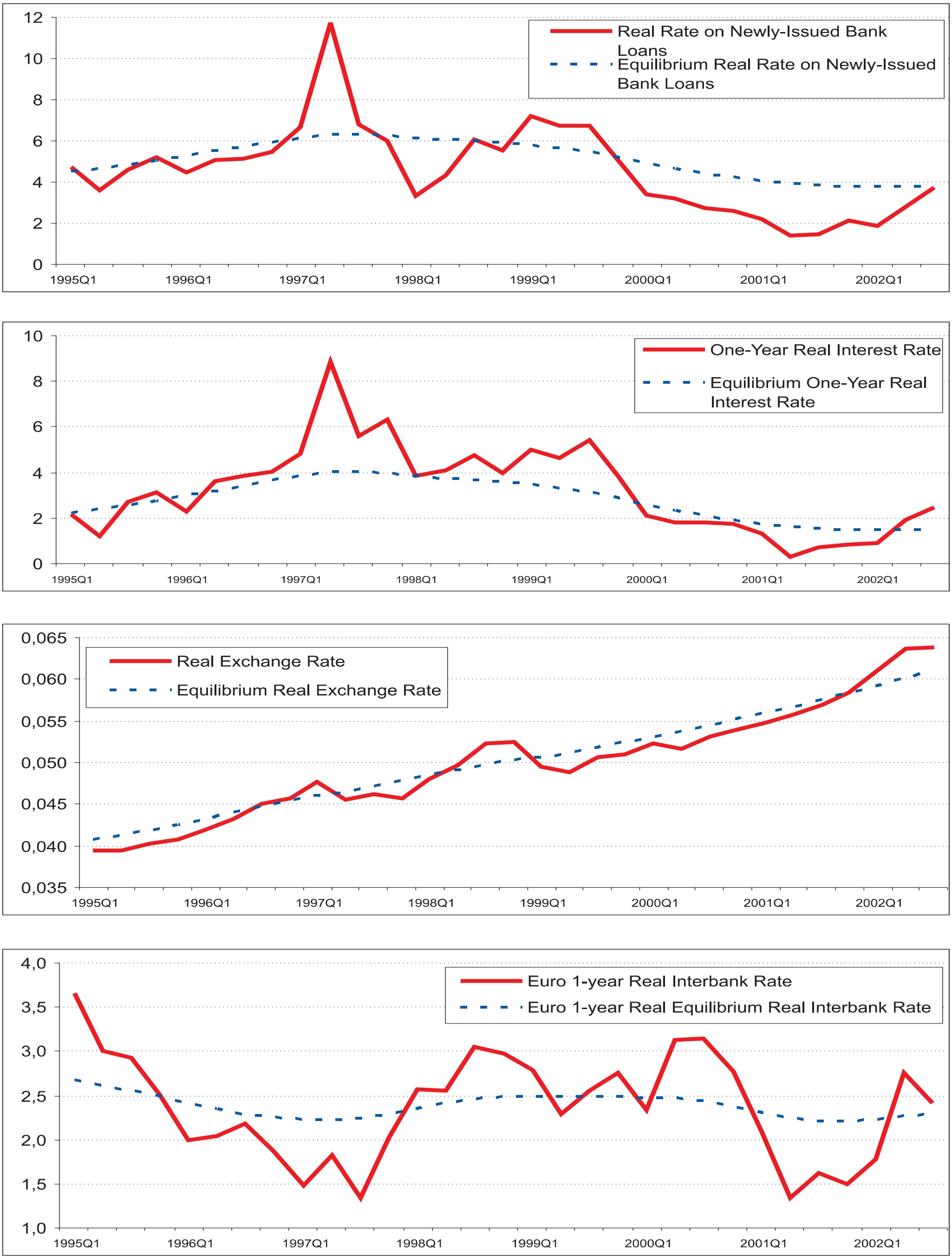
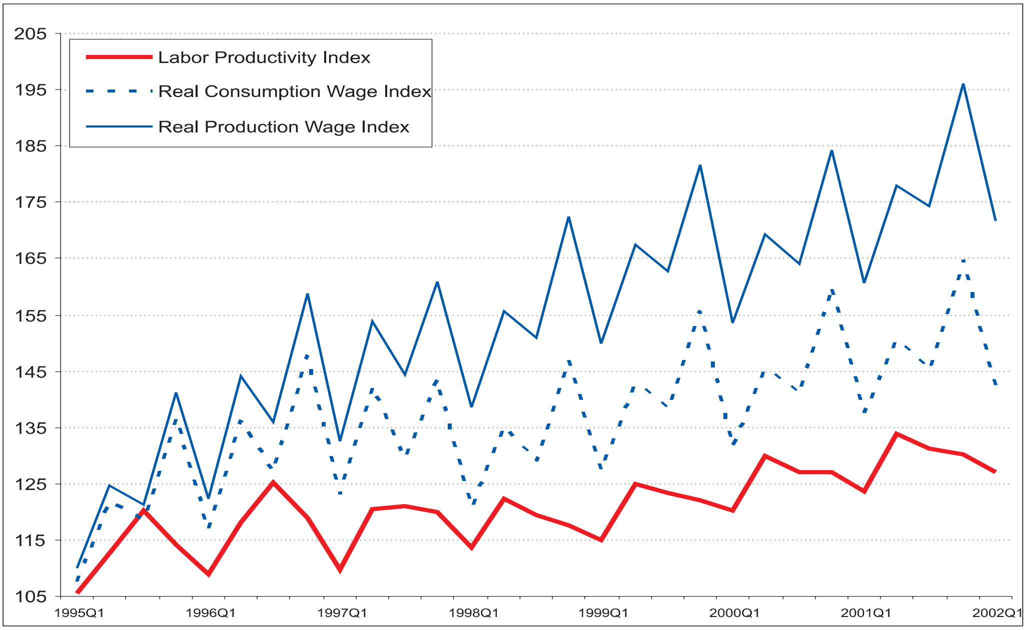


Figure 8: Labor Productivity and Wages



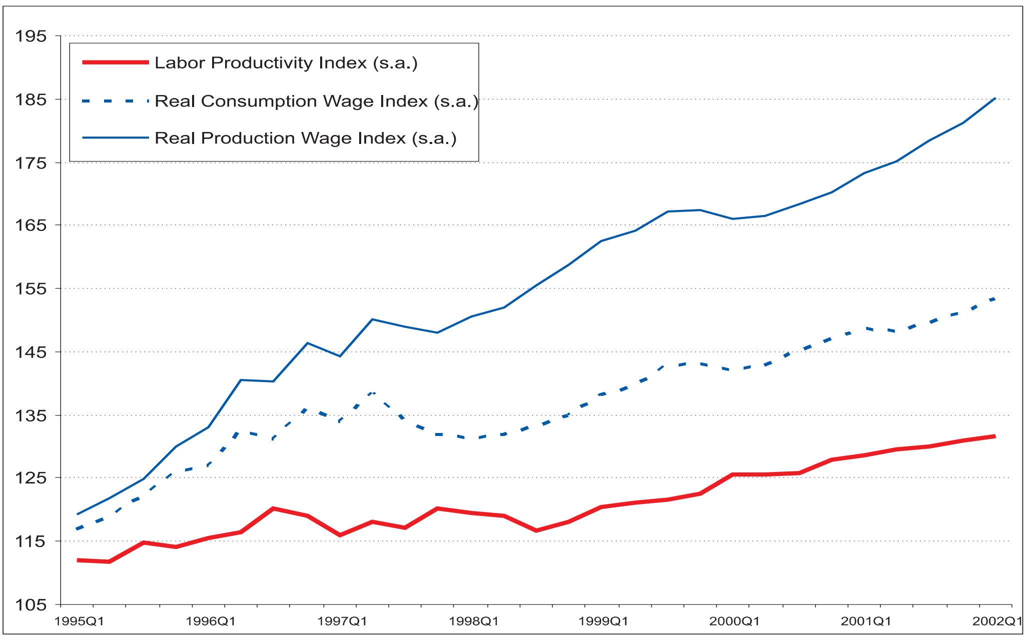


Figure 9: Real Monetary Conditions Index Decomposition

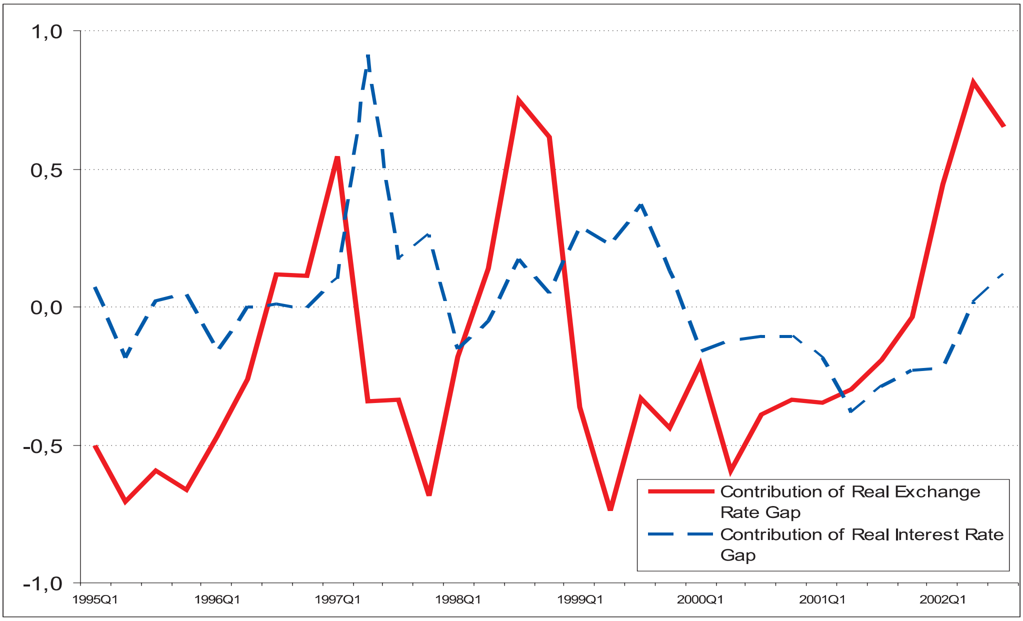
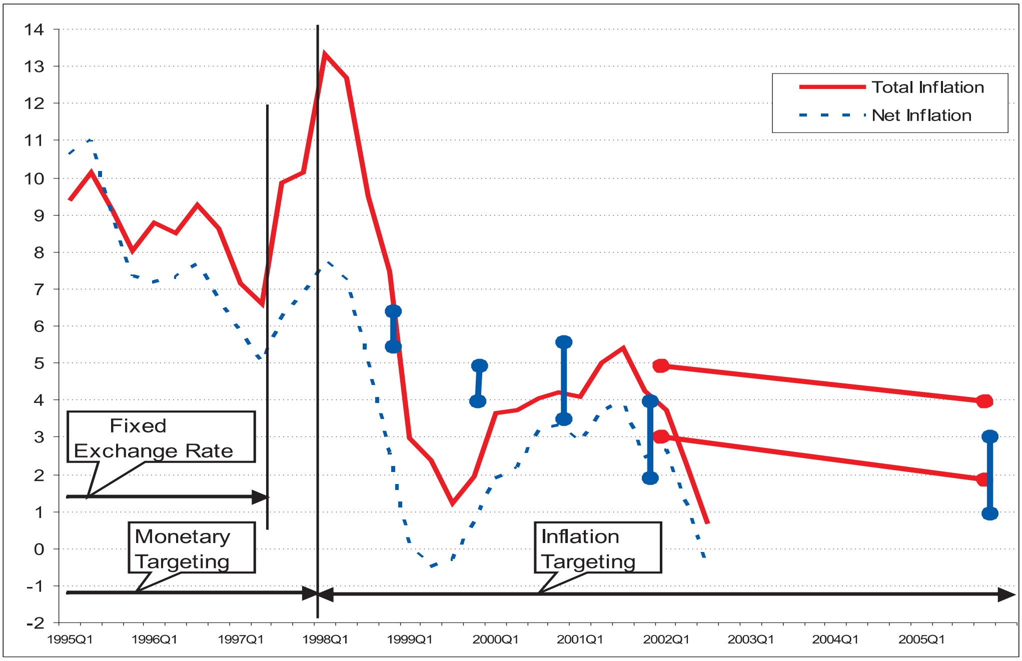


Figure 10: Targets for Total and Net Inflation



CHAPTER 2

Developing Consistent Scenarios with the Forecasting and Policy Analysis System

By Aleš Čapek, Tibor Hlédik, Viktor Kotlán, Stanislav Polák and David Vávra [1]

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INTRODUCTION

In the preceding chapter, we reviewed developments in the Czech economy that led to the abandonment of a fixed-exchange-rate regime and the adoption of inflation targeting (IT) as the basis for monetary policy under flexible exchange rate. We argued that the new regime required a new forecasting and policy analysis system (FPAS) designed to support monetary policy decisions with a medium-term horizon. The purpose of this chapter is to describe the current process of developing consistent medium-term forecasts along two lines: institutional and procedural. We begin by shortly reviewing the starting conditions in macroeconomic forecasting after the introduction of the inflation targeting regime and then briefly discuss the evolution of the system into its present state. The main focus of the chapter lies in describing the process of creating and communicating a forecast in the present system.

STARTING CONDITIONS

In a fixed-exchange-rate regime, the central bank cannot support a domestic monetary objective, since the domestic rate of inflation is given by the world rate adjusted for any trend changes in the equilibrium real exchange rate. The role of policy making is to intervene on the FX market in response to short-run pressures on the exchange rate. As mentioned in the previous Chapter, the Czech regime set-up was over burdened by an attempt of monetary targeting at the same time. The job of central bank economists was primarily collecting information and monitoring developments. Economic analysis and modelling of the medium term was not considered to be a critical activity for the success of the regime.

In contrast, a successful IT regime requires an active domestic monetary policy based on an understanding of economic mechanisms at work over the medium term. With a flexible exchange rate, the regime has to provide a nominal anchor for the domestic economy. The success of an IT regime rests in systematic responsiveness of the policy instrument to disturbances (and equally systematic neglect of small temporary shocks that do not threaten the achievement of the inflation target). The role of the central bank economists is to provide a clear encapsulation of the monetary transmission mechanism, which can help policy makers take decisions and defend those decisions publicly. For the regime to be credible, this analysis and decision-making must be transparent and clearly communicated to the markets and the general public.

As the switch to inflation targeting was basically forced by the exchange rate crisis 1997, proper analytical and forecasting tools had to be developed only gradually through time. The initial period was marked by very intense work to put into place at least basic forecasting tools. Inflation projections as well as projections of other key data were based mainly on time-series analysis and a group of experts' knowledge of special factors.

The decision making process has been evolving in monthly cycles from the very start of the inflation-targeting regime.[2] Monthly "*Situation Reports* on Economic and Monetary Developments" prepared by the staff have served as the most important background material for policy deliberations. Until 2002, each report would include not only detailed descriptions of the newly released data but also a new projection of the economy. Producing a projection on a monthly basis was a difficult task as the projection process could only start in the second half of the month, after the major data (often very volatile and hard to interpret on a monthly basis) were released.[3]

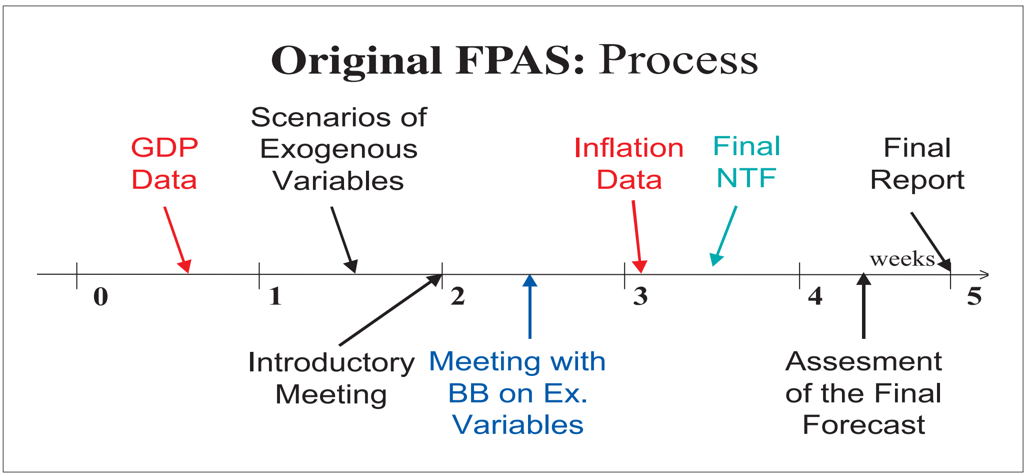
[2] Just a very few irregular meetings of the Board have taken place since the regime was implemented and these were mostly during the first years of IT.

[3] Before moving to quarterly projections there was an interim period where only a so-called "technical change" of the projection was undertaken on a monthly basis and major revisions were introduced every three months.

The projection exercise is now done quarterly. The basic reasons for this frequency is the publication of national accounts data and the length of the whole process. The role of the quarterly Situation Reports (and external Inflation Reports) is thus to present substantive evidence and analysis that serve as the basis for recommendations on policy, and in particular what actions are required to respect the inflation targets over the medium term. The two monthly Situation Reports in the interim period between the quarterly forecasts review economic developments against the last quarterly forecast. This serves as the starting point for the discussion of risks of the quarterly forecasts, which evolve throughout time. Usually one would expect that the risk considerations would mentally shift the baseline projection in the direction of one of the alternatives prepared together with the baseline. This makes policy deliberations easier even in the times when no new forecast is available.

The projection process was gradually developing over time from a rather spontaneous process into a more structured one. After the initial problems with the introduction of the new regime had been solved, the exercise was organised around a few meetings as described in Figure 1, where representatives of all the Divisions of the Monetary and Statistics Department were present (see Box 1 on organisational structure of the Department). The projection would always start by agreeing on the assumption of exogenous variables and the exchange rate. Nominal interest rates were assumed to stay constant throughout the forecasting horizon. This was, however, often disputed based on the argument that current variables (e.g. wages or the yield curve) already include expectations about future policy and the projection thus may not be truly a constant-interest-rates one (see Box 3 for a more detailed discussion of the issue).

Figure 1: Process of forecast production in the original system



Different divisions worked independently on their own parts of the Report and although there was some guidance from the Monetary Policy Division, each division was ultimately responsible for the background material it wished to include. A key role in this process was played by the Real Economy Division, which presented both background material assessing economic developments and forecasts for inflation and the key macroeconomic aggregates. The Monetary Analysis Division would write extensively about the evolution of monetary aggregates (which was partly a heritage of the previous regime – a combination of monetary targeting and fixed exchange rate) but also covered market expectations and developments in the fiscal sector. Later on, some co-operation while creating the forecast developed between the two Divisions, especially in the area of the fiscal sector. The Modelling Division stayed out of the process at first. Later it started to present a model-based forecast in the Report but it was difficult to present a coherent medium-term perspective with fixed interest and exchange rates, and the projection was thus forced to deviate from the assumptions agreed upon at the beginning of the process. Until the issue was resolved later by re-formulating the forecast as an integrated medium term macroeconomic picture, changing interest rates disqualified somewhat the model based predictions.

The work on the Situation Report used to be completed in two rounds, each followed by a Department-wide meeting, where suggestions were given and some effort to achieving consistency among the individual parts was attempted. At first, the key purpose of the meetings was to prepare the Board member in charge of the Department for a Board meeting where he would present a view on the state of the economy and necessary policy adjustment. Later, the Department would start presenting the main outcomes of the Report to the Board by itself, including a policy recommendation.[4] The second meeting was followed by a closed meeting of Division heads on the policy recommendation, which was then presented to the Board together with the Report. The Board would have about a week to consider it and prepare questions before the regular monthly monetary policy meeting took place. The meeting would usually devote substantial time to resolving inconsistencies in the Report and less time was left for key policy issues and questions requiring deeper analysis.

For communication purposes, an Inflation Report would be prepared independently of the Situation Report. The Report consisted primarily of analysis of past data in a rather “accounting” manner.[5] The Report was published shortly after the decision on interest rates was taken but the material was not very interesting for the markets, which has been repeatedly confirmed by their weak reactions. Specifically, the yield curve has tended to move more in response to what a member of the Board might say in the press, than in reaction to publication of the Inflation Report with the (very) short description of the official projection. Since 2001 the Report has become much more forward-looking, the forecast and its assumptions are more fully explained to the markets and some effort to consolidate the work on the Situation and the Inflation reports has been taken. It seems logical that the two reports might merge into a single report in the future.

IMPLEMENTING THE NEW FPAS: PRINCIPLES AND OBJECTIVES

Over time it became apparent that the Board’s decision making in the new regime of inflation targeting would be greatly facilitated by deliberating over an internally consistent and transparent view on the evolution of the economy in the medium-term. This was made even more visible after the move closer towards the “full-fledged” inflation targeting in April 2001 as described in Chapter 1. The existing forecasting tools also offered only a very limited role for the discussion of the underlying policy pressures and future risks to the projection. Although the staff possessed superior sectoral knowledge and data expertise, the internal structure provided little incentive to share this knowledge. As a result most of this knowledge was not transmitted efficiently to policymakers. Taking stock, the main challenge that the deepening of the regime posed for the staff was how to alter the process of forecast production, so that the experience and sector knowledge would be used in a consistent and transparent manner to give the Board more competent policy advice.

[4] At present the organisational structure gives the Department some autonomy in that it is managed by the Department’s Executive Director and a selected Board member performs only a supervisory role.

[5] One of the reasons for this was that the Central Bank has long been the only entity regularly analysing past data, which partially explains the very backward-looking nature of the Report.

As a partial response, the medium-term model forecast started to be presented in the Situation Reports as an alternative view since 2001. In the beginning, however, the model was not well documented and had not undergone proper scrutiny within the Department. Without understanding the mechanisms, there could hardly be any debate of the forecast results. The management of the Department realised this problem and a lot of effort was subsequently put into eliminating this “black box” perception. After the problems were largely eliminated, the Department started to search for ways to incorporate the model forecast into its regular meetings as well as policy recommendations to the Board.

These deliberations led a to an experimental implementation of a new system in the spring of 2001, drawing on the experience of other countries in similar situations. This process was facilitated by technical assistance provided throughout the period by the IMF.[6] The idea was to test whether this new system would assist the staff and the Board in achieving a more coherent view of what is happening in the economy and the implications for monetary policy, while still keeping the original system in place.

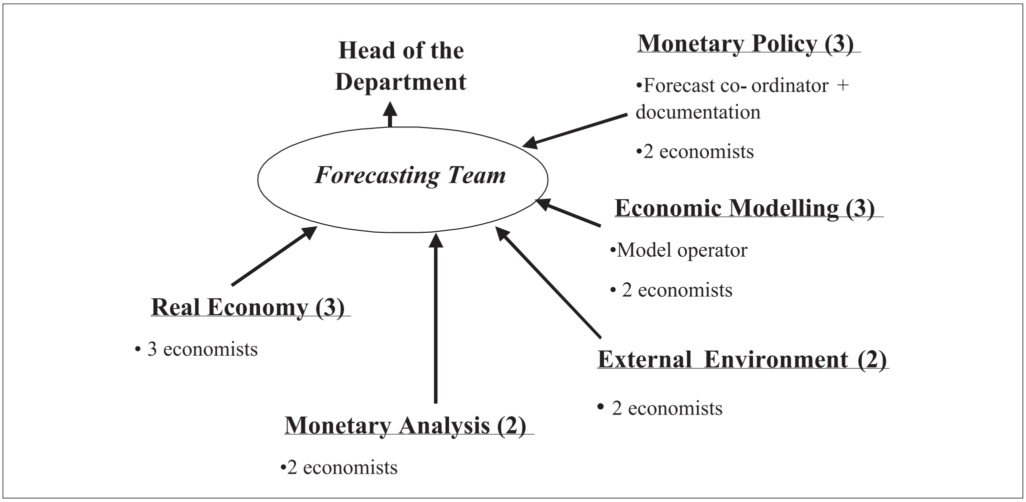
Box 1: Organisation of the Monetary and Statistics Department

The Monetary and Statistics Department of the CNB is the only unit within the CNB responsible for monetary analysis, projection creation, formulation of policy recommendations to the Board and production of strategic policy documents. The Department has eight divisions at present, of which three are concerned with statistical issues (former Statistics Department until December 2001). This box will concentrate on the five “monetary” Divisions. The Monetary Policy Division is responsible for strategic policy inputs (e.g. inflation targets or analysis on the Eurozone entry etc.), formulates policy recommendations for the Board and co-ordinates the analytical and forecasting work within the Department including the writing of the Inflation report as an external outcome. The Real Economy Division monitors macroeconomic developments, including the short-term indicators, as well as measures of inflation. As its core product, the Real Economy Division provides projections of the economy up to six quarters ahead based on various statistical and econometrical techniques and the views of experts. The Monetary Analysis and Public Finance Division collects and analyses information about monetary aggregates and monitors and analyses the fiscal sector. The Economic Modelling Division is responsible for research in the area of economic modelling and creating state-of-the-art models. The Division also operates the core model of the CNB and is a key contributor to the forecasting process. The agenda of the Division for International Economic Analyses consists of analysis of the world economy and its perspectives with special focus on the EMU and Visegrad countries’ economies, investigation of the effects and channels through which the external environment affects the domestic economy and conceptual issues of the integration process (nominal and real convergence, comparative studies, etc.)

Because initially the new FPAS was meant to complement the original system of producing forecasts, rather than to replace it, the first stage of its implementation has focused on three modest but essential objectives. First, the resources of the entire Department would be pooled when preparing a forecast, so that information and experience would be shared and communication barriers reduced, so that the output could reflect a coherent consensus view. A new forecasting team (FT) was set up with representation from all Divisions (Figure 2). This is not a new Division, but rather a group that meets each quarter to prepare the projection. It is presided over by the head of the Department and organised by the Monetary Policy Division. The Modelling Division takes the main responsibility for the database management and for the day-to-day work of running the model. Each step and meeting in the forecasting process is carefully documented and the whole exercise is thus very tractable and replicable. Board advisors have been invited to become regular members of the FT. This step has proven very effective in improving communication between the Staff and the Board.

[6] In particular, the CNB benefitted from several technical assistance missions that resulted in a book co-published by the CNB and IMF, see Coats (2000). The CNB wishes to thank Warren Coats, Kevin Clinton, Douglas Laxton, and Papa N’Diaye for participating in these early missions.

Figure 2: The Forecasting Team



The second objective was to foster coherence by integrating the model and expert forecasts. A prerequisite was the recognition that the forecast in the short term should be entirely driven by the expertise of specialists as expert knowledge proves superior in describing the current state of the economy and the details of what is likely to drive it in the near future. Over longer horizons, however, a formal macroeconomic model is required to achieve consistency and provide a clear story about the inflation process and the role of monetary policy in respecting the inflation targets. The technical system adopted enables the forecasting team to combine the expert and model-based forecasts by forcing the model solution to respect the expert-based forecast in the near term.[7] The first three quarters of the forecast are taken directly from the expert-based projection, except for those variables expected to move significantly in reaction to changes in monetary conditions. Thereafter, the model's solution becomes increasingly binding and provides a consistent story about the medium term dynamics of the economy.

The discussions held in the Bank led to a conclusion that the model at the heart of the system could be of varying complexity, but must meet a few essential requirements. First, it must allow for a flexible exchange rate. Second, it must elaborate the transmission mechanism linking monetary policy with the economy and inflation. Finally, it must contain a reaction function that closes the system by providing the endogenous policy response to anchor inflation to the target path. We must add that, to meet modern modelling standards, all of this must describe forward-looking behaviour by economic agents. We began with a simple, forward-looking flow model of the monetary business cycle (described in Chapter 4 in detail), which only marginally exceeds these minimum requirements. While it is recognized that this is a modest first step in modelling, experience to date at the CNB supports the view that considerable progress can be made in fostering a common understanding of the essential macro dynamics and the monetary control process with a simple model.[8]

[7] The technical methodology for this is described later in this Chapter.

[8] This is the recommendation in Laxton and Scott (2000), where the authors stress the benefits of starting with a simple model so that all the benefits of a co-ordinated FPAS and clearer communication between Staff and policymakers can be realized quickly. More complex forecasting models can follow as resources permit and as experience develops as to priorities for more elaboration.

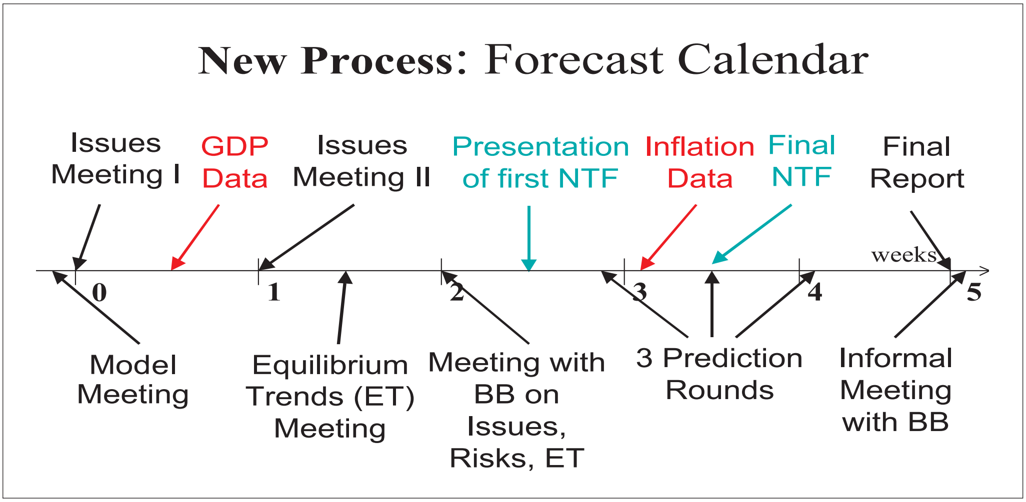
The goal of producing an integrated forecast put extraordinary pressure not only on the staff but also on the technical aspects of the new FPAS in terms of software and hardware. For the process to be truly functional, the model must simulate quickly and reliably, so that more time during the projection exercise can be devoted to substantive economic issues than to solving purely technical problems. Technical automation of the forecast also benefited greatly from international experts' advice and a manual describing step-by-step the process for producing a forecast.

The third objective was to enhance the transparency of the whole process. This entailed above all two elements: improved communication and ongoing documentation. The establishment of the forecasting team has substantially reduced the communication barriers within the CNB. Meetings of the FT are announced in advance (see Box 4 in the end of this chapter), open to everybody, and documented. Each meeting is summarised in a short memorandum, which is made available electronically in a shared directory that also contains other work commissioned by the FT. These memoranda include key observations, decisions made by the FT and tasks assigned. This provides anyone interested with the opportunity to follow the process or to get up-to-speed quickly for participation. No FT member can be expected to attend all meetings in full, given their other duties. The documentation also imposes discipline on the process by providing a written record of discussions and decisions, and facilitates an effective ex-post evaluation of the process.

IMPLEMENTING THE NEW FPAS: PROCESS OF CREATING THE INTEGRATED FORECAST

The basic overview of the present process for creating the forecast at the CNB is depicted in Figure 3. Before the formal forecast process starts, two auxiliary steps are taken: the production of a meeting calendar and the so-called *Model Meeting*. The schedule (see Box 4 in the end of this chapter) formalises the process by laying out a schedule with brief reminders of the agenda at each stage. It also includes the important deadlines and an allocation of responsibilities. This lays out in advance what must be done, when, and by whom, to meet the deadlines for the forecast. The *Model Meeting* has two purposes. First, it is a useful reminder of the model properties in order to help members of the FT to begin thinking about forecasting issues in terms of the model. This is particularly useful for those FT members whose normal duties do not involve working with dynamic macroeconomic models. Second, the meeting provides a regular opportunity for the members of the FT, both the near term forecasters and modellers, to introduce and agree on changes in their forecasting tools and the core model since the last forecast and the effects of these changes on model properties. This contributes to credibility of the whole system since any part of it, including the core model, may be reviewed and improvements may be suggested on a regular basis.

Figure 3: Process of creation of the integrated forecast



The real forecasting exercise begins with two *Issues Meetings*, which take place about a month before the final document is scheduled for presentation to the Board. Their purpose is to provide a review of the most recent data and the implications for the starting point for the forecast, as well as the major issues to be addressed in the forecast, including the main risks to be identified and studied. Although all FT meetings are open to the whole Department, wide participation is encouraged especially at Issues Meetings, because the goal is to gather the Staff's collective view and to come to some consensus on the main issues. The head of the FT must ensure that priorities are established and decisions taken as to what issues are to be dealt with formally in the projection. This is difficult, because the issues that people will raise are typically not known in advance.[9] During the first Issues Meeting, people present – in a rather brainstorming manner – their issues and concerns about current developments and explain why they think they are important. These may later become the basis for alternatives or risks to the baseline scenario. Ideally, they have already completed some analysis of the problem and a decision can be taken. If not, and the head of the FT finds the issue important enough, a follow-up for the second Issues Meeting, which takes place approximately one week after the first one, may be requested. The follow-up analysis may concern for instance the evolution of external imbalance including the decomposition of the current account according to final use or issues such as alternative measures of the fiscal stance. In cases where recent inflation figures appear too erratic, their detailed decomposition, including the analysis of seasonality and ad-hoc factors behind each component, may also be requested.[10]

[9] Laxton and Scott (2000) recommend that notes be prepared and circulated in advance of an Issues Meeting.

[10] Decomposition is invaluable because it reminds all participants that the CPI is an imperfect measure of inflation. It may move in response to technical factors, such as temporary shifts of seasonal patterns in a particular commodity that have no link with monetary developments, per se.

The Issue Meetings are followed by one or two *Meetings on Initial Conditions, Equilibrium Trends and Exogenous Assumptions*. Motivated by the discussion at the Issue Meetings, FT should have enough confidence to set the initial conditions required by the model for the unobserved variables depicting the present position of the economy in the business cycle. Examples of these variables include the initial level of the output gap or the deviation of real exchange and interest rates from their equilibrium values. This assessment is done in terms of estimating the historical equilibrium trends of variables driving the monetary cycle, in particular GDP, real interest and exchange rates. Decomposition of a variable into its equilibrium trend and gap may rely on more or less sophisticated techniques, such as the filtering methods described in Chapter 5. Most importantly though, the historical fluctuation of the variables around their trends, considered together, must conform to the collective Staff's view of how the economy has been functioning. Further assumptions involve projection of the equilibrium trends into the future. At this stage of the process, assumptions on the external environment are also frozen. Currently, the CNB uses Consensus Economics Forecast as the source for assumption on world GDP growth, inflation, oil prices and EUR/USD cross exchange rate.

Both the initial conditions and equilibrium trends are unobservable variables, they may present a key uncertainty in the process. However, it is important that the whole system enables the FT to make these uncertainties and their impact clearly visible through possible alternative assumptions. It is then the task of the Modelling Operator to evaluate all these assumptions in a series of mini-forecast rounds and present the outcomes in a comprehensive set of tables and graphs to the FT. The FT then evaluates the simulations and decides on which of the alternatives to proceed with as a baseline forecast.

Box 2: Example of initial conditions and equilibrium trends in CNB's October 2001 Forecast

This box briefly illustrates the discussion on the initial conditions and equilibrium trends on the example of October 2001 forecast. Technical aspects of arriving at the numbers are discussed in Chapter 5. The GDP decomposition suggested that the economy had not yet reached its potential output and that there had been a marked slowdown in the rate at which the output gap was closing. This slowdown was no doubt influenced by the weakening foreign demand, but what of the influence of monetary conditions? The decomposition of real interest rates suggested that real rates remained below the estimated equilibrium level, and with the recent pickup in inflation had fallen even lower. Hence, real rates were continuing to act to encourage the closing of the output gap. On the other hand, the evolution of the real exchange rate pointed to a real appreciation exceeding the assumed equilibrium rate of about 4.5 percent per annum. As a result, the real exchange rate was judged to be more than 2 percent above the estimated equilibrium. This development had shifted the impact of monetary conditions from loose to neutral, which had contributed to the slower pace of GDP recovery over 2001. The real equilibrium interest rates were held constant over the forecast horizon at the last historical estimates. The growth of potential GDP was assumed to accelerate from about 2.5 to 3.5 percent per annum by the end of 2004, based on empirical growth studies and the Staff's perception of the speed of structural changes in the economy. The trend real appreciation was set at 4.5 percent per annum, which seemed a reasonable extrapolation of the historical trend. This may appear higher than what would be implied by productivity differentials at the given growth of potential GDP. However, the FT preferred to set it higher, due to other factors that were considered at the time, such as a persistent trend in the terms of trade. See Appendix to this Chapter for an example of a formal report covering the above mentioned.

These start-up meetings are followed by the *Near-Term Forecast (NTF) Meeting*, in which field specialists explain their preliminary predictions and give suggestions as to where the final NTF might lie. The actual forecast is then produced in three to six rounds. In the *first round*, the modelling team gives a first impression of how the medium term could look based on the near-term forecast and the agreed assumptions. In between the rounds, the head of the modelling team designs a series of micro-rounds, in which the modellers experiment with the assumptions and sometimes with model properties, especially if members of the FT have expressed conflicting views about them. Ideally, all model properties should have been discussed and agreed on in the *Model Meeting*, so that the actual forecast exercise can focus on developing a consistent economic story and rationale for the forecast, based on the agreed mechanisms. However, it is to be expected, especially in the early trials of a new system, that there will be important issues associated with model properties.

A meeting with the FT follows each round, where the outcomes are evaluated and decisions made on which of the alternatives to retain. Because updates of the NTF are likely to arrive as the forecast continues and new data are released, any implications are discussed in these meetings as well. The interaction of the model and expert views beyond the NTF provides an excellent opportunity to ask counterfactual questions. Where the expert arguments are considered superior, judgement is added to modify the model predictions accordingly. In the schedule shown in Box 4, we have allowed nine working days of projection rounds for the forecast to converge.[11] The reports circulated with each projection round should be transparent about what assumptions have been used. An example of such a report is given in the Appendix together with a brief guide on how to read it.[12]

After discussing concerns with Staff and members of the Board, based on the results in the previous round, the FT meets to discuss any changes that will be made in the baseline forecast. Because one of their key roles is to ensure that the projection exercise is internally consistent, the FT will not change the baseline scenario unless that represents a clear consensus on the part of the Board. If suggested changes make the forecast internally inconsistent with other maintained assumptions, then these new changes can be considered as potential starting points for a completely separate alternative scenario. Such scenarios can highlight and quantify risks by showing the implications of alternative assumptions. If a formal alternative scenario is required, the rounds must proceed considering both cases; essentially, two full internally consistent forecast scenarios must be created. If a decision to do this comes early in the process, it is normally feasible to complete the whole exercise without disrupting the schedule.

By the time the second round is complete, the FT should have collected enough information to make a decision about the baseline and alternative scenarios in terms of the initial conditions and equilibrium trends. It is important that the Director of the Department or Board members attend the *Round 2* meeting to adjudicate, should controversies arise, and to sign off on decisions concerning the baseline and alternatives.

The forecast is then completed in the *final round* when the FT receives the final version of the NTF, following the release of the latest CPI data. The subsequent discussion should provide enough information as to what the team members wish to include and highlight in the commentary to the projection. After that, the report on the forecast is included in the Situation Report.

At this stage, the forecast is ready to be presented to the Board at the official Monetary Policy Meeting. However, the final presentation is not the first interaction with the Board. The influence of the Board on the forecast starts relatively early in the process as the Board signs off on the exogenous assumptions and equilibrium trends either after the first or at the second *Meeting on Initial Conditions, Equilibrium Trends and Exogenous Assumptions* (if there is a second meeting). The second interaction occurs later on in the process when the Board is presented with a set of preliminary *Alternative scenarios* and is to choose two or three of them that will then be finished in more detail and turned into full-blown alternatives. The last meeting with the Board, before the official Monetary Policy Meeting takes place, is a *Meeting on Policy Experiments*. This meeting has two purposes. First, in order to increase managerial comfort with the information in the Situation Report, the Board is given an additional opportunity to ask questions, which should enhance their understanding of the policy implications and

[11] Laxton and Scott (2000) recommend that the process is undertaken in five days. However, before the process settles, it is reasonable to assume that it will require more time.

[12] The report serves for illustration purposes only. The numbers presented come out of the October 2001 forecast round but do not represent the central projections of the period. The report is an example of a 'managerial' report that is presented to the FT and the Board. Much more detailed reports are needed by the Modelling Division to provide the checks that ensure the integrity of the process.

sharpen their perception of the underlying risks. Second, two or three more simulations are presented to the Board that have a special goal: to illuminate the policy options and the reaction of the economy if alternative decisions are taken. We call these simulations "policy experiments". For example, the FT may show simulations in which the Bank is expected to react in a way that inflation returns into the target faster than in the base-line forecast or in which the Bank does not react to the economic developments for some time. The experiments are usually suggested by the Monetary Policy Division and are a way to prepare the Board and the FT for policy deliberations at the official meeting. Alternatively, the "policy experiments" may be presented as part of policy recommendation at the Board meeting itself.

The forecast is then presented to the Board at the official *Monetary Policy Meeting*. This is usually done by the head of the FT or the head of the Modelling Division. Other members of the forecasting team or heads of other divisions may have specific, issue related, roles. The head of the Monetary Policy Division presents the policy recommendation that reflects the view of the heads of Divisions from the Monetary Department on the appropriate policy decision. The Inflation Report is published a week later, with the main assumptions and the prediction of inflation and GDP for the next 6 quarters. The Report presents the forecast of the most important variables. Since July 2002, a path of future short-term interest rates consistent with the baseline forecast is described verbally (see Box 3).

The last element of the process is the so-called *Post-Mortem Meeting*, where again a wide participation is encouraged. This meeting provides the Staff with an opportunity to express comments on the just-completed process, to make suggestions for improvement, air dissatisfactions, and so on. The discussion and the conclusions are again well documented and the notes are the first thing to consider in the next projection exercise.

Box 3: The role of the central bank within the forecast[13]

Central banks operating within an Inflation Targeting regime use essentially two types of inflation forecasts as the basis for their monetary policy decisions (and their subsequent communication). Either a forecast in the simple sense of the most likely future economic scenario is used or, alternatively, a "conditional inflation forecast" is used. The latter type basically simulates future economic developments under the not-necessarily-realistic assumption that the central bank will not alter the settings of its monetary policy instruments no matter the developments in the economy. The former is sometimes referred to as the "unconditional forecast" to differentiate it from the "conditional forecast". This is despite the fact that this unconditional forecast is in fact also conditional on a whole range of assumptions (e.g. about the external developments or agents' behavior), as is every forecast of complex evolution of real economic systems.

Both systems – working with the unconditional forecast and working with the conditional forecast – have their specific drawbacks. Starting with the very *construction* of the two types of forecasts, the conditional forecast is subject to the following problem. The assumption that the central bank will be completely passive will generally be in conflict with the economy-wide expectations that in the face of any looming cyclical swings of the economy, the bank will take steps to diminish these swings. Agents in the economy would interpret the unexpected passivity of the central bank as a change in its reaction function due to changes in the central bank's perception of the economy and/or its preferences. As a result, the agents would change their behavior too. The conditional forecast, to be realistic, should predict these changes and their implications for the evolution of the economy. In practice, however, most predictive models are not ideal, fully structural, micro-models where the reaction function of each agent is explicitly modeled on the basis of the agent's preferences and perception of the economy. Instead, predictive models are of a more or less reduced, aggregated form and the structure of and coefficient values in many of their relationships are based on regularities observed in past data when all agents including the central bank behaved in roughly the most likely,

13 The Box was prepared by Michal Skořepa. See Skořepa and Kotlán (2003) for a more detailed discussion of the issue.

expected way. The unexpected passivity of the central bank may therefore imply the need to change the structure and/or the values in the reduced-form relationships - this is one interpretation of the Lucas (1976) critique. It is, however, very difficult to guess exactly how the structure and/or coefficient values should change and so model builders often do not take these changes into account. The conditional forecast thus contains an error and may give a misleading message. Some central banks try to bypass this by subjecting the forecasting apparatus to a temporary "monetary shock" where the central bank is not responding only for some limited period, and behaves in the usual manner afterwards. The resulting forecast is then, however, not a constant-interest-rate forecast but rather a monetary policy experiment with only a limited value.

A difficult step in constructing an unconditional forecast (a step that is not necessary while constructing a conditional forecast) is the identification of the central bank's reaction function that would approximate the central bank's actual future behavior. Several approaches are available (via loss function, shock responses or VAR/GMM estimation) but all of them have problems of their own.

On the level of *decision making*, conditional forecasts are attractive primarily because they allow evaluation of alternative interest rate policies (forgetting for a moment about the above-mentioned problem). By comparing these forecasts with the corresponding inflation target, it is possible to assess what changes in monetary policy settings should be made today to bring inflation closer to the target. Unfortunately, this information in itself is only qualitative – it suggests the appropriate direction of change in the monetary policy instruments but does not indicate the required extent of the change. This quantitative information has to be provided by some supplementary analyses, taking into account for instance the yield curve and other important factors in transmission. Unconditional forecasts provide complete – qualitative as well as quantitative – information on the appropriate reaction. This advantage can, however, be viewed at the same time as a disadvantage. The central bank board's members may feel locked-in, i.e., they may feel a latent pressure to accept this explicit suggestion or, if they vote for a different reaction than suggested by the forecast, a latent pressure to provide numerous and very strong reasons for their disagreement.

Unconditional forecasts and conditional forecasts differ also in terms of their suitability for the central *communication* with the public. For a central bank with an explicit inflation target, communication of its inflation forecast is important for two reasons. First, it can anchor inflation expectations in cases when shocks cause the inflation target to temporarily lose its anchoring role. The only type of forecast suitable for anchoring expectations when a shock makes it clear that the inflation target will be missed for some time is the currently valid (i.e., one encompassing the decision being explained) unconditional forecast. Second, the central bank's inflation forecast can help in explaining the bank's monetary policy decisions to the public. In this respect, conditional forecasts can show what undesirable path the future inflation would follow if the monetary policy instruments remained unchanged (or, if they actually did remain unchanged, what desirable path the future inflation will follow thanks to the instruments being left unchanged). Again, unfortunately, conditional forecasts can explain the direction of change in the instruments but not the extent. Another problem with publishing conditional forecasts is that their unchanged-instruments assumption tends to be overlooked by the media, the forecasts are interpreted as unconditional, they are commonly compared to other institutions' truly unconditional forecasts, etc. On the other hand, the central bank's unconditional forecasts (encompassing the decision being explained) show explicitly what desirable path the future inflation will follow thanks to the decision that has just been made and thanks to future decisions that are anticipated by the forecast.

It may seem that at least on the level of communication, unconditional forecasts are clearly preferable to the conditional ones. There are, however, arguments against the publication of unconditional forecasts. One of them is that the forecasted trajectory of future monetary policy decisions (which is an integral part of the whole forecast) can be viewed by the public as a promise on the part of the central bank to behave that way in the future. The risk that the public will view the forecast this way certainly exists, even though it is a deep misunderstanding: the forecasted series of monetary policy decisions is not and cannot be a promise because it is conditional on the current information set. As new information arrives after the forecast is published, the updated economic outlook – and consequently the actual reactions of the central bank – may easily differ from what was anticipated in previously published forecasts. Another argument against publishing unconditional forecasts stems from the fact that these forecasts contain predicted paths of some economic variables. If the central bank's forecasts are considered by the markets as reliable, the concerned markets may react strongly to the publication of the variables' forecast. This applies especially to prices of some financial market instruments such as the exchange rates. For example, if the central bank "confirms" a general expectation of an x % appreciation of the domestic currency by the end of the year, this confirmation may lead some previously hesitating investors to buy the currency on the very day of publication of the forecast, bringing about the x % appreciation immediately rather than by the end of the year as forecasted. This would make the existing forecast obsolete and, more importantly, it could prove harmful for the economy. The argumentation does not concern interest rates, as the short end of the yield curve is under almost direct control of the central bank and long-term interest rate adjustment in line with the forecast is a desirable property of forecast communication. Moreover, central banks are usually free to chose between a more or less explicit wording of the forecast of financial market or other variables.

The decision between a conditional and an unconditional forecast on the (interconnected) levels of construction, decision making and communication is not an easy one. Many factors including some institutional ones must be concerned. After having considered the advantages and problems of the two types of forecasts, the CNB Bank Board opted to switch from the previously used conditional forecast to an unconditional forecast in the summer of 2002.

APPLYING JUDGEMENT IN THE FORECAST

A combination of "temps" and "tunes" is used to force the model solution to replicate the NTF over the first three quarters and to be partially influenced by judgement thereafter. A "tune" is a device used to replace a model equation temporarily with another equation that sets the value for an endogenous variable independent of what else is happening. A possible structure is:

$$Y_{t+\tau} = Tune_{t+\tau} * YJudgement_{t+\tau} + (1 - Tune_{t+\tau}) * YModel_{t+\tau}$$

where for a pure tune, $Tune_{t+\tau}$ is set to 1; which is what we normally have for the first three quarters. There are several possibilities for removing a tune over subsequent quarters. A common strategy is to run the tune off gradually over several quarters, so that the model's view is imposed gradually over the medium term. This limits jumps in the forecast that can occur when a tune is turned off and the pure model solution is relatively far away at that point. Our current practice is to turn the tunes off completely in the third quarter of the projection, with just a few exceptions. Tunes are retained past the first three quarters on regulated price inflation (because the exogenous information on the government's planned deregulation covers a longer horizon) and the exchange rate risk premium.

Not all judgement can be entered in the form of tunes. In some cases, this could violate an adding-up identity; in others, it would simply be inconsistent with the imposition of a macro view by the FT. For example, if specialists all had the right to set precisely the components of aggregate demand, the GDP identity would determine the outcome for the aggregate, and this could be inconsistent with a macro view, or with other aspects of judgment (the views of an income-side specialist, for example). A "temp" is entered through an add-factor in an equation. The model's disturbance terms provide one mechanism for doing this. Sometimes, however, explicit variables for add-factors are employed. A temp differs from a tune because the endogenous variable is not pinned to a specific value. Rather, judgment is entered that the variable is subject to forces that would move it by a certain amount away from where it would be predicted to be, all else equal. An example might be some special project that was thought to add something to aggregate demand, and that was not thought to be captured by the normal macro variables in the model. This extra demand could be added by setting a value for the disturbance term in the output gap equation.

In the projection rounds, it is the role of the Model Operator (MO) to incorporate judgment through the residuals of the model. This judgment usually arises from the need to refine the aggregate picture produced in earlier rounds—that is, the model should show up inconsistencies between assumptions, leading sector experts to adjust their own assumptions in the light of their impacts on the broader picture.

Judgment should be added in small increments. After the daily meeting with the FT, the MO will prepare a series of mini-projection rounds (Round 1a, 1b…) that add judgment incrementally so that it can be quantified and its impact understood. When the head of the FT has signed off these rounds, they should then be circulated so that they are available when members of the FT arrive the following morning.

While generally the case for judgment comes from taking an aggregate, "top-down" perspective on the forecast, in some cases it will be useful to take a "bottom up" perspective. Satellite models designed to provide details about specific sub-components could be used to check the consistency of the aggregate picture. For example, if the core projection model contains an aggregate Phillips Curve that is based on the CPI, it would be important to check the consistency of this forecast with other models that include explicit interactions between wages, producer prices and the CPI. If the core projection model contains an aggregate equation for the output gap, it would be necessary to check the consistency of the projection with models that attempt to disaggregate the GDP forecast into smaller expenditure components.[14] The choice of how disaggregated these components should be depends on how useful they are judged for monitoring the state of the business cycle, accounting for special factors, or linking the forecast to specific assumptions about external demand conditions.[15]

LESSONS LEARNED

Although the new FPAS is still in its early stages, we believe it has contributed towards two key objectives. First, the ultimate objective of the new FPAS is to assist the Board in policy decisions. Combining expert near-term forecasts with the model-based medium-term scenario has made the Situation Reports more coherent. Embedding the forecast within a clear macro framework has facilitated a more structured debate about risks and policy issues in the final meeting with the Board. Although the uncertainties implicit in the forecast are understood, the debate has given the Board members greater confidence in understanding the current pressures on the policy.

The second objective has been to enhance co-operation and focus the resources of the Department on a key output. It seems that most staff members feel more comfortable in what they are doing, because the final outcome makes use of all the available information and knowledge. There has been a substantial improvement in communication within the Department.[16] Duplication of work across Divisions has been reduced and previously irreconcilable stands of field experts and modellers have been resolved in the integrated forecast. This has given Department managers more confidence in using the final document and presenting its content to the Board. It also seems that the process has indeed helped the staff refine a collective view of what are the key forces shaping the economy and the main risks underlying the future. Tension has also been reduced because even if someone's views have not been adopted in the consensus, it is clear that there was an airing of those views and that there will be another chance to debate at a later date.

[14] For instance, information from a satellite model can be used to estimate the impact of fiscal stimulus over the forecast horizon. This information is then embedded into the forecast through the residual in the output gap equation.

[15] Chapter 3 provides a flow chart that shows the interactions between the core projection model and the satellite models.

[16] The model framework can be thought of as a new language that makes communication easier even though it is relatively simple at the start.

The evaluation of the process in the Post-Mortem meetings has brought interesting observations as to what has contributed to the success of the new system as well as suggestions of important necessary improvements. One issue of importance is improving our understanding of the practical issues that arise in combining judgmental and formal elements of the forecast.

A very important lesson is that the value of the formality of the process and its organisation should not be underestimated. The formality of the meeting calendar is crucial, even if the agenda may be subject to revision as the process evolves, because it symbolises commitment to the process. Sometimes, especially at the very beginning, a series of formal meetings may sound too ambitious, as the staff must learn how to do things and may not be well prepared. Yet, just being given the opportunity to discuss issues makes people co-operate and get involved. It is a major advance for the Department that a forecasting team with representation from all Divisions is meeting and working together on a regular basis.

The process should always be as transparent and open to as wide participation as possible. The ultimate success can only come through involvement of people. Therefore, care must be taken to communicate the recognition that the new system is meant as everyone's gain and its eventual adoption will not be considered as anyone's personal loss. This may not be achieved totally, but should be attempted. The success can only come through a willing participation of all major parties involved in the original system. At the very beginning, when the potential benefits from the new system's implementation may still appear unclear, some resistance to change is to be expected. As long as the process is seen to have the support of senior managers, this should not be an obstacle to continued progress.

It is important that work within the FT runs smoothly and co-operatively. This is a non-trivial issue, because FT members may have completely different views on essential things or represent different interests within the organisation. Most likely they will have never collaborated before in cross-Division work. Composition of the FT and its organisation should therefore be handled with care. This does not imply that members of the team should have a common viewpoint or the same background. On the contrary, when the system is working well, diversity of experience and perspective enriches the process. However, there must be good will and an effort to communicate. Members of the FT must inform their colleagues of developments as the forecast evolves and provide a conduit for feedback from those colleagues to the FT. It is to be hoped that this process will help prepare the various groups for the questions likely to be posed during the final meetings when the policy recommendation is discussed.

Of great importance is that the FT must be comprised of respected members of all groups in the department, and especially the key field specialists and people responsible for monetary policy formulation. This will both encourage the growth of understanding of the process by key members of the Department and command the respect of all Staff. Second, it is important that the members are chosen so that the work may be as collegial and as team-oriented as possible. In this respect, regular participation of higher-ranked officials should be treated with caution. Too much exercise of seniority during forecast meetings could stifle debate and blunt the enthusiasm of working-level economists.[17]

[17] Obviously, there are some meetings where it is desirable that Directors actually preside and exercise their authority, e.g. the issues meetings.

While the head of the FT is in charge of the whole process, the model operators will play a key role in organizing the day-to-day work, simply because technical aspects of the system are their responsibility. But ordinary meetings and other work should proceed in an informal atmosphere, to which higher management should fully subscribe, if it is to take part. Unlike the formality of the schedule and forecast process, the meetings of the FT must be anything but formal, if the communication barriers are to be dismantled and information transmitted freely. Alternative views should be considered even in cases when it is almost certain that they cannot contribute materially to the final product. The overriding principle is that members of the team must feel involved in the process. And although it takes time in the short term, inefficiencies will gradually be removed as participants learn more about what matters in the exercise.[18]

Even though considerable progress in improving the forecasting and analysis system has been achieved since the launch of the inflation targeting regime, there are still some challenges ahead. One of them, for instance, is the management of the work in a very tight schedule. The whole process, as it works now, must be accomplished within less than four weeks, including the production of two documents – the internal Situation Report and the external Inflation Report.[19] Another part of the process that will take root only gradually is the involvement of the Board in the different stages of the forecasting process. And yet other, more complex issues, such as advancing the core model in the direction of a second generation approach will always remain on the agenda.

Box 4: Rough Forecast Schedule

Time in days (T = deadline)	**Name of the meeting and the main goals**
T-30	*Model Meeting* a. Review of model properties b. Model changes
T-28	First *Issues Meeting* a. Review of new data and brainstorming of issues b. Mental Picture of the forecast, alternatives, and risks
T-26	Second *Issues Meeting* a. Discuss analyses of special issues commissioned in the first Issues Meetings b. Discuss preliminary equilibrium measures of real interest rates, real exchange rates, output and unemployment etc.
T-22	*Meeting on Initial Conditions, Equilibrium Trends and Exogenous Assumptions* a. Final Discussion on the initial position of the economy in the cycle b. Assumptions about the future evolution in equilibrium measures of real interest rates, real exchange rates, output and unemployment etc. c. Discuss various assumptions regarding exogenous variables such as oil prices, regulated prices, German output and interest rates

[18] For instance, it was found to be very valuable to run experiments demanded by some FT members, even if other members did not think they were particularly useful. This includes the assessment of the initial position of the economy within the business cycle. State-of-the-art technology of multivariate filters is used to provide systems estimates of the starting conditions (see Chapter 5). This is certainly very useful information. But given the huge uncertainties that are present in specifying the model linkages, it must be treated as just one piece of the mosaic. The expert views are equally valuable, if not superior.

[19] The forward-looking Chapter of the Inflation report is now basically identical to the Executive Summary of the Situation Report.

T-21	*Meeting with the Board on Initial Conditions, Equilibrium Trends and Exogenous Assumptions* a. Present the Board with staff's perception of the assumptions c. Discuss the Board's views
T-18	*Near-Term Forecast Meeting* a. Provide Forecasting Team with the preliminary Near-Term Forecasts and any other required inputs b. Discuss qualitatively the sensitivity of the NTF to awaited data
T-14 to T-3	*Forecast Rounds* – 3 to 6 rounds may be needed a. One meeting to close the NTF b. Several meetings to discuss and incorporate the expert judgement onto the model-based medium term outlook and close the MTF c. One to two meetings on alternative scenarios and policy experiments (see below)
T-4	Meeting on *Alternative Scenarios* with the Board a. Present the Board with ideas or preliminary results of several alternative scenarios based on the issues discussed both at the Issue Meetings in the beginning of and throughout the forecast exercise b. Let the Board fill in on the risks it considers important c. Choose two to three main alternative scenarios that will be treated in more detail in the Report
T	**Deadline for submission of the forecast to the Board**
T+8	*Meeting on Policy Experiments* - Informal discussion with the Board a. Informal discussion of the new forecast and its implication for the policy b. Simulations to illuminate the current policy options based on alternative reactions or considerations
T+9	*Monetary Policy Meeting* - presentation of the forecast and policy recommendation to the Board
T+16	*Post Mortem Meeting*

APPENDIX: AN EXAMPLE OF FORECAST REPORT

Based on October 2001 forecast exercise (not a central projection)[20]

Reported: 19-Oct-2001 10:57:18

Database: base.csv
Created: 19-Oct-2001 10:54:42

October 2001 Forecast Summary

Baseline 2

		2000:2	2000:3	2000:4	2001:1	2001:2	2001:3	2001:4	2002:1	2002:2	2002:3	2002:4	2003:1	2003:2	2003:3	2003:4	2004:1	2004:2	2004:3	2004:4
CPI	% pa y-o-y	3.7	4.0	4.2	4.1	5.1	5.4	4.6	4.9	4.4	3.6	4.0	3.3	3.4	3.3	3.3	2.9	2.7	2.7	2.7
	% pa q-o-q	1.3	5.3	3.0	6.4	5.2	6.3	0.4	7.3	3.3	3.2	2.2	4.6	3.4	2.9	2.2	3.0	2.8	2.6	2.5
	level	102.0	103.3	104.1	105.9	107.3	109.0	109.1	111.1	112.0	112.9	113.5	114.8	115.7	116.6	117.2	118.1	118.9	119.7	120.4
Real GDP	% pa y-o-y	2.4	2.6	3.7	3.9	3.9	3.5	3.0	2.4	3.2	3.8	3.8	3.9	4.2	4.1	4.0	3.7	3.4	3.1	2.7
	% pa q-o-q	0.1	3.4	6.0	6.0	0.2	1.7	4.1	3.8	3.0	4.1	4.1	4.3	4.2	3.6	3.6	3.2	3.0	2.5	2.1
	level	359.2	362.3	367.6	373.1	373.3	374.8	378.7	382.2	385.1	389.0	392.9	397.1	401.3	405.0	408.6	411.8	414.8	417.4	419.7
Unemployment Rate	%	9.2	8.9	8.7	8.5	8.5	8.5	8.3	7.9	7.8	7.6	7.5	7.3	7.1	7.0	6.9	6.7	6.7	6.6	6.6
Nominal Interest Rates																				
3-Month Interbank Rate	% pa	5.3	5.3	5.4	5.2	5.0	5.4	5.5	4.8	4.5	4.3	4.2	3.7	3.4	3.1	3.0	2.9	2.8	3.0	3.3
Policy Neutral Rate	% pa	7.7	7.7	6.7	6.7	6.2	5.4	5.6	4.8	4.7	4.5	4.4	3.8	3.6	3.4	3.4	3.2	3.2	3.4	3.7
Policy Misalignment	pp	-1.0	-1.3	-0.7	-1.2	-2.5	-1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-Year Interbank Rate	% pa	5.6	5.7	5.8	5.3	5.1	5.8	5.7	5.1	4.8	4.5	4.4	4.0	3.7	3.4	3.3	3.2	3.2	3.4	3.7
Newly-Issued Bank Loans	% pa	8.4	7.5	8.1	7.4	7.2	7.5	7.2	6.6	6.4	6.2	6.2	5.9	5.7	5.5	5.5	5.4	5.5	5.6	5.9
Euro 3-Month Interbank Rate	% pa	4.3	4.7	5.0	4.7	4.6	4.3	3.8	2.5	2.5	2.5	2.5	1.6	1.6	1.6	1.6	0.8	0.8	0.8	0.8
Nominal Exchange Rates																				
CZK/DEM	% pa y-o-y	-3.5	-2.6	-4.0	-2.7	-5.5	-4.1	-1.6	-0.6	1.6	2.9	0.5	-1.5	-3.5	-4.9	-5.8	-6.4	-6.7	-6.6	-5.8
	% pa q-o-q	5.8	-9.1	-6.4	-1.3	-5.6	-3.2	3.8	2.8	3.1	1.8	-5.8	-5.2	-5.0	-3.8	-9.5	-8.0	-6.1	-3.5	-6.3
	level	18.6	18.1	17.8	17.8	17.5	17.4	17.6	17.7	17.8	17.9	17.6	17.4	17.2	17.0	16.6	16.3	16.0	15.9	15.7
CZK/DEM Risk Premium	% of Exchng Rate	5.0	4.9	4.9	5.0	5.2	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
CZK/USD	% pa y-o-y	9.2	12.7	15.0	4.0	1.1	-2.4	-6.2	-0.5	-5.1	-3.0	-1.9	-2.7	-2.8	-3.9	-4.6	-5.2	-6.1	-5.4	-5.8
	% pa q-o-q	29.4	3.5	10.2	-25.3	17.2	-10.2	-6.0	-2.5	-1.9	-1.8	-1.6	-5.7	-2.1	-6.5	-4.5	-8.0	-6.1	-3.5	-6.3
	level	38.8	39.2	40.2	37.6	39.3	38.3	37.7	37.5	37.3	37.1	37.0	36.4	36.2	35.7	35.3	34.5	34.0	33.7	33.2
Supply-Side Assumptions																				
Real Potential GDP	% pa y-o-y	1.8	1.9	2.1	2.2	2.3	2.3	2.5	2.7	2.8	2.9	2.9	3.0	3.1	3.2	3.3	3.3	3.4	3.5	3.6
	% pa q-o-q	2.0	2.1	2.2	2.3	2.4	2.4	2.9	2.9	2.9	2.9	2.9	3.2	3.2	3.2	3.2	3.5	3.5	3.5	3.5
NAIRU	% of Labor Force	6.9	6.7	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
Unemployment Gap	% of Labor Force	-2.3	-2.2	-2.0	-1.9	-1.9	-1.9	-1.7	-1.3	-1.2	-1.0	-0.9	-0.7	-0.5	-0.4	-0.2	-0.1	-0.1	-0.0	-0.0

[20] The report serves for illustration purposes only. The numbers presented come out of the October 2001 forecast round but do not represent the central projections of the period. The report is an example of a 'managerial' report that is presented to the FT and the Board. Much more detailed reports are needed by the Modelling Division to provide the checks that ensure the integrity of the process.

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Aggregate Demand and Indicators of Real Monetary Conditions

Baseline 2

		2000:2	2000:3	2000:4	2001:1	2001:2	2001:3	2001:4	2002:1	2002:2	2002:3	2002:4	2003:1	2003:2	2003:3	2003:4	2004:1	2004:2	2004:3	2004:4
Weighted Contributions to Aggregate Demand – log terms																				
Real GDP Gap	% of Actual Value	-2.4	-2.1	-1.2	-0.3	-0.8	-1.0	-0.7	-0.5	-0.5	-0.2	0.1	0.4	0.6	0.7	0.8	0.7	0.6	0.3	-0.0
Real GDP Gap Lag	pp	-1.7	-2.2	-1.9	-1.1	-0.2	-0.7	-0.9	-0.6	-0.4	-0.4	-0.2	0.1	0.3	0.5	0.6	0.7	0.6	0.5	0.3
RMC Index Lag	pp	0.4	0.2	0.1	0.2	0.1	-0.1	0.3	0.4	0.7	0.7	0.6	0.7	0.5	0.4	0.3	0.2	0.0	-0.1	-0.2
Foreign Demand Gap	pp	0.5	0.4	0.3	0.2	0.0	-0.1	-0.1	-0.7	-0.8	-0.8	-0.7	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4
Expert Judgement	pp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Tune	pp	-2.4	-2.1	-1.2	-0.3	-0.8	-1.0	-0.7	-0.5	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	-0.0	-0.0	-0.0	-0.0	-0.0
Tune Weight	pp	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indicators of Real Monetary Conditions																				
RMC Index		-43.7	-43.3	-43.1	-43.1	-42.8	-42.6	-42.8	-42.7	-42.8	-42.8	-42.4	-42.3	-42.0	-41.8	-41.5	-41.2	-40.9	-40.7	-40.4
Equilibrium RMC Index		-43.3	-43.2	-43.0	-42.9	-42.7	-42.7	-42.5	-42.3	-42.1	-42.0	-41.8	-41.7	-41.5	-41.4	-41.2	-41.0	-40.8	-40.7	-40.5
RMC Index Gap		-0.4	-0.2	-0.1	-0.2	-0.1	0.1	-0.3	-0.4	-0.7	-0.7	-0.6	-0.7	-0.5	-0.4	-0.3	-0.2	-0.0	0.1	0.2
Real 3-Month Interbank Rate	% pa	1.7	1.7	1.5	1.1	1.0	0.4	0.0	0.4	-0.1	0.2	0.6	-0.2	0.1	-0.1	-0.2	-0.4	-0.0	0.3	0.7
Equilibrium Rate	% pa	2.7	2.4	2.2	2.0	1.9	1.9	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.6	0.7	0.8
Rate Gap	% pa	-1.0	-0.8	-0.7	-0.9	-0.9	-1.5	-1.6	-1.1	-1.5	-1.0	-0.6	-1.1	-0.7	-0.9	-0.9	-1.0	-0.7	-0.4	-0.1
Real 1-Year Interbank Rate	% pa	2.0	2.1	1.9	1.2	1.1	0.8	0.6	0.7	0.2	0.4	0.9	0.1	0.4	0.2	0.1	0.0	0.4	0.7	1.1
Equilibrium Rate	% pa	2.8	2.5	2.2	2.0	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.1
Rate Gap	% pa	-0.8	-0.4	-0.3	-0.8	-0.9	-1.2	-1.4	-1.3	-1.8	-1.6	-1.1	-1.9	-1.6	-1.9	-1.9	-2.0	-1.7	-1.4	-1.0
Real Rate on Newly-Issued Bank Loans	% pa	4.8	3.8	4.1	3.3	3.2	2.5	2.1	2.3	1.8	2.1	2.7	2.0	2.4	2.2	2.3	2.2	2.6	2.9	3.2
Equilibrium Rate	% pa	4.7	4.4	4.2	4.0	3.9	3.9	3.8	3.7	3.5	3.5	3.4	3.3	3.2	3.2	3.1	3.0	3.0	3.0	2.9
Rate Gap	% pa	0.0	-0.6	-0.1	-0.7	-0.7	-1.4	-1.7	-1.4	-1.7	-1.3	-0.6	-1.3	-0.8	-0.9	-0.8	-0.9	-0.4	-0.1	0.3
Euro Real 3-Month Interbank Rate	% pa	2.6	3.2	3.0	2.4	2.1	1.3	1.6	0.8	1.1	1.4	1.3	0.3	0.1	0.1	0.1	-0.8	-0.7	-0.9	-1.2
Equilibrium Rate	% pa	2.2	2.2	2.1	1.9	1.8	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.7	0.7	0.6	0.5	0.5	0.6	0.7
Rate Gap	% pa	0.3	1.0	0.9	0.4	0.3	-0.4	0.1	-0.6	-0.1	0.3	0.3	-0.6	-0.6	-0.5	-0.5	-1.3	-1.3	-1.5	-1.9
Real CZK/DEM Exchange Rate	level	19.3	18.8	18.5	18.3	17.9	17.5	17.7	17.6	17.6	17.6	17.3	17.0	16.7	16.5	16.0	15.7	15.4	15.3	15.0
Equilibrium Exchange Rate	level	18.9	18.7	18.4	18.2	18.0	17.9	17.6	17.4	17.2	17.1	16.8	16.6	16.4	16.3	16.1	15.9	15.7	15.6	15.4
	% pa y-o-y	-4.3	-4.5	-4.7	-4.8	-5.0	-4.3	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4
Exchange Rate Gap	% of Actual Value	-2.3	-0.9	-0.5	-0.4	0.4	2.1	-0.5	-1.0	-2.6	-3.0	-2.8	-2.1	-1.6	-0.7	0.4	1.4	1.8	2.3	2.6

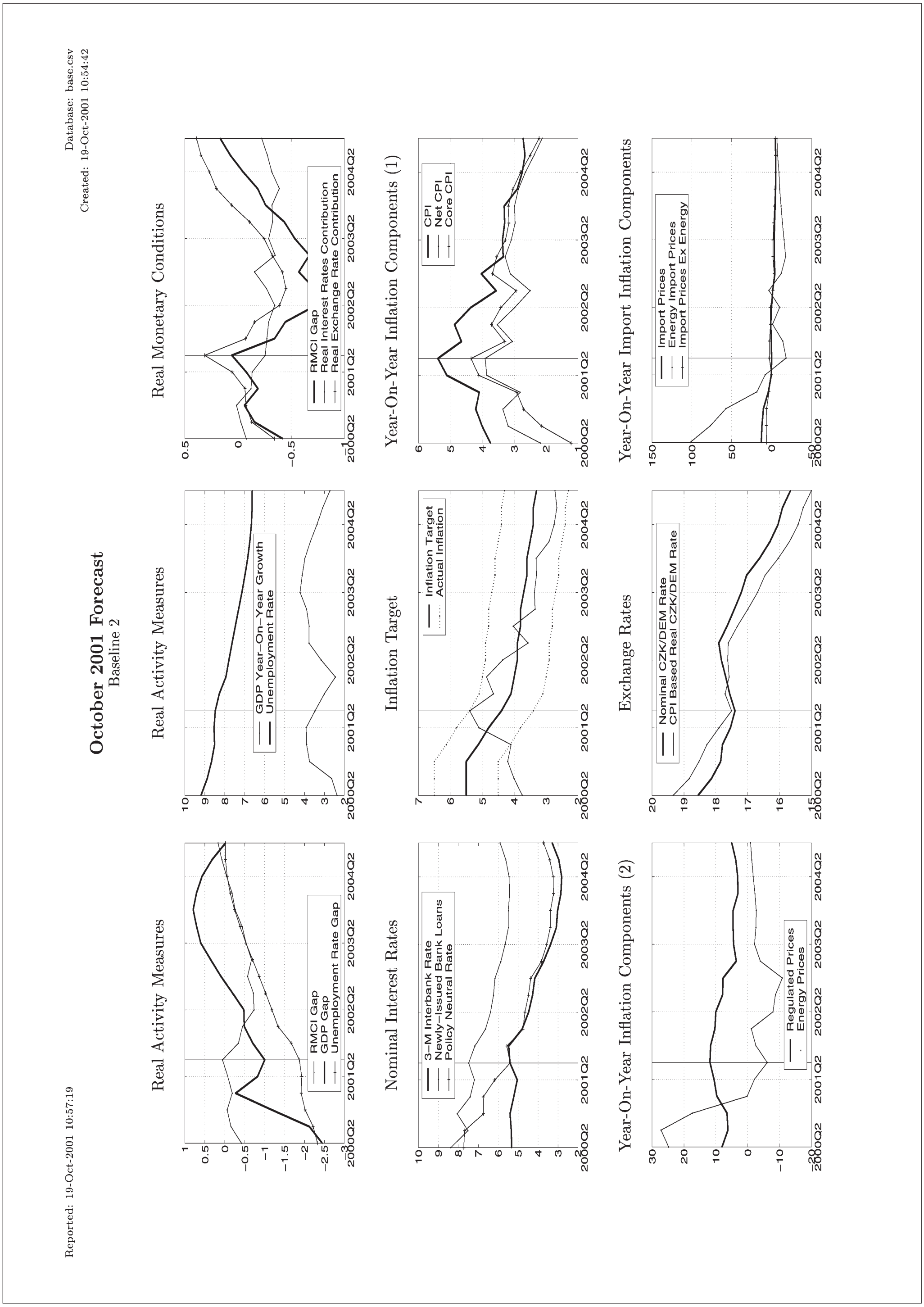
Reported: 19-Oct-2001 10:57:19

Database: base.csv
Created: 19-Oct-2001 10:54:42

Inflation Determinants

Baseline 2

		2000:2	2000:3	2000:4	2001:1	2001:2	2001:3	2001:4	2002:1	2002:2	2002:3	2002:4	2003:1	2003:2	2003:3	2003:4	2004:1	2004:2	2004:3	2004:4
Inflation Target	% pa y-o-y	5.5	5.5	5.5	5.1	4.8	4.4	4.1	4.0	3.9	3.9	3.8	3.8	3.7	3.6	3.6	3.5	3.4	3.4	3.3
Inflation Deviation from Target	pp	0.2	0.8	0.4	0.8	0.4	-0.4	0.2	-0.5	-0.4	-0.4	-0.3	-0.6	-0.7	-0.8	-0.6	-0.7	-0.6	-0.4	-0.1
Year-on-Year CPI Inflation Components																				
CPI	% pa y-o-y	3.7	4.0	4.2	4.1	5.1	5.4	4.6	4.9	4.4	3.6	4.0	3.3	3.4	3.3	3.3	2.9	2.7	2.7	2.7
Net CPI	% pa y-o-y	2.2	3.2	3.4	2.8	3.9	3.9	3.1	3.5	3.0	2.5	3.1	3.3	3.1	3.0	3.0	2.9	2.6	2.4	2.1
Core CPI	% pa y-o-y	1.2	2.1	2.7	2.9	4.1	4.3	3.3	3.7	3.4	2.9	3.7	3.5	3.3	3.2	3.2	3.0	2.8	2.5	2.2
Energy Prices	% pa y-o-y	24.8	27.2	17.4	0.2	-2.1	-6.1	-2.6	-1.1	-8.0	-8.7	-10.9	-4.0	-2.2	-2.6	-2.7	-2.3	-1.8	-1.3	-0.9
Regulated CPI	% pa y-o-y	8.0	6.2	6.5	9.7	10.5	11.8	11.6	10.3	10.0	7.9	7.7	3.6	4.4	4.6	4.6	3.0	3.1	3.7	5.0
Import Prices	% pa y-o-y	12.9	12.1	10.2	4.0	0.2	-0.1	0.3	1.0	0.0	-1.4	-4.2	-3.4	-3.3	-3.8	-4.4	-5.0	-5.3	-5.2	-4.7
Import Prices ex Energy	% pa y-o-y	6.1	6.7	6.2	3.2	0.0	2.8	2.5	1.3	1.4	-1.9	-3.3	-1.6	-1.9	-2.8	-3.7	-4.5	-4.9	-5.0	-4.5
Import Energy Prices	% pa y-o-y	102.1	76.6	57.3	18.3	8.1	-18.3	-14.1	-1.2	-10.3	3.3	-12.2	-17.7	-15.6	-13.7	-11.9	-10.1	-9.4	-7.6	-6.8
Weighted Contributions to CPI Inflation																				
CPI	% pa y-o-y	3.7	4.0	4.2	4.1	5.1	5.4	4.6	4.9	4.4	3.6	4.0	3.3	3.4	3.3	3.3	2.9	2.7	2.7	2.7
Net CPI	pp	1.6	2.3	2.4	2.3	3.1	3.2	2.5	2.8	2.4	2.0	2.5	2.6	2.5	2.4	2.4	2.3	2.1	1.9	1.7
Core CPI	pp	0.9	1.5	1.9	2.3	3.2	3.4	2.6	2.9	2.6	2.3	2.8	2.7	2.5	2.4	2.4	2.3	2.1	1.9	1.7
Energy Prices	pp	0.7	0.8	0.6	0.0	-0.1	-0.2	-0.1	-0.0	-0.2	-0.3	-0.3	-0.1	-0.1	-0.1	-0.1	-0.1	-0.0	-0.0	-0.0
Regulated CPI	pp	2.1	1.7	1.8	1.8	2.0	2.2	2.2	2.0	2.0	1.6	1.5	0.7	0.9	0.9	0.9	0.6	0.7	0.8	1.0
Weighted Contributions in Core Phillips Curve – log terms																				
Core CPI	% pa q-o-q	0.8	4.5	4.1	2.1	5.4	5.5	-0.0	3.7	4.3	3.6	2.8	3.2	3.2	3.2	2.9	2.7	2.3	2.0	1.8
Core CPI Lag	pp	0.5	0.3	1.9	1.7	0.9	2.3	2.3	-0.0	1.6	1.8	1.5	1.2	1.4	1.4	1.3	1.2	1.1	1.0	0.8
Inflation Expectations	pp	1.2	1.2	1.3	1.4	1.3	1.6	1.7	1.5	1.5	1.4	1.1	1.3	1.1	1.1	1.1	1.1	0.9	0.9	0.9
Import Prices ex Energy	pp	1.5	1.6	1.5	0.8	0.0	0.7	0.6	0.3	0.3	-0.5	-0.8	-0.4	-0.5	-0.7	-0.9	-1.1	-1.3	-1.3	-1.1
Real Eq. Appreciation	pp	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Real GDP Gap	pp	-1.0	-1.2	-1.1	-0.6	-0.1	-0.4	-0.5	-0.3	-0.2	-0.2	-0.1	0.0	0.2	0.3	0.4	0.4	0.4	0.3	0.2
Expert Judgement	pp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tune	pp	0.8	4.5	4.1	2.1	5.4	5.5	-0.0	3.7	12.4	12.2	11.9	11.4	2.7	2.6	2.6	2.5	2.4	2.4	2.3
Tune Weight		0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0


October 2001 Forecast
Baseline 2
Reported: 19-Oct-2001 10:57:19
Database: base.csv
Created: 19-Oct-2001 10:54:42
Real Activity Measures
RMCI Gap
GDP Gap
Unemployment Rate Gap
Real Activity Measures
GDP Year–On–Year Growth
Unemployment Rate
Real Monetary Conditions
RMCI Gap
Real Interest Rates Contribution
Real Exchange Rate Contribution
Nominal Interest Rates
3–M Interbank Rate
Newly–Issued Bank Loans
Policy Neutral Rate
Inflation Target
Inflation Target
Actual Inflation
Year-On-Year Inflation Components (1)
CPI
Net CPI
Core CPI
Year-On-Year Inflation Components (2)
Regulated Prices
Energy Prices
Exchange Rates
Nominal CZK/DEM Rate
CPI Based Real CZK/DEM Rate
Year-On-Year Import Inflation Components
Import Prices
Energy Import Prices
Import Prices Ex Energy
2000Q2
2001Q2
2002Q2
2003Q2
2004Q2

A Few Hints for Better Understanding the Forecast Report

Forecast Summary sheet provides a quick view on basic indicators of macroeconomic and monetary policy performance.

Nominal Interest Rates

3-Month Interbank Rate plays the role of policy instrument. Both other rates (*1-Year Interbank* one and that on *Newly-Issued Bank Loans*) are tied up using term and market premia.

Policy Neutral Rate represents the level of nominal rate corresponding to equilibrium real rate (determined outside the core business cycle model) and model-consistent inflationary expectations. It is therefore consistent with neutral policy stance in terms of its impact into real activity.

Nominal Exchange Rates

For most model behavior only *CZK/DEM* rate matters (endogenous UIP-fashion equation, real exchange rate definition etc.).

Risk premium term causes systematic deviations from UIP condition. *Risk premium* determines domestic equilibrium real interest rates along with assumptions on real rate appreciation and foreign equilibrium real interest rates

CZK/USD rate follows a (possibly time-varying) exogenous mark-up over *CZK/DEM* rate (exogenous *USD/DEM* assumed in other words). It enters energy import prices believed to be contracted on USD rather than EUR basis.

Supply-Side Assumptions

Neither *Real Potential GDP* nor *NAIRU* are of any policy significance. They only provide a basis for calculating real GDP level and growth and unemployment rate, respectively.

Unemployment Rate Gap (an alternative measure of business cycle position, redundant for the model) evolves according to a simple Okun's-like equation with a high persistence term (taking into account labor market more rigid than goods market).

Aggregate Demand and Indicators of Real Monetary Conditions sheet relates demand-side of the economy with its primary model driving forces collected in an index of real monetary conditions (weighted average of longer-term real interest rates, foreign real interest rate, and real exchange rate).

Weighted Contributions to Aggregate Demand

Real GDP Gap mirrors business cycle position of the economy. Its dynamics is contributed to by its proper persistence (*Real GDP Gap Lag*), real monetary conditions (*RMC Index Lag*), foreign demand influence (*Foreign Demand Gap*), and other terms (scope for expert judgement). Contributions are weighted so that they sum immediately to *Real GDP Gap*.

Tune is in fact near-term forecast borrowed from Real Economy Department. It applies for 2 forthcoming quarters, i.e. on the horizon where *Tune Weight* equals 1 (model mechanisms are switched off then).

Indicators of Real Monetary Conditions

RMC Index Gap underlies the cyclical movements in output gap (*RMC Index* itself and *Equilibrium RMC Index* are of no meaningful scale being reported for technical purposes only).

RMC Index Gap = *0.25 (0.25 Newly-Issued Bank Loans Real Rate Gap +*
0.50 Real 1-Year Interbank Rate Gap +
0.25 Euro Real 3-Month Interbank Rate Gap) +
0.15 Real Exchange Rate Gap

Note that both overall *RMCI Index Gap* and all its components are stated so that positive sign implies *tight* real monetary conditions and vice versa.

Inflation Determinants sheet splits the overall targeted CPI inflation development into its model components:

Net CPI CPI net of administrated prices
Core CPI Net CPI excluding energy (fuel) prices
Energy Prices
Regulated CPI
Monetary nature is attributed to *Core CPI*, which therefore lies at heart of Phillips curve. *Energy Prices* are found an error correction specification depending crucially upon *Import Energy Prices. Regulated CPI* follows from Ministry of Finance's schedule.
Inflation Deviation from Target together with business cycle position represents the engine in monetary policy rule design.

Weighted Contributions to CPI Inflation

Reported are inflation contributions in terms of percentage points weighted so that *Core CPI* and *Energy Prices* contributions sum immediately to that of *Net CPI*, and *Net CPI* and *Regulated CPI* contributions sum to overall *CPI* inflation.

Weighted Contributions to Core Phillips Curve

Firms' pricing mechanism is influenced by a number of factors formally captured in a Phillips curve equation. Three major groups of them are distinct: labor cost channel (*Real GDP Gap, Inflation Expectations*), other cost channel (*Import Prices*), and inflation from equilibrium movement in relative (tradables-nontradables) prices (*Real Eq. Appreciation*). Contributions are weighted so that they sum immediately to quarter-on-quarter core inflation.

Tune is in fact near-term forecast borrowed from Real Economy Department. It applies for 2 forthcoming quarters, i.e. on the horizon where *Tune Weight* equals 1 (model mechanisms are switched off then).

CHAPTER 3

Models Used in the Forecasting and Policy Analysis System

By Stanislav Polák and David Vávra [1]

[1] Stanislav Polák is a director of the International Economic Analyses Division and David Vávra is a director of the Economic Modelling Division, all Monetary and Statistics Department, Czech National Bank.

INTRODUCTION

There are many different types of model that have been used in policy institutions to support projections. These range from spreadsheets or other methods used to support a judgmental forecast without any formal macroeconomic model, to large, multi-sector or even multi-country models. There are also two “styles” of model, one which (in the extreme) insists that the job is to track the individual historical data series as closely as possible and that everything should be formally estimated using econometric methods, the other insisting that overall properties matter the most and that calibration to general cyclical properties of the data and stylised facts about how the macro economy works is the way to go.

Accordingly, the Forecasting and Policy Analysis System (FPAS) in the CNB uses several models. In the first place, there is the core quarterly projection model (QPM), which primarily serves as a disciplining device around which the forecast is constructed. As such, it should embody the institution’s understanding of the forward-looking transmission mechanisms based on a systematic reaction of policy interest rates to major disturbances. Apart from that it is also the key instrument of systematic risk assessment. Its description and requirements are presented in a greater detail in Chapter 4, but within the FPAS there are also important roles for other models within the system. One may think of the models that complement the core QPM in terms of two classes: models that support the inflation forecast, and models that support further theoretical development of the QPM.

This chapter reviews several types of models that are used to assist in the process of preparing inflation forecasts, summarises underlying reasons for their features and gives a few examples. A number of examples are reviewed in the Appendix. The approach emphasises the benefits of using many models, each carefully tailored to specific purposes.

When preparing a forecast, we want to paint a broad picture that starts with the question “Where is the economy now?” and moves to “What forces will drive it over the short and medium term?” In doing that, the FT will need to answer a variety of questions, such as how much inertia there is in current trends, how close to equilibrium various sectors and markets are, and what exogenous changes are likely to have an impact.[2] This process helps the Board answer the most important question of all: What does monetary policy need to do to accomplish its inflation and stabilisation objectives?

We can arrange this in the form of a timeline, running from the short term to the medium term (see Figure 1). **Monitoring and near-term forecasting models** are designed to capture short-run influences. There are important real and nominal rigidities in the economy that give the data a certain amount of momentum from current conditions that can be exploited in forecasting the near term. The degree of inertia will vary from sector to sector; asset markets are famously volatile and able to reverse trends quickly, while labour markets tend to adjust more slowly. The models used for capturing these aspects of the data will often be small time-series models (often univariate models(that are easy to estimate and maintain. Nothing in the FPAS process limits the scope for specialists to model the short term, however. These people are responsible for the short-term forecast and are free to use whatever modelling techniques they find useful in fulfilling that task. Sometimes more complex time-series models are used. An example is the MMI model, which is described in the appendix. It is an ARMAX model, and is used each month to prepare an inflation forecast.

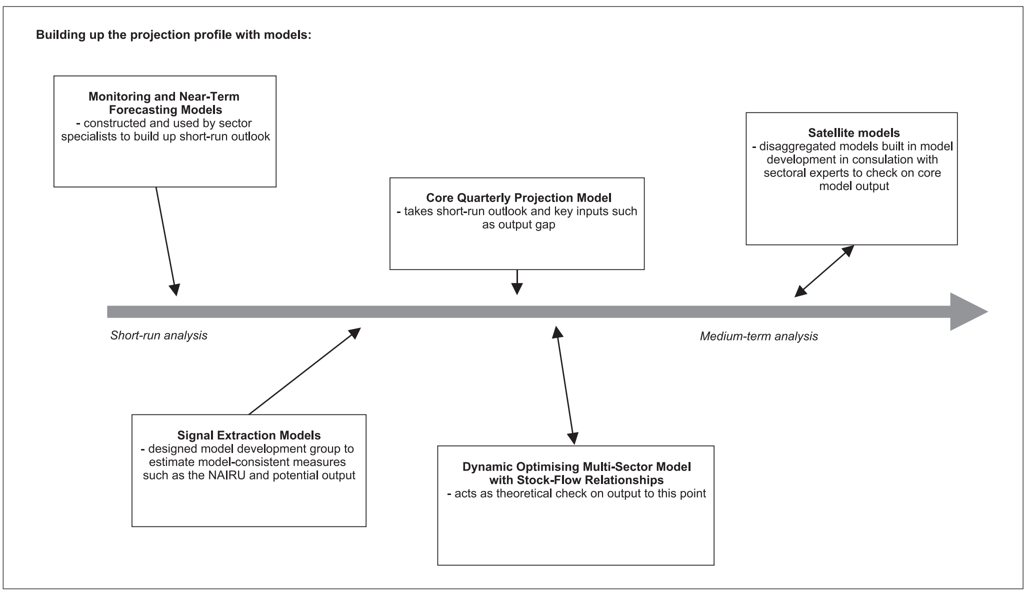
[2] Of course, random shocks cannot be anticipated, but some "shocks" to the simple system described by the QPM will be changes to those elements not formally modeled. For example, if there was a major fiscal initiative planned, this would be known, and the FT would have to take account of its effects.

Experts may also use leading indicator models and other constructs to help forecast the near term. These may be simple leading indicator relations, where some variable of interest in the macro projection, such as consumer spending, may be usefully foreshadowed by some information available sooner, such as measures of sales of particular items or measures of consumer credit. Or they may be more complex models, where more of the detail judged relevant in the short term is included in an econometric or other analysis. The core macro model ignores the details to gain clarity and focus on the essential macroeconomic processes; experts may find it useful to maintain more complex forecasting models for their particular responsibilities.

Given a picture of likely short-run outcomes, we need to form a view on what this implies for the state of the economy. Here we use **signal extraction models**, which can provide insight as to how the current part of the cycle compares to a typical business cycle, or what part of the current short-run trend represents a permanent trend (which we might associate with supply) as opposed to what represents a mean-reverting component (which we could think of as a cyclical demand effect). Part of this involves inferring estimates for potential output and the output gap. For this we use the system's application of Kalman filtering reviewed in the box in Chapter 1 and described in detail in Chapter 5. This methodology has the major advantage of providing estimates consistent with the dynamic structure of the QPM.

Once the FT has a picture of the likely short-run and the key pressures in the economy (such as the state of excess demand in the goods market, as measured by an output gap), they are in a position to use the core QPM. This model should be designed to help the staff draw a link between the current pressures in the economy and the implications for monetary policy.

Figure 1: The Role of Models in the Forecast Process



Of course, if there are issues in the forecast that relate to real shocks (such as implied by changes in fiscal policy, changes in key resource prices (oil) or the terms of trade generally), if there are important sectoral differences, or if ***flow*** models, like our QPM, are believed to miss or distort some significant effects coming from processes behind ***stock*** variables (debt, capital stock), the staff might want to have a more elaborate model. One way of putting a check on the consistency of the core QPM is to maintain a separate **dynamic multi sector model**

with stock equilibrium. Such a model could provide a check on inter-temporal constraints (wealth or debt issues), the effects of real side shocks (such as changes in fiscal policy, or changes in the real cost of capital), and any other issues relating to structural adjustment, sectoral development and long-run equilibria. The more complex model could be simulated to highlight potential areas of concern in the coverage of the QPM, and this could be used to condition the judgments made regarding the medium term in the forecast. An example of this type of model is the Hermin CR model, which is described in the Appendix.

In some cases, the FT and the Board will want to monitor and discuss developments at a higher level of detail than provided for in the simple core QPM. This does not mean that the extra detail must be added to that core model. Instead, the required information can be supplied using **satellite models**. These are small subsystems, which would use simple rules of thumb, based on observed historical patterns, to decompose variables from the core model into various subcomponents. For example, the output measure can be split into national accounts components. Moreover, a household consumption satellite might take the path for consumer spending and break that down into paths for consumption of services and non-durables, and spending on durables and "super-durables," such as housing. This breakdown can be based on long-run ratios and estimated dynamic patterns for each of the components.[3] The satellite models provide output that gives the main macro story the details that make it more understandable and convincing. Also, sector analysts can check the details for consistency with previous experience. Where there is specific insight coming from a particular development at the sector level, the FT can use this to modify judgment at the aggregate level in the core model. For example, fiscal reforms or "lumpy" expenditures on large items or projects (purchase of an individual airliner or new military expenditure making a large difference to the small-country aggregate national accounting profile) are examples.

These models therefore form part of a process for the forecast. The benefit of this proposed structure is that the aggregate QPM forms a general overview of the economy, and can therefore be kept very simple and transparent. This is important for the forecast process. It also has the benefit that the core QPM can be used easily for policy analysis.[4] It is very useful for internal communications with the Board to be able to ask general hypothetical questions of the same model that they see used for the forecast.

The forecast process looks something like the picture in Figure 2. This shows how staff experts start by interpreting the data using short-run indicator models, and then use that-in conjunction with a set of starting assumptions about exogenous paths for fiscal and external variables-to build up a near-term profile. Given that and the results of the signal extraction models for variables like the output gap, the QPM is run to obtain a complete medium-term scenario. Part of this process involves decomposing the aggregate picture via the satellite models, and this may suggest revisions to the aggregate picture. Staff experts have two basic sorts of control over the aggregate picture. The first is to revise their starting assumptions. The second is to use "add-factors" directly on the core model (such as when a large investment expenditure is known in advance) in order to alter a particular variable's path. Simulations of a theoretically tight optimising model may also imply alterations to the model's projection paths (such as if accumulating debt implied a more suppressed path for consumption than would have been projected in a model without such constraints.) There are normally a number of iterations before the scenario is finished.

[3] Note, however, that in the case of a transition economy, these historical patterns should be treated with caution. A good example is when financial and housing markets are deregulated, which can be expected to cause large shifts in the ratio of housing expenditure to overall household consumption. Under these circumstances, the model builders may find it more useful to look at the corresponding evidence for more developed economies. They might also want to have some independent analysis or even formal modeling of this process, and use that to condition judgments about the course of aggregate consumer spending.

[4] In our experience, one of the risks of attempting to build large models for policy analysis is that institutions in many cases miss some of the important insights that can be obtained from smaller models. These include developing consistent scenarios where bond market's expectations of future policy rates are assumed to gradually converge to be consistent with the underlying policy and macroeconomic assumptions embodied in any particular scenario. This does not mean that the central bank's scenarios are always dominant over the market participants' forecasts and indeed one task of the FT should be to ask what underlying macroeconomic assumptions would be consistent with the assumptions of market participants. A key aspect of the quarterly projection exercise is to eliminate logical inconsistencies, such as one set of assumptions in one part of the analysis and another set elsewhere.

The final output is a projection profile that forms the basis of advice to the Board. By this stage, the staff should be in a good position to explain what they think the pressures facing the economy are, and what that implies for monetary policy. Using this process and the models involved, the staff should also be in a position to explain their choices for starting assumptions, their interpretations of recent data, and projections for idiosyncratic events. The core model will also have been used to provide analysis of certain key risks to the scenario and the implications for monetary policy.

Other models can also be helpful in guiding the development or calibration of the core QPM. Many issues are best viewed and understood within small **stylised optimising models**, stripped down to their essential elements.[5] Models designed to address a particular issue, such as the consequences of a major change in the level of public debt, can both help us understand the issues and help us add judgment to the QPM.

A major challenge when expanding the QPM is to retain the appropriate short-run nominal and real rigidities when incorporating the features of optimising models. In many cases, the sources of the rigidities will not be incorporated in the optimising framework. Thus, it is often useful to think of these models as providing insight about the equilibrium and medium-term dynamics, but not necessarily the short-term dynamics.[6]

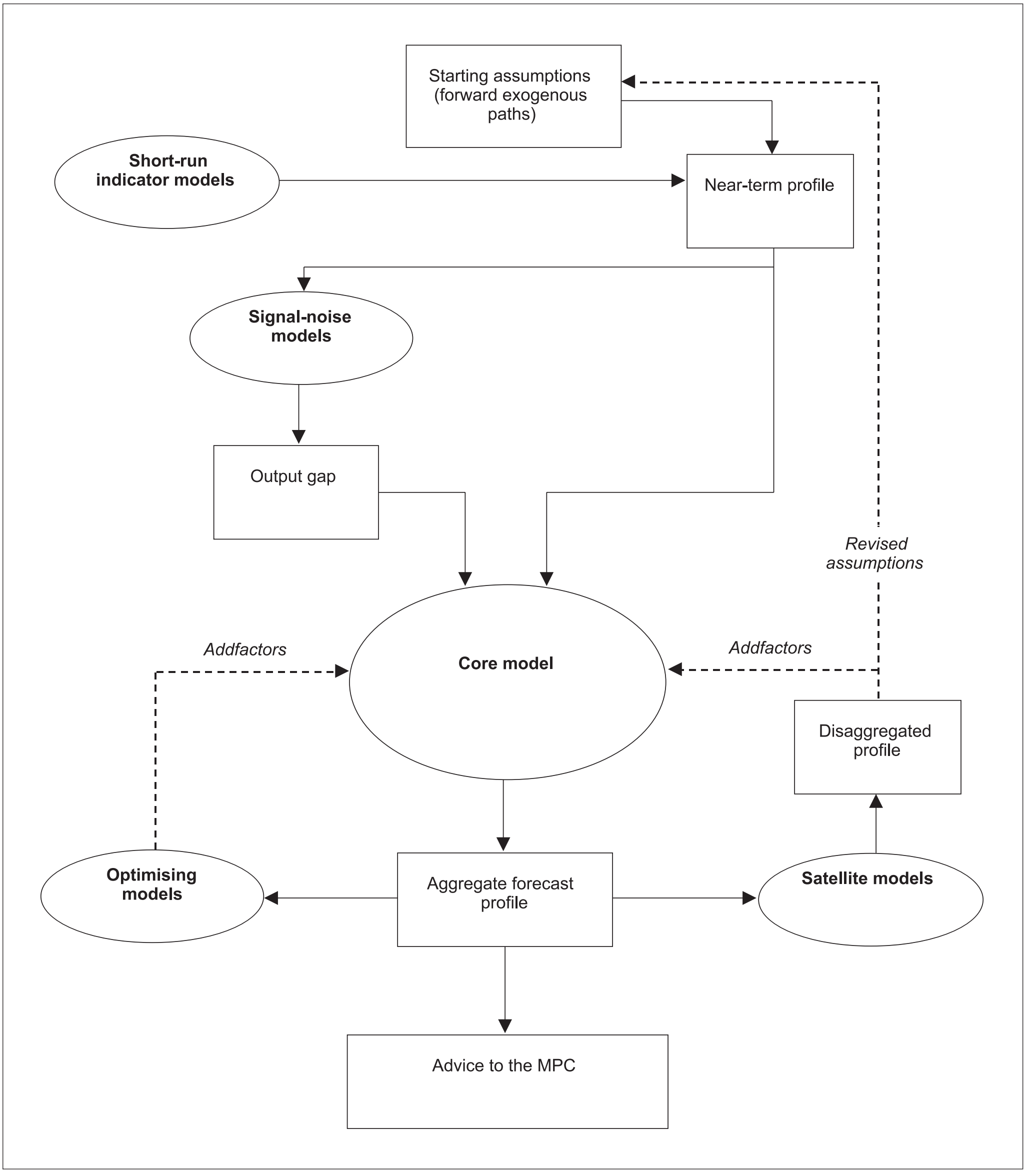
Information from **time-series models** can be extremely useful in discussions of calibrating a QPM, and especially its dynamic properties. For example, VAR models can provide information on lag structures, information on magnitudes and duration of impulse responses, and measures of some cumulative effects of shocks. They can provide insight into issues regarding time variations in parameters, the effects of structural breaks, and so on. These models provide information on what the properties were in the historical data. They are therefore most helpful when there are long runs of data under a particular policy regime and particular conditions of market development. Where the institutions or market structures are changing, they will be less reliable as indicators of properties of the system.

The FPAS thus relies on many models, both in the process of producing a projection and in the process of developing the core model. The core QPM focuses on the essential macro dynamics and particularly the monetary transmission mechanism. It is kept very simple to make it easy to use and easy to understand. These are major advantages. However, these advantages would not count for much if the staff and management did not have faith that all information was being brought to bear on the forecast and that major issues that lie outside the scope of the model had been considered. The other models in the system provide mechanisms for doing these things.

[5] For an example of an optimising model applied to the Czech Republic see Laxton and Pesenti (2002).

[6] See, for example, the discussion of the Reserve Bank of New Zealand's Forecasting and Policy Analysis System, where the authors describe how special structure is used to condition the dynamic properties of a QPM that contains formal inter-temporal optimising structure, precisely to avoid certain unwanted dynamic implications of that theory. See Black, Cassino, Drew, Hansen, Hunt, Rose and Scott (1997).

Figure 2: Models and the Forecast Process



APPENDIX: OTHER MODELS USED AT THE CZECH NATIONAL BANK

HERMIN CR

Maintained by David Vávra (Economic Modelling Division)

The model Hermin Czech Republic (HERMIN CR) is a medium-scale, multi sector econometric model built to handle small-open-economy issues. HERMIN macro models have been used successfully in the analysis of convergence of several peripheral countries of the EU (Ireland, Spain, Portugal and Greece) as well as in the investigation of impacts of the Community Support Framework (CSF) structural funds and the effects of the Single Market. HERMIN CR has been developed under the ACE PHARE with the title: "Macroeconomics and structural change in transition economies: common themes in CEE and EU-periphery countries". The objective of the project was to apply the 'methodology' of HERMIN models in construction, estimation and testing of macroeconomic models of three transition countries: Czech Republic, Romania, and Slovenia. Today, the research mostly concentrates on issues of calibration and design of likely future scenarios for the Czech economy. The model aims at improving our understanding of the implications of the likely structural changes in the last phases of transition.

Hermin CR is a four-sector (Manufacturing, Market Services, Agriculture, and Government) supply-side macro model that allows for conventional Keynesian cyclical effects. It is based on neoclassical theory in that the investment and labour decisions of firms in the two main sectors (Manufacturing and Market Services) follow cost minimisation of CES production functions. The direct incorporation of income-output-expenditure identities permits both demand and supply side experiments.

MODEL STRUCTURE

The model has three main blocks: supply side with four sectors and labour supply dynamics, aggregate demand and absorption, and the income identities. Within this framework, the most important of the behavioural equations are as follows.

A. Supply side

A.1. Manufacturing (including Mining and Quarrying)

Output = f (world demand, domestic demand, competitiveness)
Labour demand = f (output, relative factor prices)
Investment = f (output, relative factor prices)
Capital stock = Investment + Capital (-1) - depreciation
Relative factor price = wage/cost of capital
Cost of capital = f (interest rate)
Price = f (world price, exchange rate, unit labour costs)
Wages = f (price, unemployment, productivity, direct and indirect tax wedge)
Competitiveness = domestic/world output prices

A.2 Market Services

Output = f (domestic demand)
Labour demand = f (output, relative factor prices)
Investment = f (output, relative factor prices)
Capital stock = Investment + Capital (-1) - depreciation
Relative factor price = wage/cost of capital
Cost of capital = f (interest rate)
Price = f (unit labour costs)
Δ*Wages* = Δ*Wages* in A.1

A.3. Demographics and supply of labour

Population growth = f (natural growth rate)
Labour force = f (population, labour force participation rate)
Unemployment = Labour force - Labour demand

B. Demand (Absorption) side

Consumption = f (personal disposable income)
Domestic demand = f (consumption of households, government spending, investment)
Net exports = total production - domestic demand

C. Income side

Income = total output
Personal disposable income = income + transfers - direct taxes
*Public deficit = government expenditure - direct tax rate*income*
*-indirect tax rate*consumption*
Public debt = public deficit + public debt (-1) + interest
Current account = net export + net transfers from abroad

Key exogenous variables

World demand, world prices, exchange rate, real interest rates, government expenditure, indirect and direct tax rate

The HERMIN CR model has been used to support consistency in regular forecast exercises and also to study scenarios for future economic development in the Czech economy conditional on various presumed structural changes. For instance Barry et al. (2000) use the model to quantitatively asses long term convergence implications of a labour market reform and two different ‘industrialization’ strategies: one led by indigenous firms and the other by FDI and multinational corporations.

FISCAL POLICY STANCE MODEL (STRUCTURAL AND CYCLICAL FISCAL BALANCE)

Developed by Vladimír Bezděk (Adviser to the Board)

This model provides a basis for assessing fiscal policy stance and evaluating its impact on the economy. It separates the structural and cyclical part of the fiscal balance using information on the business cycle position of the economy and estimated elasticities of fiscal receipts with respect to the aggregate output. At this stage, zero elasticity is assumed for expenditures, mainly because the sorts of expenditures that might exhibit cyclical behaviour sum to a relatively small fraction of total amount and there is too little experience to seek estimates.

1. System of equations to estimate partial fiscal elasticities and total fiscal elasticity

$$\log r(i)_t = \alpha(i) + \varepsilon(i)\log(p_t y_t) + u(i)_t, \quad i = \{1, 2, 3, 4\}$$

where $r(i)_t$ is i-th type of fiscal receipts (total fiscal receipts are split into: 1. personal income tax, 2. indirect taxes, 3. social security contributions, and 4. health insurance contributions), $\alpha(i)$ and $\varepsilon(i)$ are corresponding intercept and partial elasticity, respectively, $p_t y_t$ stands for nominal output, and $u(i)_t$ are independently, identically distributed (i.i.d.) residuals.

The total fiscal elasticity is then the average of the individual elasticities weighted by the shares of the corresponding receipts in total general government receipts:

$$\varepsilon_t = \sum_i w(i)_t\, \varepsilon(i)_t, \text{ where } w(i)_t = \frac{r(i)_t}{r_t}.$$

2. Structural and cyclical parts of fiscal balance (in terms of proportion to nominal output)

$$\frac{cb_t}{p_t y_t} \equiv \frac{r_t}{p_t y_t}\varepsilon_t g_t \quad \text{and} \quad \frac{sb_t}{p_t y_t} \equiv \frac{b_t}{p_t y_t} - \frac{cb_t}{p_t y_t}$$

where cb_t and sb_t are the cyclical and structural parts of the fiscal balance b_t,and g_t is the output gap as a measure of business cycle position.

In the autumn of 1999, in the middle of the recession, the model indicated that the preponderance of the proposed budget deficit spending was cyclical and hence appropriate given economic conditions. This represented a big change at that time, for it was the first time a deficit budget was devised for cyclical reasons. Hence, the indications of the model contributed to CNB consent with the proposed deficit.

Since late 2000 and through 2001, however, the model has indicated a shift in the balance towards structural deficit as the recovery has progressed. The CNB thus became more concerned and began to argue for consolidation of the public finances. Since then, the CNB also began to portray the deficit as a medium-term risk factor for inflation, as described in Chapter 6 using the October 2001 exercise as an example.

International institutions, such as the OECD and the IMF, have since adopted both these interpretations of the fiscal stance.

TRADE BALANCE MODELS

Developed by Tomáš Holub (Adviser to the Board)

Two simple quarterly models have been built to catch potential inconsistencies in the FT's discussions regarding the contribution of foreign demand to the expected changes in the domestic current account balance and economic growth. Reduced-form equations are estimated for the current account and net exports (in terms of their ratio to the real output) so that there is no need to investigate direct links between exports and imports.

Model specification:

$$dgs_t = \alpha_0 + \alpha_1\, dy_t + \alpha_2\, dy^f_{t-1} + \alpha_3 dy^f_{t-4} + \alpha_4\, dz_{t-1} + \alpha_5 \pi^{com}_t + u_t$$

$$nxcont_t = \beta_0 + \beta_1\, dy_t + \beta_2\, dy^f_{t-2} + \beta_3 dy^f_{t-3} + \beta_4\, dy^f_{t-4} + \beta_5\, dz_{t-1} + w_t$$

where *dgs* denotes percentage year-on-year change (pcty henceforth) in share of foreign trade (goods and services) balance in GDP, *nxcont* is contribution of net exports to the output growth, dy is pcty in real domestic demand, dy^f is pcty in foreign industrial production (index of 25 countries accounting for 85 pct of Czech exports), *dz* is pcty in real exchange rate (both CPI-based and PPI-based rates tested with similar results), and π^{com} is pcty in commodity price index (released by the Czech statistical agency), *u* and *w* are i.i.d. residuals.

The specification of both equations is obviously conditioned upon an unchanged rate of growth in equilibrium real output, the equilibrium real exchange rate, and the equilibrium share of net exports in output. This apparent drawback may turn out to be an advantage in the Czech case, where we know very little about supply side of the economy and any indirect indicator of supply-side changes is thus to be strongly welcomed.

MODEL OF OPTIMISING IS CURVE AND MONETARY POLICY EFFECTS

(Developed by Economic Modelling Division)

Two channels enable real impacts of monetary policy in a sticky-price model of a small open economy: those related to the real interest rate and the real exchange rate. Both are captured in an IS (or aggregate demand) curve. For estimation, the IS curve often takes an ad-hoc form with vague foundations, such as:

$$y_t = \alpha_1\, y_{t-1} - \alpha_2\, r_t + \alpha_3\, z_t + \ldots + u_t\,,$$

where *y* denotes output gap, *r* stands for real interest rate and *z* for real exchange rate, so that real monetary conditions are measured in terms of the *level* of the interest rate and the *level* of the exchange rate.

However put into a relatively general class of monetary business cycle models (with IS-PC-UIP-Rule at the behavioural core), this IS formulation ends up with an uninvited consequence: the real interest rate effect might counteract the real exchange rate effect. The nature of monetary policy actions is thus determined by particular parameter calibration and no unambiguous paradigm can be established within a monetary business cycle framework.

It is easy to show that the lack of well-defined microeconomic foundations accounts for this drawback. Based primarily on the Euler condition for consumption smoothing, the optimising IS curve evolves into

$$y_t = y_{t+1}^e - \alpha_2 r_t - \alpha_3 \left(z_{t+1}^e - z_t\right) + \ldots + u_t$$

where superscript '*e*' denotes expectation. Real monetary conditions now consist of the *level* of the interest rate and the *expected change (depreciation or appreciation)* in the exchange rate. A UIP-like equation (as a part of a standard monetary business cycle view) taken in real terms then clearly ensures that both effects (real interest rate and real exchange rate) push the output gap in the same way The model serves primarily as a theoretical device, to study, for instance, optimal monetary policy functions. His impulse responses are also being compared to those of the QPM. This comparison serves as a basis for a further development of the model.

MMI (NEAR-TERM INFLATION FORECAST)

Developed by Jan Hošek (International Economic Analyses Division)

MMI is a time-series model of the ARMAX class operated on a monthly basis. Its structure incorporates both elementary microeconomic theory of consumer demand and influence of aggregate macroeconomic development. The model focuses on *net* inflation, that is, inflation excluding administered prices. Two elements are featured to deal with the scarcity of domestic time series observations.

1. The estimate of the AR part relies on polynomial distributed lags, which allows us to identify a gradually diminishing impact of the explanatory variables (supported by empirical evidence) with no substantial loss in degrees of freedom.

2. Pseudo error-correction terms are included to stabilize the model behaviour on reasonable medium- or long-term paths: the rate of inflation is related to levels of the unemployment rate and the real interest rate.[7]

Model specification:

$$\pi_t^{NT} = \alpha_0 + A_1(L) r_t + A_2(L) \pi_t^{reg} + A_3(L) di_t + A_4(L) ds_t^{DEM} + M_1(L) u_t$$
$$\pi_t^{T} = \beta_0 + B_1(L) ur_t + B_2(L) \pi_t^{reg} + B_3(L) ds_t^{DEM} + B_4(L) ds_t^{USD} + M_2(L) v_t$$
$$\pi_t^{F} = \gamma_0 + C_1(L) ur_t + C_2(L) \pi_t^{reg} + C_3(L) di_t + C_4(L) ds_t^{DEM} + M_3(L) w_t$$

where π^{NT}, π^{T}, π^{F} are respectively year-on-year net inflation in the non-tradable sector, in the tradable sector excluding foods, and in food prices, where *ur* is unemployment rate, *r* is the real interest rate, π^{reg} is year-on-year inflation in administered prices, and where *di* denotes the year-on-year percentage change in households' disposable income, and ds^{DEM} and ds^{USD} denote the year-on-year percentage change in the CZK/DEM and CZK/USD nominal exchange rates.

The model has been used for short-term forecasting for about three years and its forecasting accuracy is tested continuously. The structure has not changed and the coefficients do not show severe instability although a gradual change is observed. The model is a part of the formal tools used by the Real Economy Division in compilation of their Neart Term Forecast. It has shown relatively robust forecasting properties.

[7] Co-integration techniques are not feasible at present, given the limited amount of data available.

SMALL LINEAR ERROR-CORRECTION MODEL WITH MODEL-CONSISTENT EXPECTATIONS

Developed by Tibor Hledik (advisor to the Board)

The key behavioural relationships include an aggregate demand curve for private demand, a simple fiscal rule for government spending (capturing some counter-cyclical properties of government consumption that are expected to be more pronounced in the future than at present), a UIP condition, a Phillips curve, an approximation for long-term interest rates and an exponential function approximating the CNB's disinflation target. Long interest rates, the exchange rate and inflation are jump variables in the model. The model is closed by an optimal (and time-consistent) monetary policy rule, which is derived by dynamic programming. The code of the model has been written in GAUSS. The behavioural relationships were determined as a combination of estimation (OLS, TSLS) and calibration. The equations are specified in error-correction form. The model provides a tool within which the implications of the use of various monetary policy rules are studied.

GENERALISED TOTAL RETURN PARITY FOR THE EXCHANGE RATE

Developed by Alexis Derviz (Economic Modelling Division)

A model of the uncovered interest rate parity condition using secondary market yields (total returns) of default free instruments, instead of money market rates is being developed to asses market expectations for both koruna/euro and euro/dollar exchange rates. This model, based on mainstream stochastic general equilibrium micro-foundations, shows very promising empirical performance.

CHAPTER 4

The Quarterly Projection Model and its Properties

By Jaromír Beneš, Tibor Hlédik, David Vávra and Jan Vlček [1]

[1] Jaromír Beneš is Senior Economist in the Economic Modelling Division, David Vávra works as a director of the Economic Modelling Division and Jan Vlček is an Economist in the Economic Modelling Division, all Monetary and Statistics Department, Czech National Bank. Tibor Hlédik works as an advisor to the Bank Board of the Czech National Bank, he is based in the Economic Research Department.

INTRODUCTION

The goal of the CNB's Quarterly Projection Model (QPM) is to provide a high-level description of the core dynamics of the macro economy.[2] The model has three basic roles. As a research tool, it provides a means of learning about the functioning of the economy and studying policy options. Within the context of the forecast, the model has two roles. First, it provides an organizational framework for the exercise, and a consistent story about how the short-term conjuncture will evolve into the medium term. A crucial part of this is a description of what needs to be done, conditional on all the other assumptions in the forecast, to respect the inflation target. This is the primary contribution of the model to a baseline scenario. Second, the model plays a more central role in dealing with uncertainty. Given the judgmental baseline forecast, the model can be used to study the implications of the major risks to the forecast. To create consistent alternative scenarios without a model is very time consuming. By exploiting the model's power to simulate the implications of varying the key assumptions in the baseline forecast, we are able to expand greatly our ability to quantify the implications of the main risks. The model also allows us to create confidence intervals around the baseline forecast.

This characterization of the role of the model is important, because it influences the model's design. We do not seek a model that is expected to forecast well over the short term. That is seen as the job of the specialists. Rather, we seek to specify a model that captures the essential macroeconomic linkages, and especially the way monetary policy choices influence the economy and inflation. We want the model to be simple and clear in its description of these things, so that it can provide a focus for debates on policy issues and so that it can be helpful in communicating monetary policy choices to markets.

WHY START WITH A SMALL MODEL?

Spreadsheet models, time-series models, and estimated relationships have all been found useful by specialists tracking sector developments. Spreadsheets have also become very powerful and flexible tools for organizing large quantities of data. Indeed, modern spreadsheets have the power to do simple extrapolative forecasting with ease. It is evident that one can organize a short-term forecast elegantly and flexibly using such techniques, including, with some care and understanding, basic adding-up restrictions, such as a national accounts identity.

This approach, however, can never offer a "model" of the macro economy. A model must, at least in principle, have the power to explain the workings of the economy such that counterfactual questions can be posed. Any method capable of extrapolation will provide useful information over short horizons if conditions do not change markedly. However, it is precisely when conditions do change, or when the questions have a longer-term focus, where the fundamental simultaneities in a macro system matter, that an economic model is needed.

The original approach to macroeconomic modelling in policy institutions, in the 1960s, 1970s and early 1980s was to construct large econometric models, with equations specified and estimated independently, or in small subsets. It was thought that the goal of modelling was to provide as good a job as possible in tracking historical dynamic properties of the data, and that, somehow, everything would work out at the higher level. This approach requires a lot of resources, not just in the original model construction, but also in maintenance. Moreover, it was found that re-estimation often changed model simulation properties dramatically. Researchers usually spent more time patching up the models to provide acceptable answers to specific questions, or to cater to the idiosyncrasies of the forecasting issues of the day, than in carrying out contemplative research on policy issues. Many of these models could not simulate very far into the future, because insufficient attention had been paid to the consistency requirements of a general equilibrium system.

[2] In a sense, it is misleading to call it a projection model, because much of the short-term forecast comes from the judgment of specialists. The model does, however, play a larger role in shaping the medium-term projection.

Economists have learned a lot about modelling since those days, and some institutions, most notably the Board of Governors of the Federal Reserve System in the United States, are still committed to large-scale estimated models. Many other institutions, however, have abandoned this tack, at least in part because of the major resource commitment required to do this type of work. Canada and New Zealand are good examples.[3] [4]

For a developing country, or a country like the Czech Republic that is undergoing major changes in the structure and organization of the economy, Fed-style modelling is a non-starter. The data are very limited, both in terms of the coverage and the duration of series.

Calibrated models have many advantages for countries like the Czech Republic with limited experience with a market economy and limited experience in creating and using models of market economies in policy analysis. Of particular importance is the move to a flexible-exchange-rate regime and the adoption of inflation targeting as the role for the central bank. Many countries in similar circumstances have gone the route of calibrated models, and there is considerable experience that can be used to guide us in developing a useful model. We know, for example, that for a number of years both Canada and New Zealand have been using calibrated models in forecasts to support inflation-targeting regimes. However, in both of these cases, the models are larger dynamic general equilibrium models, not the simple structure we are proposing as a starting point.[5]

Our approach is to specify a simple model of the key flows in the macro economy, the minimal model necessary to explain the nexus of output, employment, interest rates, exchange rates and inflation, with a framework for the way monetary policy works to influence the economy and inflation. The model is a version of what has been called a "gaps" model, because the task attempted is to explain the dynamics of disequilibrium paths and, in particular, how "gaps" or deviations from equilibrium values develop and are dissipated over the medium to long term. Little is said about the nature of the levels of equilibrium, and, in particular, there is no supply side, no stocks, and no attention to asset equilibrium as part of the model.[6]

There are three reasons, essentially, to start with this simplified framework. First, there are insufficient data and experience to support calibration of a more ambitious model at this time. Second, the CNB Board, whose decisions determine the short-term instrument settings, has expressed a desire to participate in discussions of modelling issues germane to evaluating the forecast. The Board is comprised of individuals with varied backgrounds; it is essential that the model be simple, at least initially, for communication to develop well. Third, we ourselves are new to this type of modelling, and there is little experience with using simulation models within the institution. We need time to learn and develop our understanding of the model, and to develop all the rest of the infrastructure necessary to support a regular model-based forecast. Moreover, while it cannot answer all questions that might arise as policy issues, our model can answer a lot of questions.

[3] For an overview of the Bank of Canada's model, see Poloz, Rose and Tetlow (1994).For a detailed description of the model see Black, Laxton, Rose and Tetlow, (1994) and Coletti, Hunt, Rose and Tetlow, (1996).

[4] For information on the New Zealand model, see Hunt, Rose, and Scott (2000) and Black, Cassino, Drew, Hansen, Hunt, Rose and Scott (1997).

[5] Work is in progress to provide more elaborate alternative models.

[6] There is another, larger annual model of the economy of the Czech Republic, called HERMIN, maintained within the CNB that can be used as a check on some of these points. See Chapter 3 for further details and an overview of other models used at the CNB to support monetary policy.

Models are tools. The modern view of macroeconomic modelling is that it is not designed to reproduce the economy in a literal sense. The equations often do not describe any particular agent's behaviour. The important question is are they useful, do they capture properties of the macro economy sufficiently well to provide value added in policy analysis? This question must be posed on two levels. We know from international experience that such models can be used effectively and provocatively in doing research on policy issues. A major advantage for such work is that the model is small and easy to change or recalibrate as dictated by the needs of the project. Combined with the highly effective modern technology for simulating forward-looking models, these simple models can be very powerful research and learning tools.

A more difficult issue is how useful such models can be in forecasting. In thinking about this issue, it is helpful to consider what others have said and found on this subject. Both Canada and New Zealand have calibrated dynamic general equilibrium models at the heart of their forecasting in support of inflation targeting regimes. These models are complete, with supply sides and full integration of stock-equilibrium conditions. In other words, they are much more ambitious in scope than our simple "gaps" model. Yet both institutions are very clear in their documentation that the model does not produce the forecast. A forecasting team produces the forecast. Indeed, in the very short run, normally the current and the next quarters, the forecast is virtually 100 percent judgment. Thereafter, the model begins to take over, and for the medium term the model plays a much larger role.[7] It is thus accepted in these institutions, and many others, that the model does not have to provide an accurate short-term forecast to be useful. Indeed, economists in these institutions argue explicitly that the model should not be expected to forecast well over short horizons. The focus in the modelling is on capturing the essential general equilibrium nature of the system, not tracking the nuances of the data or exploiting all the useful high-frequency information in the data that can help in preparing a short-term forecast.

What about the issue of whether the model needs to be able to forecast well over longer horizons? Again, the balanced answer from countries that use calibrated models is a qualified no. To begin with, there can be no true "forecast" of the most endogenous variables in a macro system. Some institutions even avoid using the term "forecast" to describe an inflation scenario produced by a model under particular assumptions about what policy will do over that period. The real test of the model's usefulness is whether it helps policy makers to succeed in respecting the announced targets for inflation. The model has to be good enough that in the absence of severe shocks or changes of circumstance, a policy maker following its indications will not make systematic errors and fail to respect the targets. However, a model cannot be expected to anticipate the shocks that will buffet the economy. Ex post error in a scenario is to be expected; it just cannot be systematic. Moreover, the policy maker always has the chance to respond to events next quarter, or sooner if new information changes views as to appropriate settings. Errors will be made in any forecasting system; even substantial errors in any particular short-term forecast need not cause concern over meeting the target a few quarters into the future, or generally over time.

The power of the model comes not so much in the preparation of the baseline scenario or "forecast". There, judgment will always play the key role. What the model offers is consistency and the power to address risks and uncertainties. First, the model does provide a consistent framework for the medium-term baseline scenario, where judgment becomes less important. However, the main advantage is that the model provides the power to add considerable information about the *risks* inherent in the baseline scenario. It can do this in two ways. First, specific alternatives can be quickly and easily investigated. This can include things like the sensitivity of the scenario to specific assumptions, both in the model itself and in the judgments used for the baseline forecast. Board members will be able to ask questions regarding the sensitivity of the forecast to the assumptions made in its preparation. To prepare a new judgmental forecast under alternative assumptions could take a long time. Using the properties

[7] There is a very well developed set of tools available to modelers and forecasting teams to allow for the input of judgment in a forecast, while respecting model properties in the medium to longer term.

of the model, and the power of modern simulation techniques, consistent model-based quantifications of the main risks to the baseline scenario are quick and easy to generate. Second, with modern *stochastic* simulation techniques, meaning techniques that use repeated simulation of the model under hypothetical drawings from the assumed distributions of the shocks that can affect the outcome, the model can help quantify the uncertainty in any forecast, by providing statistical confidence bands for that forecast.

In a nutshell, the real power of the model comes in its ability to help deal with the issues involving the risks and uncertainty inherent in a forecast, and the implications for policy choices.

THE ESSENTIAL ISSUES FOR THE MODEL

We seek a simple model of the inflation process and of the way monetary policy can influence that process. What are the key elements to such a model? The economy of the Czech Republic is small and open.[8] Traded-goods prices matter a lot. We can start with the simple observation that traded-goods prices will be linked to world prices adjusted for the exchange rate. Written in terms of inflation rates, we have as an arbitrage condition:

$$\pi^T = \pi^W - \dot{s} \tag{a1}$$

where π^T is the rate of increase of traded-goods prices in domestic currency, π^W is the rate of inflation in the external currency, and $\dot{s}$ is the rate of change of the external value of the koruna (appreciation means a positive number). This need not hold all the time, of course, but in a competitive market, it must hold in equilibrium. In a fixed-exchange-rate regime, where $\dot{s}$ is zero, the domestic inflation rate for traded goods will be the world rate of inflation. In a flexible-exchange-rate regime, with an inflation target on some general price measure that combines traded and non-traded goods, there will be a link between the domestic policy choice and the exchange rate. In the simplest case, where all goods are traded, or where there is strong substitutability between traded and non-traded goods, such that π^T is equal to the overall domestic inflation rate, then equation (a1) says simply that the nominal exchange rate will depreciate at a rate equal to the difference between the domestic and word inflation rates.

Suppose that the weight of traded goods in the general domestic price level is ω_T, so we can write:

$$\pi = (1-\omega_T)\cdot\pi^N + \omega_T\cdot\pi^T = (1-\omega_T)\cdot\pi^N + \omega_T\cdot(\pi^N + \pi^{REL}) = \pi^N + \omega_T\cdot\pi^{REL} \tag{b1}$$

or $$\pi = \pi^T - (1-\omega_T\cdot)\cdot\pi^{REL} \tag{b2}$$

where π^{REL} is the *rate of change* of the relative price of traded goods.

We can extend equation (a1) by writing:

$$\pi^T = \pi - \dot{z} \tag{a2}$$

where $\dot{z}$ is the rate of appreciation in real terms. We see comparing (a2) and (b2) that there is a direct link between the trend change in the relative price of traded goods and the trend change in the real exchange rate. Where there are trend productivity gains in producing traded goods, relative to trading partners, there will be appreciation of the real exchange rate, all else equal. This is the case, we believe, that applies to the Czech Republic.[9]

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[8] The ratio of real imports to GDP has more than doubled in the last 6 years to over 80 percent. The ratio of real exports to GDP has almost doubled, and stands at about 75 percent. Both ratios continue to rise.

[9] For an example of a multi-sector model applied to the Czech Republic see Laxton and Pesenti (2002).

For the next point, let us simplify and ignore the trend real appreciation. The exchange rate and interest rates are linked by an uncovered interest parity condition. This is an arbitrage condition that says that with mobile short-term capital, risk-adjusted rates of return will be equated across currencies. We have, ignoring risk premiums:

$$i = i^* - \dot{s} \qquad \text{(c)}$$

where i is the domestic nominal interest rate, i^* is the foreign nominal interest rate and $\dot{s}^e$ is the expected rate of appreciation of the exchange rate. A foreign investor, who can get a rate of return i^* at home, will only make a similar investment in the domestic economy at the same rate if the exchange rate is constant. If the exchange rate is expected to depreciate ($\dot{s}^e < 0$), the investor will demand compensation in the form of a higher domestic interest rate.

The system described by (a), (b) and (c) provides a stylised version of one of the two key elements of the link between monetary policy and inflation, the exchange rate channel. If the central bank increases i, then according to (c), with the foreign rate unchanged, the exchange rate will immediately appreciate, such that the expected *change* in the exchange rate will be negative.[10] It may be useful to think of this asset-pricing rule in terms of more traditional flows; a higher domestic rate will attract short-term capital, all else equal, and this will put upward pressure on the exchange rate (and, all else equal, create an expectation of a depreciation to come, which then chokes off the capital flow). In any case, there is a clear and strong immediate link between the domestic interest rate and the exchange rate. From (a1) we know that appreciation of the exchange rate will put downward pressure on the inflation rate for traded goods, and from (b1) we know that this will have some immediate effect on the overall inflation rate-more if non-traded-goods prices respond. Thus there is a link between the domestic interest rate and inflation, through the exchange rate and the prices of traded goods.

But what of the economy? Standard economic theory suggests that a higher real interest rate will reduce aggregate demand by increasing the reward to saving and by making it cheaper to add to capital. Let us summarize this idea in the simplest possible way, by writing that the level of excess demand, let us call it *ygap*, responds negatively to the difference between the real interest rate and its equilibrium value, which we will call *rgap*:

$$ygap = -\beta \cdot rgap \qquad \text{(d1)}$$

In an open economy, the exchange rate also matters, since an appreciation will, all else equal, make domestic goods more expensive in foreign markets and reduce demand for domestic goods abroad. Similarly, imports will be cheaper and may displace domestic goods, reducing demand for domestic goods at home. To capture this idea, let us modify (d1) by writing that *ygap* will respond negatively to the difference between the real exchange rate and its equilibrium value, which we will call *zgap*, so that:

$$ygap = -\beta_1 \cdot rgap - \beta_2 zgap \qquad \text{(d2)}$$

There are complications in dealing with real versus nominal values. Since prices tend to respond sluggishly to macro signals, however, it is a reasonable simplification for this discussion to think of changes in interest rates and exchange rates coming from a monetary policy intervention as having an important real component, at least in the short run.

[10] This idea is explained more completely in the next section.

This creates the basis of the second main element of the monetary control mechanism. We have a link between the policy instrument and the economy through interest rates directly, and indirectly through the link between interest rates and exchange rates. To complete the discussion, we need a link between the economy and inflation. That is provided by a Phillips curve, which in its simplest form says:

$$\pi = \pi^{e} + \lambda \cdot ygap \qquad \text{(e)}$$

This says that inflation will tend to rise, relative to what was expected, if there is excess demand. Now the policy linkage through the economy is complete; by influencing *ygap*, the central bank can influence the course of inflation.

These two channels for monetary policy, the exchange rate channel through traded-goods prices and the real economy channel through the Phillips curve, describe the essence of what we need to model. The QPM is essentially the above story, with added attention to the details of real versus nominal values, to how expectations affect the dynamics of the macro economy, to the lags and other important details of the specification that influence dynamic properties, and with a few elaborations, such as a partial link to the labour market and a bit more detail on import prices.

A final point comes from the form of (e). Note that if we consider the conditions in a real equilibrium, where *ygap* = 0, equation (e) says simply that inflation will be whatever is expected. There is nothing that will produce the target rate of inflation automatically. The fundamental role of monetary policy is to anchor inflation expectations to the target rate of inflation.

KEY EQUATIONS IN THE QUARTERLY PROJECTION MODEL

In this section, we describe the essence of the QPM. Our goal here is to describe the logic of the macroeconomic system described by the model. The complete model is larger than the small system described here, comprising about 85 equations. However, the majority of these equations are simple definitions or identities providing links between levels and growth rates, and so on. For our purposes here, the model can be distilled down to the 14 equations shown in Table 1.[11] For this discussion, we use a simplified notation. The same equations appear, along with the rest of the model, in the TROLL code appended to this volume, in the form they are actually used for simulations.

In equation (1), y_t is the log of real GDP, $\bar{y}_t$ is the log of potential output, and $ygap_t$ is output gap. The scaling is to convert the gap units to percent (of potential output). Equation (1) is an identity; it simply defines what we mean by $ygap_t$, or more precisely the relationship between y_t, $\bar{y}_t$, and $ygap_t$. For our purposes here, what we need to note is that measures are defined and equations structured so that the gap variable can sensibly be thought of as tending to zero over a typical medium-term simulation horizon (ten years, say).[12]

In equation (2), u_t is the unemployment rate, $\bar{u}_t$ is the level of the non-accelerating inflation rate of unemployment, NAIRU, and $ugap_t$ is the unemployment gap. Again, this is an identity defining a relationship among these variables. Note that we have defined the unemployment gap such that positive values mean excess demand for labour, yielding an expected positive correlation with the output gap measure and positive coefficients in equations linking these measures. It should be clear from the term NAIRU that we are thinking of "equilibrium"

[11] Wherever appropriate, the data have been seasonally adjusted. Our discussion of dynamic properties thus abstracts from seasonality issues.

[12] Recall that "potential" output is not intended to be some maximum attainable level. Rather, the concept of "potential" is tailored to the purpose of the model—to facilitate forecasts and policy decisions in a central bank attempting to respect an inflation target. In short, in this model, "potential output" means what can be produced under current conditions without generating pressures for inflation to rise or fall.

in the labour market using the perspective of the effect on inflation. In an economy undergoing major structural change, it may well be that the level of unemployment consistent with stable inflation will, for a time, be well above what can be achieved in the longer run. If monetary policy can influence the process of structural change, then this becomes a consideration for a model of inflation targeting. It is standard, however, to argue that the influence of short-term monetary decisions on longer-term real trends is negligible, and that such longer-term real trends can be taken to be exogenous. That is the assumption we make here.

Table 1: The Main Equations of the Core Model

$$y_t = \overline{y}_t + ygap_t / 100 \tag{1}$$

$$u_t = \overline{u}_t - ugap_t \tag{2}$$

$$lz = ls + lcpi - gr\_lcpi \tag{3}$$

$$\begin{aligned} \pi core_t = {} & a_0 \left[\pi 4_t^{MexE} + 100 * \Delta_4 lz_t^{eq}\right] + a_1 E0_t \pi 4_{t+1} + \left(1 - a_0 - a_1\right) \pi core_{t-1} \\ & + a_2 ygap_{t-1} + \varepsilon_t^{\pi} \end{aligned} \tag{4}$$

$$\begin{aligned} ygap_t = {} & d_0 ygap_{t-1} - d_1 rr12gap_{t-1} - d_2 rr4gap_{t-1} - d_3 gr\_rrgap_{t-1} - d_4 lzgap_{t-1} \\ & + d_5 gr\_ygap + \varepsilon_t^{ygap} \end{aligned} \tag{5}$$

$$ugap_t = f_0 ugap_{t-1} + f_1 ygap_t + \varepsilon_t^{ugap} \tag{6}$$

$$\begin{aligned} ls_t = {} & g_0 E_t ls_{t+1} + (1 - g_0)(ls_{t-1} - 2E0_t(\pi 1_{t+1} - gr\_\pi 1_{t+1})/400 + 2\Delta lz_t^{eq}) \\ & + (rs - gr\_rs - prem)/400 + \varepsilon_t^{ls} \end{aligned} \tag{7}$$

$$prem_t = rr_t^{eq} + 100(lz_t^{eq} - lz_{t-4}^{eq}) - gr\_rr_t^{eq} + \varepsilon_t^{prem} \tag{8}$$

$$rs_t = m_0 rs_{t-1} + (1 - m_0)(rr_t^{eq} + E_t \pi 4_{t+4} + m_1(E_t \pi 4_{t+4} - \pi_t^{Tar}) + m_2 ygap_t) + \varepsilon_t^{rs} \tag{9}$$

$$rs4_t = j_0 + j_1 \cdot \left(\sum_{i=0}^{3} E_t rs_{t+i}\right) / 4 + (1 - j_1) \cdot rs + \varepsilon_t^{rs4} \tag{10}$$

$$rs12_t = p_0 + p_1 \cdot \left(\sum_{i=0}^{11} E_t rs_{t+i}\right) / 12 + (1 - p_1) \cdot rs + \varepsilon_t^{rs12} \tag{11}$$

$$\begin{aligned} \pi_t^{MexE} = {} & k_1(gr\_\pi_t - 400(ls_t - ls_{t-1})) + (1 - k_1)\pi_{t-1}^{MexE} \\ & - k_2 \cdot 100(lpmexe_{t-1} - gr\_lcpi_{t-1} + ls_{t-1} + \mathrm{k}_0) + \varepsilon_{\mathrm{t}}^{\pi^{\mathrm{MexE}}} \end{aligned} \tag{12}$$

$$\begin{aligned} \pi_t^{ME} = {} & h_1(\pi oil_t - 400(lsu_t - lsu_{t-1})) + (1 - h_1)\pi_{t-1}^{ME} \\ & - h_2 \cdot 100(lpme_{t-1} - lpoil_{t-1} + lsu_{t-1} + \mathrm{h}_0) + \varepsilon_{\mathrm{t}}^{\pi^{\mathrm{ME}}} \end{aligned} \tag{13}$$

$$\pi_t^{EN} = n_0 \left[\pi 4_t^{ME} + 100 * \Delta_4 lz_t^{eq}\right] + n_1 E0_t \pi 4_{t+1} + \left(1 - n_0 - n_1\right)\pi_{t-1}^{EN} + n_2 ygap_{t-1} + \varepsilon_t^{\pi^{EN}} \tag{14}$$

Equation (3) is a simple definition, but is included here owing to its importance in the discussion. Variable *lz* is the log of the real exchange rate (*z*). Equation (3) defines *lz* to be *ls* (the log of the spot rate, *s*, which is defined as the bilateral rate with the Deutchsmark (DM), in the form of the external value of the koruna), plus the log of the Czech CPI minus the log of the German CPI.[13] In the period following the formal linking of currencies in the Euro, the data for the DM rate are derived from the Euro data using the fixed ratio for the DM. It is an interesting question as to whether the U.S. dollar should be given some weight in the model through the calculation of an effective exchange rate. The U.S. dollar exchange rate is still important, as much of the Czech Republic's oil and raw materials imports are priced in U.S. dollars. However, virtually all exports are sold in the Euro market, and the main competitive pressures facing the domestic economy come with respect to European trading partners. For these reasons, we have decided to formulate this first version of the model using the bilateral rate, while paying attention to the role of the U.S. dollar in modelling import prices.

The rest of the equations in Table 1 describe core macroeconomic system in the model. These equations are not identities, but rather behavioural specifications, albeit at a high level.[14] It is appropriate to think of these equations as reduced-form or quasi-reduced-form descriptions of the macro economy, not as literal descriptions of agent behaviour.

Equation (4) is the model's reduced-form equation for the dynamics of inflation. Variable π_t is the measure of inflation we choose to model, based on the "core CPI" (CPI excluding all regulated prices and excluding unregulated energy prices, essentially petrol).[15] It is measured as a percentage change, quarter-over-quarter, at annual rates. We choose to model this core measure of inflation because the logic of the link between excess demand and inflation does not apply in the same way to the parts of the CPI that change for exogenous reasons. It is important to note that the choice of an inflation measure to explain in the model's Phillips curve does not limit, in any way, the choice of what the policy maker tries to control. Indeed, in our case, the official target for inflation is based on the headline CPI; this is reflected in the model's reaction function, which is described below.[16]

The equation describes inflation dynamics using an expectations-augmented Phillips curve, with some special features to reflect the local economy. The influence of excess demand is captured through the one-quarter-lagged value of the output gap. The lag reflects our judgment that there is delay in the response of prices to economic conditions.

Expected inflation enters through the term E0, which is defined in the model as a weighted combination of a backward-looking component (the one-quarter lag of the four-quarter rate of change of the overall CPI) and a forward-looking component (the predicted value of overall CPI inflation over the next four quarters). Using the overall CPI in the expectations model provides an explicit link between changes in regulated and energy prices and pressures on the rate of inflation for market prices. One can think of this as capturing, at least in part, the effect of pressures on costs coming from the influence on wage bargaining.

[13] The basic definition of a real exchange rate in levels is $z = s \cdot p / p^*$, where the exchange rates are defined to be external value of the domestic currency. The real external value is then the value of the domestic good in foreign currency divided by the foreign price.

[14] This is indicated by the presence in each of a disturbance, ε_t, with a superscript for the variable chosen for the left side of that equation. In general, in a simultaneous system of equations, one can choose any variable for the normalization (the variable placed on the left-hand side), so the linking of equation disturbances and shocks of a particular type is not automatic. However, we are writing this system with a view to making such inferences from the empirical system. Thus, for example, we want to be able to interpret historical residuals in the "potential output equation," $\varepsilon_t^{\bar{y}}$, as measures of the historical supply shocks.

[15] See the appendix for details on the measurement of core CPI. The data were constructed by the CNB, based of information provided by the Statistical office.

[16] There is, however, a link between the economics of specifying the Phillips curve in terms of core inflation and the qualifications to the targeting commitment in the "caveats." See Chapter 1 for a review of this issue.

Import price effects enter through the first term. The variable $\pi 4_t^{MexE}$ is the four-quarter rate of change of import prices, excluding energy, and lz_t^{eq} is a proxy for the log of the equilibrium real exchange rate, defined such that an increase is an appreciation.[17] The operator Δ_4 denotes a four-quarter difference. The real exchange rate term removes the effect of a trend in the equilibrium real exchange rate on imported goods prices.[18]

Finally, in addition to the lags operating through expectations, we have a direct effect of lagged core inflation. This represents intrinsic dynamics—the effects of things like contractual lags or other costs of adjustment that lead to stickiness in prices, even in the absence of expectations lags.

The disturbance term ε_t^{π} represents shocks to inflation from all other sources.

An important feature of equation (4) is the homogeneity restriction on the parameters. One implication is that we specify the model to be super-neutral, there is no long-run trade-off between output and inflation. But there is a second important implication. Equation (4) determines the dynamic path of inflation, but has nothing to say about its equilibrium level. In an expectations equilibrium, where expected inflation is realized, output is at potential and import price inflation adjusted for the trend in the real exchange rate is equal to the core domestic rate of inflation, the equation collapses. In other words, the equation says only that in equilibrium, inflation must be at its expected level, but not what that level will be. This is why we say that the fundamental role of monetary policy is to anchor expectations to the target rate of inflation.

Equation (5) describes the dynamics of the output gap. The gap is formulated to evolve according to a first-order autoregressive process, reverting to zero in a steady state, but allowing for effects from interest rates, exchange rates and a foreign (German) business cycle. There are four additional gap terms used for the effects of domestic monetary conditions: *rr*12*gap* is the deviation of the 3-year (12-quarter) real interest rate from its equilibrium trend level, *rr*4*gap* is the deviation of the 1-year (4-quarter) real interest rate from its trend level, *gr_rrgap* is the deviation of the German quarterly real interest rate from its trend level, and *lzgap* is the deviation of the real exchange rate from its trend level, where this is defined such that a positive value means that the real exchange rate is appreciated relative to its equilibrium level.

The German rate gap is included to capture the effect of foreign financing of domestic investment. The rest of these terms provide the model's mechanism for the influence of monetary choices on the real economy, through *ygap*, and then, through the Phillips curve, on inflation. In the interest rate part, we have allowed for two channels, reflecting a judgment about what rates are important in influencing aggregate demand. However, these channels are not independent in the model, since the 3-year rate and the 1-year rate are linked through a term-structure model.

The other term in equation (5) allows for the influence of the real exchange rate on aggregate demand. This is not a policy instrument in the same sense as is a domestic interest rate, but in the model the exchange rate and domestic interest rates are linked by a version of an uncovered interest parity condition, so there is a clear channel for monetary policy influence on the real economy through the exchange rate. We refer to the combined effects of the interest-rate and exchange-rate terms in this equation as our index of real monetary conditions. It is important for model properties that we have introduced a lag into the link between monetary conditions and excess demand. This means that there is a discrete delay of one quarter before the effects on excess demand of any monetary policy intervention begin to appear.

[17] The measure of import prices excluding energy was constructed by the CNB based on information supplied by the Czech Statistical Office. See the appendix for details.

[18] This makes the term in square brackets equal to the domestic inflation rate in a steady state, even if the real exchange rate has a trend.

Finally, the domestic output gap is assumed to be influenced directly by the German output gap, representing here the role of an excess foreign demand. The disturbance term, ε_t^{ygap}, is interpreted as shocks to aggregate demand.

Equation (6) is an Okun equation that links the movements in the unemployment gap to those in the output gap. Some degree of persistence in the dynamics of the unemployment gap is captured by the presence of the lagged values of unemployment gap. The disturbances ε_t^{ugap} are interpreted as shocks affecting unemployment other than those already captured through aggregate demand.

Equation (7) is a version of the uncovered interest parity (UIP) condition. In essence, the UIP condition is an arbitrage condition that says that international investors will act to equalize effective rates of return on investments in different currencies, allowing for any country-specific risk premiums (in the past, foreigners investing in the Czech Republic have demanded a substantial risk premium). The key point in terms of "effective" rates of return is that changes in the exchange rate must be taken into account. A foreign investor who expects a depreciation of the koruna will demand compensation for that in the form of a higher return from Czech assets. Similarly, a foreign investor who expects an appreciation of the koruna will need a smaller risk premium than would otherwise have been the case.

Equation (7) embodies these ideas. The terms in the first line represent the expected exchange rate one-quarter ahead (more on that later). The term in the second line is the difference between Czech and German short-term interest rates adjusted for the risk premium, *prem.* If the expected change in the exchange rate were zero, and there were no risk premium, this equation would say that the Czech interest rate would equal the German interest rate.

The first line represents the expected exchange rate. An important feature of the Czech Republic's experience is that there is a trend real appreciation of the koruna relative to the DM, and this needs to be taken account of in the model. The second term in the first line reflects this; the lagged exchange rate is augmented by the two-quarter trend real appreciation and reduced by twice the (expected) inflation differential between the domestic economy and the German economy. It therefore reflects a measure of where the spot exchange rate will be one-quarter ahead, all else equal. This is combined with the first term in the first line, which is the model forecast of the exchange rate one-quarter ahead. The weighted average of these two terms is the model's representation of the expected exchange rate.[19]

It is common practice in models in policy institutions to use this kind of combination of a model-consistent forecast and other measures that converge to the same thing in the longer run as a model of expectations. If we were to use only the model-consistent forecast, that is, set g_0 to 1, then the exchange rate would become a "jumper" variable,[20] and this has been found to yield much too much volatility in simulations.

[19] The expected domestic inflation rate is for the headline CPI; it is defined as a weighted combination of the model-consistent solution for the quarterly rate of change of the CPI at annual rates and the previous observation on the 4-quarter rate of change.

[20] When a forward-looking model is solved such that expected future values are set to model forecasts, certain variables must move immediately (jump) to create consistency. Here, for example, if interest rates are sluggish to adjust, or pinned down by policy intervention in the quarter, the only way the model can solve consistently is to put all the action into the solution for the current exchange rate. Thus, if the exchange rate is expected/forecast to appreciate over the quarter and interest rates are assumed fixed for the sake of argument, then under a purely model-consistent formulation, the current exchange rate solution would have to jump down (depreciate) to create consistently the expected appreciation. In the formulation chosen for this model, only part of the weight in the expectations is applied to the formally model-consistent solution, and this has the effect of moderating the "jumper" problem.

Equation (8) serves two roles. For the database, this equation serves to define the risk premium, *prem*, as that part of the observed difference between Czech and German "equilibrium" real rates that is not attributable to trend change in the real exchange rate.[21] In simulations and forecasts using the model, the risk premium is set to what it was (for history) or by a simulation rule, with judgment, for the expected future path. The result is essentially exogenous to the model. Thus, equation (11) determines the path for the equilibrium real rate of interest when the model is used to forecast or to perform other simulations, such as the response to a shock .

Equation (9) is the model's reaction function. It is a forward-looking reaction function, in which decisions on where to set the policy instrument (the short-term interest rate) today are made by considering what is likely to happen in the future. The equation says that if headline CPI inflation is forecast to be above the target rate, π^{Tar}, where the forecast is for the next four quarters, then the central bank acts to push up the short-term (one-quarter) interest rate, all else equal.[22] Similarly, if there is perceived to be excess demand in the system at the decision point, the central bank acts to push up the short-term interest rate, all else equal. Note that even if inflation is forecast to be below target over the next year, if there is strong enough excess demand in the system, the central bank acts to push up rates. This can be interpreted in two ways. It can be seen as a preventative measure to stop inflation from exceeding the target in subsequent periods. It can also be interpreted as reflecting an objective function where there is some weight on conditions in the product market directly. The first term(s) in the reaction function provide both a long-term level for rates and some additional dynamic structure. In a steady state, the nominal rate goes to the equilibrium real rate plus the rate of inflation over the next year. In the short term, there is some inertia; all else equal, the one-year rate moves to its equilibrium according to a first-order autoregressive process.

An important point follows from the lag structure in the model. Since there is some inertia in the reaction function, and since the output gap itself is given some weight by the central bank in setting the short-term rate, and since there is considerable inertia in the process linking monetary conditions and the output gap, and since there is a delay before changes in the output gap begin to have a direct effect on inflation, it is not feasible to set the short-term rate such that the projected inflation rate will always be on target. Rather, forecast scenarios involve setting interest rates such that inflation is projected to return to target over a reasonably short horizon, in the absence of new shocks. Of course, there will be shocks, and the outcome will not be as projected, even with a perfect model.

Equation (10) is an example of the interest-rate, term-structure relationship used in the model. In the expectations model of the term structure, the one-year (4-quarter) rate will move to provide the same return as a sequence of four, one-quarter investments at the quarterly rates anticipated over the year, plus perhaps a term premium.[23] Generally speaking, the empirical evidence suggests that rates are more correlated over the term structure than suggested by the expectations theory under model-consistent forecasts. As in other examples we have discussed, where we want model-consistency over the longer term, but not necessarily over the short term, we address the problem by adding some inertia by making the solution for the one-year rate a weighted average of the current one-quarter rate and the prediction of the expectations theory under model-consistent expectations.

A similar structure is used for the three-year rate in the Equation (11). For the three-year rate we use the rate on newly issued loans to businesses. This provides a measure of the cost of credit in domestic markets for firms.

[21] Evidently, this measure is dependent on the measures chosen for the component trends. That subject is covered elsewhere in this volume.

[22] One should not presume that simply because only the next four quarters are considered explicitly in the comparison that this is the only horizon that matters. Since the model is forward-looking in several other respects, the entire future path of a forecast affects, to some degree, the forecast for the next four quarters.

[23] In equation (10), the term premium is assumed constant; it is represented by j_0. The data for the one-year rate comes from the rate on government bonds.

Equation (12) is a simple error-correction model of inflation in the price of imported goods, excluding energy. The first two terms provide the pure inflation dimension, written as a weighted average of German inflation, adjusted for changes in the exchange rate, and lagged non-energy import price inflation. The latter provides some inertia in the pass-through of foreign inflation shocks. The term in the second line provides the error-correction mechanism. It ensures that purchasing price parity in levels is respected in the long run, albeit with allowance for a permanent "wedge" between the two price levels, as captured in the exogenous term k_0.[24]

Equation (13) is a similar equation for inflation in the price of imported energy. Most imported energy for the Czech Republic comes from Russia and is priced in U.S. dollars. Therefore, this equation keys off the exchange rate with respect to the dollar, *lsu*, and the world price of oil in U.S. dollars, but the basic structure is the same. The inflation term picks up the rate of change of world oil prices, adjusted for exchange-rate changes. The error-correction term makes the level of the domestic price of energy move to the word price of oil in koruna, adjusted for a level "wedge" term (h_0).

Equation (14) is similar to equation (4), but applied to the rate of increase of the energy component of the CPI. It has the same general structure as equation (4), including the link to general excess demand. In the calibration, the coefficient on this term is set much lower than in equation (4); imported energy prices play the principal role in determining the dynamics of CPI energy price inflation.

The model focuses on the DM exchange rate in equations (3) and (7). The DM/US$ cross rate is taken as exogenous, over history. For simulations, including forecasts, the model has a simulation rule that makes the nominal value of the koruna in U.S. dollars move with the nominal value of the koruna in DM (*lsu* moves with *ls*), shock-control, although judgment can always be added to tune to any assumption regarding the DM/$ cross rate in the control (forecast).

The target rate for inflation in the Czech Republic is now specified in terms of the headline CPI, which the model respects in the definition of π^{Tar} and the formulation of the reaction function. The model has the complete identity system that links the overall CPI to its components, and particularly to the specific measures for which we specify behavioural equations-the energy component and the core basket. We complete the system with a simulation rule for the regulated price component of the CPI. In this rule, we take the neutral stance that regulated prices will inflate in line with unregulated prices. In shock-control experiments, this removes any automatic influence of relative price effects associated with regulated prices. For forecasts, the simulation rule provides a base case that can be overridden by judgment as deemed appropriate.[25] This system allows us to determine headline inflation from the combined results for its components.

[24] Over history, k_0 will be a balancing residual, varying through time. Over the forecast horizon, it can be set to capture any anticipated trend changes in the German price of Czech imported goods relative to the German CPI.

[25] The impact of regulated prices on the course of general inflation has been a major issue in the past, as is likely to remain an issue. The model provides the necessary mechanisms to investigate the effects of risks associated with changes of regulated prices. This is one of the examples we consider in the section on model properties.

CALIBRATION OF THE MODEL

The discussion above treats the model as a logical system of equations. Although that is a useful and necessary beginning, the model does not become a model of the economy of the Czech Republic until we complete it with specific parameter values. It is this process that gives the model its properties. Ideally, the calibration of the model should be designed to reflect stylised facts about the economy, and particularly the systematic dynamic linkages among the main macro variables. These stylised facts ideally come from applying statistical analysis to the data, from research on macroeconomic issues, and experience in dealing with business cycles.[26] In our case, there has been very little experience with monetary policy under a flexible exchange rate, so it is difficult to base the calibration on established facts. In general, we have chosen a calibration that looks reasonable as a starting point, based on what other central banks have done in establishing properties for their models, and our judgment.[27] In this section, we describe some of the considerations that led to particular choices. In the next section, we provide some illustrations as to how particular choices influence model properties.

ESTIMATION VERSUS CALIBRATION

In estimated models, the equations are fit to historical data, with some criterion like minimizing the sum-of-squared errors in explaining those data. Estimation can be a powerful tool, and we expect to use estimation as part of the overall modelling work, and certainly as part of the work that will go into the other systems that will be necessary to support the forecast. However, for the core macro model, we follow that practice increasingly adopted by central banks around the world, of calibrating the model to achieve acceptable simulation properties. There are several reasons why estimation would be a bad idea for this model at this time. The data sample is very short and describes a period of major structural change in the economy and major change in policy regimes, including the move to inflation targeting. Even if we believed that the model equations represented something close to a complete description of the underlying data generation process in the macro economy, we would have to expect very imprecise identification of the parameters from any estimation.

There is a more fundamental point, however. We do not present the model as a complete representation of the economy. No model, no matter how complex, can describe “the truth.”[28] All models are simplifications and make heroic assumptions in abstracting from details that we know matter at some level in understanding what is going on in an economy. Ours is extremely heroic in this respect. On the issue of calibration versus estimation, this matters for the following reason. In the historical data, all the myriad forces at play influence the outcome. There may well be, and in our case with the major structural changes almost certainly are, major influences in the data that reflect processes that are essentially independent of the core nexus linking the monetary instrument, the economy and inflation. To estimate a core monetary relationship thus risks picking up idiosyncratic effects in a particular sample rather than the essence of the macroeconomic linkages.

[26] Laxton and Scott (2001) summarize this as follows: “Perceptions of reasonable ranges for parameter values will gradually be refined over time. This should be done judgmentally after reviewing available evidence, such as: (1) unrestricted estimation; (2) more-restricted estimation; (3) empirical evidence from other sources (estimation of disaggregated models and information from Input-Output Tables would be an example); (4) information from Input-Output Tables; (5) a thorough analysis of system properties; and (6) an evaluation of potential Type I and Type II policy errors.”

[27] Some members of the Board have expressed interest in working with the modeling group to study the core macroeconomic linkages and to come to a shared understanding of what constitutes reasonable properties for a model of the economy of the Czech Republic.

[28] The Reserve Bank of New Zealand’s discussion of this point with respect to their calibrated model, which is much more elaborate than our “gaps” model, ends with a quote from George Box, “All models are wrong. Some are useful.”

There is also a logical problem in using data to infer parameters in a policy model. Consider, first, an extreme example. Suppose it were possible to set the monetary instrument such that inflation was perfectly controlled at a target rate. In the data, we would see the instrument moving continuously to offset the shocks, but there would never be any evidence from the inflation outcome that any action was necessary in the first place. This problem is not uncommon for policy makers, who must defend their action to raise rates in the face of excess demand to remove inflationary pressures, when questioned by critics who ask “what inflation?” The issue affects modellers too, because the simultaneity of the system makes it hard to infer the structural parameters. To extend the example, if a policy action to raise rates to cut off growing excess demand is successful, the outcome (smaller excess demand) makes it look like a lot of action was necessary in the face of a modest cyclical problem, whereas the real issue is what would have happened had there been no policy response, and what was the effect of the policy response in changing the outcome. Estimation is not very powerful in finding parameters in systems with this type of feedback.

This problem arises even more strongly for identifying linkages from policy to exchange rates and from exchange rates to economic activity. Many things will affect the movements in an exchange rate, some associated with core macroeconomic issues, but many associated with things that are, from the policy perspective, completely exogenous. If the exchange rate is subject to pressures that lead to depreciation, and, all else equal, this would cause inflation to rise from the import price effect, and if the central bank responds by raising the short-term interest rate to blunt this effect, we will see a correlation in the data of depreciation with rising interest rates. A blind econometrician would discover that to fight depreciation one would need to lower rates! Central bankers and markets know better, of course, but that does not make it any easier to extract the right calibration of how this link works.

CALIBRATION OF THE CORE QPM

The calibration of the model requires a number of steps. To begin, we need some measures of key exogenous “gaps”-the measures we use for monetary conditions. This is done using a variant of a univariate filter, called the LRX or PC filter. These measures are treated as exogenous for the rest of the exercise. A number of other exogenous variables are treated in the same manner.

We also use this methodology to get starting estimates for the other “endogenous” gaps, including the output gap and the unemployment gap. These provide both starting values for the multivariate filter and preliminary data for some pre-screening estimation of, for example, the Phillips curve. We stress, however, that the parameters used in the model do not come from these initial estimates.

The calibrating procedure was based on the recognition that econometric estimates can provide only limited guidance on the structural parameters of the QPM (see before). Primarily therefore, the chosen parameter values should reflect economic theory and satisfy long-term properties of a monetary model in an IT regime. Further, the parameters have to be chosen so as to give reasonable model behaviour in response to particular types of shocks. Conveniently, reasonable behaviour can be judged by comparison to similar models in other small open economies. In both of these respects, Laxton and Scott (2001) provide a useful starting reference.

As an important step in the procedure, we also examined how well the model performs over the historical sample. Given the nature and purpose of the QPM, prediction errors as such were of secondary importance in this analysis. If, however, we found that a particular equation gives systematically biased predictions, it might reflect omission of an important economic mechanism driving the results. We report the historical within-sample residuals in Figure 7 at the end of the chapter.

Finally, we also subjected the relevant equations to a 'curve fitting' technique in which the structural parameters were estimated using a least-squares (LS) method. The purpose of this exercise was to complement the analysis of the model's within-sample tracking properties by comparing the imposed parameter values with their free estimates. Results are given for each case in the tables below.

Calibrating the influence of monetary conditions on the economy

There are usually significant lags in the monetary transmission mechanism of most economies. This is addressed, in part, through the discrete lag in the effect of monetary conditions on the output gap. However, this does not end the matter. Laxton and Scott (2001), henceforth LS, suggests that the sum of the parameters on the real interest rate terms and the real exchange rate (d_1, d_2, d_3, d_4, d_5) in equation (5) should be small relative to the weight on lagged dependent variable (d_0). They report that for most economies the sum of coefficients on the monetary variables would lie somewhere between 0.10 and 0.40 and that $d_0$would likely lie somewhere between 0.75 and 0.95. We judge that the Czech economy has relatively high inertia, so we pick $d_0 = 0.9$, towards the top of the recommended range. For very open economies LS expect d_4 to be larger than the sum of coefficients on the real-interest-rate terms, and for fairly closed economies they expect the opposite. The economy of the Czech Republic is increasingly open, but newly so. We have decided to start with a coefficient of 0.15 on the exchange rate gap, and a sum on the interest-rate gaps of 0.25, with half the weight on the one-year rate and one-quarter each on the other two rate gaps. This gives us an overall sum of coefficients on the components of monetary conditions of 0.4, well below the value chosen for d_0, but at the upper end of the range suggested by LS. We choose a value at the high end of the suggested range based on the limited information from the one major half cycle we have experienced under the new regime. The evidence suggests that the influence of the monetary contraction was relatively strong.

As regards the calibration of the pass-through of the German cycle, we imposed the coefficient's value at 0.4. This is about the sum of the contemporaneous and AR(1) effects when we regressed the residuals on the estimates of the foreign output gap. It also corresponds to elasticity values found in other partial studies on sensitivity of domestic output on foreign demand.

We also estimated the relationship using LS where we imposed the relative weights of the real interest rate part of the monetary condition according to the above. The estimated pass through of the monetary condition index was indeed close to one, but within the index more weight was ascribed to the interest rate than the exchange rate channel. The relationship confirmed a very high persistence of the output gap (see d0 in Table 2), but showed lower correlation with the estimates of German output gap (see d5 in Table 2).

Table 2: Calibration of the link between monetary conditions and the output gap

Parameter	*d0*	*d1*	*d2*	*d3*	*d4*	*d5*
Value	*0.90*	*0.062*	*0.125*	*0.062*	*0.15*	*0.40*
Estimation	*0.92*	*0.048*	*0.095*	*0.048*	*0.05*	*0.21*

Calibrating the Link Between Product and Labour Markets

In economies with important hiring and firing costs, there are usually significant lags between output gaps and unemployment gaps. This suggests that the parameter on the output-gap term in the unemployment gap equation (6), f_1, should be small relative to the weight on the lagged dependent variable, f_0. Indeed, LS argue that for most economies f_1 will lie somewhere between 0.05 and 0.25 and that f_0 will lie somewhere between 0.50 and 0.95. We judge that the lags in the case of the Czech Republic are relatively long. We therefore choose a relatively high value of 0.9 for f_0 and a relatively low value of 0.1 for f_1. As the table below reveals, the chosen values are very close to free estimates of the relationship.

Table 3: Calibration of the link between unemployment and output

Parameter	F_0	f_1
Value	*0.9*	*0.1*
Estimation	*0.88*	*0.08*

Calibrating the Inflation Equations

The parameter α_0 in equation (4) measures the effects of imported price inflation on the core CPI. This parameter should be approximately the weight of non-energy imported goods in the CPI basket. LS suggest that as a first pass, the parameter be set within 0.05 of the best point estimate of this weight. We have set α_0 at 0.2484, which comes from an estimate of the overall import weight of 0.27, adjusted down by 8 percent to account for the weight of the excluded energy component. The parameter α_1 measures the effects of expected inflation and $(1-\alpha_0-\alpha_1)$ measures the effect of lagged inflation. LS are not very helpful regarding these parameters or how they should be determined, suggesting only that 0.5 should be considered an upper bound for α_1. These parameters are typically determined by considering the appropriate level of the "sacrifice ratio," which is meant to measure how costly it is to reduce the rate of inflation permanently. The weight on the forward-looking coefficient will be sensitive to the degree of credibility in the targeting system and the performance of the central bank. Higher values of α_1 tend to dampen economic cycles when the target is being met over the medium term, since agents see this through their own longer-term forecasts and, with less weight on the lagged value, positive shocks do not cumulate as much. In turn, this means that the central bank has to do less to credibly react to the shock, and so real cycles are less volatile. We have chosen a coefficient of 0.33 for α_1, well below the upper bound identified by LS. This gives a value for the coefficient on the lagged inflation term of 0.4216. We return to this discussion below. The last parameter quantifies the inflationary pressure given by the position of the economy in the cycle, lagged one quarter. Currently, we leave it at 0.5, which is a relatively strong link, but reasonable given the extent of the observed disinflation and estimates of the output gap.

The estimation of the parameters with the linear constraint demonstrates that the effects of imported inflation and business cycle position are in line with these estimates. However, estimation sets the relative effect of past versus expected inflation more in favour of the past inflation. This suggests that inflation in the past may have been more backward looking than we currently impose. The shift in this parameter appears, however, a reasonable assumption when the regime is still gaining its credibility.

Table 4: Calibration of the Phillips Curve

Parameter	α_0	α_1	α_2
Value	*0.2484*	*0.33*	*0.5*
Estimation	*0.2676*	*0.106*	*0.43*

We also estimated equation (14), albeit with an imposed 0.25 coefficient on the output gap, n_2. This is half the value assigned to the parallel coefficient in the core inflation Phillips curve, reflecting the assumption of a smaller effect of the cycle on pricing in the energy sector. The estimated coefficient on the energy-import inflation term, n_0, is 0.28, which is about the same as the coefficient on non-energy import price inflation in the core Phillips curve. The weight on the expectations term estimates at about 0.5, which is at the upper end of the LS recommendation for this coefficient in normal Phillips curves. In this context, this means that general inflation will pass relatively quickly into domestic energy prices.

Table 5: Calibration of the energy price Phillips curve

Parameter	n_0	n_1	n_2
Value	*0.28*	*0.5*	*0.25*

Calibrating the Term Structure Equations

There are two term-structure equations in QPM, one linking the one-year rate to the 90-day rate (equation (10)), the other linking the 3-year rate to the 90-day rate (equation (11)). They both have the structure of equation (10). The coefficient j_1 reflects how close to the pure theory of the term structure under model-consistent expectations we want to be. One would expect this coefficient to be smaller for shorter-term rates and larger for longer-term rates. Most central bank models set this parameter fairly low, even for longer rates, reflecting evidence that rates tend to move together more than would be expected from "rational" expectations. This is again an issue that highlights the importance of credibility to dynamic properties. Consider a shock that raises inflation above the target. We know that the central bank must raise the short-term rate to signal that the inflation target will be respected. If the policy regime has credibility, longer rates may not move much, especially if the shock is perceived to be transient.[29] We set the one-year rate, j_1, at 0.15, putting a weight of 0.85 on the short rate. We believe that this is a reasonable starting point, based on the evidence from the half cycle. For the three-year rate, we set p_1 in equation (11) at double this value, 0.3, which still leaves a substantial weight of 0.7 on the short rate. The constant in the equation reflects a risk or term premium associated with the particular instrument. This is set based on the evidence from the historical residuals of the equation. For the one-year rate, which we measure using a government security, we need a small constant, 0.25 (one quarter of a percentage point), but for the three-year rate, which we measure from data for rates on newly issued credit in the private market, the premium is much higher, 2.5 percentage points.

Table 6: Calibration of the term-structure equation

Parameter	p_0	p_1	j_0	j_1
Value	*2.5*	*0.3*	*0.25*	*0.15*

Calibrating the UIP Equation

There is just one parameter to pick in the UIP equation, g_0, the weight on the expected exchange rate. LS offer no guidance on this choice. The higher is this coefficient the more volatile will be the exchange rate in simulation, and in the limit as the coefficient goes to 1, the exchange rate becomes a pure "jumper" variable.[30] We have set the coefficient at 0.5.

Table 7: Calibration of the UIP equation

Parameter	g_0
Value	*0.5*

[29] In contrast, if the shock leads to doubt about whether the target will be respected and longer-term inflation expectations are revised up, then longer-term interest rates will move by more.

[30] To review this issue, see the discussion in the sections above on the logic of putting a lag in this equation.

Calibrating the Equations for Import Price Inflation and Energy Price Inflation

We estimated equations (12) and (13) using data from 1995Q1 to 2000Q1. The results seemed reasonable, so we accepted them for the model, with the exception of parameter h_1, which we impose at 0.9, which imposes strong pass-through of oil price shocks into energy import prices. In equation (11), the equivalent parameter linking non-energy import prices to German CPI inflation is estimated at 0.58; this coefficient should be considerably lower than the value for energy imports, so we are content to accept these results as plausible for now. The two estimated error-correction coefficients also seem plausible. For the non-energy equation we have k_2 at 0.52, which means that for a 1 percentage point price-level "error", the rate of change will rise by 0.52 points at annual rates, or 0.13 points at quarterly rates. For the energy equation, we obtain a slightly higher estimate, 0.67.

Table 8: Calibration of the import price equations

Parameter	h_1	h_2	k_1	K_2
Value	*0.9*	*0.67*	*0.58*	*0.52*

Calibration of the Reaction Function

Calibration of the reaction function normally comes from studying model properties, particularly the nature of cyclical responses to shocks. If, for example, the parameter on the difference between the forecast of inflation and the target rate is set very high, meaning that monetary policy is extremely aggressive in responding, the economy may be hit very hard and inflation may overshoot, with a lot of secondary cycling. Too little response may imply unrealistically long adjustment periods. Tension is created by the lag on the short rate in the reaction function. One way of thinking about the lag is to consider the structure as a response to uncertainty regarding the measures and the reasons for the disequilibrium. If we call the term with weight $(1\text{-}m_0)$ the "desired" rate setting under the assumption that the shocks are long-lasting so that the gaps remain open, the partial response of $(1\text{-}m_0)$ of this effect reflects the caution of wanting to avoid over-reacting to a temporary disturbance. As time goes on, the response builds if the disequilibrium remains.

We have started with a fairly aggressive formulation of the "desired" response, setting m_1 at 5 and m_2 at 1. We set m_0 at 0.5, so that about 94 percent of the "desired" response would come within a year.[31]

Table 9: Calibration of the reaction function

Parameter	m_0	m_1	m_2
Value	*0.5*	*5*	*1*

PROPERTIES OF THE QPM

The best way to communicate the properties of a model is to provide a number of illustrative simulations of the model's solution for the response of the main macroeconomic variables to specific shocks, considered in isolation. "In isolation" means two things here. The shocks are generally considered one at a time, and they are entered as one-time shocks or shocks of brief duration. We also start with a baseline solution of the model in equilibrium. The task is to describe the shock-control properties of the model's response to the shocks.

[31] This is an active area of research and discussion. We are considering other calibrations with less aggressive response.

In reality, shocks do not arrive one at a time, and they do not arrive with everything in equilibrium. That is one reason why doing a forecast with a model is a very different and more difficult exercise. To study model properties, however, it is helpful to keep things as simple as possible and look at one issue at a time. Moreover, although model properties can, in general, depend on the conditions in the control solution, this early version of our model is linear, and the shock-control properties in a linear model are essentially independent of the control values.

A Policy Choice to Reduce the Target Rate of Inflation

In this experiment, the authorities decide to lower the target rate of inflation by one percentage point. We start with inflation at one target level and then introduce a new target, one percentage point lower.

Figures 1a and 1b show what happens in our model, given the base-case calibration. The units are percent or percentage point, shock-control, depending on the variable. In the first panel, we show the 90-day interest rate and the DM exchange rate. To achieve the desired disinflation, the CNB must raise the short rate by about 0.7 percentage points initially (Figure 1a, panel 2; Figure 1b, panel 4). This triggers an appreciation of about the same amount in the first quarter. Note that through the term-structure equations, longer-term interest rates also rise, but by much less than the short rate (Figure 1a, panel 3).

Import prices begin to fall quickly (Figure 1a, panel2). The higher rates and appreciated currency act to reduce aggregate demand, and a negative (excess supply) output gap begins to open. The lags and inertia in the system imply that the initial effect on output is small, but this gradually builds so that after one year the output gap bottoms at about -0.5 percent (Figure 1a, panel 4). The model has been calibrated to reflect substantial inertia in labour markets and important lags between unemployment and excess demand. This is shown clearly in Figure 1a, panel 4. Initially, unemployment responds very gradually to the emerging excess supply. The relative shock-control effect is muted, but more long-lived than for the output gap.

The combined effect of the import price decline and the excess supply gap works to gradually pull down the rate of inflation. There is considerable inertia in the inflation rate, however, and it takes over two years to get the bulk of the reduction and about three years to approach the new target.

After the first quarter, the CNB must begin to lower rates. By the end of the first year, the short rate is slightly below control, as there is sufficient latent disinflationary pressure embodied in the output gap by that time to provide for eventual achievement of the desired new target. In the exchange market, the lags act such that appreciation continues, despite the small reduction in rates in the second quarter, but then the exchange rate turns and slowly returns to its initial control level, albeit with some low frequency overshooting.[32] Note that since this is a purely nominal shock, and since the model is super-neutral, there is no change to any real equilibrium in this shock, including the real exchange rate. The nominal exchange rate changes, of course, with the cumulative change in the relative price levels, as does the equilibrium rate of change of the nominal rate, owing to the new, lower domestic inflation rate. This is shown in panel 2 of Figure 1b.

In the end, all inflation rates are lower by the desired one percentage point (Figure 1a, panel 2; Figure 1b, panel 3), and domestic nominal interest rates are all one percentage point lower (Figure 1a, panel 3; Figure 1b, panel 4).

[32] Note that this causes a small cycle in trade price inflation overlaid on the transition to the new, lower level.

Panel 1 of Figure 1b shows the cumulative effects of the disinflation on output and employment. In the end, the cumulative output gap is about 3; this is what is called the "sacrifice ratio" in the model, because it takes a cumulative loss of output of 3 percent of one-year's potential output to lower inflation by a percentage point.[33] The equivalent number for the labour market is 2. These numbers are similar to those seen in other models of industrial economies.

A Shock to Aggregate Demand

The disinflation shock is an example of analysing what happens when a policy authority decides to change something. Most shocks that must be dealt with in a forecast are those that arise elsewhere and necessitate a response from the central bank to respect the inflation target. This next shock is perhaps the quintessential example, a shock to aggregate demand. We study the effect of a one-percentage-point positive shock to the output gap, which lasts just one quarter, under the assumption that the central bank knows immediately that the shock has occurred. The shock will put upward pressure on inflation. The job of the central bank is to raise the short-term interest rate to fight against the inflation pressure. We see that because the central bank knows of the shock and reacts immediately (Figure 2a, panel 3; Figure 2b, panel 4), the effect of an appreciating currency on inflation through import prices comes very quickly and indeed sends inflation below control for one quarter before the direct effects of the higher demand emerge (Figure 2b, panel 3). It is an interesting question as to whether this aspect of the properties of the calibrated model is reasonable. If it is judged to be a fair reflection of reality, then communicating actions in the face of a demand shock will be made more difficult, since the real problem is not seen in terms of inflation until the next quarter. In any case, this result illustrates well the importance of forward-looking analysis in discussions of policy actions. In this case, it would be crucial to stress the logic of the link between excess demand and inflation and the importance of lags in the system.

Despite the strong monetary response, there is eventually some inflation relative to control (Figure 2b, panel 3), and some permanent upward drift in the price level (Figure 2b, panel 2). It is important to remember that the policy rule is specified in terms on the rate of inflation. There is nothing in the policy rule that calls for a response to the effects of shocks on the level of nominal variables. In all shocks there will be some permanent effects on all nominal levels, including the exchange rate (Figure 2b, panel 2).

In this shock, the cumulative effect on output is very close to zero. This is a feature of linear models; to control inflation in the face of demand shocks, the integral (cumulative sum) of the output gap will be close to zero, meaning that there has to be equal and offsetting periods of excess supply to counteract the effects of shocks that create excess demand (Figure 2a, panel 4, Figure 2b, panel 1).

Delayed Monetary Response

In the next shock, we ask what happens in the case of the same shock to aggregate demand as considered above, but now with a delay in the monetary policy response.[34] Short-term interest rates are fixed at the control level for four quarters and then freed to respond normally. In this case, without the strong immediate import-price effect, there is substantially more build-up in inflation; indeed, we see almost double the effect at the peak (Figure 6, panel 1). Therefore, the central bank has to do more when it does respond; interest rates rise correspondingly more (Figure 6, panel 2). The resulting cycles are more pronounced; for example, the secondary contraction of the output gap is more extreme (Figure 6, panel 4). The cumulative effects on nominal values are more extreme, of course (Figure 6, panel 3).

[33] It is important to note that this is a purely cyclical measure of the welfare loss associated with disinflation from a model that is structured to assume that nominal levels and rates of change do not affect real equilibrium values. A complete welfare analysis would have to add any real benefits that might come from a permanently lower rate of inflation.

[34] This shock was simulated using a later version of the model than the rest of the analysis, so there are some differences in the results for the case of immediate response.

This experiment provides a useful reminder that the role of monetary policy is to respond to shocks to keep inflation anchored to the target. It makes no sense to hold interest rates fixed in a forward-looking model like this, because without the monetary response to anchor the solution, there will be a rapid increase in inflation expectations. If delay is too long, the model will cease to solve, reflecting the fact that without the actions of the monetary authority there is no nominal equilibrium if agents are forward-looking.

A Shock to the Exchange Rate

Next we consider a shock to the exchange rate, coming from something like asset preferences, not anything directly in the macroeconomic system. Again, it is a blip shock, on for just one quarter and then off. The shock is a one percent depreciation in the nominal DEM/CZK rate, which, because of sluggishness in price response, is essentially the same shock in real terms. This shock is inflationary through two channels. The depreciation acts to increase aggregate demand, opening a positive output gap (Figure 3a, panel 4); but this effect is relatively small. Quantitatively more important is the effect of the depreciation on imported goods prices, and the pass-through of this into general inflation (Figure 3, panel 2).

The central bank must raise the short-term interest rate to resist the inflationary pressures. In this case, it takes roughly a 70 basis point increase in the nominal rate for two quarters (Figure 3a, panel 3), which is slightly less in real terms (Figure 3a, panel1). After that, the rate can come down again, albeit faster in real terms than in nominal, owing to the lingering inflation. Although the shock is off by the second quarter, there is some persistence of its effects in the exchange market; the real exchange rate remains above control for a year. The interest rate response is sufficient to reverse the immediate direct effects of the depreciation on the output gap by the second quarter, and a larger negative gap opens up. This, plus the reversal of most of the import-price effect, is sufficient to return the rate of inflation to control over two years. An important feature of the QPM calibration is that there are long lags in the inflation process.

In this case, the cumulative output gap is positive. A long secondary cycle with small amounts of excess demand is sufficient to offset most of the effects of the monetary response, and we are left, in the end, with a cumulative effect of much the same magnitude as the initial effect of the shock. There is not much movement in unemployment in this shock.

Since the policy anchor is on inflation, and no weight is given to temporary drift in the price level in the reaction function, any shock like this one that temporarily raises inflation will have permanent effects on the price level and the nominal exchange rate (Figure 3b, panel 2).

A Shock to Regulated Prices

In this shock, regulated prices are raised gradually over a year, such that the 4-quarter rate of increase rises linearly to 1 percentage point and then falls linearly back to zero, relative to control (Figure 4b, panel 3).

The goal of the central bank in this shock is to prevent the increase in regulated prices from spilling over into general inflation. To do this there must be a rise in interest rates (Figure 4b, panel 4). In this shock, the power of the exchange rate mechanism on import prices is there and working (Figure 4a, panel 2), but it is not sufficient to offset the direct effects of the shock on the overall CPI. Note, however, that inflation in the net CPI falls below control. To prevent the effects of the increase in regulated prices from creating generalized inflation, there has to be relative price declines elsewhere to offset the relative price increase in the shock.

A Shock to Prices

In this shock, we suppose that there is a negative shock to prices, directly, in the form of a negative one-percentage-point shock applied to the residual in the Phillips curve.[35] Again, we assume that the central bank knows the shock immediately and responds without delay. To respond to this negative shock to prices, the central bank cuts the short-term rate by about 150 basis points for two quarters, and then begins to move rates back towards control levels.

The initial effect of the shock on inflation is largely offset by the effect on import prices of the depreciation of the koruna that follows from the cut in interest rates (Figure 5a, panels 1 and 2). Thereafter, the influence of a relatively substantial positive output gap begins to be felt, further limiting the fall in general inflation (Figure 5a, panels 4 and 2).

The lingering power of this shock is revealed by the fact that despite the substantial monetary response, and the opening of a persistent output gap, which peaks at close to 1.5 percent, inflation still falls for a while, approaching though not quite attaining, the size of the initial shock. In this case, there is a substantial permanent gain in output (Figure 5b, panel 1).

The initial depreciation of the exchange rate is eventually reversed as the policy task becomes one of limiting the effects of the excess demand. There is some overshooting necessary, in the sense that the real short-term rate has to be raised relative to control for a short time in the secondary cycle (Figure 5a, panel 1). There is a corresponding cycle in the real exchange rate, while the nominal exchange rate must overshoot more, reflecting the permanent effect of the downward drift in the domestic price level (Figure 5b, panel 2).

[35] This shock is sometimes described as a supply shock, in that prices move as they would in response to a shift in an aggregate supply curve. Indeed, some theoretical models motivate the Phillips Curve from a framework that leads to this interpretation. However, it is important to distinguish this direct shock to inflation from a shock wherein potential output changes.

Figure 1a: Disinflation Shock (reducing target rate of inflation)

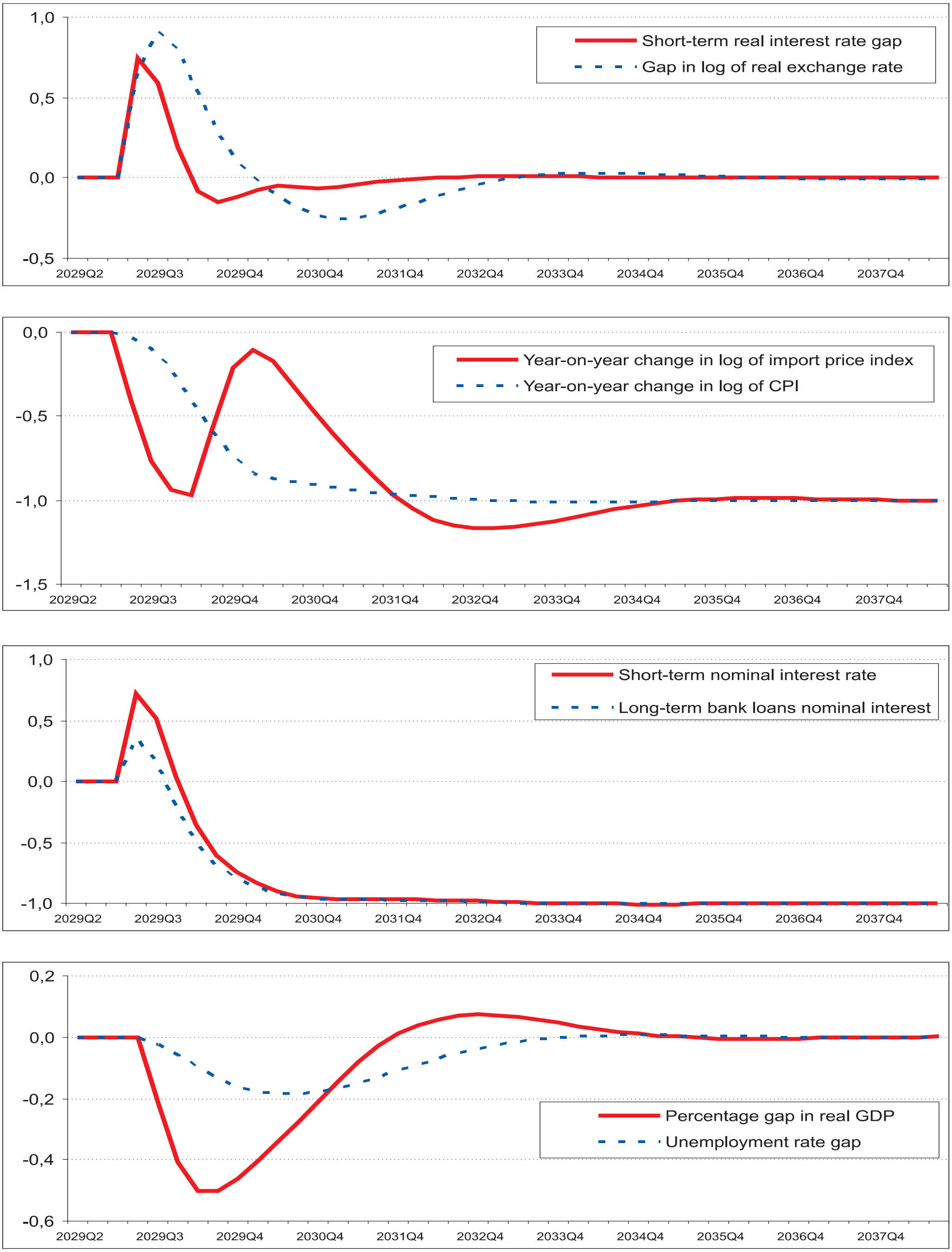

Figure 1b: Disinflation Shock (reducing target rate of inflation)

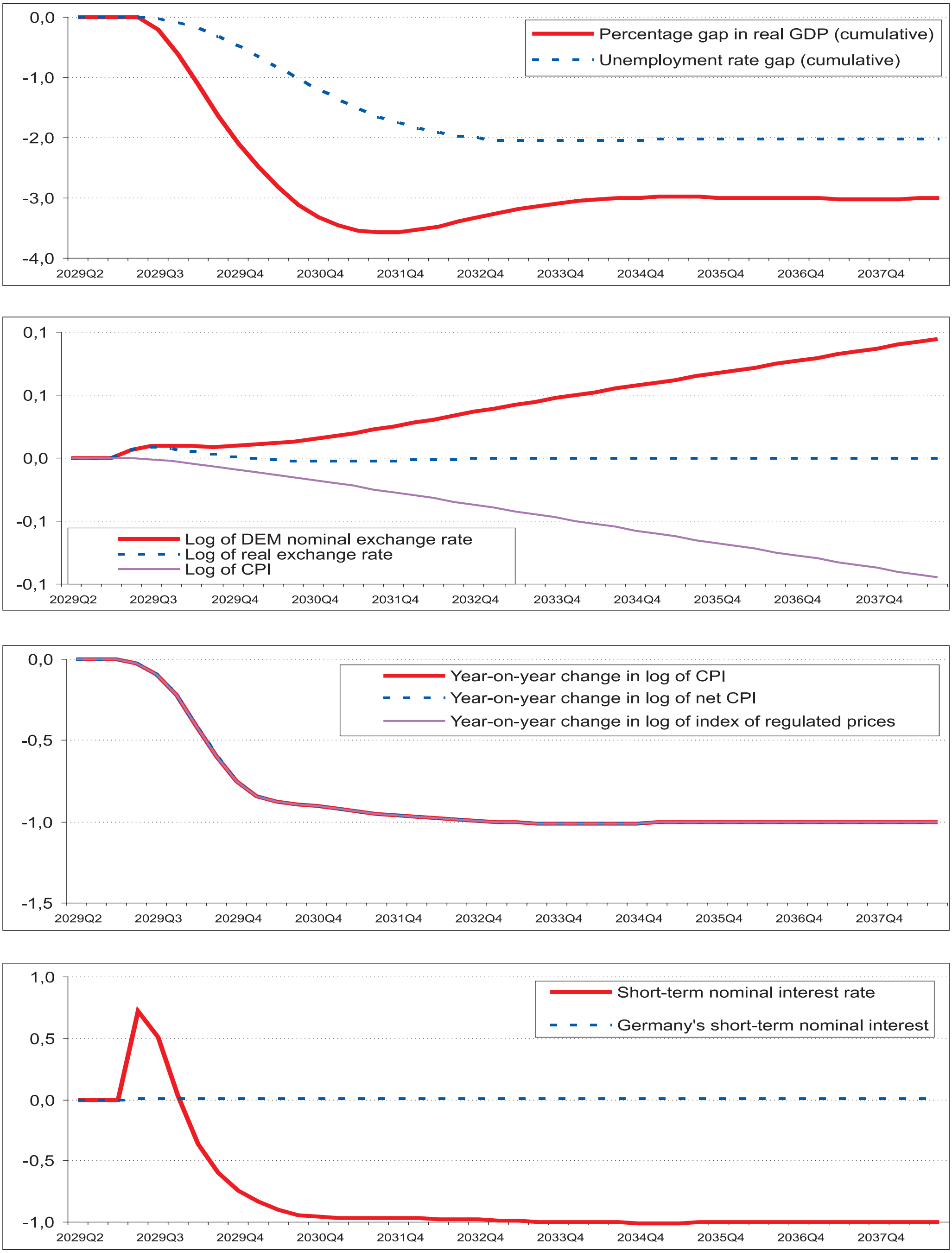

Figure 2a: Aggregate Demand Shock

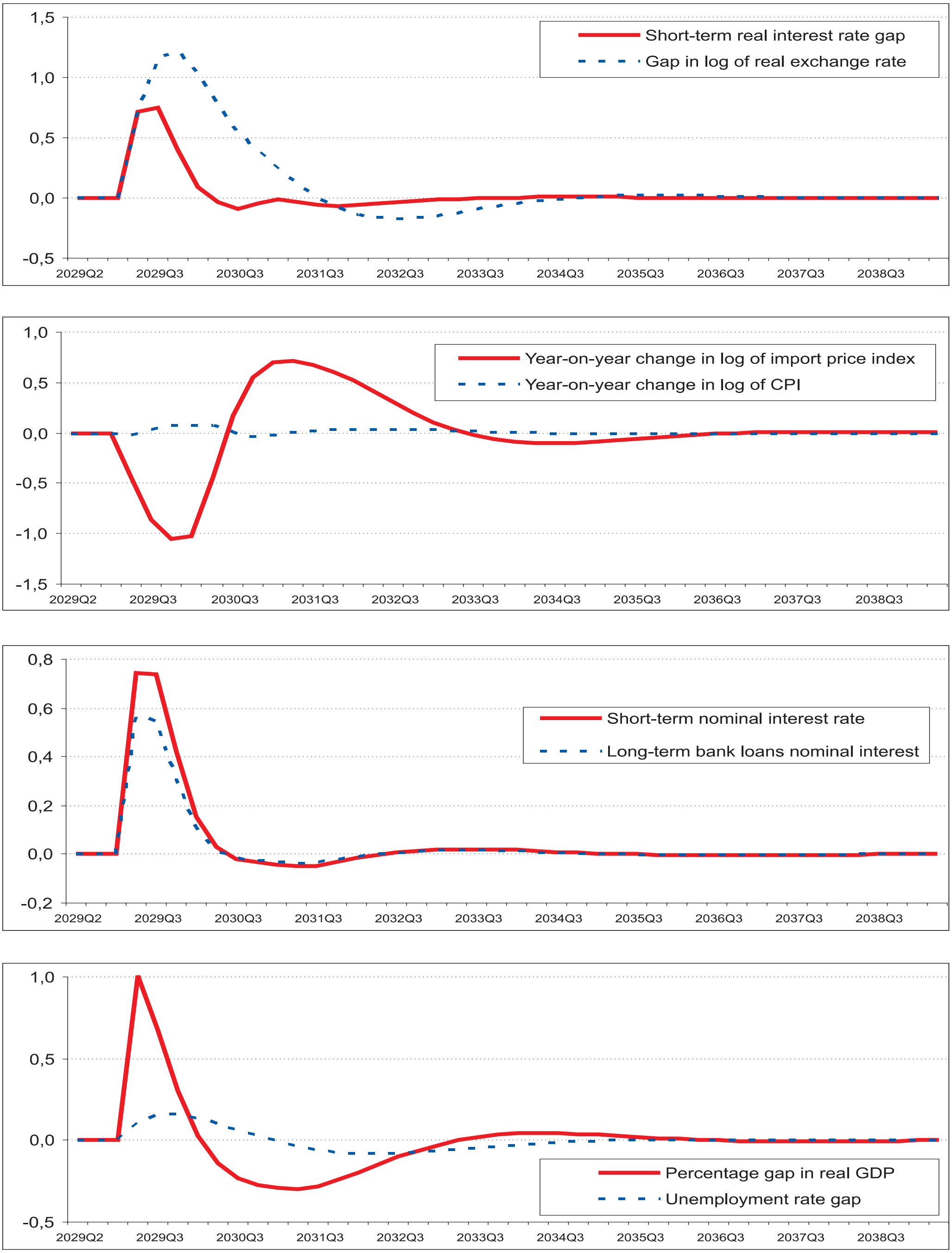

Figure 2b: Aggregate Demand Shock

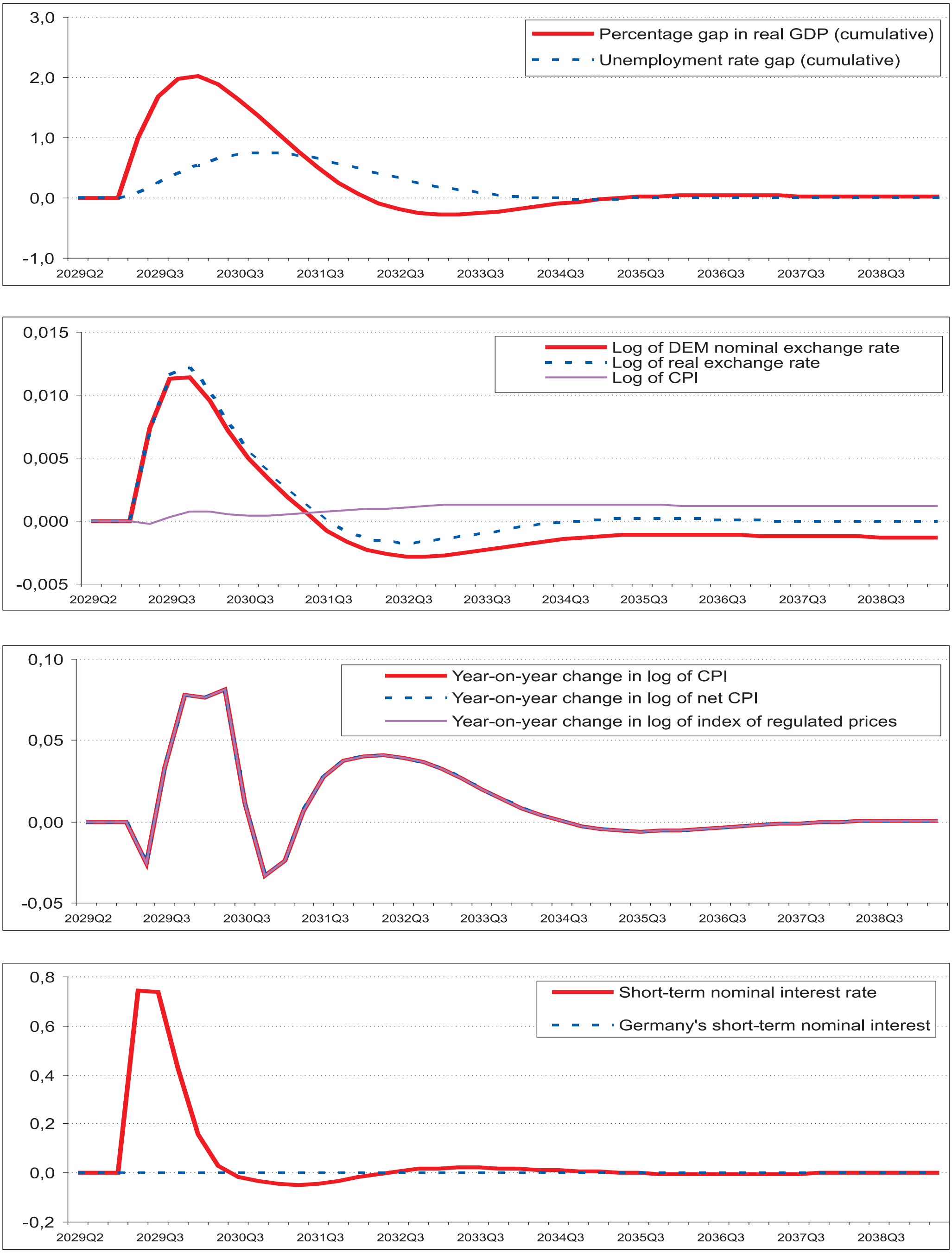

Figure 3a: Exchange Rate Shock

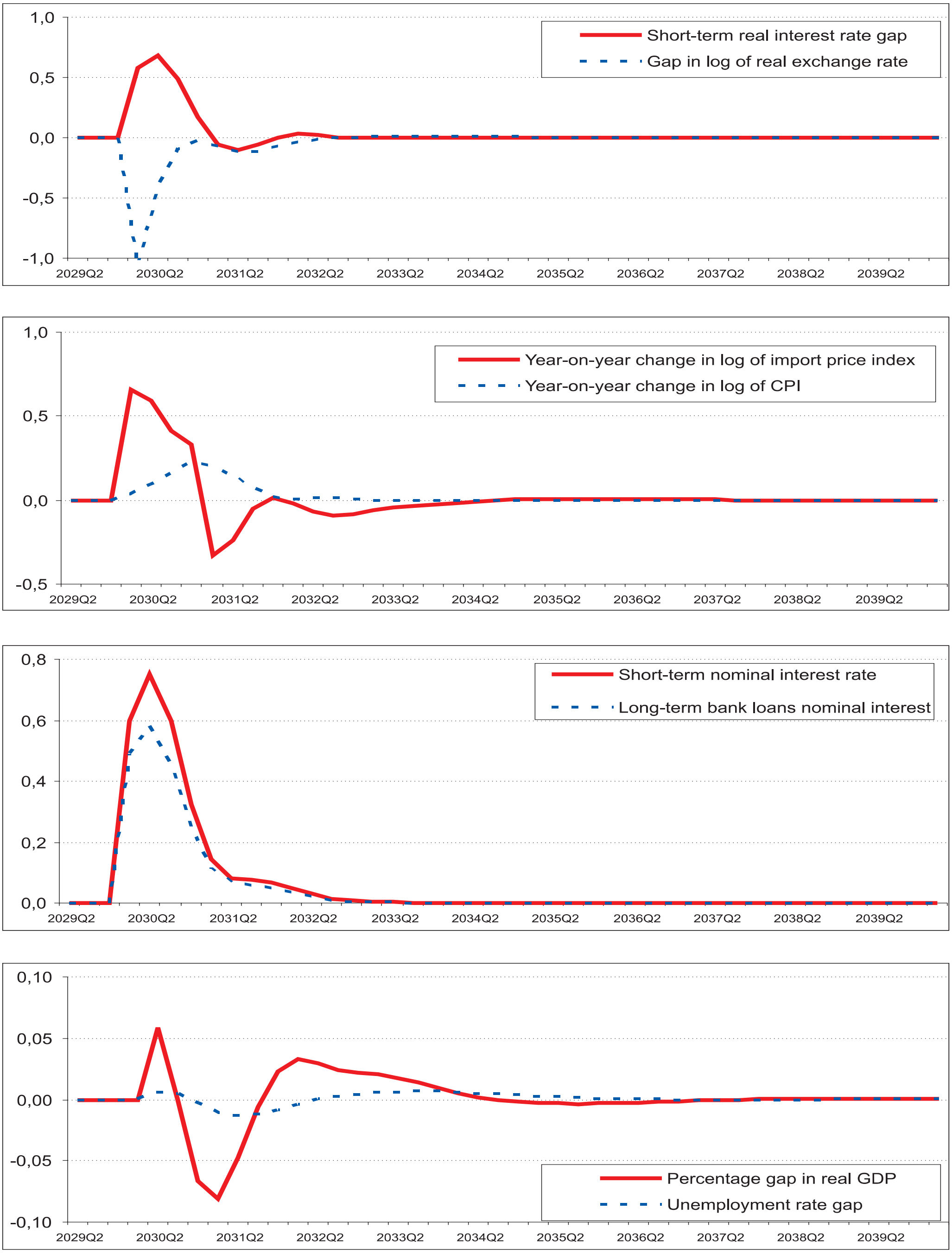

Figure 3b: Exchange Rate Shock

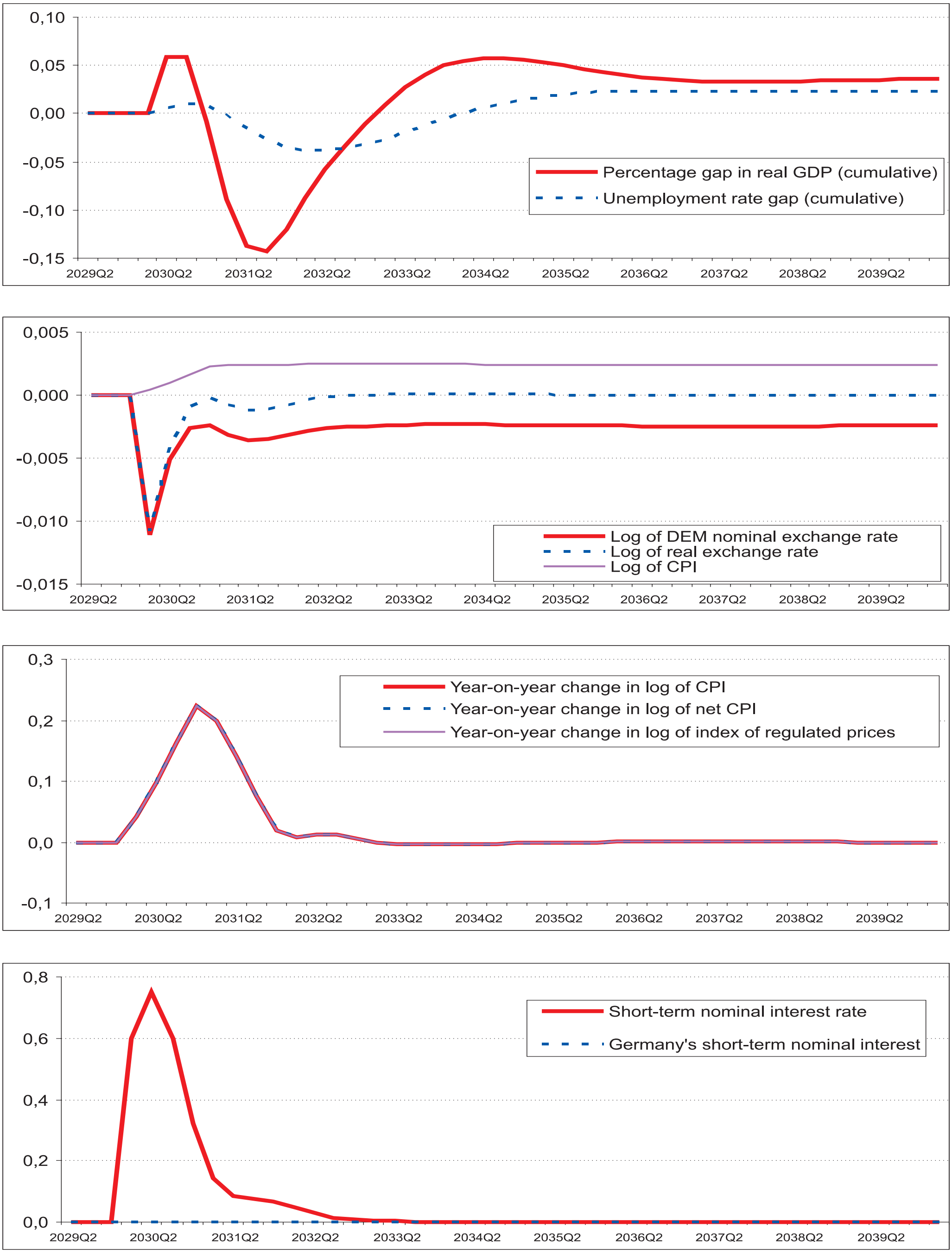

Figure 4a: Regulated Prices Shock

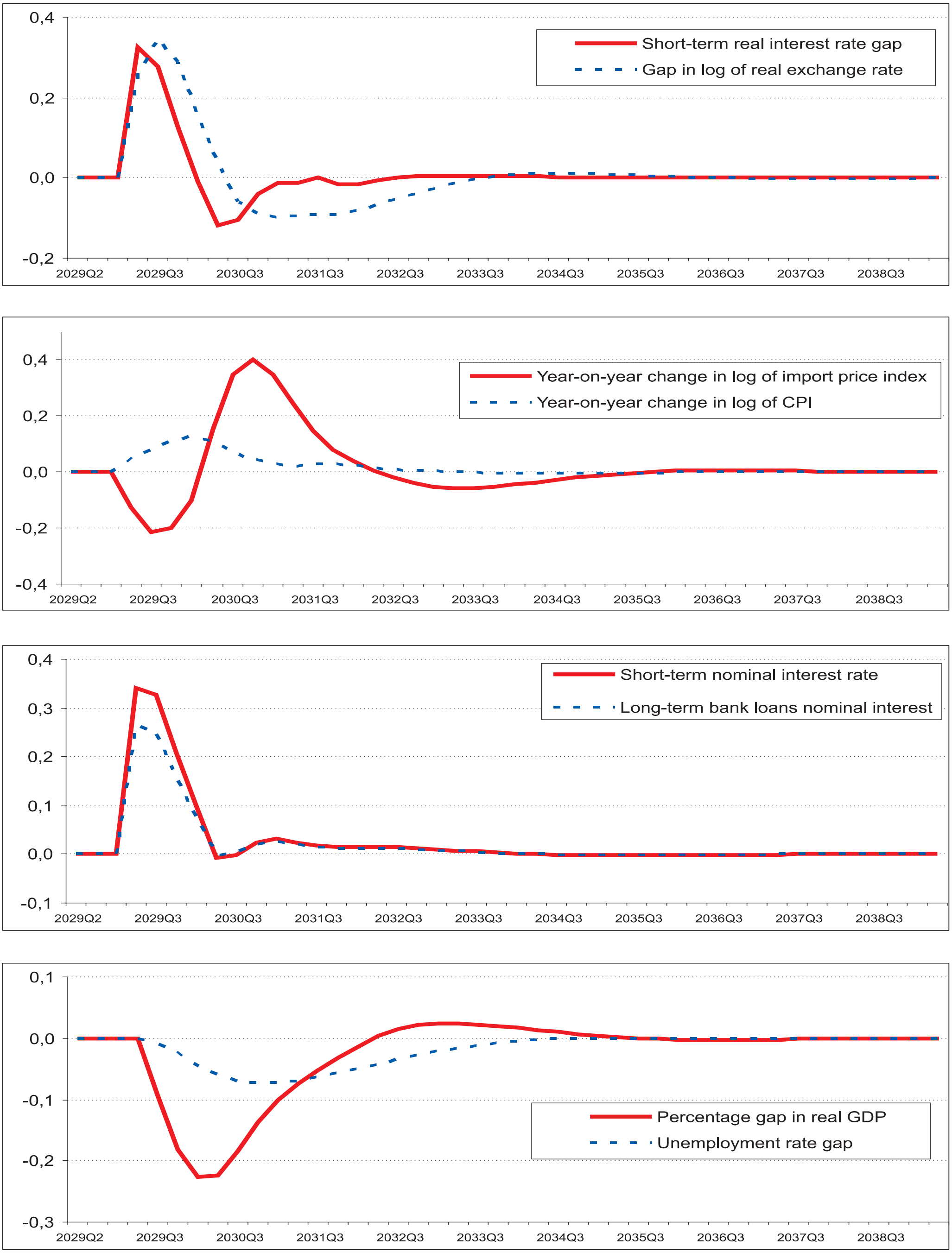

Figure 4b: Regulated Prices Shock

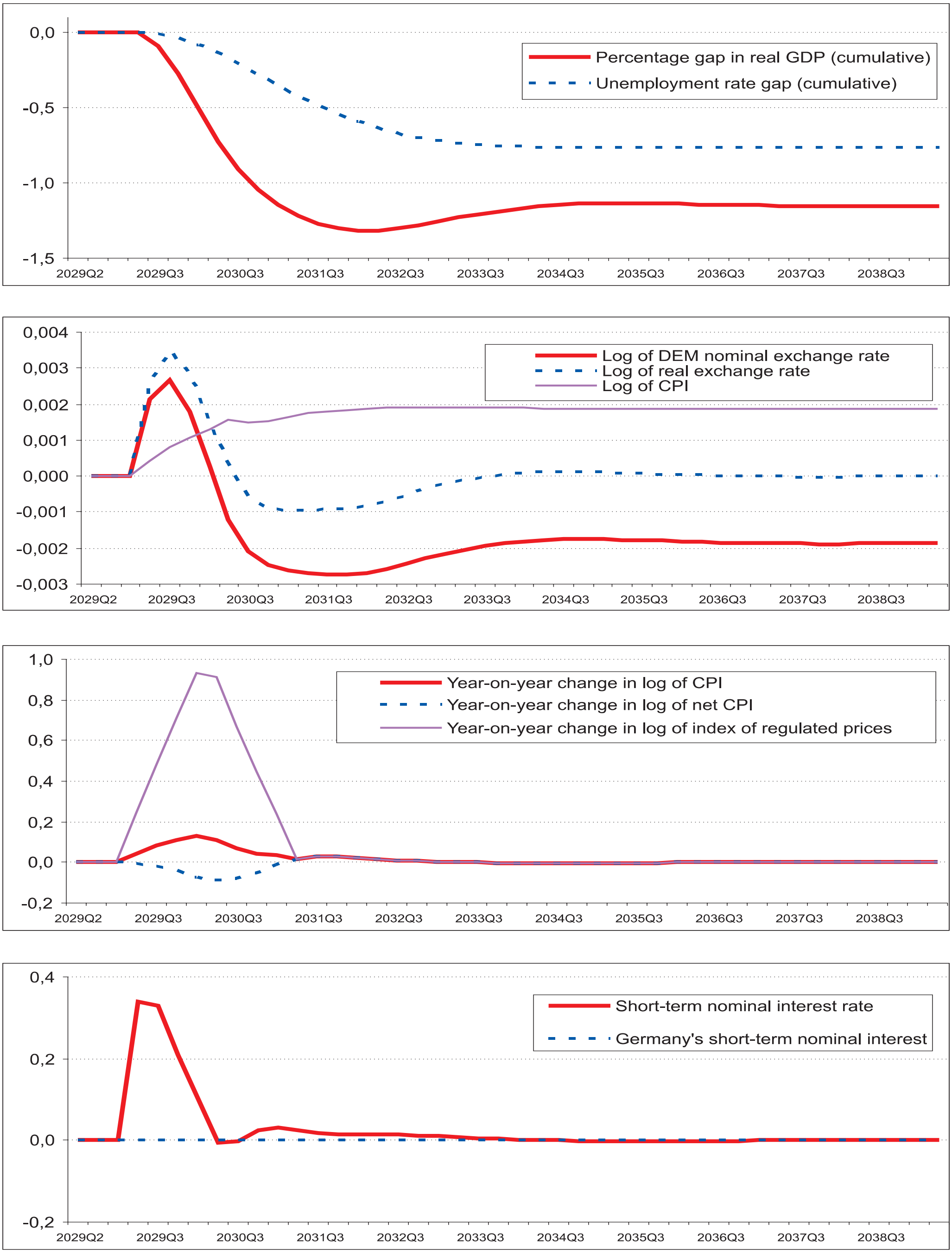

Figure 5a: Aggregate Supply Shock

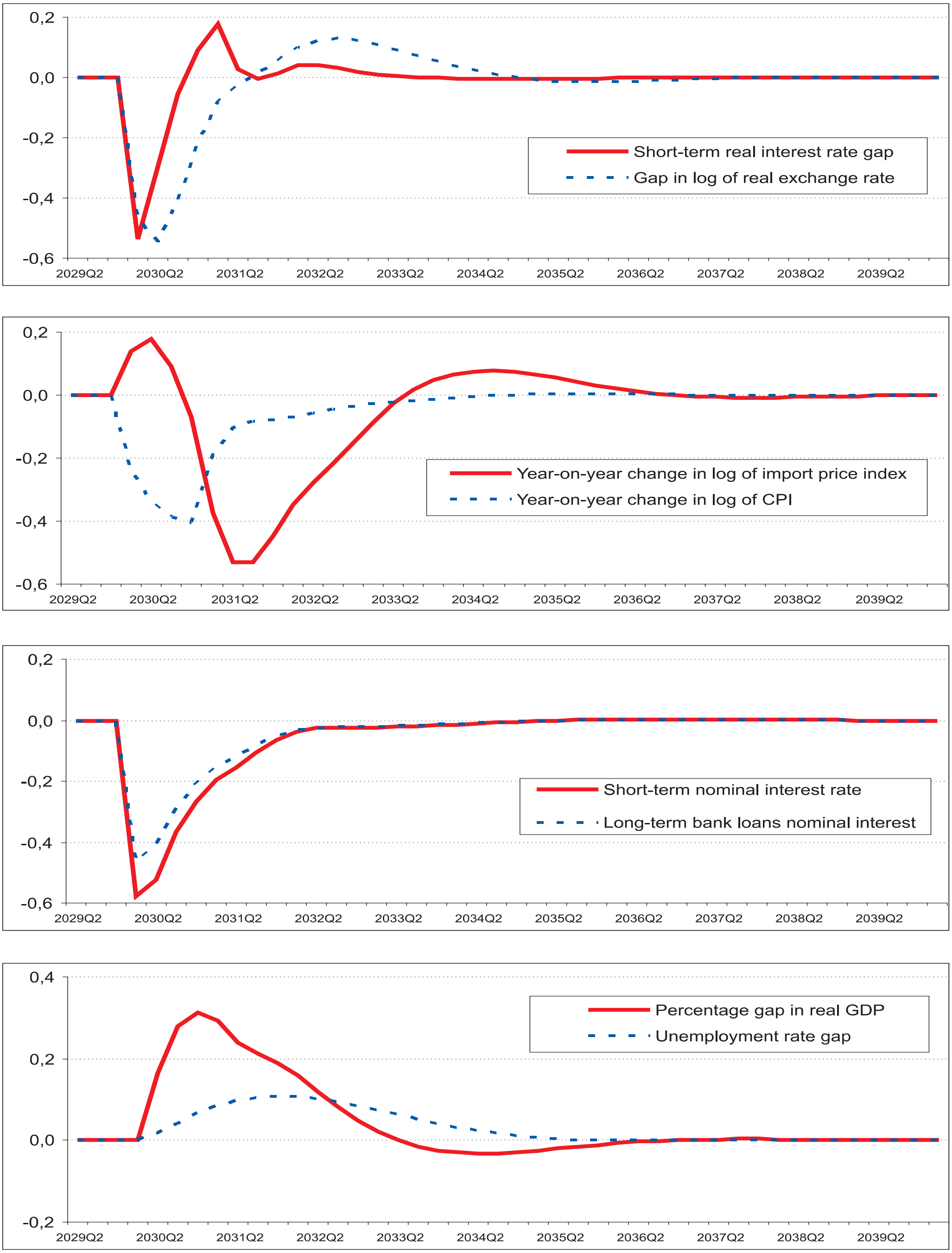

Figure 5b: Aggregate Supply Shock

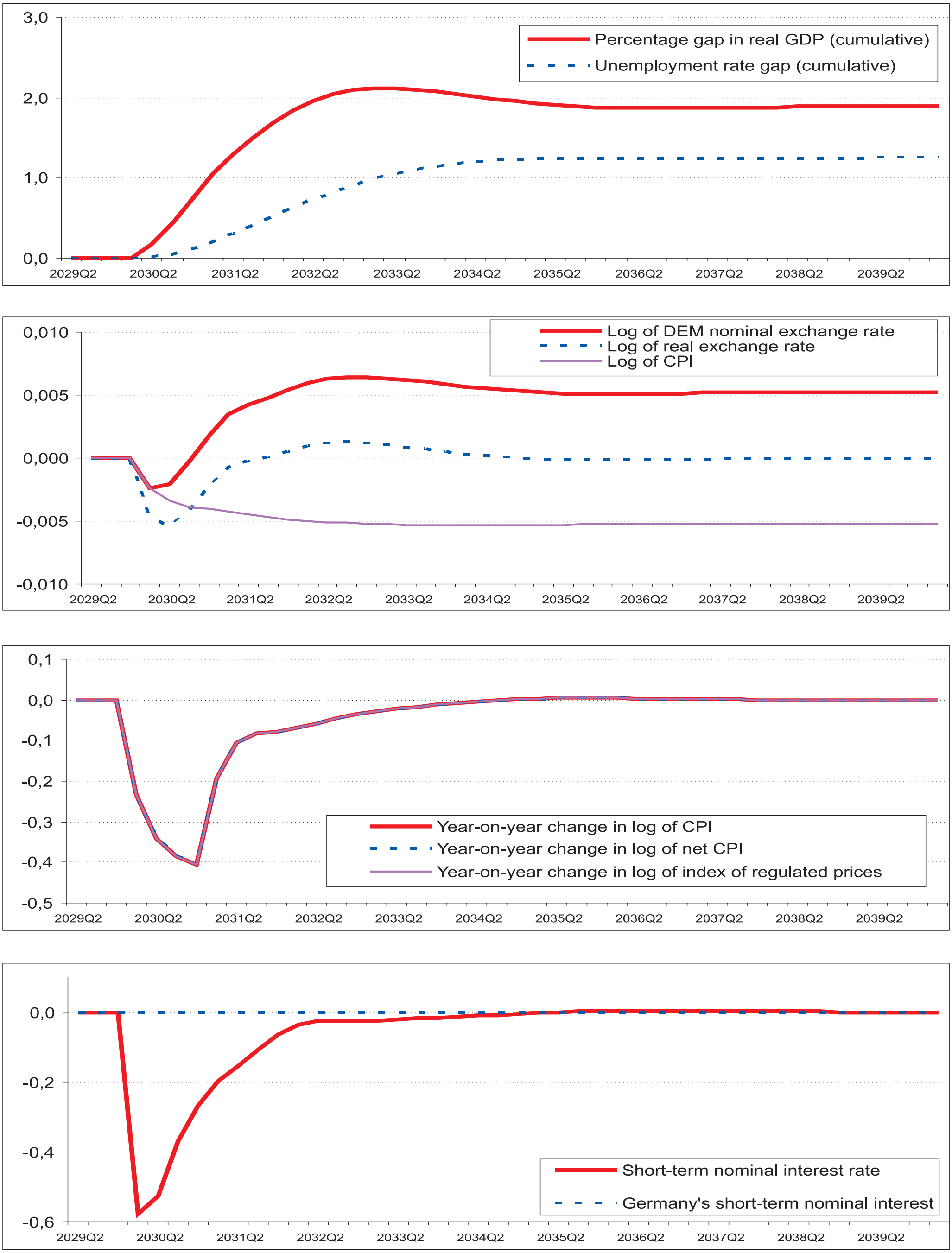

Figure 6 : Demand Shock with Delayed Response

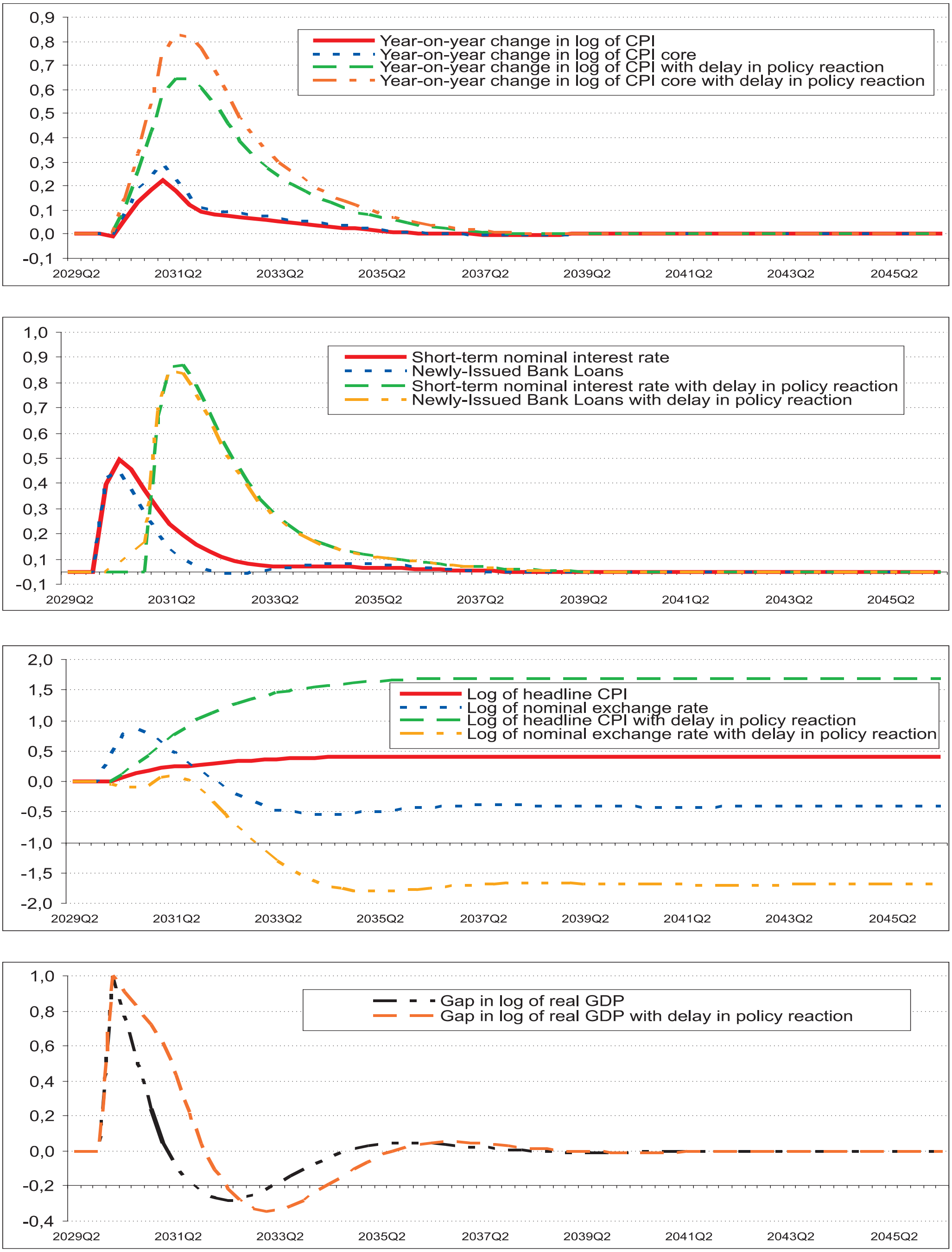

Figure 7 : Within Sample Historical Residuals of the QPM