

THÓRARINN G. PÉTURSSON¹

The transmission mechanism of monetary policy

The Central Bank of Iceland bases its monetary policy on setting its interest rate in transactions with other financial institutions in the money market, in order to affect the behaviour of individuals and firms, thereby keeping aggregate demand in line with its growth potential and maintaining inflation expectations which are consistent with the Bank's 2½% inflation target. The process through which monetary policy decisions affect aggregate demand in the economy, inflation expectations and the inflation rate is generally known as the monetary policy transmission mechanism. This paper discusses this process and the lags from monetary policy decisions to its effect on the economy. The findings suggest that Central Bank of Iceland monetary policy changes are in general first transmitted to domestic demand after roughly half a year, with a peak effect after one year. Policy first affects inflation after a year, with a peak effect about 1½ years after the interest rate rise. In the long run, however, monetary policy has no effects on the real economy. Broadly speaking this is consistent with other countries' experience. It should be underlined that the transmission mechanism is a complex process which may alter from one time to another.

1. Introduction

In implementing its monetary policy, the Central Bank of Iceland needs to assess the impact that its decisions have and the time considered before they affect the economy. This is particularly true now that the Bank has adopted a formal inflation target, which calls for a forward-looking monetary policy (cf. the discussion in Pétursson, 2000).

This paper discusses the transmission mechanism of monetary policy, i.e. how changes in the central bank policy rate are transmitted through the economy, affecting aggregate demand, inflation expectations and the rate of inflation. As will emerge, this is

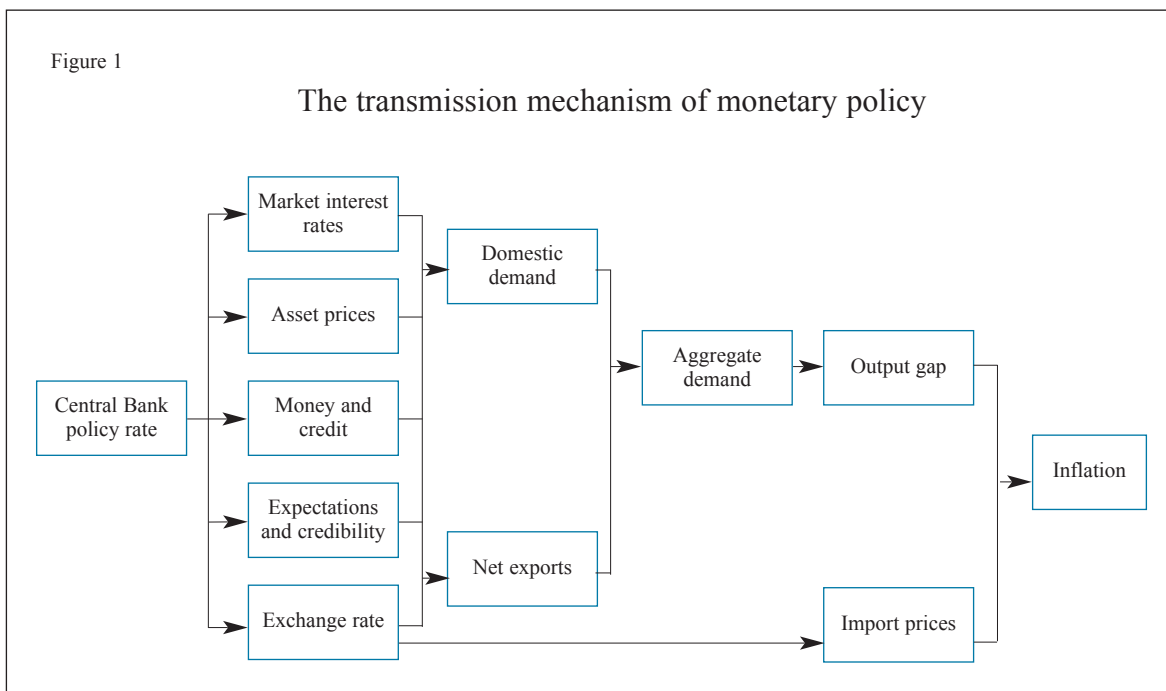
a fairly complex process and the impact may vary from one time to another. However, the typical effects of monetary policy actions in Iceland and the time lags before they have any effect appear broadly speaking to be consistent with the experience of other countries.

1.1. Overview of the transmission mechanism

The reason that central banks can affect interest rate formation in the economy is that they have monopoly power in supplying money in the economy, i.e. base money which comprises notes and coin in circulation and the reserves of financial institutions in the central banks. By setting the price of base money, i.e. the interest rate at which financial institutions can borrow short-term capital from central banks, they can influence the volume and price of liquidity in the financial system, which in turn affects interest rate formation in the economy.

Like its counterparts in other countries, the Central Bank of Iceland attempts to influence interest rate formation in the financial system by adjust-

1. The author is division chief of economic research at the Economics Department of the Central Bank of Iceland, and an assistant professor at Reykjavik University. He would like to thank Ingimundur Fridriksson, Jón Steinsson, Lúdvík Eliasson, Már Gudmundsson and seminar participants at the Central Bank of Iceland on October 15, 2001 for their constructive remarks. The views presented here are those of the author and do not necessarily reflect the views of the Central Bank of Iceland.



ing the interest rate on its repurchase agreements with financial institutions, which are transactions whereby the Bank and other financial institutions swap securities and liquid assets on condition that these transactions are reversed after fourteen days.²

Central bank interest rate decisions affect short- and long-term interest rates, liquidity in the financial system, the quantity of money and bank credit, exchange rates, other asset prices and, last but not least, market expectations about the future development of all these variables. All this, in turn, influences consumption and investment decisions of individuals and firms, and thereby aggregate demand and, ultimately, inflation, as shown in Figure 1.³

It should be emphasised that the following discussion is primarily confined to the economy's typical reactions to changes in the central bank policy rate. In each case, the ultimate effect of monetary policy is determined by whether the measures are foreseen or not, and how they affect expectations about future monetary policy actions. The economy

may therefore show different responses from one time to another, depending upon conditions within it in each case.

2. The transmission of monetary policy through the financial system

The first stage of the transmission mechanism is the financial system channel. There, monetary policy actions are primarily manifested by changes in short- and long-term interest rates, asset prices, liquidity and the exchange rate of domestic currency.

2.1. Short- and long-term interest rates

A change in the central bank policy rate has an immediate impact in the money market (the market for securities with maturity from one day to one year). A rise in the policy rate generally leads to an immediate rise in interbank and treasury bill rates, although not necessarily by the same amount; this depends among other things on the securities' maturity compared with that of the instrument priced by the policy rate, and how actively the instrument in question is traded. Interest rates on commercial banks' short-term instruments should rise relatively quickly, since they are normally financed to a large

2. For a more detailed description of the Central Bank of Iceland's instruments and implementation of monetary policy, see Kristinsson (2000).

3. Different transmission channels may work in tandem and affect each other. For simplicity, these interactions are not shown in the figure.

extent in the money markets. Interest rates on short-term variable-rate loans rise soon afterwards. Rates on short-term fixed-rate instruments also rise, but in general after some lag. Monetary policy generally does not have much effect on the spread between lending and borrowing rates, so deposit rates should also rise fairly soon after a rise in the policy rate (see, for example, MPC, 1999).

The impact of a policy rate change on long-term nominal rates is not as obvious as on short-term rates. A higher policy rate may cause either a rise or a fall in long-term interest rates, since these are broadly speaking determined by the average of current and expected future short-term interest rates for the maturity of the longer instruments (see, for example, Pétursson, 1998a). The impact on long-term interest rates therefore depends on the effect that the policy rate rise has on market expectations about future developments of short-term rates, and especially about future inflation developments, which are an important determinant of nominal interest rates. For example, if market participants expect short-term rates to fall substantially in the future, long-term interest rates could even fall in response to a policy rate rise. Such expectations might reflect, for example, confidence that the interest rate rise is sufficient to prompt a sizeable reduction in the inflation rate in the future. On the other hand, expectations that the policy rate rise is the first of many on the part of the central bank may push up long-term interest rates by more than the short-term rates.

The most common effect, however, is that short-term interest rates will gradually revert to their original level. This implies that long-term interest rates will rise, but not by the same amount as short-term rates.⁴

2.2. Asset prices

A central bank policy rate change also affects asset prices, e.g. equity prices and housing prices. In general, a rise in the policy rate leads to a fall in equity prices, since the income stream which the share price

4. In Iceland, the relation may be even more complex, since a large part of long-term liabilities have indexed-linked interest rates. If prices are sluggish and there is some substitutability between indexed and non-indexed bonds, a rise in the policy rate should lead to a temporary rise in indexed interest rates. See Pétursson (2001b) and the findings in Box 1 below.

measures is now discounted at a higher rate of long-term interest than before. Thus equity will be worth less, all things being equal (especially inflation expectations). Equity prices can also fall because rising interest rates and decreasing supply of money reduce the demand for equity, for example in favour of bonds which now pay higher interest and are therefore a more attractive investment option (see, for example, Meltzer, 1995).

However, a rise in interest rates need not necessarily lead to a fall in share prices. Market participants might interpret the higher interest rate as indicating that the central bank foresees faster economic growth in the future than had previously been assumed. In such a case, a rise in interest rates could push up equity prices, since expectations of more economic growth and consequently higher corporate profits would outweigh the direct impact through the discount factor. The effects of monetary policy on expectations will be discussed in more detail below.

Generally speaking, a rise in the policy interest rate should also cause a fall in housing prices, since housing finance costs will increase with a corresponding reduction in demand. All things being equal, less demand for housing ought to lead to smaller rises, or even reductions, in housing prices. The same applies to other assets such as land.

2.3. Liquidity, money and bank credit

Monetary policy also affects the volume of liquid funds in the economy (i.e. financial assets that can easily be converted to cash at short notice, bearing little or no interest). When the central bank raises its policy rate, the opportunity cost of holding such liquid assets increases, since other interest-bearing financial assets have become more attractive compared with liquid funds. The demand for liquid funds should therefore decrease.

A higher policy rate can also affect the demand for broad money. However, this effect is not as obvious, since broad money generally pays interest, at least in Iceland. Generally speaking, a rise in the policy rate will push up interest rates on both securities and broad money. The effect on the opportunity cost of money (i.e. the interest rate spread) is therefore unclear. Nonetheless, all things being equal a rise in the policy rate will lead to a lower price level and reduce income and wealth (or slow the growth of

these aggregates), hence reducing the demand for money.⁵

If the demand for money contracts in the wake of a rise in the policy rate, a corresponding reduction takes place in bank deposits, which in turn could impair the banking system's lending capacity if banks encounter difficulties in funding their lending in other ways. The cost of financing credit also increases, since banks need to seek other, more expensive sources, and lending rates rise as a result. Falling supply of credit and rising lending rates can have widespread effects on individuals and firms that do not have easy access to alternative sources of financing. This effect is discussed in more detail below.

2.4. The exchange rate

Central bank interest rate decisions also have an impact on the exchange rate of the domestic currency. The precise effect is uncertain, however, since it is determined by expectations about subsequent domestic and international economic developments, including domestic and foreign interest rate and inflation developments. Given market expectations, an unexpected rise in domestic interest rates proportionate to comparable rates abroad should in general cause the exchange rate to appreciate.⁶ The reason is that higher interest rates make domestic financial assets more attractive than comparable foreign assets, all other things being equal. Demand for domestic currency therefore increases, causing a rise in its price, i.e. an appreciation.

This appreciation should be large enough for the expected return on domestic and foreign assets to be equal. Otherwise, unexploited arbitrage opportunities would exist. At any given time, the interest rate differential between comparable domestic and foreign securities should therefore correspond to the expected change in the domestic currency over the maturity of the investment, plus a risk premium that investors demand for investing in domestic assets

(which for Iceland could reflect, for example, the long history of depreciations of the króna, the lack of Central Bank credibility, the small size of the market and lesser liquidity of domestic securities relative to comparable foreign ones).

However, a rise in nominal interest rates which reflects higher inflation expectations generally causes the domestic exchange rate to depreciate since investors expect higher future inflation to reduce its value, i.e. cause a depreciation. Therefore they immediately sell the domestic currency to avoid exchange rate losses later. This increased supply of currency then causes it to depreciate. A rise in the policy rate may therefore weaken the domestic exchange rate if it is insufficient to offset higher inflation expectations, meaning that the central bank's real policy rate has in fact fallen, despite the nominal rise.

2.5. Expectations and confidence

As mentioned earlier, expectations about the future developments of, for example, economic growth and inflation are a major determinant of the ultimate impact of monetary policy actions. Monetary policy can affect these expectations and the confidence with which they are held. Such changes in expectations influence the behaviour of financial market participants and other agents in the economy, including individuals' expectations about employment prospects and firms' expectations about future sales and profits. Monetary policy can thus affect the behaviour of individuals and firms through their expectations; such effects may even become evident before those which are channelled through the price and volume of the various financial assets discussed above. Even expected monetary policy decisions can affect behaviour, without actually being implemented.

However, the precise impact of monetary policy on expectations is difficult to ascertain precisely, and probably varies from one time to another. In general a rise in the policy rate would be interpreted as signalling a need to slow down the economy in order to achieve the inflation target, with future growth prospects deteriorating and inflation expectations falling if the policy action is credible. Such a response would reinforce the bank's efforts to raise interest rates to curb excess demand in the economy. If the policy action lacks credibility, e.g. if the public

5. An estimation of money demand in Iceland, finding a negative relation between money demand and the opportunity cost of money, is found in Pétursson (2001a). See also Gudmundsson (1986).

6. Exchange rate developments are generally characterised by substantial short-term fluctuations and the factors causing this volatility could easily swamp the short-run effects of monetary policy on the exchange rate.

Box 1 The effects of Central Bank monetary policy on the financial system

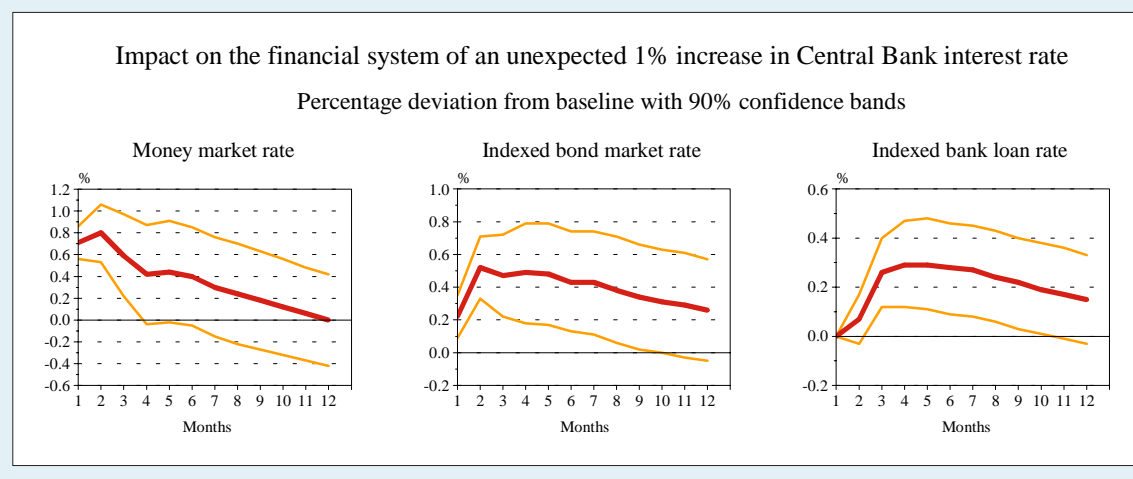
The first effects of monetary policy actions are on financial markets, particularly those where short-term financial assets are traded, e.g. the domestic money market.

As with the monetary policy transmission mechanism in general, the time it takes Central Bank of Iceland actions to have an impact within the financial system is subject to uncertainties. The lags may depend on factors such as the extent to which market participants foresaw the actions, how they interpret their impact on future economic prospects and their predictions of the Central Bank's future actions. Thus the time lags probably vary from one period to another.

To give some idea of how policy actions work through the financial system, the figure below shows the impact of an unexpected 1% increase in the policy rate on money market interest rates (3-month treasury bills), indexed treasury bond interest rates (5-year treasury bonds) and bank lending rates (average interest rate on indexed lending). The estimation is based

on a VAR analysis, see Pétursson, 2001b). It represents an estimation of a typical response by these market rates to an unexpected rise in the policy rate over the past ten years and should not be interpreted as a forecast of responses to the Bank's actions in the future.

According to this analysis, money market rates immediately rise by 0.7% following a 1% rise in the Central Bank rate. The effect peaks during the first months after the rise, then gradually fades out. Bond rates also rise immediately by roughly 0.2%, an impact transmitted through money market rates. The effect peaks during the first months after the rise, then gradually fades out. The analysis shows that indexed lending rates do not rise immediately, but have risen by roughly 0.3% when the effect peaks around four months after the policy rate rise, largely transmitted through the bond market. The effect gradually wanes after that and fades out after around a year, based on the statistical confidence bands.



regards the bank's efforts to slow down the economy as inadequate, expectations of further interest rate rises could arise, which would magnify the contraction impact. A higher policy rate could even be interpreted as reflecting that the bank views that the economy is growing faster than had earlier been thought,

thereby spurring future growth expectations. This response could diminish the tightening imposed by the interest rate rise.

Uncertainty about monetary policy's effects on expectations and confidence in the economy thereby increases the uncertainty surrounding its effects on

other economic variables, which underlines the importance of a credible and transparent monetary policy. This point will be discussed in more detail below.

2.6. Time lags from policy decisions to the financial system

Through their interest rate decisions, central banks directly influence other short-term interest rates and, through them, long-term rates, asset prices, the quantity of money and the exchange rate. In general an unexpected policy rate hike causes a rise in long-term interest rates, a fall in asset prices, a reduction in the quantity of money and a strengthening of the domestic currency. These effects are generally transmitted fairly quickly, usually within a few months, as shown in Box 1 which discusses the impact of monetary policy on the money, bonds and bank lending markets in Iceland. However, the effects vary from one time to another and are determined by factors such as the business cycle, expectations and central bank credibility.

3. From the financial system to spending decisions

The second stage of the transmission mechanism describes the impact of monetary policy from the financial system and onto the rest of the economy, i.e. how central bank interest rate decisions affect spending decisions by individuals and firms. In turn, these decisions affect aggregate demand and ultimately the rate of inflation. Before describing this process, however, the impact of monetary policy on real interest rates and the real exchange rate need to be discussed.

3.1. Real interest rates and the real exchange rate

As discussed in the preceding section, a rise in central bank policy rate generally produces a rise in other nominal interest rates and the nominal exchange rate of the domestic currency. However, it is not these variables that are most important for expenditure decisions of individuals and firms, but rather the development of real interest rates and the real exchange rate.⁷ It is real interest rates, i.e. nominal interest rates adjusted for expected inflation through the maturity of the investment, rather than

nominal rates, that determine the profitability of investments and other spending decisions.⁸ Likewise, it is the real exchange rate, i.e. the nominal exchange rate adjusted for domestic prices relative to foreign prices, and not the nominal exchange rate, that determines the competitive position of domestic firms.

Extensive research shows that prices and inflation adjust slowly. It can therefore be assumed (as also confirmed by research) that inflation expectations are also sticky (see, for example, the discussion in Taylor, 1995). Thus a rise in nominal interest rates and the nominal exchange rate will result in a higher real exchange rate and real interest rates, all other things being equal.⁹ An increase in these variables due to a rise in the central bank policy rate, however, will only prove temporary, while inflation and inflation expectations are adjusting to the new interest rate and exchange rate levels. As discussed below, this means that the effect of monetary policy on real variables such as growth, employment and the current account can only be temporary.

3.2. Spending decisions of individuals

By influencing interest rates, asset prices, the exchange rate of the domestic currency and the quantity of money, monetary policy has an effect on individuals' behaviour through various channels. One of the most important effects of monetary policy is probably through disposable income. By influencing market interest rates, monetary policy affects the interest rate on savings, as well as on outstanding short-term liabilities (for example borrowing on credit cards and overdrafts) and long-term liabilities with variable interest rates, which are a relatively common debt instrument in Iceland. A rise in the policy rate thus reduces disposable income of net debtors, which in turn affects their spending decisions.¹⁰ Higher interest rates prevent individuals from maintaining the same level of spending on con-

7. Nominal interest rates and the nominal exchange rate can be important for spending decisions of individuals and firms if their access to financial markets is restricted in some way, since these nominal aggregates affect their cash flow.

8. Thus it is the real policy rate that determines the tightness of the monetary stance, and not the nominal policy rate.

9. As seen in the chart in Box 1, where interest rates on bonds and bank lending are real interest rates.

sumption without incurring more debt or drawing on savings, which in both cases has become more expensive. All things being equal, individuals' consumption expenditure ought to contract when interest rates rise. The rise in interest rates does not affect long-term debts with fixed interest until they reach maturity, but all new debtors are immediately affected by the higher interest rates.¹¹

Monetary policy also affects the timing of consumption decisions, since interest rates in effect represent the price of current consumption relative to that in the future. When interest rates rise, current consumption becomes more expensive compared to future consumption, i.e. current saving. Individuals should therefore reduce their current consumption by a corresponding amount.

Thirdly, monetary policy affects individuals' wealth. As discussed above, a rise in interest rates generally leads to a fall in stock and housing prices. Since these assets constitute an important part of individuals' aggregate wealth, their consumption expenditure should decrease, since they are no longer as wealthy. Likewise, their access to credit becomes more difficult, because housing is often used as collateral for loans. Since the market prices of their assets has fallen, their borrowing capability decreases. The impact of monetary policy on the access to credit for individuals and firms is discussed in more detail below.

Monetary policy can also affect the consumption expenditure of individuals through consumers' expectations about their future income and employment prospects. For example, if individuals expect that a tighter monetary policy stance will reduce medium-term economic growth, they are likely to cut back their expenditure on consumption and their current indebtedness in order to sustain future consump-

tion more easily. However, a tighter monetary policy could be interpreted as signalling that the rate of economic growth is faster than had been thought. Individuals' expectations could thereby be kindled, and likewise their willingness to spend. This effect is therefore uncertain and probably varies from one period to another.

Monetary policy also affects individuals' consumption patterns through the exchange rate channel. An appreciation makes imported goods and services relatively cheaper. The effect is to reduce relative demand for domestic goods and channel it out of the economy, temporarily weakening the competitive position of domestic businesses, as will be discussed later. An appreciation may also affect total consumption, although its main impact is probably on the composition of consumption expenditure, if for example a major part of individuals' assets or liabilities is denominated in foreign currencies. Thus a currency appreciation would reduce the indebtedness of individuals who have part of their liabilities in foreign currencies, since their income is generally in domestic currency. Total wealth of these individuals would therefore increase, and with it consumption expenditure through the wealth effect. This may soften the impact of monetary policy if net foreign liabilities form a major part of total individual debt. On the other hand, the positive wealth effect of an appreciation which is prompted by a rise in interest rates is probably offset by the fact that it entails a greater likelihood of a subsequent depreciation, thereby increasing the currency risk faced by individuals with foreign liabilities.

Finally, monetary policy affects consumption expenditure of individuals through their access to credit (especially for financing expenditure on consumer durables such as housing and motor vehicles). The possibility that a decrease in money supply following a rise in central bank policy rates could reduce bank deposits and thereby the lending capacity of banks has already been pointed out. In general, individuals have few other finance options than borrowing from banks. Other things being equal, individuals' scope for financing their consumption also diminishes. However, it seems likely that the importance of this bank lending channel has decreased with the more diverse finance options available to banks in recent years.

10. Net indebtedness of Icelandic households was estimated at more than 160% of disposable income in 2000. Based on a rough evaluation of interest-bearing financial assets (excluding equity holdings and pension fund assets), Icelandic household debt net of interest-bearing assets could be in the region of 60-70% of disposable income.

11. Disposable income of individuals who are net savers obviously increases when interest rates rise. Other things being equal, their propensity to spend ought to increase. Nonetheless, studies show that the overall impact of higher interest rates is generally a contraction in consumption expenditure, although this is probably only small at first. As discussed later, the second-round effects, i.e. when aggregate demand is contracting, are more important (see, for example, MPC, 1999).

Monetary policy has, however, another and more important effect on individuals' access to credit through the banking system, called the balance-sheet channel. With a rise in the policy rate, the net worth of individuals diminishes since their balance sheets have deteriorated (e.g. through the above-mentioned rise in interest expense on outstanding current liabilities and the negative wealth effect). Such circumstances exacerbate the problems of adverse selection and moral hazard.¹² By reducing the banking system's willingness to lend, this reduces individuals' spending ability (see, for example, Bernanke and Gertler, 1995). In general lending ability within the banking system also diminishes, since the interest rate rise has the same effect on its net worth and access to new credit. Monetary policy can also affect individuals' willingness to borrow through a liquidity channel, because a rise in interest rates can increase the probability of financial distress later on. They therefore reduce their demand for assets which could be difficult to liquidate at short notice, such as housing and consumer durables, but increase their demand for highly liquid assets such as bank deposits and securities (see, for example, Mishkin, 1978).

The impact of monetary policy is therefore transmitted to individuals' spending decisions through a wide range of channels. In general a rise in the central bank policy rate will cause a contraction in total expenditure by individuals. Furthermore, they will tend to switch their spending from domestic to foreign goods in response to the exchange rate effect which makes imports relatively cheaper. The extent of the effect of monetary policy on individuals' expenditure decisions, and even sometimes on the direction they take, may vary from one time to another, depending upon factors such as its effect on individuals' expectations and confidence.

12. Adverse selection refers here to an increase in the average risk of lending following a reduction in the net worth of borrowers, whereby low-risk borrowers defer or back out of borrowing due to a rise in the interest rate and thereby the required return on the underlying decision. Moral hazard refers here to an increase in the average risk of lending as borrowers are prepared to take more risk when their net worth decreases, since they have a lower equity stake in the project, giving them increased incentives to engage in risky investments.

3.3. *Spending decisions of firms*

Monetary policy also affects firms' spending decisions through interest rates, asset prices, the exchange rate and the quantity of money. This effect may vary according to the nature of the business, the size of the firm and its sources of finance.

Firms relying on bank financing, or other types of credit funding linked to domestic short-term interest rate developments, are affected directly. Increased borrowing costs reduce their profit and raise the required return on all new investments. The willingness and ability to embark on new projects is therefore diminished, other things being equal. Likewise, higher interest rates increase firms' inventory costs, which are often financed with short-term credit. Higher interest rates also affect the demand for labour, by reducing their willingness to hire new staff. Firms might even reduce employment or hours worked.¹³

Monetary policy also affects the cost of capital through its temporary impact on long-term real interest rates. Thus a rise in the policy rate should also prompt a temporary rise in the required return on new projects, making it more likely for firms to postpone or simply abandon such plans.

However, it should be borne in mind that some firms are probably little affected by changes in the policy rate. For example, those with minimal liquid assets or short-term liabilities will have their cash flows largely unaffected. The same applies to firms whose liquid assets and short-term liabilities are roughly matched. Nonetheless, they will be affected by monetary policy changes through long-term real interest rates whenever they need to use the capital markets to fund long-term investments. This is less true of large firms or those able to raise funds in international financial markets, because they are less dependent on funding through the domestic financial system and domestic interest rate developments. They will, however, have greater exchange rate risk if they have foreign-denominated liabilities and part of their revenues or assets are in domestic currency.

13. However, higher interest rates can have a positive impact on firms which have favourable liquidity positions, since they improve their cash flow. These firms might therefore increase their investment following a rise in interest rates. But it is also possible that these firms will decide to channel their extra cash flow into financial assets or, say, higher dividend payments to shareholders.

Another effect of monetary policy on firms' spending decisions is through the asset price channel. As mentioned above, a rise in the policy rate usually leads to a fall in equity prices, causing the market value of firms to fall relative to the replacement cost of capital (a fall in the q -ratio, see Tobin, 1969). Accordingly, it becomes relatively more expensive for firms to issue new equity to finance new investments.

Firms experience a similar wealth effect to individuals. Higher interest rates reduce their net worth and their cash flow worsens, as well as lowering the price of assets which can be used as collateral. Firms could then encounter problems in funding new projects. Adverse selection and moral hazard problems increase accordingly, making the banking system even less willing to lend (this effect is known as the financial accelerator effect). This applies particularly to small and new firms which lack easy access to other sources of financing outside the banking system (see Bernanke and Gertler, 1995).

Exchange rate changes are another important influence on firms' spending decisions. A temporary real appreciation of the domestic currency worsens the competitive position of domestic firms that have costs in domestic currency but produce for export markets or in competition with imports. They need to counteract the appreciation either by reducing the prices of their products, which leads to a lower profit margin, or by keeping their prices unchanged, which leads to a lower market share. Various services such as tourism also experience a contraction in the wake of an exchange rate appreciation. Monetary policy can also affect firms which produce solely for the domestic market or firms that are not in international competition if they have, for example, unhedged foreign debt positions. By raising the net worth of firms with net foreign debt, a stronger exchange rate could also increase their willingness to spend. Counteracting this is the greater probability of a subsequent depreciation, which would increase their foreign exchange risk. Fluctuating exchange rates would, in addition, increase the risk of investing in such firms, leading to higher financing costs than otherwise.

Finally, monetary policy has an effect on firms' expectations and confidence about the economic outlook, just as it does for individuals. This can be a cru-

cial factor, especially for long-term irreversible investments. Expectations about future sales, interest rate developments and future risk play a major role in the timing of investments. If a firm foresees a contraction in the near future, optimism about future sales will be dampened, making the investment less attractive. Increased uncertainty about the future is also important, since the greater the uncertainty, the riskier the investment, with a corresponding increase in required rate of return. The impact on expectations is difficult to predict for firms, just as in the case of individuals, and probably varies from one period to the next.

Monetary policy therefore has an impact on corporate expenditure decisions through various channels. In general, a rise in central bank policy rate will cause a contraction in firms' activities. However, the scale of the impact is difficult to predict, and it can sometimes operate in the opposite direction. It is probably determined among other things by changes in expectations and confidence.

4. From expenditure to demand and inflation

As shown in Figure 1, the next stage of the transmission mechanism describes how individual and business expenditure decisions affect aggregate demand, i.e. how aggregate demand is affected by monetary policy when expenditure decisions by all individuals and firms are added up to determine total expenditure.¹⁴ Changes in spending decisions by individuals and firms then affect the rest of the economy, even those agents not directly affected by monetary policy.

4.1. Aggregate demand

As discussed in the previous section, a rise in the policy rate causes at least some individuals and firms to reduce their expenditure on consumption and investment. Total expenditure contracts, with a corresponding drop in aggregate demand.

14. Aggregate demand is defined as national expenditure and net exports, where national expenditure is the sum of private consumption expenditure, government consumption expenditure and investment spending, and net exports are the difference between exports and imports of goods and services. Aggregate demand is therefore equivalent to the gross domestic product at market prices (GDP).

When individuals reduce their expenditure, this means that their private consumption decreases (or grows at a slower rate). The same applies to their investments in residential housing and other durable goods. All these factors cause private consumption and thereby aggregate demand to decrease (or grow at a slower rate). Likewise, individuals shift their demand from domestic goods to imports, which are relatively cheaper after the domestic currency has appreciated. Demand is thereby channelled out of the economy, boosting imports and also slowing down growth of aggregate demand.

Firms also reduce their outlays, so that their investments and activities decrease (or grow more slowly). The same applies to inventories and various expenditure decisions such as maintenance projects and dividend payments to shareholders. All these factors combine to reduce the growth rate of demand.

Lower aggregate demand has an impact on firms and individuals that were unaffected directly by higher interest rates. For example, demand for the products of a firm that was not directly affected by the interest rate rise could contract when private spending declines. Demand could also shrink if its products are used as inputs by other companies which are directly affected by the interest rate rise. Likewise, the disposable income of individuals who were not affected by higher interest rates could decrease if, for example, the firms they work for are forced to cut back operations in response to less demand for their products. The fact that these second-round effects can to some extent be anticipated also affects expectations, amplifying the total effect. A manufacturer, for instance, could cut back production because he expects decreasing demand in the near future following a tighter monetary policy, even if he is not directly affected by the interest rate rise. This decision will then affect other firms supplying inputs that it uses for its production.

Firms and individuals thereby scale down their own activity because they expect a general contraction throughout the economy, even though they remain unaffected directly by the higher central bank policy rate. Lower demand can then reduce the net worth of businesses and individuals, curtailing even further their ability to raise finance. These second-round effects of monetary policy on demand proba-

bly weigh heavier than the direct first-round effects discussed above.

4.2. Demand, inflation and inflation expectations

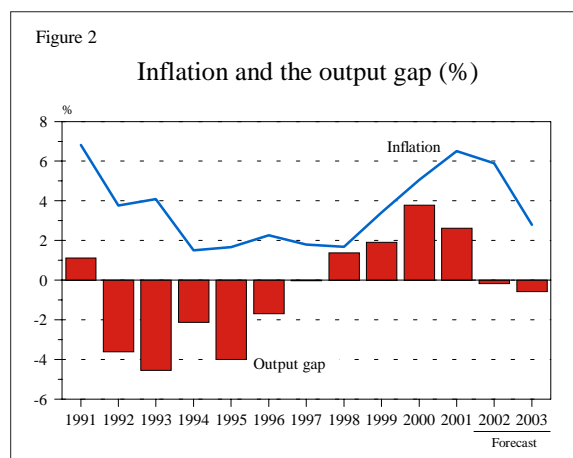
The above discussion examined how monetary policy can temporarily affect aggregate demand. As Figure 1 shows, central banks can ultimately exert an impact on domestic inflation through this demand channel. More specifically, the demand channel operates through the output gap, which is the difference between the actual level of production and the potential output of the economy, i.e. the level of production where domestic firms are operating under normal capacity utilisation (see further below). When aggregate demand exceeds potential output, a positive output gap develops whereby firms operate at a capacity level above their normal capacity levels, and output is above its sustainable level. This is, for example, reflected in excess demand for labour, leading to upward pressures on wage costs. Firms pass on part of their extra costs to prices, fuelling inflationary pressure. Excess demand for their products also gives firms an opportunity to raise their markup. Conversely, a negative output gap eases wage and inflationary pressures.

An increasing output gap during economic upswings is generally accompanied by escalating inflation, as can be seen from in Figure 2 which shows the development of the output gap and inflation in Iceland since 1991.¹⁵ There, a negative output gap during the first half of the decade went hand in hand with falling inflationary pressures. In the past few years, however, the output gap has widened and inflationary pressures have built up.

The output gap is thus an important indicator for the future development of inflation.¹⁶ Only at the level of demand where actual output corresponds to its potential level can inflation be stable. It is important to realise that this level of inflation can be either high or low, depending on inflation expectations. Holding actual output at its potential level will sim-

15. The figure shows the average of different estimation methods of the output gap. More detailed information is given in *Monetary Bulletin* 2000/4, pp. 14-15. The forecast is based on the Central Bank's last inflation forecast and the National Economic Institute's forecast from October 1, 2001.

16. This is confirmed in an econometric study for Iceland in Pétursson (2001c).



ply give the level of inflation that agents expect, as reflected in wage settlements and product prices.

Even though maintaining actual output at its potential level can be compatible with high or low inflation (as long as it remains steady), the cost of higher inflation is much greater, since even when steady and foreseen it entails considerable social losses, including distortive taxation. The role of monetary policy is therefore to maintain actual output close to its potential level and a low, steady rate of inflation. This aim can only be achieved if monetary policy is considered credible, so that inflation expectations reflect the Central Bank's inflation target.

4.3. The exchange rate, import prices and inflation

Figure 1 shows how monetary policy can also affect domestic inflation through the direct effect of the exchange rate on imported inflation. This arises because imported goods are an important component of domestic prices, both via imported consumer goods and services and as a major cost item for domestic producers who use imported inputs in their production. The exchange rate can therefore directly affect prices of these goods by affecting their price in domestic currency. A rise in the policy rate which strengthens the domestic currency can cause a direct reduction in domestic prices (or the rate at which they rise) by reducing the domestic currency price of imported goods and services. This effect is obviously more important the more open that the economy is for international trade and the more dependent it is on imported consumer goods and services. A number

of studies have confirmed the historical importance of this channel for Iceland (e.g. Gudmundsson, 1990; Andersen and Gudmundsson, 1998; and Pétursson, 1998b, 2001c).

While this direct exchange rate channel would generally reduce the time lags from policy decisions to the final effects on inflation, some time may pass before the effect on prices of imported goods is transmitted to final prices to consumers. The exchange rate effect needs to pass through a number of intermediaries from importers to retailers, each of whom may respond differently. Moreover, the effect may vary from one time to another, depending on the nature of the underlying exchange rate shock. For example, if importers regard the exchange rate change as being temporary, it can be sensible for them to absorb it through their markup instead of passing it on to consumers with the risk of losing market share, besides the fact that frequent price changes can be costly to implement (see e.g. McCarthy, 1999). Likewise, importers can invest in different financial products to hedge against short-term exchange rate fluctuations. An importer would thus not pass through an exchange rate change to prices until it was obviously permanent.

The size of the exchange rate pass-through also depends on how much competition prevails at different levels of the import chain. Strong competition among intermediaries makes it more difficult for any single one to pass on an exchange rate change, since he would risk losing market share if the others do not raise their prices as well.

Another crucial factor may be the level of domestic demand. Robust domestic demand growth makes it easier for intermediaries to pass on a exchange rate depreciation to prices without the risk of losing market share. On the other hand, this is much more difficult if the economy is in a recession where importers are likely to be forced to absorb some of the exchange rate depreciation through their markup.

The exchange rate pass-through probably varies from one period to another. Nonetheless, Icelandic and international experience suggests that the pass-through has weakened somewhat in the past few years (see e.g. Sveriges Riksbank, 2001). Various possible reasons have been cited. Global competition has probably decreased firms' scope for passing through exchange rate changes to prices. Similarly,

firms now have better techniques for hedging against short-term exchange rate fluctuations. Exchange rate flexibility has also increased in Iceland and many other countries. The public probably views changes in the exchange rate differently when it can fluctuate from one day to the next, compared with a period when changes are rare. Infrequent exchange rate changes are probably interpreted as being permanent, which will naturally be quickly passed through to domestic prices. The more frequent that exchange rate changes are, the more likely they are to be interpreted as temporary. Such changes do not need to be reflected in prices until it is clear that they are permanent, as pointed out earlier.

Thus the impact of short-term exchange rate fluctuations on domestic prices probably decreases with greater exchange rate flexibility and increasing financial innovations. Permanent changes in the exchange rate, on the other hand, will ultimately be passed through to prices. Nonetheless, it is important to distinguish between the price level impact and inflationary impact of exchange rate changes. A permanent depreciation will lead to a permanent rise in prices in the long run. While prices are adjusting towards the new steady state, inflation will emerge. This inflation will only be temporary while the adjustment towards the new steady state takes place and in the long run the inflationary effect will disappear, assuming that the exchange rate depreciation does not alter long-term inflation expectations.

4.4. Time lags from policy decisions to the economy

As pointed out above, it can take a considerable time for monetary policy to affect economic activity. Changes in the policy rate generally affect prices of financial assets in the domestic money market very quickly, which then pass through to prices of other financial assets, such as the exchange rate, equity prices and long-term bond prices. However, it can take considerably longer for these price changes to affect expenditure decisions by individuals and firms. For example, some time may elapse before interest rate changes begin to affect the repayments burden on long-term loans, such as housing loans, and even longer before their impact is felt on individuals' spending behaviour. Similarly, changes in individuals' spending behaviour can lead to a buildup in retail inventories. The retailer responds by cutting

back on orders from suppliers, who then need to reduce production. This can then result in a lower level of activity and falling demand for labour, which leads to a reduction in the disposable income of individuals. All these changes take time to emerge.

Empirical evidence from industrialised countries suggests that, on average, it takes up to six months for a change in monetary policy to affect domestic demand, with a peak effect after roughly 1-1½ years. These studies also suggest that it takes up to a year for a change in monetary policy to affect domestic inflation, with a peak effect after roughly 1½-2 years or even later (see e.g. MPC, 1999 and Viñals and Vallés, 1999).

Box 2 presents a rough estimation of the monetary policy lags for Iceland. It shows that the lags and the orders of magnitude are more or less the same for Iceland as other industrial countries. The impact on economic activity is first felt around half a year after a rise in Central Bank interest rates, with a peak effect after roughly one year. The initial impact on domestic inflation appears around one year after the interest rate rise, with a peak effect after 1½ years. The time lags from policy decisions to inflation might therefore be somewhat shorter in Iceland than in most other industrial countries, which could reflect the relative importance of the exchange rate pass-through.

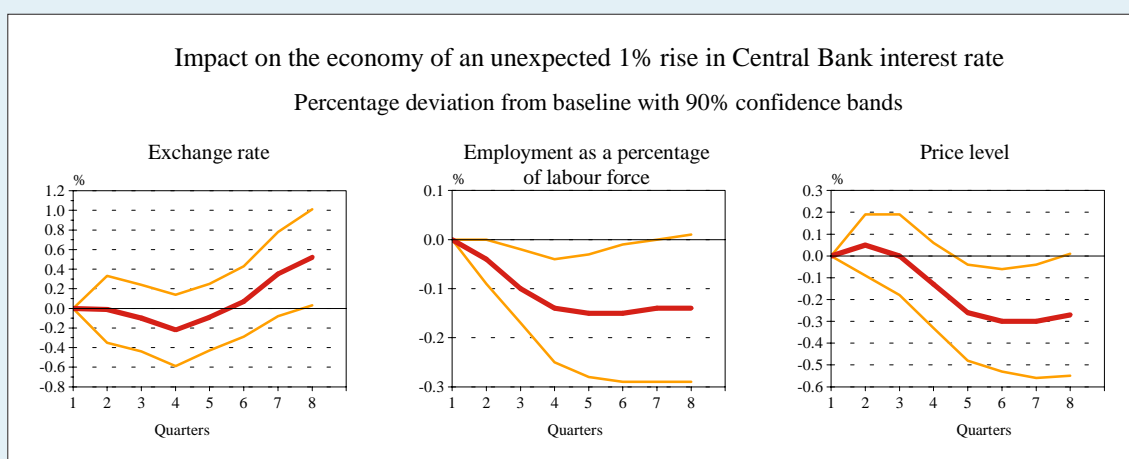
It should be emphasised that any analysis of the lags in the transmission mechanism of monetary policy is subject to great uncertainty, both in Iceland and abroad. The uncertainty is probably even greater in Iceland since a relatively short data period underlies the econometric estimates, besides the fact that major reforms have been made to Iceland's institutional and monetary policy framework over the past decade. In addition, the transmission lags probably vary from one period to another, governed by factors such as the business cycle, expectations and the credibility of the Central Bank. Monetary policy is thus likely to work through long, variable and uncertain lags which are difficult to determine precisely. The above estimation of the transmission lags therefore only presents the economy's typical responses to monetary policy decisions at "normal" times. As discussed in the following section, conditions may arise in which the economy responds in a completely different way.

Box 2 The effects of Central Bank monetary policy on the economy

The time that it takes for Central Bank of Iceland interest rate changes to have an impact on economic activity and inflation is subject to uncertainties in the same way as the financial market pass-through. It could even be argued that this uncertainty increases, the further we travel along the transmission mechanism. As the main text suggests, the time lags depend on factors such as the extent to which agents foresaw the actions, how they interpret their impact on future economic prospects and their predictions of the Central Bank's future actions. Thus the time lags probably vary from one period to another.

interpreted as a forecast of responses to Bank's actions in the future.

According to this analysis, monetary policy has little initial impact on the exchange rate of the króna, employment and prices. After a while the króna gradually begins to appreciate (as the exchange rate index falls) and the maximum impact has emerged after just under one year, with an appreciation by roughly 0.2% from the baseline. From then on the króna starts to depreciate again, which is broadly consistent with standard theories of the relationship between exchange rates and interest rates, i.e. a positive inter-



The figure above shows an estimation of the typical impact of an unexpected 1% rise in the policy rate on the exchange rate (log of the effective exchange rate index), employment (as a proportion of the labour force) and prices (log of the CPI). The estimation is based on a VAR analysis which includes foreign short-term interest rates (weighted average) and international commodity prices in order to adjust for the impact of supply shocks, plus the above variables. It is based on quarterly data covering the period from 1989 to 2000. The figure only shows a typical response of the economy to an unexpected rise in the policy rate over the past ten years and should not be

est rate differential vis-à-vis abroad corresponds to an expected future depreciation of the exchange rate. The initial appreciation of the króna takes place somewhat later than in standard models, but is consistent with the findings of Eichenbaum and Evans (1995) for other countries. The estimation results are, however, subject to considerable uncertainty and the exchange rate effect is not found statistically significant from zero. This probably reflects the relatively short data period on which the estimation results are based (the data only cover 1-1/2 business cycles). Also, for most of the period monetary policy was based on an exchange rate peg. A depreciation of the

króna was countered by interest rate rises which would suggest a negative relation between interest rates and the exchange rate if the causation was misinterpreted.

The interest rate rise gradually leads to lower employment, with a statistically significant effect occurring after roughly half a year. The effect peaks after one year when unemployment has increased by 0.15% of the labour force (deviation from baseline).

The effect gradually decreases and has vanished after roughly 1½ years, based on the confidence bands. A statistically significant effect on prices occurs roughly one year after the interest rate rise. The effects peaks after about 1½ years when prices have fallen by roughly 0.3% from the baseline. This corresponds to a maximum impact on the annual rate of inflation after some 15 months, when inflation has fallen by 0.35 percentage points from the baseline.

4.5. *Non-linear and asymmetric effects*

So far this discussion has been confined to the economy's typical responses to changes in monetary policy. Under certain circumstances, however, these responses can be fundamentally different.

Some studies imply, for example, that interest rates rises and cuts can have different real effects. Downward stickiness of nominal prices and wages, for example, could cause interest rate rises to have greater real effects than equivalent interest rate cuts, i.e. an interest rate rise would have proportionally greater contractionary effects than an equivalent interest rate cut would have an expansionary effect, given the economy's position in the business cycle (see e.g. Cover, 1992).

Monetary policy can also have an asymmetric effect on expectations. For example, higher interest rates could cause the domestic currency either to strengthen or weaken, depending on the effect on expectations. There are two effects working against each other. All things being equal, a rise in interest rates should slow down the economy and thereby reduce the probability of future inflation. This should make domestic financial assets more attractive and thereby strengthen its exchange rate. Offsetting this is the possibility that by slowing down the economy, higher interest rates could weaken the exchange rate by reducing the number of attractive investment opportunities. The final effect of higher interest rates on the exchange rate depends on which of these two effects proves stronger. Empirical studies indicate that the former effect is generally stronger and that currencies rarely depreciate following a monetary policy tightening (see e.g. Zettelmeyer, 2000).

The effects of monetary policy on the real economy can also depend on its position in the business

cycle. For example, research suggests that the real effects of monetary policy may be proportionally greater during recessions than equivalent actions during booms (see e.g. Garcia and Shaller, 1995). The main reason is the reliance of individuals and small firms on easy access to credit, as discussed earlier. Since credit is generally tighter during recessions, monetary policy can both help to steer the economy out of the recession with interest rate cuts which create easier access to credit, and also push the economy into further recession if the monetary stance happens to be tightened during a recession. The reason is that the increased tightening would squeeze access to credit for firms and individuals that rely on funding through the banking system, which could cause problems for them and even increase the probability of bankruptcies. Both these effects are probably stronger than the effects of a corresponding tightening during a boom, when access to credit is much easier.¹⁷

The impact on the real economy may also depend on the size of the interest rate change. Menu cost models, for example, indicate that small changes in demand have little impact on firms' price decisions, since it can be expensive to adjust prices. Large demand shocks, however, may lead firms to decide to do so. In this case, minor changes in the central bank policy rate would have strong real effects, but large

17. The effect of tighter money during a recession could be even greater still if accompanied by disinflation which raises the real indebtedness of net debtors. All things being equal their net worth deteriorates and bankruptcies become more likely, amplifying the recession. Bernanke (1983), for example, argues that Federal Reserve actions at the onset of the Great Depression, and the disinflation in its wake, played a key role in turning a potentially relatively small contraction into the deep crisis that actually occurred. There is much less probability of such a scenario during a boom.

interest rate changes proportionally smaller effects (see e.g. the empirical study by Ravn and Sola, 1996). However, the effects might conceivably be the complete opposite. A large interest rate rise could be more likely than a small one to turn the economy into a recession, increasing the likelihood of bankruptcies among debtors, and possibly even breaking the financial system. Likewise, a large interest rate change can affect the credibility of monetary policy, which could amplify the real effects of monetary policy. In both cases the real effects of a large interest rate change would be proportionally greater than that of a smaller one. It is therefore unclear whether large or small changes in monetary policy have relatively greater real effects, but the effects are not necessarily symmetric.

4.6. The long-run effects of monetary policy

Monetary policy affects aggregate demand in the short to medium term. In the long run, however, the trend level of output is determined by its potential level, i.e. the output level that is compatible with normal capacity utilisation. This level defines the long-term growth path of output, where firms have no incentive to change their production decisions and product prices change at the rate of expected inflation.

Potential output is determined on the supply side of the economy, for example by available technology, production factors, the size and skill of the labour force, the flexibility of the market system and the institutional set-up in the economy. The government can influence this level of production, for example with changes in the tax structure, by changing the regulatory framework of the economy, and by improving the functioning of the market system. Monetary policy cannot, however, influence the long-run capacity level of the economy. If a central bank tries to maintain output above its potential, aggregate demand will eventually outstrip potential output and inflationary pressures emerge. This could even end up in hyperinflation with the severe social costs that usually accompany such episodes.

Monetary policy can thus affect the real economy in the short and medium term. Bad monetary policy can even be harmful to the real economy in the long term, by reducing the effectiveness of the market mechanism and creating increasing uncertainty. The

general rule, however, is that with a relatively low and stable rate of inflation, monetary policy can only have long-term effects on nominal aggregates such as inflation, nominal interest rates and the nominal exchange rate. It cannot have permanent effects on the long-term growth of real variables.¹⁸ Rather, in the long run, monetary policy determines the monetary value of these variables, i.e. the general price level. Inflation therefore indicates how their monetary values change over time, namely how the purchasing power of money changes over time. It is in this sense that inflation is a monetary phenomenon (See e.g. MPC, 1999 and Viñals and Vallés, 1999).

5. Conclusions

This paper discusses the transmission mechanism of monetary policy, i.e. how changes in the policy rate are transmitted through the economy and affect aggregate demand, inflation expectations and inflation.

Empirical evidence from industrial countries suggests that it takes up to six months for a change in monetary policy to affect domestic demand, with a peak effect after roughly one year. It takes up to a year for a change in monetary policy to affect domestic inflation, with a peak effect after roughly 1½-2 years. In the long run, however, monetary policy only affects nominal variables and cannot maintain output growth above the growth rate of potential output. Attempts to do so will eventually only lead to persistent and even accelerating inflation. The lags and orders of magnitude appear roughly the same for Iceland. However, the effects on inflation appear to take a somewhat shorter time, which might be due to the relative importance of the exchange rate pass-through via imported goods and services. The relatively long lags from the policy rate decisions to their effects on the economy mean that monetary policy at any time needs to be forward-looking and based on inflation prospects for the coming 1-2 years rather than on the current inflationary developments. With the new monetary policy framework in Iceland, such a framework has been formalised.

18. A well formulated monetary policy can, however, reduce the volatility of real variables, such as the output gap.

The transmission mechanism and its length, however, may change from one time to another, and the effects can furthermore be non-linear or even depend on whether the central bank is tightening or easing the monetary stance and on the position of the business cycle. Considerable uncertainty thus surrounds the transmission mechanism and the ultimate effects

of monetary policy. To a large extent, they will depend on how policy affects expectations of economic agents and the confidence with which they hold these expectations, further underlining the importance for monetary policy to be transparent and credible.

Bibliography

- Andersen, P. S., and Gudmundsson, Már (1998), "Inflation and disinflation in Iceland", Central Bank of Iceland Working Papers, no. 1.
- Bernanke, B. S., (1983), "Nonmonetary effects of the financial crisis in the propagation of the Great Depression", *American Economic Review*, 73, 257-276.
- Bernanke, B. S., and M. Gertler (1995), "Inside the black box: The credit channel of monetary policy transmission", *Journal of Economic Perspectives*, 9, 27-48.
- Cover, J. P., (1992), "Asymmetric effects of positive and negative money-supply shocks", *Quarterly Journal of Economics*, 107, 1261-1282.
- Eichenbaum, M., and C. L. Evans (1995), "Some empirical evidence on the effects of shocks to monetary policy on exchange rates", *Quarterly Journal of Economics*, 110, 1975-2010.
- Garcia, R., and H. Schaller (1995), "Are the effects of monetary policy asymmetric?", University of Montreal, Working Paper Series, no. 95-6.
- Gudmundsson, Gudmundur, (1986), "Peningamagn og vextir", *Fjármálatíðindi*, 33, 95-104. (Money and interest rates).
- Gudmundsson, Gudmundur, (1990), "Tölfræðikönnun á verðbólgu á Íslandi", *Fjármálatíðindi*, 37, 43-53. (Statistical analysis of inflation in Iceland).
- Heikenstein, L., and A. Vredin (1998), "Inflation targeting and Swedish monetary policy – experience and problems", Sveriges Riksbank, *Quarterly Review*, 4/1998, 5-33.
- Kristinsson, Yngvi Ö., (2000), "Implementation of monetary policy and Central Bank instruments", *Monetary Bulletin*, 2000/4, 40-48.
- McCarthy, J., (1999), "Pass-through of exchange rates and import prices to domestic inflation in some industrialised economies", BIS Working Papers, no. 79.
- Meltzer, A. H., (1995), "Monetary, credit and (other) transmission processes: A monetarist perspective", *Journal of Economic Perspectives*, 9, 49-72.
- Mishkin, F. S., (1978), "The household balance sheet and the Great Depression", *Journal of Economic History*, 38, 918-937.
- MPC [Bank of England Monetary Policy Council] (1999), "The transmission mechanism of monetary policy".
- Pétursson, Thórarinn G., (1998a), "Explaining the term structure: The expectation hypothesis and time varying term premia", University of Iceland Institute of Economic Studies, IoES Working Paper Series, W98:06.
- Pétursson, Thórarinn G., (1998b), "Price determination and rational expectations", *International Journal of Finance and Economics*, 3, 157-167.
- Pétursson, Thórarinn G., (2000), "Exchange rate or inflation targeting in monetary policy?", *Monetary Bulletin*, 2000/1, 36-45.
- Pétursson, Thórarinn G., (2001a), "The representative household's demand for money in a cointegrated VAR model", *Econometric Journal*, 3, 162-176.
- Pétursson, Thórarinn G., (2001b), "The transmission mechanism of monetary policy: Analysing the financial market pass-through", Central Bank of Iceland, Working Papers, no. 14.
- Pétursson, Thórarinn G., (2001c), "Wage and price formation in a small open economy: Evidence from Iceland", Central Bank of Iceland, Working Papers, forthcoming.
- Ravn M. O., and M. Sola (1996), "A reconsideration of the empirical evidence on the asymmetric effects of money-supply shocks: Positive vs. negative or big vs. small?", University of Aarhus, Working Paper Series, no. 1996-4.
- Taylor, J. B., (1995), "The monetary transmission mechanism: An empirical framework", *Journal of Economic Perspectives*, 9, 11-26.
- Tobin, J., (1969), "A general equilibrium approach to monetary theory", *Journal of Money, Credit, and Banking*, 1, 15-29.
- Viñals, J., and J. Vallés (1999), "On the real effects of monetary policy: A central banker's view", CEPR Discussion Paper Series, no. 2241.
- Zettelmeyer, J., (2000), "The impact of monetary policy on the exchange rate: Evidence from three small open economies", IMF Working Papers, WP/00/141.