

Developments in monetary economics and central bank practice

The monetary policy advice that economic theory, empirical research, practical experience and models provide for central banks has become much more consistent. This article discusses the advances made over the past two decades, especially within monetary economics, and how it has established a firmer footing for central banks' monetary policy in many countries. New Keynesian economics plays a key role in this development and a fairly broad consensus on this approach has been achieved in recent years. However, many questions remain unanswered and new Keynesian economics will clearly continue to evolve in the near future. One challenge has been how to adapt it to the open economy. These developments in economics have had an impact on central bank practice, including activities of the Central Bank of Iceland. Greater transparency in monetary policy-making and communication, a shift away from individual interest rate decisions towards the medium-term policy rate curve and enhanced forecasting methods all reflect advances in new Keynesian economics. There is a growing emphasis that monetary policy should be systematic, credible and transparent in order to maximise its effect on inflation expectations.

Introduction

Central banks take four main factors into account in formulating their monetary policy. First, the latest economic theories at any time. Second, empirical research results on e.g. the transmission mechanism of monetary policy and determinants of inflation. Third, practical experience from monetary policy-making, and finally, forecasts of models that aim to reflect all three. All these fields have been flourishing recently. Rapid advances have been made in macroeconomic theory, especially in the field of monetary economics. Extensive research has been made into the transmission mechanism of monetary policy, properties of inflation and optimal monetary policy design. Central bank measures appear to have succeeded in recent years in maintaining a low rate of inflation in spite of robust growth and high oil prices. However, views still differ on the reasons for low inflation and whether monetary authorities actually deserve most of the credit for it (see e.g. Rogoff, 2006). Also, a new generation of models has appeared incorporating theoretical advances, empirical research and practical experience.

Much more convergence has now been established between the lessons on central bank monetary policy objectives, design and communication that are offered by the different foundations of monetary policy, i.e. theory, empirical research, practical experience and modelling. Nonetheless, they are not completely consistent. Many questions remain to be resolved, especially concerning the monetary framework in a small open economy such as Iceland. While it is important to be

1. The author is an economist at the Central Bank of Iceland Economics Department. He would like to thank Arnór Sighvatsson, Ásgeir Danielsson, Thórarinn G. Pétursson, Ragnhildur Jónsdóttir, Karen Vignisdóttir, Tómas Örn Kristinsson and participants at a Central Bank of Iceland seminar on May 23, 2006 for useful comments. The author alone is responsible for any errors or omissions. The opinions expressed in this article are those of the author and do not necessarily represent the views of the Central Bank of Iceland. Part of this article builds on a recent working paper by the author, The New Keynesian Phillips Curve: In Search of Improvements and Adaptation to the Open Economy, *Central Bank of Iceland Working Papers* No. 31.

aware of the footing that this greater consistency has provided for monetary authorities, it is also vital to discuss how far this compatibility extends, review the remaining bones of contention and steer research towards them.

Foundations of monetary policy in a closed economy

Due to the wide gulf around twenty years ago that separated economic theory, research and models from actual practice, central banks operated in a partial theoretical vacuum at that time. Modern monetary policy, on the other hand, is based on a fairly firm theoretical and empirical foundation which presents quite consistent advice for policy making. Although this convergence spans a period of at least two decades, developments have been very rapid in recent years. Four parts may be identified in this convergence.

First, advances in macroeconomics and monetary economics have aligned theory more closely with central banks' ideas of the importance and effectiveness of monetary policy. Second, changes in the framework, communication and design of monetary policy-making have also impacted theory – the introduction of inflation targeting is probably the clearest example. Third, the focus of research has increasingly shifted towards central bank tasks. Finally, model design has been reshaped in light of new knowledge. Academic economists and central bank experts now work closely together on developing new Keynesian general equilibrium models. These four points are discussed in more depth below.

Theory

Over the past two decades, macroeconomics has evolved from a divided field, which in many ways lacked a solid foundation, into a more comprehensive discipline built on a fairly firm microeconomic foundation. The quest for this microfoundation was most intense about twenty years ago. Keynesian models, which dominated macroeconomics in its heyday in the 1950s and 1960s, were derailed by the great inflation of the 1970s and fierce criticism from economists such as Edmund S. Phelps (1967), Milton Friedman (1968) and Robert E. Lucas (1976). Real business cycle theory, which dismissed the role of monetary policy, enjoyed an ascendancy within macroeconomics at this time. Its models assume perfect competition and flexible prices and wages, and that the economy is always in equilibrium. The economy moves from one steady state to another through the agency of shocks originating in technological advances, preferences or fiscal policy. This view was sharply at odds with central bank experience and empirical research which demonstrated that wages and prices were sticky. Nonetheless, academics increasingly championed the view that central banks should not act because their activities had little impact and did more harm than good. At most it was recognised that an unexpected change in monetary policy could have some impact.

In recent years a fairly broad consensus has been reached on the new Keynesian approach. New Keynesian economics reconciles the general equilibrium approach of the real business cycle school with the

clear role of rigidities advocated by Keynes and Phelps. The general equilibrium approach derives the equilibrium conditions from the optimisation problem of forward-looking households, firms and fiscal and monetary authorities in conditions of uncertainty. It consolidates the economic foundation of new Keynesian models compared with their predecessors and provides them with some defence against the Lucas critique.² The existence of various kinds of rigidities, e.g. imperfect competition, price stickiness, labour market heterogeneity and market information problems, implies an important role for monetary policy.

The on-going debate on the appropriate specification of new Keynesian models, which is reflected in part in this paper, implies that certain questions remain to be resolved. Different modelling approaches still confront one another and give rise to different policy advice. Krugman (2000) and Mankiw (2006) both refer to this convergence as a truce rather than a synthesis. The history of macroeconomics is a series of revolutions and counterrevolutions, so any prediction of how long the new Keynesian approach will last is untimely.

Macroeconomics is not the only branch of economics where advances are being made. Two decades ago, monetary economics was in decline and in conflict with both the latest movements in macroeconomics and central bank perceptions of the importance and effectiveness of monetary policy. Walsh (2006) points out that models in monetary economics at this time were static, lacked a clearly defined economic foundation and assumed that the money stock was still the instrument used by central banks, even though most of them managed interest rates rather than money supply by then.

The main growth area in monetary economics at this time was analysis of the monetary authorities' ability to fulfil their commitment to ensure price stability vis-à-vis the motives of central bank governors in their work (see Kydland and Prescott, 1977, and Barro and Gordon, 1983). This growth accompanied an increasing emphasis on forward-looking expectations and the ascendancy of institutional economics. The main idea in the literature was that even though central banks should preferably maintain a low rate of inflation, they cannot commit themselves to ensure price stability by credible means. If households expect low inflation in line with declarations by the monetary authorities, central banks would be tempted to try to reduce unemployment and boost output growth by allowing inflation to rise slightly above target. Realising this, households would then expect the monetary authorities to succumb to such a temptation and would raise their

2. Lucas (1976) emphasised the importance of expectations in economic models and the potential effect on them of changes in monetary and fiscal policy. He argued against relying too heavily on trying to exploit statistical relations between economic aggregates for economic policy purposes. Expectations reflect a change in policy which could cause statistical relations between economic aggregates to change. Models designed to analyse the impact of economic policy measures, he maintained, must take into account that those measures alter people's behaviour. The Lucas critique was directed in particular at the Phillip curve of this time, which appeared to give monetary authorities a choice between minimising unemployment or inflation. However, the critique has more general implications. DSGE models based on the optimisation problem of households and firms in conditions of uncertainty are not as sensitive to this criticism, because market agents' actions reflect measures implemented by the monetary and fiscal authorities. Coefficient values in the equilibrium relations in DSGE models are therefore well defined functions of underlying structural production and utility functions and of the price adjustment structure.

inflation expectations accordingly. Central bank measures to reduce unemployment would therefore only lead to higher inflation without any benefits in the form of lower unemployment or higher output growth. This is known as the time inconsistency problem of monetary authorities.³ Methods discussed in the literature for solving this credibility challenge include appointing a conservative governor, incentive contracting or target rules (see Persson and Tabellini, 1990).

The new Keynesian approach has created a common foundation for macroeconomics and monetary economics. Two decades ago there was a confrontation between the general equilibrium approach, which dominated macroeconomics, and smaller models (such as AS-AD) with no clearly defined economic foundation, which were most common in monetary economics.⁴ Now, both disciplines are based on the new Keynesian approach. This has contributed to more clearly defined models for the transmission mechanism of monetary policy under conditions of imperfect competition and sticky prices.

However, advances in monetary economics are not limited to the common foundation of new Keynesian economics. In recent years a number of important advances have been made in monetary economics which have had a bearing on central bank monetary policy-making. These include the assessment and development of monetary policy rules (Taylor, 1993) and the derivation of the so-called Taylor's principle, which states that the policy interest rate should be raised by more than the change in inflation in order to ensure price stability. It highlights the importance of real policy rates and raising them to reduce inflation (and vice versa).

The new Keynesian emphasis on expectations and forward-looking behaviour in markets has similarly had major consequences for monetary policy implementation, as Walsh (2006) points out. If private agents' expectations about future inflation are the main determinants of inflation, it is crucial for monetary policy-making to be systematic, credible and transparent to maximise its impact on them. This expectational channel of monetary policy introduces a new instrument for monetary authorities, i.e. the possibility to influence inflation by influencing forward-looking expectations. This has led to an ongoing discussion on the advantages of commitment versus discretion, which differs from the debate of the 1980s and 1990s spawned by the time-inconsistency literature. The current debate centres on the benefits from committing to price stability even in the absence of a time inconstancy problem, e.g. by introducing an official inflation target, and being transparent in formulation, communication and implementation of monetary policy in order to anchor future inflation expectations and improve the trade-off between stabilising inflation and output gap volatility.

3. A policy is time-consistent if the measures planned at period t to take effect at period $t+i$ are still optimal when period $t+i$ arrives. It is inconsistent if the measures are not optimal at period $t+i$ (only because time has elapsed and not as a result of new information, etc.).
4. AS-AD models in monetary economics are generally based on a Lucas supply function with a conventional IS-LM model on the demand block. Lucas (1972) proposed a supply function in which the output gap (deviation of GDP from potential output) is a function of unexpected inflation. Thus output only deviates from potential output when inflation is higher than expected.

Walsh (2006) draws attention to the strong contrasts between this new transparency literature and the policy advice of models from the 1970s through the 1990s which implied that policy was only effective if policy makers succeeded in surprising private agents in the economy. Now the emphasis is on transparency, credibility and systematic measures to hinder inflation expectations from deviating substantially from the inflation target.

Practical experience

Recent positive experience of monetary authorities' measures is another factor contributing to broader consensus on monetary policy framework and implementation. The experience of central bank measures in the 1970s and early 1980s was extremely negative. In many countries, inflation ran rampant and unemployment increased as well. There was disagreement about how to solve the problem and even about the instruments that monetary authorities should use to fight inflation. However, a broader consensus emerged that price stability should be the main objective of monetary policy. Since then the outlook for monetary authorities has brightened. Inflation has generally been low in spite of high growth for most of the period. Important reforms have been made to most central banks' monetary policy framework, objectives and policy making, alongside advances in communicating about measures. These reforms have contributed to much-needed changes within monetary economics.

The best known example is when the Reserve Bank of New Zealand became the first central bank to move onto a formal inflation target at the beginning of 1990. Since then the number of countries operating under an official inflation target has soared and in many cases academic discussion of monetary policy takes targeting by the monetary authorities for granted. Empirical experience from inflation targeting has underlined the importance of inflation forecasting as an intermediate target for central banks. A growing number of central banks publish regular forecasts in dedicated inflation reports. These publications have underscored the importance of rhetoric in communication of monetary policy measures. Transparency in the interpretation of information and presentation of the rationale behind interest rate decisions have also been given more precedence. A current issue is how far transparency should be taken. Norway's Norges Bank has been one of the main exponents of greater transparency and publishes the interest rate path that it considers will ensure that the inflation target is attained at any given time (see e.g. Woodford, 2005a, Svensson, 2006 and Qvigstad, 2006).

Japan's struggle with the deflationary challenge is another example of the way that practical policy experience has been incorporated into monetary economics. By creating awareness of the risks of the deflation trap, it led many central banks to adjust their targets in order to avoid excessively low inflation or deflation, and academics began constructing models which emphasised the expectational channel of the transmission mechanism to tackle this problem (see e.g. Eggertson, 2003, 2006).

Low interest rates and abundant liquidity in the past few years have caused the role of price stability as the single final objective of

monetary policy to be questioned. White (2006) and Borio (2006) advocate a wider perspective, pointing out that price stability offers no guarantee for macroeconomic stability. A longer-term view is needed to assess the possible financial instability that can build up as a result of monetary policy measures. The debate on whether central banks should respond to asset market bubbles has similar roots.

Finally, Greenspan (2003, 2004, 2005) has repeatedly argued the importance of risk management in monetary policy decision-making. Blinder and Reis (2005) distinguish between the risk management and the optimisation approaches to monetary policy. Greenspan frequently cited the Federal Reserve rate cut in autumn 1998 as an example of effective risk management, when the US monetary authorities opted to hedge against the conceivable effects of a collapse in the rouble and bankruptcy of the Long Term Capital Management hedge fund, despite the negligible impact these events were likely to have on the US economy.

Empirical research

Research topics and findings have been the third main factor in consolidating the foundation for monetary policy decision-making. Roughly two decades ago, research showed that the Phillips curve, one of the most important economic relationships for monetary authorities at that time, had “disappeared” when inflation and unemployment both grew in the 1970s. Research also focused on other tasks beside those of the monetary authorities, partly as a result of the ascendancy of the real business cycle school. A further shift of focus occurred in the 1990s with an upswing in research into business cycles and time series analysis of the properties of inflation and the transmission mechanism of monetary policy. Business cycle studies proliferated with the rise of the real business cycle school, but contrary to its predictions, they demonstrated that monetary policy does have an impact due to sticky prices and wages. This prompted further studies of the transmission mechanism of monetary policy, which benefited from the increased use of time series analysis and advances in that field. Following this research and the introduction of monetary policy rules, studies were made aiming to identify the optimum monetary policy rule based on the empirical picture of the transmission mechanism and properties of inflation.

Models

Finally, economic modelling has been radically overhauled in recent years. Two decades ago there was a vast difference between the large macroeconomic models used by central banks for forecasting and the smaller general equilibrium models that dominated the real business cycle school. Models used in monetary economics fell outside both categories but were fiercely criticised by both central banks and the real business cycle school academics.

The gap between academic macroeconomic models and applied policy models has decreased in recent years. There has been a clear tendency away from the large-scale disaggregated models of the 1970s towards tractable small- and medium-sized models, well suit-

able for medium-term policy analysis, which are the basis for efficient monetary policy-making in an uncertain environment. The older large-scale models were criticised on a number of fronts, e.g. for lacking microeconomic foundation, their treatment of expectations formation, their forecasting abilities in comparison to simple vector autoregression (VAR) models, their underlying econometric methodology and their modelling of the cost of disinflation in terms of output losses. In the words of Pesaran and Smith (1995): “The models did not represent the data [, ...] did not represent the theory [... and] were ineffective for practical purposes of forecasting and policy” (Pesaran and Smith, 1995: 65-66).

New Keynesian models – the latest generation – have quickly gained wide acceptance by both academia and central banks. The transmission mechanism of monetary policy is given a high profile in these models and their specification is consistent with the view that the main role of monetary authorities is to provide a credible anchor for inflation expectations. These models are examined in more detail in the following section.

New Keynesian Models

New Keynesian models provide a tractable framework for analysis of optimal monetary policy design. The combination of dynamic optimising agents, nominal rigidities and other market imperfections provides a better understanding of transmission of various types of shocks and allows for the derivation of optimal policy based on welfare analysis.

New Keynesian models represent a convergence between (i) simple (static) policy-oriented models such as the IS-LM model, (ii) a Keynesian emphasis on the role of monopolistic competition, markups and costly price adjustments, and (iii) dynamic general equilibrium models with their roots in the real business cycle literature.

A small-scale new Keynesian model for a closed economy basically consists of three components. The demand block is represented by an expectational IS curve, which is a linear approximation to the representative household’s intertemporal Euler equation.⁵ This relates the level of real activity to expected (and sometimes past) real activity and the real interest rate. The supply block is represented by a price-setting equation – the new Keynesian Phillips curve – which can be derived from various price-setting behaviour (see Roberts, 1995). It relates inflation to expected (and sometimes past) inflation and a measure of excess demand. The model is closed by a monetary policy rule, which can either be directly specified or derived from the minimisation of a central bank’s loss function. The policy interest rate setting

5. The Euler equation is a solution to the optimisation problem of households and describes the necessary development of household consumption in order to optimise its allocation across time based on their intertemporal budget constraints. For example, if households reduce their current consumption slightly and use the saving to increase consumption at a later time, the Euler equation states that the marginal cost and benefit of this decision must be equal. In simple small three-equation new Keynesian models, a linear approach of this Euler equation is applied (generally assuming 0% steady-state inflation) and it is written in an output gap form excluding investment and central government expenditure so that household consumption is equal to output.

is thus commonly a reaction function where the monetary authorities respond to the output gap and (expected) inflation.⁶

A small-scale new Keynesian model hence provides a very stylised representation of the key aggregates in the economy whilst trying to capture the essence of the transmission mechanisms of monetary policy. An extensive literature has dealt with optimal monetary policy design in such a framework in recent years, e.g. Taylor (1999), Svensson (1999), Clarida, Galí and Gertler (1999), Woodford (2003a) and Walsh (2003).

New Keynesian models range from these small-scale three-equation models to full-blown dynamic stochastic general equilibrium (DSGE) models where equilibrium conditions are derived from optimisation problems faced by forward-looking consumers, firms and monetary authorities in an environment characterised by uncertainty and various forms of rigidities. DSGE macroeconomic models used for quarterly economic forecasting in practice at central banks, e.g. BEQM at the Bank of England, TOTEM at the Bank of Canada and JEM at the Bank of Japan, are more complex in structure as they seek to have a well defined steady state and a careful accounting of stock-flow relations.

DSGE models represent an ambitious attempt to combine progress in macroeconomic theory, structural forecasting and practical monetary policy-making. Disagreement remains on the precise structure of these models and how well they manage to combine theoretical consistency and empirical coherency.

Many issues remain unsolved. First, the precise modelling of the microeconomic foundation of DSGE models with regard to imperfections in various markets, price setting and expectations is still controversial. Second, various classical and Bayesian estimation approaches to DSGE models have been tried, while others favour calibrating methods. Third, forecast performance of these models has to be tested more. Finally, another burning research issue is extending DSGE models to an open-economy framework.

The adaptation of DSGE models to practical use in policy making is a red-hot research area in some of the main central banks and policy institutions in the world. One focus has been on the new Keynesian Phillips curve. Few considerations are more crucial for central banks aiming to follow a forward-looking monetary policy than to be able to predict short- and medium-term inflation. The new Keynesian Phillips curve plays a key role in small DSGE models for forecasting and analysis of the inflation outlook.

The new Keynesian Phillips curve and inflation forecasting

Short-run inflation dynamics is a pivotal issue in macroeconomics, model design and monetary policy-making. Various improvements

6. Many larger central bank models can also be broken down into three components in this way even though they are based on a more precise disaggregation of demand and more complex price and wage formation. The demand block of such models is comprised of equations describing household consumption, investment and net exports with, for example, the real interest rate and real exchange rate paths. The supply block is comprised of equations for price and wage formation and the relationship between exchange rate changes and prices.

have been made in model design with regard to inflation dynamics. In the old IS-LM framework, prices or wages were fixed and there was no room for a price adjustment structure. Like many of the models used in monetary policy analysis in the 1970s and 1980s, the equilibrium conditions in the IS-LM model are not the results of optimisation of private agents in the economy (see McCallum and Nelson, 1999 for a discussion on the weakness of the IS-LM paradigm). The Phillips curve also entered the economic field without a microeconomic foundation as a simple empirical relationship between wage inflation and unemployment.

The last two decades of the 20th century were turbulent yet fruitful times where the Phillips curve re-entered macroeconomic models as a more solid economic relation with a stronger microfoundation than before. The new Keynesian Phillips curve is now the dominant approach to wage and price modelling in macroeconomics and a key relationship in modern macroeconomic models. It is nevertheless still very controversial.

A particular bone of contention is how closely the new Keynesian Phillips curve converges with research findings on inflation dynamics and the effects of monetary policy. For example, it has trouble in reproducing the inflation persistence that is common in practice although this characteristic has diminished as average inflation has fallen in recent years. Also, the forward-looking nature of the curve causes monetary policy measures to impact inflation immediately in new Keynesian models, enabling monetary authorities to contribute to disinflation without a corresponding opportunity cost in the form of lower output growth and higher unemployment. This conflicts with central banks' empirical experience of their measures.

A large part of the author's companion working paper (Ólafsson, 2006) is devoted to discussing the approaches that have been tried to amend these problems of the new Keynesian Phillips curve. A popular path to improve the new Keynesian Phillips curve is to assume that only some firms are forward-looking in their price setting while others reflect past inflation. This hybrid form, which produces more persistent inflation dynamics, has been heavily debated in recent years. Lately, real rigidities in various forms have been introduced to solve the empirical problems which still emerge with the hybrid Phillips curve. Novel attempts to introduce search and matching frictions in the labour markets and allow for firm-specific capital give rise to renewed optimism that the empirical problems of the new Keynesian Phillips curve will decline in the near future (see e.g. Walsh, 2005, Christoffel and Linzert, 2005, Woodford, 2005b and Christoffel et al., 2006).

Krugman's (2000) question on whether this approach is building a proper microfoundation for aggregate supply or coming up with "micro-excuses" for the form of the new Keynesian Phillips curve is still unanswered.

Monetary policy-making in open economies and new Keynesian economics

The above discussion implies that questions still remain about the foundations of monetary policy in closed economies, although more

convergence has now been achieved. More uncertainty surrounds monetary policy measures in open economies. The introduction of open-economy elements into DSGE models marks the frontier of current research. Open-economy macroeconomics has progressed by leaps and bounds in recent years but many questions remain unanswered, and it has been an arduous task to adapt new Keynesian economics to open economies. Exchange rate economics has been particularly difficult to reconcile. This is not surprising. Exchange rate economics is one of the most challenging areas within macroeconomics and a heavily debated issue in monetary policy design. It is a field considered filled with anomalies and puzzles.⁷ Ceaseless efforts to develop models for exchange rate forecasting have turned out to be a Sisyphean task. Nor has extensive research succeeded in satisfactorily charting the relationship between inflation and the exchange rate. It is therefore not surprising that model building and forward-looking monetary policy-making is more difficult in these circumstances. In a small open economy like Iceland, where exchange rate volatility can have widespread repercussions on the economy, this becomes even more crucial.

New open-economy macroeconomics

The so-called new open-economy macroeconomic (NOEM) literature represents an attempt to introduce new Keynesian economics into an open-economy framework. NOEM has brought new insights into international transmission of shocks, different price setting behaviour and policy coordination. The NOEM DSGE models are still to a certain degree fragile as the precise modelling approach is not fully established and different approaches yield different policy advice. This is of course also true for their closed economy counterparts, but not to the same degree.

NOEM literature has grown exponentially in volume since the publishing of the pioneering redux paper by Obstfeld and Rogoff in 1995. The models in the early papers of the NOEM literature are deterministic: e.g. Obstfeld and Rogoff (1995) and Betts and Devereaux (1996, 2000). Obstfeld and Rogoff (1998, 2000) introduced uncertainty into the models and this has become standard (see Lane, 2001, for a survey of the first wave of the NOEM literature and Bowman and Doyle, 2003, for its monetary policy implications).

A major strength of DSGE models is that they enable welfare analysis and are thus able to address normative policy questions. A limitation of the early open-economy DSGE models in the NOEM literature was that they modelled monetary policy as a choice of a monetary aggregate instead of short-term interest rate setting. Monetary policy is modelled in the closed-economy new Keynesian models either as a simple rule in the tradition of Taylor (1993) or derived from a loss function of monetary authorities where an inflation target is often explicitly assumed. This has happened with a lag in the open-economy

7. The main puzzles are the exchange rate disconnect puzzle, purchasing power parity puzzle and forward bias puzzle. Sarno (2005) provides a good overview of the main puzzles in exchange rate economics and advances made towards solving them.

DSGE models. The first examples of the use of monetary policy rules in an open economy new Keynesian model are Ball (1999), Svensson (2000) and Batini, Harrison and Millard (2001).

A common result in a number of the early NOEM papers was that optimal monetary policy design was in no important way different in an open-economy environment compared to the closed-economy framework (see e.g. Ball, 1999 and Clarida et al. 2001, 2002). This isomorphic result is based on a number of strong assumptions. The law of one price is assumed to hold and there is full pass-through from exchange rate changes into prices. The law of one price states that when trade is open and costless, identical goods should trade at the same relative price wherever they are sold. These assumptions are in strong opposition to wide-ranging empirical research (see e.g. Engel 1993, 1999, 2002, Campa and Goldberg, 2002 and Marazzi et al., 2005).

Recent research supports this finding and shows that the introduction of open-economy factors has important influences for model design, inflation dynamics and monetary policy-making. Svensson (2000) notes that the main implications are (i) additional channels for the transmission of monetary policy, (ii) further emphasis on forward-looking behaviour and the role of expectations, and (iii) transmission of foreign shocks to the domestic economy.⁸

Firms' price setting has received much more attention in NOEM literature than before. Price setting assumptions are crucial in any DSGE model, whether in a closed or open-economy framework. The specification of price setting is more complex in open-economy models than in models for closed economies. First, the specification must take into account the firm's choice of currency. Second, it must account for the effects of competition from abroad. Lastly, the models must describe the level of exchange rate pass-through into prices.

On first impression, divergent assumptions for price setting may seem to make little difference. However, research indicates that completely different results are yielded for the optimal exchange rate regime according to the type of price setting that is assumed. Likewise, price setting assumptions are crucial in deriving the new Keynesian Phillips curve for open economies, which plays the main role in small DSGE models for understanding and forecasting inflation developments. Donald L. Kohn, Vice Chairman of the Board of Governors of the Federal Reserve System discussed the importance of price setting in a recent speech: "I have a lengthy list of macroeconomic inflation puzzles whose answers would make me a better policymaker, but, for the most part, the solutions to the puzzles rest on a better understanding of how workers and firms set wages and prices." (Kohn, 2005)

Inflation forecasting in a small open economy and the new Keynesian Phillips curve

Price setting specifications in open-economy DSGE models are crucial for the derivation of the new Keynesian Phillips curve, as said earlier. Its adaptation to the open economy has proved very difficult as it faces

8. He does not discuss the issue of incomplete exchange rate pass-through.

bigger problems in an open economy framework. The microfoundation is weaker as the modelling of price setting is more complex and the introduction of various forms of real rigidities in the spirit of what Christoffel and Linzert (2005) and Walsh (2005b) have done in closed economy models is harder to model in an open-economy framework, especially in an era characterised by increased globalisation. NOEM literature has nevertheless made important contributions to the adaptation of the new Keynesian Phillips curve to the open economy, especially with regard to modelling price setting and exchange rate pass-through. The works of Batini, Jackson and Nickell (2000, 2005) and Balakrishnan and López-Salido (2002) are good examples of empirical use of some of the theoretical contributions made by NOEM literature. They demonstrate that the new Keynesian Phillips curve for open economies can describe inflation dynamics in the UK. Prices of imported intermediate goods are an independent variable in the curve, reflecting theoretical advances and development of models for price setting in open economies (the adaptation of the new Keynesian Phillips curve is discussed in more detail in Ólafsson, 2006).

Inflation forecasting plays a pivotal role in the conduct of forward-looking monetary policy-making. It is well known that the exchange rate can influence inflation through the prices of traded final goods and imported intermediate goods, as well as through its effects on inflation expectations. Exchange rate changes have a demand effect by altering the relative prices of domestic and foreign goods, which encourages households to shift their demand to the relatively cheaper one at any time. Exchange rate changes also have a supply effect, e.g. when an appreciation lowers the price of imported goods, which have a heavy weight in the consumer price index and therefore exert direct downward pressure on inflation (see Pétursson, 2001).

Small open economies usually import a larger share of their consumer goods than large economies and this makes the exchange rate one of the most important relative prices in these economies. Hence, exchange rate fluctuations matter more for domestic inflation in small open economies. These fluctuations are famously difficult to forecast and this can make forward-looking monetary policy-making, which relies on inflation forecasting, more difficult in practice in small open economies than in larger ones. Thus the monetary authorities lack a desirable degree of foothold for policy making in this respect. There are strong indications of a shift in the relation between prices and the exchange rate in recent years, towards a longer lag and weaker pass-through to consumer prices (Ólafsson, 2005). However, the impact is much stronger in small open economies such as Iceland than in larger closed economies. But models that analyse optimal monetary policy within a DSGE framework with limited exchange rate pass-through have just very recently emerged.⁹

9. See e.g. Smets and Wouters (2002), Justiano and Preston (2004), Lindé, Nessén and Söderström (2004), Monacelli (2005), Corsetti and Pesenti (2005), Corsetti, Dedola and Leduc (2005) and Liu (2006).

The Central Bank of Iceland and new Keynesian economics

The objectives, design and communication of the Central Bank of Iceland's monetary policy have changed radically in recent years, in pace with the advances described above. Iceland moved onto an inflation target in March 2001 which, as elsewhere, ushered in a much stronger emphasis on forecasting and systematic presentation of the rationale behind the Central Bank's measures. Ever-growing transparency in Central Bank policy making and communication is clearly evident from the rhetoric in *Monetary Bulletin* and enhancements to its forecasting methods. The Central Bank has striven to anchor inflation expectations more firmly and reduce uncertainty in the markets by providing more information on the probable medium-term policy rate path. This has included more focused and frank rhetoric, statements on the expectations that can be read from forward market interest rates, publication of the policy interest rate curve which simulations from the Central Bank's models show to attain the inflation target over the forecast horizon, and scheduling of prearranged interest rate decision dates. Another aspect of transparency has involved changes to the Central Bank's forecasts. The underlying assumption behind the baseline scenario has been altered from an unchanged policy rate across the forecast horizon to a policy interest rate curve reflecting expectations of market agents and analysts about the medium-term policy rate path. The Bank of England and Sweden's Sveriges Riksbank are among central banks that have opted for the same course.

Research at the Central Bank has also been substantially boosted since preparations began for moving onto an inflation target. Focuses have included charting the transmission mechanism of monetary policy, the business cycle and inflation dynamics. A major effort has also been made in developing a quarterly macroeconomic model (QMM) which replaced the earlier forecasting model in the beginning of 2006 (see Daniélsson et al., 2006). The QMM is not a new Keynesian model and its equilibrium conditions are not generated by optimisation of private agents in the economy but by a statistical estimation of the (long-term) relation of various aggregates.¹⁰ The degree of empirical coherence is therefore given precedence over the degree of theoretical coherence in Pagan's terms (2003).¹¹

10. Equations and short- and long-term conditions in QMM are selected with reference not only to statistical estimation but also to the dynamic properties of the model as a whole (see further Daniélsson et al., 2006).

11. Fukac and Pagan (2006) distinguish four generations of central bank macroeconomic models in which the DSGE model represents the fourth. The Central Bank of Iceland's QMM model would be classified as second-generation. These models are much smaller than the first generation and emphasise clear presentation of the supply block with a production function and use of an error correction form to describe the short-term properties of the main economic relationships. In terms of the importance it attaches to forward-looking expectations, the QMM is actually closer to a third-generation model. The chief characteristic of third-generation models is that they are based on a clear presentation of the optimisation problem of forward-looking households and firms to produce a well defined steady state, which often proved difficult to identify in second-generation models. The fourth generation of models introduces imperfect competition and more complex price and wage setting, substantially changing their dynamic properties compared with those in the third generation, where perfect competition and flexible prices and wages prevailed.

The Central Bank's inflation forecasting methodology has also evolved over the years (see e.g. Box VIII-1, *Monetary Bulletin* 2006/1, 46-47). A clear trend towards a greater new Keynesian focus may be discerned in the evolution of the Central Bank's forecasting. The output gap was given a greater weight in forecasts in 2002 and the inflation forecasting equation in QMM is a Phillips curve which, while not derived from firms' price setting, is highly new Keynesian in character. Inflation forecasting has occasionally been complicated by unexpected exchange rate volatility and the resulting inflationary spikes and higher inflation expectations have eroded the Central Bank's monetary stance, most recently this spring.¹² While unexpected exchange rate fluctuations are frustrating for most monetary authorities and forecasters, in some cases it is the timing of exchange rate movements that is unexpected, while their signs and scope are less of a surprise.

From the above, it is clear that the Central Bank of Iceland's monetary policy has in many ways been put on a much firmer footing in recent years. The Central Bank has brought its policy objectives and communication of the rationale behind its measures into line with best international practice and the new QMM ought to bolster its analysis of economic developments and outlook. Indeed, the OECD's most recent Economic Review of Iceland points out that "given its limited resources, the Central Bank of Iceland[s] ... analysis, forecasting and communication display exceptional competence and professionalism" (see OECD, 2006, 49).

The Central Bank of Iceland aims to strengthen these pillars of its activities even further. For example, it is very interested in DSGE models and preparations have already been launched for building such a model. But model building is a time-consuming effort and a stone-by-stone approach can often be well advised, especially since the Central Bank currently has a new model. The first stage is to survey the landscape and collect the most up-to-date knowledge of these models. This paper and the companion working paper are envisaged as part of this task. The next step is to construct a small new Keynesian model for forecasting, analysis of economic questions and comparative analysis of the findings of the Central Bank's other models.¹³ Further, work is in progress on assessing the equilibrium real exchange rate and potential output of the economy, which play a major role in new Keynesian models as they explain deviations in the aggregate economy from steady-state levels. All these factors should contribute to putting Central Bank monetary policy on a more consolidated footing in the future.

12. The Central Bank has long incorporated exchange rate developments into the risk profile of its inflation forecasts. In QMM the exchange rate is forecast with a hybrid equation mainly driven by the interest-rate differential with abroad and convergence to purchasing power parity. The baseline scenario is now based on this exchange rate path (from a policy rate curve based on expectations of market agents and analysts) instead of assuming an unchanged exchange rate from the forecast date and across the forecast horizon.

13. Hunt (2006) and Honjo and Hunt (2006) have estimated a small new Keynesian model for Iceland using a Bayesian approach, which will be taken into account in construction of the new DSGE model.

Concluding Remarks

There is plenty of momentum behind central bank activities. Monetary economics is advancing by leaps and bounds, central banks are increasingly coming out into the open and changing their policy making and communication to match new theoretical findings and rapid progress is being made in economic modelling around the world. The new Keynesian approach is being rapidly refined and spreading through most branches of macroeconomics. A wealth of new literature appears every month applying new Keynesian approaches to the classical themes of economics. Central banks need to monitor developments closely and play an active part in the continuing evolution of theory and empirical research in order to enhance their own inflation forecasting and policy making. At present, central banks enjoy a boost from the broader academic consensus on the importance of monetary policy and methods of designing analytical models for economic and monetary developments and outlook.

This paper attempts to provide an overview of developments over the past two decades and the greater agreement on the advice that the foundations of monetary policy provide to central banks about how to conduct it in practice. An attempt has also been made to chart the extent of this convergence and highlight a number of disputed issues.

The Central Bank of Iceland has already adopted many of the focuses that have come to the fore in recent years. It has taken steps towards making its monetary policy systematic, credible and transparent.

References:

- Balakrishnan, Ravi and J. D. López-Salido, (2002). Understanding UK inflation: the role of openness, *Bank of England Working Paper* No. 164.
- Ball, Laurence, (1999). Policy Rules for Open Economies, in John Taylor (ed.) *Monetary Policy Rules*, University of Chicago Press, Chicago, 127-144.
- Barro, Robert J. and David B. Gordon, (1983). A Positive Theory of Monetary Policy in a Natural-Rate Model, *Journal of Political Economy* 91 (4), 589-610.
- Batini, Nicoletta, Brian Jackson and Stephen Nickell, (2000). Inflation Dynamics and the Labour Share in the UK, *External MPC Unit Discussion Paper* No. 2.
- Batini, Nicoletta, Brian Jackson and Stephen Nickell, (2005). An open-economy new Keynesian Phillips curve for the U.K., *Journal of Monetary Economics* 52, 1061-1071.
- Batini, Nicoletta, Richard Harrison and Stephan P. Millard, (2001). Monetary Rules for an Open Economy, *Norges Bank Working Paper* 2001/4.
- Betts, Caroline and Michael B. Devereux, (1996). The exchange rate in a model of pricing-to-market, *European Economic Review* 40, 1007-1021.
- Betts, Caroline, and Michael B. Devereux, (2000). Exchange rate dynamics in a model of pricing-to-market, *Journal of International Economics* 50, 215-244.
- Blinder, Alan S. and Ricardo Reis, (2005). Understanding the Greenspan Standard, paper presented to a symposium organised by the Federal Reserve Bank of Kansas City: *Understanding the Greenspan Era: Lessons for the Future*, Jackson Hole, Wyoming, August 25-27, 2005.
- Borio, Claudio, (2006). Monetary and prudential policies at a crossroads? New challenges in the new century, *BIS Working Papers* No. 216.
- Bowman, David and Brian Doyle, (2003). New Keynesian Open-Economy Models and Their Implications for Monetary Policy, *Board of Governors of the Federal Reserve System International Finance Discussion Papers*, No. 762.

- Campa, José Manuel and Linda S. Goldberg, (2002). Exchange Rate Pass-Through into Import Prices: A Macro or Micro Phenomenon?, *NBER Working Paper Series No. 8934*.
- Christoffel, Kai, Keith Küster and Tobias Linzert, (2006). Identifying the role of labor markets for monetary policy in an estimated DSGE model, *Deutsche Bundesbank Discussion Paper Series 1: Economic Studies No. 17/2006*.
- Christoffel, Kai and Tobias Linzert, (2005). The role of real wage rigidity and labor market frictions for unemployment and inflation dynamics, *ECB Working Paper Series No. 556*.
- Clarida, Richard, Jordi Gali and Mark Gertler, (1999). The Science of Monetary Policy: A New Keynesian Perspective, *Journal of Economic Literature* 37 (4), 1661-1707.
- Clarida, Richard, Jordi Gali and Mark Gertler, (2001). Optimal Monetary Policy in Open Versus Closed Economies: An Integrated Approach, *American Economic Review* 91 (2), 248-252.
- Clarida, Richard, Jordi Galí and Mark Gertler, (2002). A simple framework for international monetary policy analysis, *Journal of Monetary Economics* 49 (5), 879-904.
- Corsetti, Giancarlo and Paolo Pesenti, (2005). International dimensions of optimal monetary policy, *Journal of Monetary Economics* 52, 281-305.
- Corsetti, Giancarlo, Luca Dedola and Sylvain Leduc, (2005). DSGE Models of High Exchange-Rate Volatility and Low Pass-Through, *Board of Governors of the Federal Reserve System International Finance Discussion Paper Series No. 845*.
- Danielsson, Ásgeir, Lúdvík Eliasson, Magnús F. Guðmundsson, Björn Hauksson, Ragnhildur Jónsdóttir, Thorvarður Tjörvi Ólafsson and Thórarinn G. Pétursson, (2006). "QMM – A Quarterly Macroeconomic Model of the Icelandic Economy", *Central Bank of Iceland Working Paper*, forthcoming.
- Eggertsson, Gauti B., (2003). How to Fight Deflation at Zero Nominal Interest Rates: Committing to Being Irresponsible, *IMF Working Paper No. 03/64*.
- Eggertsson, Gauti B., (2006). The Deflation Bias and Committing to Being Irresponsible, *Journal of Money, Credit and Banking* 380 (2), 283-321.
- Engel, Charles, (1993). Real exchange rates and relative prices: an empirical investigation, *Journal of Monetary Economics* 32, 35-50.
- Engel, Charles, (1999). Accounting for U.S. Real Exchange Rate Changes, *Journal of Political Economy* 107, 507-538.
- Engel, Charles, (2002). The Responsiveness of Consumer Prices to Exchange Rates: A Synthesis of Some New Open Economy Macro Models, *The Manchester School Supplement*, 1-15.
- Friedman, Milton, (1968). The Role of Monetary Policy, *American Economic Review* 58 (1), 1-17.
- Fukac, Martin and Adrian Pagan, (2006). Issues in Adopting DSGE Models for Use in the Policy Process, *CAMA Working Paper Series No. 10/2006*.
- Greenspan, Alan, (2003). Opening remarks at a symposium organised by the Federal Reserve Bank of Kansas City: *Monetary Policy under Uncertainty: Adapting to a Changing Economy*, Jackson Hole, Wyoming August 28-30, 2003.
- Greenspan, Alan, (2004). Risk and Uncertainty in Monetary Policy, *American Economic Review* 94, 33-40.
- Greenspan, Alan, (2005). Reflections on Central Banking, presentation at a symposium organised by the Federal Reserve Bank of Kansas City: *Greenspan Era: Lessons for the Future*, Jackson Hole, Wyoming August 25-27, 2005.
- Honjo, Keiko and Benjamin Hunt (2006). Stabilizing Inflation in Iceland, *IMF Working Paper*, forthcoming.
- Hunt, Benjamin, (2006). Simple efficient policy rules and inflation control in Iceland, *Central Bank of Iceland Working Paper No. 30*.
- Justiano, Alejandro and Bruce Preston, (2004). Small Open Economy DSGE Models: Specification, Estimation and Model Fit, *Columbia University Department of Economics Working Paper*.

- Kohn, Donald L., (2005). Modeling Inflation: A Policymaker's Perspective, speech at the *International Research Forum on Monetary Policy* in Frankfurt am Main May 20, 2005.
- Krugman, Paul R., (2000). How Complicated Does the Model Have To Be?, *Oxford Review of Economic Policy* 16 (4), 33-42.
- Kydland, Finn E. and Edward C. Prescott, (1977). Rules Rather than Discretion: The Inconsistency of Optimal Plans, *Journal of Political Economy* 85 (3), 473-491.
- Lane, Philip R., (2001). The new open economy macroeconomics: a survey, *Journal of International Economics* 54 (2), 235-266.
- Lindé, Jesper, Marianne Nessén and Ulf Söderström, (2004). Monetary Policy in an Estimated Open-Economy Model with Imperfect Pass-Through, *Sveriges Riksbank Working Paper Series* No. 167.
- Liu, Philip, (2006). A Small New Keynesian Model of the New Zealand Economy, *Reserve Bank of New Zealand Discussion Paper Series* No. DP/2006/03.
- Lucas, Robert E., Jr., (1972). Expectations and the neutrality of money, *Journal of Economic Theory* 4, 103-124.
- Lucas, Robert E., Jr., (1976). Economic Policy Evaluation: A Critique, *Carnegie-Rochester Conference Series on Public Policy* 1, 19-46.
- Mankiw, N. Gregory, (2006). The Macroeconomist as Scientist and Engineer, unpublished manuscript.
- Marazzi, Marion, Nathan Sheets and Robert Vigfusson, with Jon Faust, Joseph Gagnon, Jaime Marquez, Robert Martin, Trevor Reeve and John Rogers, (2005). Exchange Rate Pass-through to U.S. Import Prices: Some New Evidence, *Board of Governors of the Federal Reserve System International Finance Discussion Papers* No. 833.
- McCallum B. and Edward Nelson, (1999). An Optimizing IS-LM Specification for Monetary Policy and Business Cycle Analysis, *Journal of Money, Credit and Banking* 31 (3), 296-316.
- Monacelli, Tommaso, (2005). Monetary Policy in a Low Pass-through Environment, *Journal of Money, Credit and Banking* 37 (6), 1047-1066.
- Obstfeld, Maurice and Kenneth Rogoff, (1995). Exchange Rate Dynamics Redux, *Journal of Political Economy*, 103, 624-660.
- Obstfeld, Maurice and Kenneth Rogoff, (1998). Risk and Exchange Rates, *NBER Working Paper* No. 6694.
- Obstfeld, Maurice and Kenneth Rogoff, (2000). New directions for stochastic open economy models, *Journal of International Economics* 50, 117-153.
- OECD, (2006). OECD Economic Surveys: Iceland, OECD.
- Ólafsson, Thorvardur Tjörvi, (2005). Króna-denominated Eurobond issues, *Monetary Bulletin* 2005/4, 55-83.
- Ólafsson, Thorvardur Tjörvi, (2006). The New Keynesian Phillips Curve: In Search of Improvements and Adaptation to the Open Economy, *Central Bank of Iceland Working Paper* No. 31.
- Pagan, Adrian, (2003). *Report on modelling and forecasting at the Bank of England*, Bank of England, London.
- Persson, Torsten and Guido Tabellini (eds.), (1990). *Macroeconomic Policy, Credibility and Politics*, Harwood Academic, Switzerland.
- Pesaran, M. Hashem and Ron Smith, (1995). The role of theory in econometrics, *Journal of Econometrics*, 67 (1), 61-79.
- Pétursson, Thórarinn G., (2001). The transmission mechanism of monetary policy, *Monetary Bulletin* 2001/4, 62-77.
- Phelps, Edmund S., (1967). Phillips Curves, Expectations of Inflation and Optimal Unemployment over Time, *Economica*, 34 (135), 254-281.
- Qvigstad, Jan F., (2006). When does an interest rate path "look good"? Criteria for an appropriate future interest rate path, *Norges Bank Working Paper* 2006/5.
- Roberts, John M., (1995). New Keynesian Economics and the Phillips Curve, *Journal of Money, Credit and Banking* 27, 975-984.
- Rogoff, Kenneth, (2006). Impact of Globalization on Monetary Policy, presented at a symposium organised by the Federal Reserve Bank of Kansas City: *The New Economic Geography: Effects and Policy Implications*, Jackson Hole, Wyoming August 24-26, 2006.

- Sarno, Lucio, (2005). Viewpoint: Towards a solution to the puzzles in exchange rate economics: where do we stand?, *Canadian Journal of Economics* 38 (3), 673-708.
- Smets, Frank and Raf Wouters, (2002). Openness, imperfect exchange rate pass-through and monetary policy, *Journal of Monetary Economics* 49, 947-981.
- Svensson, Lars E.O., (2006). The Instrument-Rate Projection under Inflation Targeting: The Norwegian Example, unpublished manuscript from February 2006.
- Svensson, Lars E.O., (1999). How Should Monetary Policy Be Conducted in an Era of Price Stability, presented at a symposium organised by the Federal Reserve Bank of Kansas City: *New Challenges for Monetary Policy*, Jackson Hole, Wyoming August 26-28, 1999.
- Svensson, Lars E.O., (2000). Open economy inflation targeting, *Journal of International Economics* 50, 155-185.
- Taylor, John B., (1993). Discretion versus Policy Rules in Practice, *Carnegie-Rochester Conference Series on Public Policy*, 39, 195-214.
- Taylor, John B., (1999). Staggered price and wage setting in macroeconomics, chapter 15 in Taylor, John B. and Michael Woodford (eds.), *Handbook of Macroeconomics*, Elsevier.
- Walsh, Carl E., (2003). *Monetary Theory and Policy*, 2nd edition, MIT Press.
- Walsh, Carl E., (2005). Labour Market Search, Sticky Prices, and Interest Rate Policies, *Review of Economic Dynamics* 8 (4), 829-849.
- Walsh, Carl E., (2006). The contribution of theory to practice in monetary policy: recent developments, seminar paper presented in *Monetary Theory: A Journey from Theory to Practice: An ECB Colloquium held in Honour of Prof. Otmar Issing*, Frankfurt March 16-17, 2006.
- White, William R., (2006). Is price stability enough?, *BIS Working Papers* No. 205.
- Woodford, Michael, (2003). *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press.
- Woodford, Michael, (2005a). Central Bank Communication and Policy Effectiveness, paper presented to a symposium organised by the Federal Reserve Bank of Kansas City: *The Greenspan Era: Lessons for the Future*, Jackson Hole, Wyoming August 25-27, 2005.
- Woodford, Michael, (2005b). Firm-Specific Capital and the New Keynesian Phillips Curve, *International Journal of Central Banking* 1 (2), 1-46.