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Central Bank interventions in Iceland's foreign exchange market and its effect on the exchange rate of the króna

Since the establishment of an organised foreign exchange market in mid-1993, the Central Bank's role in the market has changed considerably. For most of the period the Bank was an important participant in the market and took part in a large share of trading in order to ensure continuous trading of foreign exchange and as effective pricing of foreign currency as possible. With the development of the market, however, the Bank's role has gradually decreased, with the Bank only intervening on its own initiative, either directly to influence the exchange rate of the króna or under special circumstances which are not directly related to monetary policy. This article discusses Central Bank of Iceland interventions in the foreign exchange market and their effectiveness. The article maintains that the direct effects of interventions have been fairly limited and generally short-lived. However, it cannot be ruled out that the Bank managed to delay the weakening of the króna sufficiently to make its main impact felt when the most serious economic overheating was over.

1. Introduction

From the second half of January 2001 to mid-October the same year, the Central Bank of Iceland sold foreign currency for more than 24 b.kr. in exchange for domestic currency. With these actions, the Central Bank aimed to counter the weakening of the króna and to reduce exchange rate volatility. However, the exchange rate weakened by 15% over this period and the Bank does not seem to have succeeded to halt the depreciation, although it is impossible to say what would have happened had it not tried.

These actions are known as central bank interventions in the foreign exchange market, i.e. the central bank enters the foreign exchange market on its own initiative and buys or sells deposits in domestic currency in exchange for deposits in foreign currency. A distinction is normally made between whether a central bank intervenes in the market with the objective of influencing the exchange rate and whether the aim is solely, for example, to prevent changes in the size or composition of its foreign reserve from having a temporary effect on the exchange rate of the domestic currency. Such central bank trades are not defined as intervention in this paper (see, for example, Baillie, Humpage and Osterberg, 1999).

This article discusses central bank interventions in the foreign exchange market and its success. The second section of the paper is a general discussion of interventions, their implementation and the results of international studies of their success. Section three discusses the different motivations behind intervention and section four addresses the secrecy that gen-

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erally seems to surround them. The fifth section discusses alternative ways to implement interventions. Section six discusses interventions by the Central Bank of Iceland and the way they have developed as Iceland's foreign exchange market has evolved and the monetary policy framework has changed. Implementation of interventions is then discussed, followed by an appraisal of their effectiveness and conclusions.

2. Central bank interventions in foreign exchange markets

Central bank monetary policy actions are always reflected in changes in the composition and size of their balance sheets. The most important monetary policy actions involve changes to the marginal cost of new financing at the central bank. The central bank usually achieves this by using open market operations which involve changing the interest rate on repurchase agreements (repos) with the financial system. For example, if the central bank wishes to increase liquidity in the financial system in order to stimulate economic activity, it will lower its repo rate (referred to as the policy interest rate), which makes the financial system's short-term funding from the bank cheaper. All things being equal this will spur demand for liquid funds. The interest rate cut then increases general demand in the economy which ultimately leads to a rise in the inflation rate (a more

detailed discussion of the transmission mechanism of monetary policy can be found in Pétursson, 2001). By such measures, the central bank contributes to an increase in supply of domestic currency relative to other currencies, which all things being equal ought to reduce its relative value, i.e. bring down its exchange rate, as the exchange rate defines the relative price of currencies.

As Box 1 shows, the central bank can achieve the same effect with direct interventions in the domestic market for foreign exchange, i.e. by buying foreign currencies (deposits denominated in foreign currencies) in exchange for domestic currency, instead of exchanging domestic currency and domestic securities, as it does in conventional open market operations. The effects are the same: the value of the domestic currency decreases and money supply increases, causing market interest rates to fall. Thus monetary policy has the same impact as before and effectively one and the same monetary instrument is at work, i.e. the central bank can either lower its policy rate directly or buy currency in the foreign exchange market. In both cases liquidity increases, interest rates fall and economic activity is stimulated.

2.1. Sterilised and unsterilised intervention
The intervention described above is known as an unsterilised intervention, i.e. the central bank does not adopt any countermeasures to prevent its intervention from affecting the size of its balance sheet.

Box 1 The effects of foreign exchange interventions on banking system's balance sheets

If the Central Bank wants to increase liquidity in the system, it reduces its policy interest rate which makes marginal funding of the financial system through the Bank less expensive, hence increasing the demand for liquidity, all other things being equal.[1] This is reflected in the balance sheets of the Central Bank and the banking system as a whole (i.e. the Central Bank and deposit institutions). The accompanying table shows a simple example of how this can occur. The Central Bank's holding of domestic securities, which deposit institutions use as collateral or repo loans, increases by

1 m.kr.[2] The Bank deposits this amount at the deposit institutions' account at the Bank, leading to a corresponding increase in base money (notes and coin in circulation and reserves with the Central Bank). This is offset by a 1 m.kr. decrease in the deposit institutions' domestic securities portfolio since the Central Bank owns the securities temporarily, until the repo trade

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2. Under the accounting method used to record Central Bank repo auctions, it is in effect the Central Bank's claims on credit institutions which increase by 1 m.kr. rather than its domestic securities portfolio. By the same token, it is the deposit institutions' claims on domestic agents that decrease by 1 m.kr., rather than their domestic securities portfolios. The scenario is presented in this way for consistency with the main text, which is a conventional description of the impact of monetary policy on central bank balance sheets. In economic terms, the two effects are identical.

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1. A more detailed discussion of the arrangement of repo auctions with the Central Bank of Iceland is found in Kristinsson (2000).

The banking system's balance sheets (m.kr.)

Monetary policy action	Central Bank		Deposit institutions	
	Assets	Liabilities	Assets	Liabilities
Market operation (Central Bank buys domestic securities)	Domestic securities +1	Base money +1	Domestic securities -1 Reserves with Central Bank +1	
	Central Bank		**Deposit institutions**	
	Assets	Liabilities	Assets	Liabilities
Unsterilised intervention (Central Bank buys foreign securities)	Foreign reserves +1	Base money +1	Foreign securities -1 Reserves with Central Bank +1	
	Central Bank		**Deposit institutions**	
	Assets	Liabilities	Assets	Liabilities
Sterilised intervention (Central Bank buys foreign securities and sells domestic securities)	Foreign reserves +1 Domestic securities -1		Foreign securities -1 Domestic securities +1	

reverts two weeks later. Instead, deposit institutions have more liquidity which they can use to increase lending to the public. The banking system's liabilities towards the public increase and so does the money supply, and because of the money multiplier the actual increase exceeds that in base money.

Unsterilised interventions have virtually the same effect. All that changes is that, instead of an increase in the Central Bank's domestic securities portfolio, its foreign portfolio increases, i.e. the Bank's foreign reserves increase. The Central Bank sells deposits denominated in domestic currency in exchange for deposits denominated in foreign currency amounting to 1 m.kr. The Bank deposits this sum in the institutions' account at the Bank and base money increases by 1 m.kr. By the same token, the deposit institutions' foreign securities portfolio falls, but their liquidity increases. The liabilities of the banking system as a whole increase, as does money supply just as if this were a conventional open market operation.

However, if the Central Bank sterilises the intervention in the foreign exchange market, it reduces liquidity again by reducing its repo transactions with deposit institutions, since it removes liquidity from the system and replaces it with domestic securities to the amount 1 m.kr. The overall impact of this transaction is that base money remains unchanged and all that has altered is the relative shares of domestic and foreign assets held by the Central Bank and deposit institutions. The Central Bank now owns less domestic securities and larger foreign reserves, while the deposit institutions' foreign portfolio shrinks to match its greater domestic securities. Thus the liabilities of the banking system as a whole towards the public remain unchanged, and so does the money supply.

The above analysis is a simplification of the process behind these transactions. It ignores the possibility that the Central Bank could intervene by buying foreign deposits from foreign banks (for example with foreign-denominated borrowing) or that domestic institutions could borrow abroad and sell the equivalent amount to the Central Bank. Domestic deposit institutions' foreign liabilities would then increase by 1 m.kr. instead of their foreign securities portfolio decreasing by the same amount. Thus the above analysis shows in effect the total impact on (domestic and foreign) credit institutions, but the impact on the money supply remains the same. In evaluating the economic effects of interventions, such a simplification is irrelevant.

Unsterilised interventions thus inevitably have an impact on the economy and thereby on the exchange rate of the domestic currency. However, a crucial point is that the impact on the exchange rate of the domestic currency is not caused by the intervention itself (except to a limited extent, while the effect of the actual trade in the market lasts, as discussed later) but rather by its effect on the money supply and domestic interest rates.

If a central bank does not want its intervention to have any effect on the money supply and domestic interest rates, it can sterilise the intervention. As Box 1 shows, the central bank then removes the liquidity, which it injects into the market with its original currency purchase, from the market again by reducing its repo transactions, i.e. by selling domestic securities in exchange for liquid funds. The intervention will consequently have no effect on the money supply. All that changes is the composition of the banking system's portfolio of domestic and foreign assets. The central bank's foreign reserves have increased, but its holding of domestic assets has declined by a corresponding amount. Likewise the deposit institutions' foreign exchange holdings have fallen and their domestic assets increased correspondingly.

Economists are unanimous that unsterilised interventions effect exchange rates, insofar as conventional market operations do so at all, since they have an identical effect on liabilities of the central bank.[2] However, the impact of sterilised interventions on exchange rates is much more uncertain. If a sterilised intervention influences exchange rates, it effectively represents a third policy tool (besides monetary and fiscal policy), i.e. monetary policy can affect the economy (and the exchange rate) solely by altering the composition of domestic and foreign assets held by the central bank, and thereby by the public.

Theoretically this cannot be ruled out and several possible channels have been suggested.

2.2. The impact of sterilised interventions on exchange rates

2.2.1. The portfolio-balance effect

As pointed out above, sterilised interventions affect the composition of domestic and foreign assets held by the central bank and the public. By purchasing foreign securities the central bank increases its foreign reserves and its domestic securities holdings are reduced by the same amount. Since the volume of outstanding securities (domestic and foreign) has not increased, and as asset markets must clear, this change is reflected in the fact that the public has increased its holdings of domestic securities and reduced its holdings of foreign ones. According to the portfolio-balance effect, the public will only be willing to hold relatively more domestic assets if the price of these assets falls, i.e. if the domestic currency depreciates.[3]

A precondition for the portfolio-balance effect to be present is that investors must not regard domestic and foreign securities as perfect substitutes.[4] If domestic and foreign assets are perfect substitutes, agents will be indifferent as to the relative amounts of domestic and foreign assets they are holding - all that matters is their total amount, which remains unchanged. Hence, no change in market clearing prices or quantities is required.

Obstfeld and Rogoff (1996) also point out that imperfect substitution between domestic and foreign securities is not a sufficient condition for sterilised interventions to affect exchange rates, bearing in mind that the central bank balance sheet is part of the overall government balance sheet. An increase in the

2. Exchange rates are determined by numerous factors, some of which remain unaffected by monetary policy, such as commodity prices, capital flows and domestic and foreign productivity trends, along with expectations about all of them. Monetary policy is therefore only one of many determinants of exchange rates. High-frequency volatility in exchange rates is therefore determined to a much greater extent by investor expectations, new information and the market's interpretation of it, than by monetary policy. In the long run, however, exchange rates should in principle be determined by the relative supply of the value that they measure, i.e. the relative supply of domestic and foreign monies.

3. See, for example, Branson and Henderson (1985). Surveys can be found in Sarno and Taylor (2001) and Weber (2001). Note that the depreciation of the domestic currency has to be sufficiently large to leave the real supply of domestic assets relative to foreign assets the same as before.

4. The reason that investors do not regard domestic and foreign securities as perfect substitutes could be some types of market frictions such as capital controls and the risk that such controls might be imposed in the future. Likewise, agents might be risk averse and prefer domestic securities since investment in them entails less risk than foreign securities, due to uncertainties about exchange rate developments or differences in default risk.

central bank's holdings of domestic assets resulting from sterilised interventions implies a reduction in public sector debt, which ought to lead to a lower expected tax burden in the future, assuming that government spending remains unchanged. If agents take this consideration into account, the domestic currency need not depreciate despite the increase in private agent's holdings of domestic assets, since their net future tax burden will decrease correspondingly.[5]

Nonetheless, research suggests that while this effect may be present to some extent, it is far from complete. The public does not appear to fully take into account the effect on its future tax burden when purchasing government assets. All the same, the importance of the portfolio-balance effect in explaining the impact of sterilised intervention on exchange rates still seems limited, except perhaps in the very short term (see, e.g., Weber, 1986, and Obstfeld and Rogoff, 1996). There appears to be a high level of substitution between assets denominated in different currencies, especially the main currencies, in addition to which studies of relative supply of securities in different currencies indicate very little impact on exchange rates. These findings have, however, been challenged in papers such as Dominguez and Frankel (1993). However, economists generally seem to agree that the importance of this effect is fairly limited and will probably diminish with increasing international trade and more active global currency markets. Even though this effect probably makes little difference for the main world currencies, their importance for less developed foreign exchange markets and currencies which are less traded in international currency markets cannot be ruled out.

2.2.2. The signalling effect

Even under perfect substitutability of domestic and foreign assets, sterilised interventions can still in theory affect the exchange rate if it is regarded as signalling future monetary policy decisions which are not yet reflected in exchange rates. Assuming that the central bank has better information than private agents, for example about the state of the economy or its own responses to it, a sterilised intervention can inform markets of the bank's views on exchange rate developments and where it should go in the future. In this way the central bank would possibly be relaying information about future monetary policy decisions which would impact the exchange rate immediately because of the effect on exchange rate expectations.[6]

It is important to realise that, in order for this signalling effect to work, the signal must be credible, i.e. it must eventually followed up by the response that it implies. Thus a sterilised intervention is not really an independent monetary policy instrument, as it might seem on first impression, but rather serves the sole purpose of signalling future monetary policy decisions. In effect it is therefore the message about future monetary policy decisions which influences the current exchange rate, and not the intervention in its own right.

An increased number of studies of the signalling effect have been made now that improved access is available to data about central bank interventions in many parts of the world.[7] It should be remembered that there may be a long lag in transmission of the signalling effect, making empirical evaluation of it difficult (see, e.g. Heikensten and Borg, 2002). Nonetheless, these studies suggest that sterilised interventions may exert an influence through the signalling effect, especially if it is clearly explained in public by the central bank and conducted in cooperation with several other central banks. This effect is particularly important in the short term, e.g. if an unrealistic price bubble can be burst (see e.g. Sarno and Taylor, 2001, and Heikensten and Borg, 2002). It should be emphasised, however, that the effect is not the result of the intervention itself, but rather of its impact on investor expectations about future monetary policy decisions. Thus it is sometimes claimed that sterilised intervention is an effective way for central banks to signal future monetary policy actions as they take an open currency position, which could cause financial losses if they do not follow the intervention through with the measures they are seen as signalling. However, the sums involved are really minor in comparison with annual government tax revenues. It is therefore not obvious that this is

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5. This is the Ricardian equivalence effect, see Barro (1974).

6. See Mussa (1981). A survey can be found in Sarno and Taylor (2001).

7. The Federal Reserve began publishing historical data on its interventions in the early 1990s. Bank of Japan and the Bundesbank followed soon afterwards (see Sarno and Taylor, 2001).

necessarily the most effective or credible way for central banks to relay their view of future monetary policy, as pointed out by Obstfeld and Rogoff (1996).

2.2.3. The interaction of sterilised interventions with the functioning of foreign exchange markets

A number of studies indicate that foreign exchange market trading is characterised by herd behaviour and self-fulfilling expectations (see, e.g., Box 3 in *Monetary Bulletin* 2001/4). Such behaviour can cause the exchange rate to deviate from underlying economic fundamentals for a protracted period. A correction may not happen, even though a significant share of market participants believes that the exchange rate is misaligned, unless they acted simultaneously to prick the bubble. For an individual trader such an attempt to play against the market trend would take a great deal of courage. Hence, the market would be characterised by a coordination failure as no single trader dears making the first attempt to correct the misalignment. In this case a publicly announced sterilised intervention could fulfil this coordination role in that it might organise the "smart money" to enter the market at the same time, thus turning the market sentiment and pricking the bubble (see Sarno and Taylor, 2001).

A sterilised intervention might also have an effect on exchange rates through the impact of the central bank's order on the foreign exchange market. In a perfectly functioning foreign exchange market where the exchange rate reflects all relevant and publicly available information, the impact of individual currency orders should not have any effect on price formation (see, e.g. Evans and Lyons, 2001). If this assumption is relaxed, the market structure and response of market participants to order flows can cause a sterilised intervention to influence the exchange rate,[8] especially in a thinly traded market. This order flow effect can prove particularly important when the foreign exchange market is characterised by a hot potato problem.

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8. It is impossible to explain the large-scale trading that takes place in a foreign exchange market every day without assuming that information is costly and asymmetrically distributed between market participants, see e.g. Grossman and Stiglitz (1980) and Baillie, Humpage and Osterberg (1999).

2.2.4. Summary: The effects of sterilised interventions on exchange rates

The above overview specifies a number of potential channels for sterilised interventions to affect exchange rates. The findings from empirical studies are somewhat ambiguous about the importance of these effects. Following the end of the Bretton-Woods system, economists in general had little faith in the effectiveness of sterilised interventions, as reflected for example in the Jurgensen Report (1983), the first study based on detailed data about central bank interventions in many parts of the world. According to this report, the effectiveness of sterilised interventions was non-systematic and only short-lived if at all. This view may have slightly changed in recent years. A survey by Sarno and Taylor (2001), for example, finds some support for the idea that sterilised interventions can have greater affects on exchange rates than previously assumed. They emphasize however that a positive result is not always guaranteed, but the likelihood of success increases substantially if interventions are clearly presented to market participants and the public, and are implemented jointly by a number of central banks. Findings by Fatum (2000) also appear to suggest that the likelihood of success diminishes as the frequency of interventions increases. Others are more sceptic, such as Weber (1986) and Baillie, Humpage and Osterberg (1999) who maintain that the effects of interventions are highly uncertain and difficult to evaluate.

The effects of interventions on exchange rate fluctuations have also been examined. As discussed later, central banks commonly refer to excessive exchange rate fluctuations when intervening in the foreign exchange market. These studies suggest, however, that the effects are minimal, and in fact most of them indicate that interventions amplify exchange rate fluctuations rather than dampening them (see, e.g. Heikensten and Borg, 2002, and Brandner, Grech and Stix, 2001). Nor is it theoretically clear that a sterilised intervention should reduce exchange rate volatility. If they manage to reduce uncertainty they could do so, but if their aim is to communicate new information, for example about future monetary policy, it is not unnatural to assume a temporary increase in volatility while market participants trade on the basis of this newly received

information. Interventions could also heighten uncertainty about monetary policy, especially if it is conducted in secrecy, while publicly announced interventions could reduce exchange rate volatility (Dominguez, 1998, and Fatum, 2000).

Despite the uncertainty surrounding the impact of sterilised interventions, central banks often adopt this measure, although its use has diminished.[9] Certainly instances can be cited when sterilised interventions appear to have succeeded, although it is difficult to tell whether this is the result of the interventions themselves or some other factors. An example is when the US dollar weakened by roughly 20% (trade-weighted exchange rate) in the six months following the Plaza Agreement of September 1985, when the G5 countries (the USA, UK, France, Japan and Germany) agreed to attempt to depreciate the dollar, which was felt to be overvalued. The Plaza Agreement was followed through with the Louvre Accord in which the G7 countries (G5 plus Italy and Canada) undertook to reduce volatility in the US dollar by interventions. An example of a less successful coordinated central bank intervention to reverse an exchange rate trend was the European Central Bank's efforts, in cooperation with the Federal Reserve, Bank of England, Central Bank of Japan and Bank of Canada to strengthen the euro against the US dollar in September 2000. The euro weakened soon afterwards and has only recently returned to its original parity with the dollar after the US economy slowed down and some confidence in it was lost. Thus there are clear examples both of how coordinated interventions by the central banks of many countries have managed to boost market participants' confidence in the exchange rate, and others which have also been less successful.

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9. For example, the Federal Reserve intervened in the foreign exchange market 235 times from February 1987 to July 1990 (the duration of the Louvre Accord), or roughly once every four business days. This was nonetheless much less frequent than in the 1970s and first half of the 1980s. In the following three years the Federal Reserve intervened only 38 times, and since 1995 it has done so only twice. At the same time as the number of interventions decreased, the average amount of each intervention increased, however. See Baillie, Humpage and Osterberg (1999) and Neely (2001).

3. Different objectives of interventions

Central bank interventions may have different objectives. The motive could be to try to reverse an exchange rate trend, for example if the domestic currency is felt to have weakened excessively so as to threaten monetary policy targets, be it either an inflation target or a fixed exchange rate target. Another motive could be to reinforce an exchange rate trend, for example if the central bank identifies an opportunity to expedite or consolidate an upward or downward exchange rate trend in the market. Preserving financial stability could be another motive. For example, the bank might wish to dampen excessive short-term volatility which reflects uncertainty in the market, or to try to reduce or resolve some market failure in the foreign exchange market. The central bank could regard new information or changes in the interest rate differential with abroad as causing an overshoot in the exchange rate which would lead to excessive volatility due to herd behaviour by market participants. An appropriate move for the central bank could then be to intervene in order to prevent such herd behaviour from becoming entrenched. Another objective behind an intervention could be to profit from trading. For example, if a central bank manages to reverse a downward domestic exchange rate trend it could later buy back the currency it had used for the intervention, at a more favourable price. Even though the survey by Neely (2001) of 22 central banks in various parts of the world indicates unequivocally that the profit motive plays no part in their intervention decisions, bad experience of previous interventions could be one reason for reluctance on behalf of the central bank to enter the market again. Central banks would not be expected to intervene in the market in order to reverse an exchange rate trend or dampen volatility if they see little likelihood of success but feel they would probably sustain considerable losses from it. Kim and Sheen (2002), for example, find evidence of such behaviour by the Reserve Bank of Australia. Finally, central banks could enter the foreign exchange market in order to adjust their foreign reserve position if they consider reserves too small or too large. They could take advantage of the opportunity to do so in periods of market tranquillity, so that their intervention would be unlikely to have much impact on the

domestic exchange rate. Research has shown that the most common reasons for interventions seem to be to attempt to reverse exchange rate trends and dampen volatility (see the summary given in Sarno and Taylor, 2001). This is also consistent with Neely's survey (2001).

It is also obvious that the motivation behind interventions is determined by the monetary policy framework of the central bank in question. If the central bank pursues some form of fixed exchange rate policy, the main reason for interventions will clearly be to contribute towards maintaining the exchange rate of the domestic currency as closely aligned to the target as possible. However, as experience from many countries shows, a central bank has extremely limited ability to maintain an exchange rate target which is inconsistent with underlying economic fundamentals or views of market participants.

Interventions could also remain an option even if the central bank has an inflation target and the exchange rate floats. Although the central bank's main instrument for attaining its inflation target is its policy interest rate, cases may arise where it can be useful to use interventions as well. The most obvious example is if the country has become caught in a liquidity trap, i.e. the central bank has lost control of inflation developments so that the economy is disinflating at the same time as the bank's policy rate is close to zero and real interest rates are very high. The central bank's ability to bring down the real inflation rate and attain its inflation target solely by cutting interest rates would then be very restricted. In such a case the bank could use interventions in order to try to depreciate the exchange rate, in order to get the economy moving again and turn the disinflation process around (see, e.g. Heikensten and Borg, 2002).

Interventions can also be an attractive option for reducing exchange rate volatility which may threaten financial stability, and for contributing towards achieving the inflation target. For example, if the bank regards the domestic exchange rate development to be in obvious contradiction to the assumption on which it bases its inflation forecast, and thereby the prevailing monetary stance, it can use interventions along with a change in the policy rate to achieve the inflation target. The chief argument would then be that, by also using interventions, the

bank would need a smaller interest rate change than would otherwise be the case to attain the inflation target, so that the negative effects on the real economy would be smaller (Heikensten and Borg, 2002). Central banks with inflation targets have, however, in general not used interventions to attain the target since it is difficult to exert a permanent effect on the exchange rate with interventions. Furthermore, the exchange rate pass-through to domestic prices varies from one time to another, and the impact of short-lived exchange rate changes on inflation is only temporary.

4. Transparency of interventions and central bank openness

Given that the most important effect of sterilised interventions is deemed to be signalling future monetary policy, it is puzzling that central banks seem to have a tendency to keep their interventions secret. Details of interventions are generally revealed some time after their implementation, if they are made public at all (see, e.g. Neely, 2001).[10] Implementation of interventions and decisions on them therefore remain largely secret, which differs significantly from the current trend towards openness and transparency in monetary policy (see Pétursson, 2000).

At first sight one could suppose that the arguments in favour of more transparent monetary policy would also apply to interventions. More transparency imposes further discipline on the central bank, enabling the public to make a better evaluation of the bank's capability and credibility. Greater transparency can also strengthen the transmission of monetary policy. However, information about future interventions and their implementation can also clearly have detrimental effect on their effectiveness. Balke and Haslag (1992) demonstrate the need for central banks to maintain asymmetric information between themselves and market participants if sterilised interventions are to signal future monetary decisions. In this light, it is inappropriate for a central bank to inform market participants of its future intervention decisions. Completely transparent interventions are

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10. The survey by Neely (2001) reveals, in fact, that few central banks considered sterilised intervention an important instrument for relaying information to markets about future monetary policy decisions.

Box 2 The Central Bank of Sweden's procedures on foreign exchange market interventions

Heikensten and Borg (2002) present the Riksbank position on foreign exchange interventions and its procedures regarding their implementation. These procedures are the most detailed that have been made public by any central bank. Although transparent, the bank assumes that exceptions may be made if conditions demand. Experience suggests that the decision-making process must not be too complex, in order to be able to respond to different conditions in the foreign exchange market. Although the bank has prepared clear procedures for interventions it will continue to use interventions with restraint, since Sweden has a floating exchange rate regime and interventions in the foreign exchange market are decided solely with reference to its main objective of price stability. General rules are therefore made to apply, just as in the case of interest rate decision.

Decisions on interventions in the foreign exchange market are made as a rule by the Central Bank of Sweden's executive board. However, the Governor can decide an intervention unilaterally if the need is so urgent that it cannot wait for a decision by the entire board. The board shall be notified of such decisions as soon as possible, however. Furthermore, the board can mandate the bank to make an intervention, although this is only valid until its next meeting, when it shall be reviewed and renewed if necessary.

As a rule, interventions shall be prepared in the same way as interest rate decisions. This secures a clear connection to other monetary policy decisions at the same time as the risk of mistakes is minimised. Before interventions are put onto the executive board's agenda, they should normally have been prepared by the drafting committee for monetary and foreign exchange policy.

The executive board needs to make two separate decisions on interventions in the foreign exchange market, which are also recorded separately in the minutes. Firstly, it needs to decide on an intervention and issue a mandate for it. How detailed the mandate should be depends on the circumstances, but should normally state the time period for implementing the intervention and give a framework for its scope. Secondly, the board needs to present a motivation for the intervention, the main elements of which should be published in the form of a press release.

Minutes are published for each meeting of the executive board. Deliberations with regard to the motives for the interventions should be reported in the minutes of the meetings, the same form as those for other monetary policy issues. The minutes are normally published with a time lag of a minimum of one month and a maximum of one year after the meeting. Minutes concerning an intervention need not be published at the same time as the regular minutes if information in them can be assumed to counteract the purpose of the decided or anticipated measures.

The Riksbank may delegate its interventions to other central banks, in which cases it may have reason to deviate from parts of the procedural system.

therefore not appropriate.[11] However, this does not change the fact that the great secrecy surrounding central bank interventions is difficult to explain given that some openness could increase their effectiveness.

Several explanations for this secrecy puzzle have been suggested (see, e.g. Sarno and Taylor, 2001). The central bank might want to be less open if decisions on intervention are not exclusively made by the bank (for example, partly or entirely in the hands of the ministry of finance instead, as in the case of the USA), in order to reduce the ambiguous signal that they gave about monetary policy. Another explanation could be that the central bank fears that a publicly announced intervention would amplify exchange rate volatility. Thirdly, the central bank might simply be adjusting the composition of its foreign reserves and sees no reason to make this adjustment public.[12] A fourth reason could be that the

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11. Thus a certain amount of secrecy about the timing of interventions, their volume and duration, choice of currencies and counterparties, at the time of implementation and some time after, could enhance their effectiveness.

12. The survey by Neely (2001) reveals that none of the 22 central banks regarded an adjustment of the composition of the foreign reserve as an important reason for secrecy about its interventions. More than 75% of them cite as a reason always or sometimes trying to maximise the

central bank knows that the exchange rate it is trying to achieve through the intervention is incompatible with underlying economic fundamentals, so the bank attempts to intervene secretly in order to reduce the potential damage on its credibility.

Despite these arguments, central bank interventions have gradually been becoming more transparent. It was mentioned above that in the early 1990s the world's main central banks began publishing details of their interventions after they were made, whereas previously such information was not even made public. Other central banks have gone even further, for example in Switzerland and Sweden (see Neely, 2001, and Heikensten and Borg, 2002). The Riksbank in Sweden has recently published its procedures for deciding and implementing interventions (see Box 2). Heikensten and Borg (2002) argue that general arguments for monetary policy transparency also apply to interventions, and in line with the Riksbank general commitment to monetary policy transparency it is natural to make these procedures public. Nonetheless, they emphasise that interventions are to some degree inherently different from conventional monetary policy measures, so that the bank must have a certain amount of scope for deviating from them.

5. Technical implementations of interventions

According to the survey by Neely (2001), interventions are almost always implemented through the spot market with the counterparty being domestic financial institutions.[13] The fact that central banks most commonly use domestic commercial banks when they intervene in the foreign exchange market should hardly come as a surprise, since domestic financial institutions generally specialise in trading with their own currency. Roughly half the respondents in the survey also traded with other central banks and investment banks.

Central banks also use the forward and options markets for interventions.[14] One advantage of trading in these markets is that payment is deferred, and in the case of options it is not certain that the right will be exercised. An example is the Central Bank of Thailand's forward contract to buy its own currency in 1997.

Currency swaps have also been used by central banks, but primarily to sterilise their interventions. They have also been used for liquidity management purposes, for example the Central Bank of Switzerland used swaps heavily when the bank had a money supply target. In effect a currency swap involves two separate contracts, a spot contract and a counteracting forward contract. Such contracts therefore do not have a direct impact on exchange rates. The Reserve Bank of Australia has used currency swaps to sterilise its interventions, for example by selling Australian dollars in the spot market and buying them back in the forward market. Such agreements are classified as off balance sheet items, i.e. the principal of the trade does not affect the central bank's or its counterparty's balance sheet, and although the bank's flexibility increases, its balance sheet becomes less transparent as a result (see, e.g. Blejer and Schumacher, 2000).

Options have also been used in interventions. A central bank attempting to prevent the domestic currency from depreciating can sell a put option for the domestic currency or a call option for foreign currency. Option prices do not have a direct effect on the spot price of the domestic currency, but investors prefer to buy options rather than shortening their positions in a weak currency. By writing options and thereby increasing the flow in the market, the central bank creates a hedge and reduces the probability of an attack on an already weak currency. The risk exposure of the central bank is the same as if the bank conducts spot or forward trades with the currency. A side-effect is that the central bank earns revenue on the issue of options.

It is common for central banks to issue options to reduce their need to resort to direct interventions. The Central Bank of Spain is thought to have used

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effect of the intervention. On the other hand, more than 57% mentioned that the reason was sometimes to minimise the effect. These disparate results could reflect instances where central banks are not alone in deciding on interventions.

13. Spot trades have a two day settlement period.

14. Forward trades have a settlement period beyond two days. Options involve the sale of the right to buy or sell currency at a specified price, either on a specified day or over a specified period.

options and sold calls on the peseta in order to prevent it from depreciating in 1993, although the bank has never admitted it (Neely, 2001). The Central Bank of Mexico has also been using options since August 1996 in order to bolster its foreign reserves. It sold put options on the US dollar, entitling buyers of the option to sell dollars back to the bank at a strike price based on the previous day's exchange rate. This option may only be exercised if the peso has appreciated during the previous month, i.e. if the exchange rate is not higher than a 20-day moving average of previous strike prices. This restriction is designed to prevent the bank from having to buy dollars during a period of peso depreciation and from being forced to enter the market to acquire dollars assets (Neely, 2001).[15]

The survey by Neely (2001) suggests that interventions are almost always made in the spot market, at least in part, and more than 95% of respondents reported that interventions always included spot trades. Some 53% reported sometimes using the forward market, for example, in conjunction with the spot market, but none reported using the forward market exclusively. One central bank reported using the futures market for interventions. The most common arrangement is that central banks phone directly those parties they wish to trade with, and all respondents said they had arranged their interventions partly or entirely by telephone. At the time of the survey 44% used electronic transactions for their interventions and central banks appear to be moving increasingly towards electronic trading along with other market participants.

Furthermore, the survey reveals that most interventions take place during the business day. Half of the sample had intervened in the market outside business hours, both prior to and after. One out of four central banks reported they always intervene in the market at a specific time of day, either in the mornings or just before closing.

Finally, according to the survey, governments have sometimes used indirect methods for influencing the exchange rate. These refer to measures which fall outside the definition of central bank currency trading with the aim of exerting an influence on the exchange rate. Examples are government restrictions on capital flows, currency restrictions or efforts to control capital flows by legislation or other means. In the 1970s, for instance, the governments of Spain, Italy, France and the UK managed foreign assets of state enterprises with the aim of influencing their countries' exchange rates without direct intervention in the foreign exchange market. In the early 1990s the governments of Spain, Ireland and Portugal countered speculative attacks by imposing restrictions on capital flows.

6. Central Bank of Iceland interventions in the foreign exchange market

An organised foreign exchange market was formally established in Iceland in May 1993.[16] Prior to that, the exchange rate was unilaterally determined by the Central Bank of Iceland, and was adjusted when the need was felt. With the establishment of an organised market in 1993, fixing meetings were introduced at the Central Bank, where market participants traded with each other and the Bank. The exchange rate of the króna was then determined at the end of the meetings, although trading could also be conducted outside the meetings. The final step towards a fully function market was taken on July 1, 1997 when the foreign market trading hours were extended to match bank business hours, i.e. from 9:15 to 16:00 weekdays.[17] Continuous price formation of the króna was established as market participants undertook market making responsibilities. The reference amount for market quotes was 1 million US dollars from July 1 1997 until October 2000, when it was raised to 1½ million US dollars. Market makers also agreed to maintain a specified bid-ask spread.[18] The Central

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15. The Central Bank of Columbia has used similar methods. Numerous other examples can be cited where central banks use the possibilities offered by derivatives for their foreign exchange market interventions. The central banks of Brazil and Chile, for example, have issued exchange rate-indexed securities to ensure ample liquidity in the domestic market and fulfil demand from domestic deposit institutions for hedging instruments, and the Central Bank of the Philippines has used forward sale equivalents to provide the market with hedging instruments.

16. A survey of the development of the foreign exchange market in Iceland is found in *Monetary Bulletin* 2001/3.

17. Previously, capital movements between Iceland and abroad had been deregulated in steps which essentially were completed in the beginning of 1995.

18. The bid-ask spread was deregulated as of January 1, 2003.

Table 1 Central Bank of Iceland trading in the foreign exchange market 1994-2002

	Purchases of foreign currency (m.kr.)	Sales of foreign currency (m.kr.)	Total trade (m.kr.)	Number of days	Total market turnover (m.kr.)	Central Bank share (% of total turnover)
1994	14,861	30,686	45,547	229	53,355	85.4
1995	22,530	26,089	48,619	227	54,499	89.2
1996	40,474	24,532	65,006	236	80,864	80.4
1997	36,715	22,593	59,308	165	162,122	36.6
1998	33,960	16,980	50,939	104	401,819	12.7
1999	15,628	3,649	19,277	37	467,972	4.1
2000	1,787	15,643	17,430	28	768,008	2.3
2001	0	29,538	29,538	16	1,218,045	2.4
2002	4,528	0	4,528	35	834,444	0.5

Bank may trade with the market makers at any time, but does not trade with others agents (Regulation no. 913/2002 on the foreign exchange market) apart from the Treasury. With the changes made to the market in 1997 and those that had taken place in its external environment, for the first time a genuine foreign exchange market was formed on the lines of those in other countries. Financial institutions could increasingly hedge their foreign exposures and offer enhanced services for investors.

An organised currency swap market was established on November 26, 2001 and became regulated as other interbank markets in March 2002 (see Ísberg, 2002). Market participants are the same as in the foreign exchange market. The market facilitates the Central Bank in using swaps in its transactions with market participants if, for example, to sterilise its interventions.

As Table 1 shows, turnover in the foreign exchange market has grown substantially since its establishment. In 1994, the first whole year of its operation, turnover amounted to 53 b.kr., of which the Central Bank's share was more than 85%. Turnover in the market grew and the Central Bank's share shrank from one year to the next and in 2002 it was less than 1%.

6.1. Changed Central Bank role in the foreign exchange market

The foreign exchange market's almost ten-year history can be divided into five periods on the basis of the Central Bank's role in the market and the different functions that its interventions have assumed.

The first period, from the market's establishment until its reorganisation in mid 1997, were its formative years after capital movements to and from Iceland were deregulated in the beginning of 1995. Over this period the Central Bank was responsible for the bulk of trading and its share was as high as 90%, in 1995. The Bank's main role was to ensure continues trading of foreign exchange and as effective pricing of currency as possible. The Central Bank was on both sides of the market and traded in a number of currencies, although most of the trading involved US dollars. The Bank entered the market almost every business day, even many times during the day. Little trade was, however, between the commercial banks themselves. Turnover in the foreign exchange market increased between the years but the Bank's share remained very high throughout the whole period.

As Table 2 shows, the Central Bank bought foreign currency almost as often as it sold currency in this period. The Bank entered the market on 93% of business days, although the transactions were usually very modest in size. On one occasion the Bank purchased foreign currency for the equivalent of more than 2 b.kr., but otherwise most of its trading involved less than ½ b.kr. Its largest selling amount was ½ b.kr. at a time. This period was therefore characterised by a strong Central Bank presence in the market and very small trading intensity.

The second period was from mid 1997 to June 15, 1999. During these first years of continuous operation, turnover in the market grew even further but

Central Bank trading was still significant. Almost all the Bank's trading was now in US dollars. Gradually the Bank's share diminished but it continued to attempt to smooth exchange rate fluctuations and ensure continues trading in foreign currency. The reform in July 1997 involved a shift the market making role from the Bank to other market participants, which was a precondition for reducing the Central Bank's transaction share. Although the Bank's share declined noticeably, the Bank was still an important participant in the market and the market makers' day-to-day trading environment. Table 2 clearly shows the Bank's involvement in the market declining, with the Bank's frequency falling to 40% of business days. The Bank was slightly more active on the buying side of the market but intensity remained relatively low. Thus the Central Bank still had an important role to perform in sustaining the market and trying to ensure as effective pricing of foreign currency as possible.

During the third period, from June 16, 1999 to June 14, 2000, the Central Bank did not enter the market at all. The Bank's trading frequency had gradually been falling since mid 1997 with market turnover increasing rapidly. The Bank therefore considered it important to allow the market to operate with little intervention. The exchange rate of the króna strengthened for the greater part of this period and the trade weighted foreign exchange index reached its lowest point on April 28, 2000 at 107.8 points. The target zone band for the index was extended to 9% from a central value in February

Table 2 Central Bank trading frequency and trading volume in the domestic interbank currency market 1994-2002

		Number of days				
Foreign currency trade	Sum of all periods	T-I	T-II	T-III	T-IV	T-V
Purchases in excess of 3.5 b.kr.	0	0	0	0	0	0
Purchases in the range 3 - 3.5 b.kr.	0	0	0	0	0	0
Purchases in the range 2.5 - 3 b.kr.	0	0	0	0	0	0
Purchases in the range 2 - 2.5 b.kr.	1	1	0	0	0	0
Purchases in the range 1.5 - 2 b.kr.	3	0	3	0	0	0
Purchases in the range 1 - 1.5 b.kr.	17	4	13	0	0	0
Purchases in the range 0.5 - 1 b.kr.	67	35	32	0	0	0
Purchases in the range 0.25 - 0.5 b.kr.	111	75	35	0	1	0
Purchases less than 0.25 b.kr.	354	270	35	0	14	35
No transactions	1,162	65	292	250	292	263
Sales for less than 0.25 b.kr.	368	346	22	0	0	0
Sales in the range 0.25 - 0.5 b.kr.	94	66	25	0	3	0
Sales in the range 0.5 - 1 b.kr.	36	10	23	0	3	0
Sales in the range 1 - 1.5 b.kr.	15	0	2	0	12	1
Sales in the range 1.5 - 2 b.kr.	2	0	0	0	2	0
Sales in the range 2 - 2.5 b.kr.	3	0	1	0	2	0
Sales in the range 2.5 - 3 b.kr.	2	0	0	0	2	0
Sales in the range 3 - 3.5 b.kr.	2	0	0	0	2	0
Sales in excess of 3.5 b.kr.	2	0	0	0	1	1
Total number of business days	2,239	872	483	250	334	300
Number of Central Bank trading days	1,077	807	191	0	42	37
Central Bank trading days as a percentage of total number of business days	48%	93%	40%	0%	13%	12%
Central Bank purchase days as a share of Central Bank trading days	51%	48%	62%	.	36%	95%

T-I is the period from January 4 1994 to July 7 1997. T-II is the period from July 8 1997 to June 15 1999. T-III is the period from June 16 1999 to June 14 2000. T-IV is the period from June 15 2000 to October 12 2001. T-V is the period from October 13 2001 to December 31 2002.

2000, as the index began to approach the lower limit of the previous band. The Bank felt that the previous band was beginning to hinder it from tightening the monetary policy stance in order to prevent overheating, which was beginning to permeate the economy, from leading to an excessive rate of inflation at a later stage.

The fourth period extends from June 15, 2000 to October 12, 2001. The period began when the Central Bank entered the market for the first time in almost a year. In the preceding weeks the króna had been weakening and the Bank felt it important to lean against the wind. The intervention was small and did not manage to halt or reverse the depreciation of the króna. The Bank re-entered the market towards the end of June and again in mid July 2000. The following period was characterised by a continuing depreciation of the króna and attempts by the Central Bank to reverse this trend and later to defend the target zone band. However, over the two-month period from August 9 to October 10, 2000 the Central Bank bought US dollars for the equivalent of 1.7 b.kr. As the market had settled after the turmoil in the summer the Bank took advantage of the opportunity to bolster its foreign reserve when market makers had currency to sell. The maximum amount in any trade was 1 million US dollar. The Bank did not enter the market for a while after the change to the monetary framework on March 27, 2001, but as the króna started to depreciate again in June, the Bank entered the

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Box 3 Special foreign exchange trades by the Central Bank of Iceland in 2001 and the pre-announced program to buy back foreign currency in 2002-2003

From the summer 2000, when the Central Bank re-entered the foreign exchange market, and until October 2001, most of its transactions with market makers were direct interventions in order to influence the exchange rate of the króna.

On several occasions the Bank has made special trades with market makers. In December 2001 the Bank sold 10 million US dollars to one market maker and 38½ million US dollars to another a few days later. Simultaneous with the latter trade, the Central Bank made a corresponding currency swap with the market maker, split into four equal parts with a term of one, two, three and four months, whereby the Bank bought dollars and sold them forward. This is the only occasion on which the Bank has formally sterilised its interventions in the foreign exchange market. At the end of August 2002 the Bank sold foreign currency forward for the equivalent of 3 b.kr., for three different maturities in four different currencies. These two trades are the only times that the Central Bank has used forward contracts in its transactions.

In September 2002 the Central Bank began buying foreign currency with the aim of strengthening its net foreign position. Earlier the same year, the Bank had announced in *Monetary Bulletin* that it would buy foreign currency when it considered that circumstances permitted it to do so. The Central Bank contacted foreign exchange market makers before a final decision was made about the most suitable arrangement for the purchases. A press release was issued on August 27, 2002, stating that the Central Bank intended to purchase the equivalent of up to 20 b.kr. before the end of 2003. The Bank purchases 1½ million US dollars each time on Mondays and Wednesdays, with the possibility of buying on Fridays as well. It also reserves the right to trade with market makers on their initiative for higher amounts, provided that the króna has strengthened from the day before. The Bank may also cancel this program if it considers that market conditions have deteriorated. Purchases are made before the market opens, between 9:00 and 9:15 in the morning, when the Bank receives bids from market participants and accepts the most favourable one. The Bank's first regular purchase under this program was on September 2 and by the end of 2002 it had bought 52½ million US dollars, or the equivalent of 4½ b.kr.

These regular purchases represent the Central Bank's first transactions outside the foreign exchange market's business hours, and also the first time that it has announced in advance the format in which it plans to trade. It should be reiterated that the Bank's aim is not to try to influence the exchange rate of the króna through these purchases, and they are not part of monetary policy measures. Above all they are designed to improve the bank's net foreign position, which deteriorated considerably in 2001.

market again in an attempt to prevent further weakening of the króna.

The Bank's involvement in the foreign exchange market had changed fundamentally, so that interventions were only used when the market was very tight, the króna was under pressure and volatility pronounced. Interventions were no longer based on the need for market making on behalf of the Bank, since the market makers had taken up that responsibility.

Table 3 Number of trades and Central Bank trade intensity in intra-day transactions

Number of trades within each day	All periods	T-I	T-II	T-III	T-IV	T-V
Average	3	3	4	0	8	1
Maximum.................	35	13	23	0	35	1
Minimum.................	1	1	1	0	1	1
Total amount of CBI trading each day (m.kr.)						
Average	307	239	499	0	997	260
Maximum.................	4,017	2,197	2,156	0	3,768	4,017
Minimum.................	< 1	2	< 1	0	80	122
Average amount of CBI trading each day (m.kr.)						
Average	98	82	139	0	121	260
Maximum.................	4,017	423	914	0	482	4,017
Minimum.................	< 1	2	< 1	0	77	122

T-I is the period from January 4 1994 to July 7 1997. T-II is the period from July 8 1997 to June 15 1999. T-III is the period from June 16 1999 to June 14 2000. T-IV is the period from June 15 2000 to October 12 2001. T-V is the period from October 13 2001 to December 31 2002.

Chart 1

Daily spot exchange rate (trade-weighted index) and Central Bank of Iceland net purchases of foreign currency 1994-2002

Trade-weighted exchange rate index

Central Bank net purchases of foreign currency

Source: Central Bank of Iceland.

This is reflected in less frequent but more intensive interventions, as Table 2 shows. The Central Bank entered the market on 13% of business days during the period and significantly more often on the selling side of the market than before. Transactions were larger and on several occasions the Bank sold currency during the period for the equivalent of more than 2½ b.kr, and once for more than 3½ b.kr. This change in Central Bank involvement reflects the fact that for much of the period the Bank was leaning against the wind to defend the króna, which called for more intensive interventions. The Central Bank's last intervention for these purposes was made on October 12, 2001.

During the fifth period, from October 13, 2001 to the time of writing, the Bank has entered the market
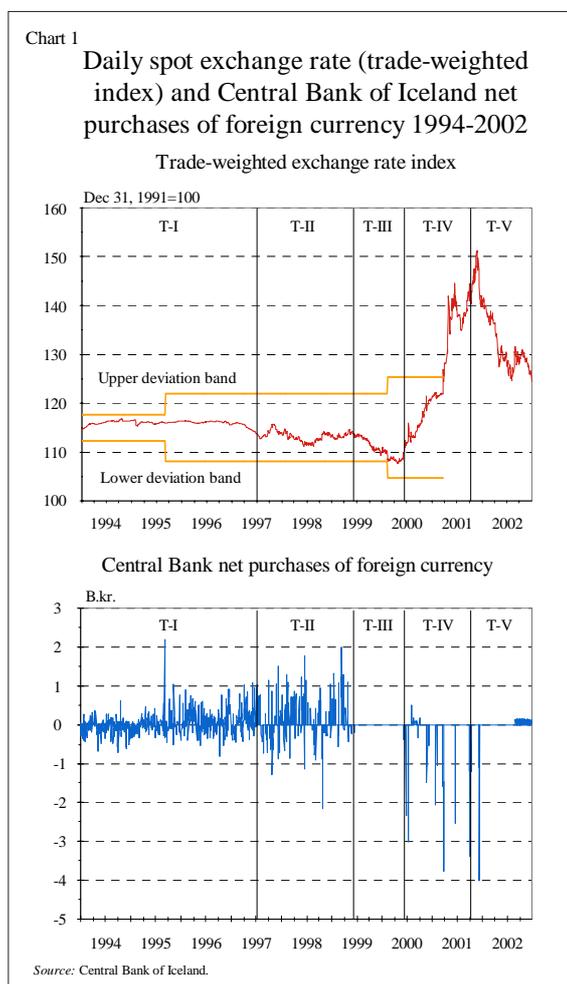
on several occasions, although the purpose is not to affect the exchange rate of the króna. As discussed before, these transactions (discussed in more detail in Box 3) are not defined as interventions.

The changes in Central Bank involvement in the market can also be seen in Table 3 which shows the number of trades conducted each day by the Central Bank and the Bank's intra-day trading intensity over the whole period. The Bank entered the market frequently every day over the first two periods, even entering both sides of the market within the same day depending on market makers demand.[19] The frequency of trades per day increased even more in the fourth

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19. The last time the Central Bank bought and sold currency within the same day was April 28, 1999.

period, with trading intensity increasing as well. In the most recent period, however, the Bank has only traded with one market maker on each occasion.

Chart 1 shows the development of the exchange rate index from the beginning of 1994 to the end of 2002 and net Central Bank purchases of foreign currency over the same period. It shows how the Central Bank fulfilled the role of a market maker during the first two periods, with the Bank entering the market frequently and on both sides of the market. At the same time, the transaction intensity was relatively small. Thus the Bank's role was primarily to smooth out exchange rate fluctuations and to fulfil a market making role in an undeveloped market.

After the Bank re-entered the market in mid 2000 its main role was to lean against the wind and to curb the risk of a spiral forming in situations of significant one-way flows and uncertainty in the market. Its role had therefore changed to monitoring the market and intervening solely if it identified the need to ensure the effectiveness of its monetary policy stance. In fact, this changed role was established before the monetary framework was changed at the end of March 2001. After order was restored in the foreign exchange market the Central Bank's involvement altered again and it now enters the market only under special conditions which are not directly related with advancement of the prevailing monetary policy. The declared aim of the recent purchases of foreign currency is to boost the Bank's net foreign position. Nonetheless, the possibility remains open for the Bank to enter the market if it considers that this would contribute to attaining its monetary policy objectives or if it considers exchange rate volatility a potential threat to financial stability.

6.2. Decisions on interventions and their objective
Decisions on intervention are made by the Governors of the Central Bank after consultation with the Bank's staff. The Governors decides on the scope of the intervention and its duration. The Monetary Department, in addition to monitoring market movements and communicating with the market, implements the transactions.

Changes in the objectives of Central Bank interventions have reflected revisions of the monetary framework. Until March 27, 2001 the intermediate target of monetary policy was to maintain the exchange rate against a trade weighted average of foreign currencies within a specific target band. Until September 6, 1995 the band was ±2¼% from a central value, later extended to ±6%. The band was extended again to ±9% on February 14, 2000, before finally being abolished on March 27, 2001 when the króna was floated and a formal inflation target was adopted as a nominal anchor of monetary policy.

During the exchange rate peg the main objective of Central Bank interventions was obviously to ensure that the króna remained within the exchange rate band. For most part of the period, however, the Central Bank entered the market more frequently than would probably have been necessary in order to ensure this, which reflects the fact that Iceland's foreign exchange market was very underdeveloped at the time and could hardly have withstood major fluctuations, even if they had remained within the exchange rate band. As the band was extended and the foreign exchange market matured, the Bank could increasingly focus on ensuring a low and stable rate of inflation, and for a while it withdrew from the market completely. However, it returned to reverse the depreciation of the króna and defend the exchange rate band until the peg was abolished. After the Bank adopted inflation targeting, the role of interventions as a monetary policy instrument has obviously been greatly reduced. The Central Bank has announced that interventions will be used solely if the Bank considers that exchange rate developments pose a threat to the inflation target or excessive exchange rate fluctuations could threaten financial stability. Interventions will therefore not be applied to defend a specific exchange rate, as was the case when the Bank followed an exchange rate peg.

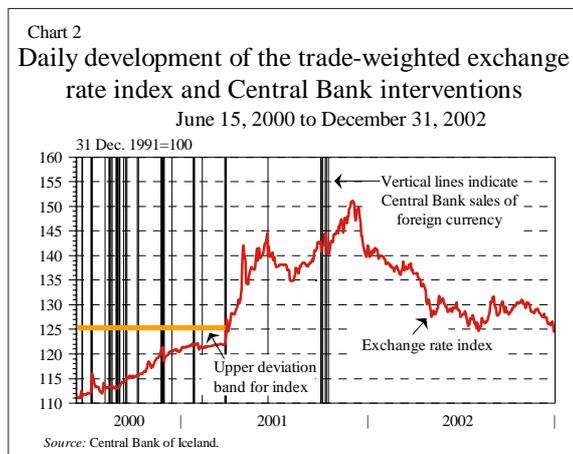### 6.3. Implementation of Central Bank interventions
As common among other central banks, the Central Bank of Iceland mainly conducts interventions through telephone. The Bank contacts all market makers at the same time and asks for a quote for the reference trading amount. However, there is nothing to prevent the Bank from requesting quotes for different amounts, although this has not been done in recent years. The Bank can trade with market makers as often as it deems necessary. Once the Bank enters the market, market prices move, and the aim behind placing orders with all

market makers simultaneously is to avoid creating information asymmetries among them.[20]

As discussed earlier, central banks have more than one method of intervening in the foreign exchange market at their disposal. The Central Bank of Iceland has almost exclusively conducted interventions in the spot market. There are, however, two exceptions, once the Bank used a forward contract and once a currency swap. As discussed in Box 3, in both cases these were ad hoc trades with a single market maker. Some central banks enter the market at specific times of day. The Central Bank of Iceland has not done so, apart from the pre-announced program to buy back foreign currency to strengthen the Bank's net foreign reserve position described in Box 3.

The Central Bank of Iceland has not made systematic announcements of its interventions. Occasionally it has issued an announcement after an intervention has been made, and the Bank has also described them in its publications.[21] News of interventions have often been reported by the market makers themselves. Central Bank purchases to improve its net foreign position were announced in advance in a press release. Other market makers have likewise been notified when the Bank has traded larger amounts with a single market maker.

Formally, the Central Bank does not sterilise its interventions in the foreign exchange market in order to eliminate their effect on its base money (with the exception of the trade in December 2001 mentioned in Box 3). However, in practice they become more or less sterilised due to the formulation of repo auctions at the Bank. Since March 1998, the Bank has held weekly auctions of repo contracts with domestic credit institutions which are subject to required reserve

Chart 2

Daily development of the trade-weighted exchange rate index and Central Bank interventions

June 15, 2000 to December 31, 2002

Source: Central Bank of Iceland.

provisions. The auctions have from the outset been implemented using a fixed price format implying that the counterparties have unlimited access to funds at the Bank as long as they hold enough of acceptable securities that they can use as collateral. The term of the repo agreement is two weeks, after which the trade is reverted. Institutions subject to required reserve provisions also have access to overnight funding with the Bank, using the same collateral.

This arrangement for repo auctions enables market participants to respond to liquidity changes caused by Central Bank interventions, and in effect sterilise them even though the Central Bank does not formally do so itself. For example, in 2001 Central Bank interventions in the foreign exchange market amounted to 29½ b.kr., or 25½ b.kr. excluding the 4 b.kr. sale of currency to one market maker in December 2001 which the Bank formally sterilised with a currency swap. Outstanding repo contracts increased by almost 22 b.kr. at the same time, while base money decreased by only 1½ b.kr. The liquidity that the Central Bank withdrew from the market with its interventions was thus channelled back out to it through increasing demand for repo contracts, implying that the interventions were more or less sterilised.[22]

Table 4 Central Bank of Iceland interventions to strengthen the króna (sales of foreign currency)
June 15 2000 to October 12 2001 (T-IV)

			Changes in exchange rate index	
		Share of	within	within same day
	Sale of foreign	total turnover	same day	and the following
Date	currency (m.kr).	(%)	(%)	day (%)
June 15 2000	383	5.3	0.3	0.6
June 26 2000	2,330	12.1	0.2	0.5
June 27 2000	309	3.8	0.3	-0.2
July 12 2000	1,167	9.1	0.6	2.4
July 13 2000	2,853	18.5	1.8	1.6
July 14 2000	3,029	14.6	0.2	-0.2
September 19 2000	339	7.6	0.3	0.4
November 21 2000	1,075	15.1	0.7	1.0
November 22 2000	1,078	13.8	0.3	0.2
November 23 2000	541	40.0	-0.1	-1.9
November 24 2000	1,483	11.7	-1.8	-2.0
November 27 2000	531	4.5	-0.2	0.3
December 11 2000	524	10.8	0.0	-0.2
January 24 2001	2,060	21.9	-0.2	0.0
January 25 2001	1,039	17.8	0.1	-0.2
January 26 2001	1,031	40.0	-0.3	-0.3
February 9 2001	1,033	23.6	-0.4	-0.4
March 23 2001	1,592	26.7	0.1	0.6
March 26 2001	1,464	14.7	0.5	2.2
March 27 2001	3,768	20.4	1.7	1.5
June 21 2001	2,545	8.7	-3.3	-2.7
September 28 2001	1,063	10.0	-1.2	-2.2
October 1 2001	1,207	7.4	-1.0	-0.2
October 3 2001	1,199	9.9	0.4	1.2
October 8 2001	3,390	29.3	0.0	0.4
October 10 2001	1,834	14.5	-2.0	-2.6
October 12 2001	1,208	12.7	-0.2	0.0

Changes in the exchange rate index within the same day measure changes from market opening to closing prices on the day of the intervention. Changes in the exchange index within the same and following day measure changes from market opening prices on the day of the intervention to the close price the day after the intervention.

6.4. The effectiveness of Central Bank interventions on the exchange rate of the króna

As discussed earlier, empirical findings suggest that sterilised interventions have a fairly limited effect on exchange rates. There are examples of successful reversals of depreciation trends, but more examples of failure. This is consistent with theoretical findings suggesting that sterilised interventions have limited effects on exchange rates, if any.

Given that adjustments in the demand for repo contracts causes the Central Bank's interventions to be more or less sterilised, it is not surprising that their impact on the exchange rate has been fairly limited, especially in the long run. This is evident from Chart 2 which shows the development of the exchange rate index and Central Bank interventions since June 15, 2000.[23]

As can be seen, the exchange rate of the króna returns to its earlier level shortly after the intervention, hence affecting the level of the exchange rate only for a short period. There are, however, instances which have coincided with periods of great uncer-

23. It should be reiterated that the chart shows only the Bank's trading that this paper defines as interventions, i.e. trades aimed to affect the exchange rate of the króna. Hence, the Bank's trading in December 2001 and 2002 are excluded, since these did not constitute conventional interventions aimed at influencing the exchange rate.

Box 4 Central Bank interventions in the foreign exchange market in the build up to and wake of the changed monetary policy framework in March 2001

When the Central Bank intervened in the foreign exchange market on March 23, 2001 rumours had begun to circulate that an announcement of a change in its monetary policy framework was pending at its annual meeting three days later. It was said that the Bank planned to move onto an inflation target and float the króna, which would probably cause greater exchange rate volatility, in the short term at least. Last but not least, it would remove the investors' safety net, i.e. the Central Bank's obligation to defend the exchange rate band. Fuelling this speculation was a remark by the Prime Minister that major news was expected from the meeting (quoted in *Morgunbladid* on March 27, 2001). Great uncertainty broke out in the foreign exchange market and the króna came under heavy strain to sell. The Central Bank intervened in an attempt to halt the depreciation, but with little effect. In spite of sizeable interventions the foreign exchange rate index rose over these days and was higher at the close of the day than when the market opened.

The Central Bank's annual meeting was held on March 27, 2001 (after the closure of the foreign exchange market) where it announced that it would introduce inflation targeting and float the króna. When the market closed on March 27, 2001 the foreign exchange rate index stood at 125.1 points, while the upper band was 125.4. Thus the Central Bank had succeeded in defending the band, although it was a close call and it was uncertain whether the Bank could have managed to do so for much longer. Subsequently, the króna continued to weaken. Turnover was heavy in the foreign exchange market and participants tried to put pressure on the Central Bank to intervene. Difficult days followed in the market, and May 2, 2001 is probably the most memorable. The participants' positions had worsened and the market was very one-sided. Under strong pressure, the króna fell by 5.8% over the day. Turnover in the foreign exchange market amounted to more than 36 b.kr., the highest volume ever in a single day.

The subsequent period was very one-sided too, and on June 21, 2001 the Central Bank decided to re-enter the foreign exchange market for the first time after the reform of the monetary policy framework. By then the foreign exchange rate index had risen above 145 points and the króna had fallen by more than 13% since the Bank moved onto an inflation target. As well as entering the market, the Central Bank had negotiated with market participants on the payment of a temporary commission for market making (which was discontinued at the end of 2002). At the same time it was announced that the government had made a new 25 b.kr. foreign loan which would be used to strengthen the Central Bank's foreign reserve. This calmed the market down and the index went below 135 points in August. Nonetheless, it rose again and passed 141 on September 20. The Central Bank's next intervention was at the end of September, when part of the foreign loan that had been promised in June was disbursed. It was hoped that the króna could be strengthened and the trend possibly even reversed. From September 28 to October 12, 2001 the Central Bank sold US dollars to market participants for the equivalent of almost 10 b.kr.

Following a short-lived strengthening in the wake of the intervention, the króna continued to weaken until November 28 when the highest index value for the year was recorded, or 151.2. After that the trend reversed and by the end of the year the króna had strengthened by 6½% since November 28. News on more favourable foreign trade and inflation developments were published at the same time. In December labour market participants also announced that a wage agreement review scheduled for February 2002 would be postponed until May, serving to reduce the likelihood of excessive wage rises which could have weakened the króna and caused mounting inflationary pressure.

It can therefore be said that the exchange rate depreciation trend was not reversed until domestic economic developments improved, which caused market participants' views and expectations to become more favourable for the króna.

tainty among market makers as to where the currency is heading. In these instances the Bank seems to have been able to halt or reverse the króna depreciation for a more sustainable period, such as on June 21, 2001. This, however, coincided with a declaration by the government on a new foreign loan to strengthen the Bank's foreign reserves and a new compensation scheme for market making in the foreign exchange market (see Box 4). It is therefore unclear how much of this change can be attributed to the intervention itself.

Table 4 presents an overview of the Bank's interventions over the period June 15, 2000 to October 12, 2001 (period IV). No systematic relation is apparent between the intensity of the intervention and its impact on the exchange rate index in the following two days (which is statistically confirmed).[24] For example, the Central Bank sold currency on November 24, 2000 in trades amounting to less than 12% of total turnover that day. Nonetheless the exchange rate index fell by almost 2% over the day and the impact had not disappeared the following day. In comparison, the Bank sold currency on January 26 which amounted to 40% of total turnover that day. In spite of such a large share of total turnover, the foreign exchange index remained virtually unchanged. Similarly, there are numerous examples of interventions which have failed to reverse a depreciating exchange rate trend even though they accounted for a fairly large share of the day's turnover. Thus the outcome of interventions seems to be determined more by current conditions than by their intensity.

This is also seen from Chart 3 which shows the development of the exchange rate index over the day during the period just before and after the abandonment of the fixed exchange rate regime in favour of inflation targeting in March 2001. The first three charts show the last three days before the Central Bank adopted inflation targeting. One intervention was then made in the summer and a series of them in September and October (these developments are described in more detail in Box 4). As a rule the

exchange rate index fell immediately after the intervention but rose again afterwards, although generally the increase was somewhat less than the original decrease following the intervention. Nonetheless, the index had generally risen to the same, or higher, level by the end of the day. A clear increase in volatility can also be seen following an intervention.

Further confirmation is given by an econometric analysis which is discussed in more detail in Box 5. The empirical results imply that interventions generally did not manage to reverse a weakening of the króna. More positive results are apparently achieved, however, if the Bank makes a more intensive effort with larger interventions lasting several days. Likewise, the Bank does not seem to succeed in dampening exchange rate volatility with its interventions. On the contrary, this appears to increase, which is consistent with the experience of other central banks, especially after the widening of the fixed exchange rate band in February 2000. Volatility in the wake of interventions increased somewhat less after the fixed exchange rate framework was abolished in March 2001, however. Volatility also appears to increase less, the larger the scope of the intervention.

Thus the results appear to be that Central Bank interventions have had a relatively limited effect. They did not succeed in preventing the weakening of the króna, or in systematically reducing volatility. On the other hand, it is virtually impossible to guess what would have happened if no intervention had taken place when uncertainty was at its height in the market. It can be argued that the weakening of the króna and exchange rate volatility could have become even more pronounced without any interventions. Nor can it be ruled out that the Bank managed to delay the depreciation trend so that the main weakening of the króna was not felt when the overheating of the economy was at its peak, and the risk of being transmitted to domestic prices was thereby greatest, but rather somewhat later when the economy had cooled down and the inflationary risk was less than otherwise.

The possible indirect effect of interventions to quell uncertainty and slow down a depreciation trend should therefore not be underestimated, although the Bank clearly did not manage to reverse the trend permanently with interventions. This required tradition-

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24. According to the survey by Neely (2001), most central banks regard that the impact of their interventions is primarily felt during the following hours, and lasts for the days immediately following the intervention.

Chart 3

Intra-day exchange rate development (5 minutes tick-data on the exchange rate index) and Central Bank of Iceland interventions March 23 - October 12, 2001

Vertical line indicates Central Bank sale of foreign currency
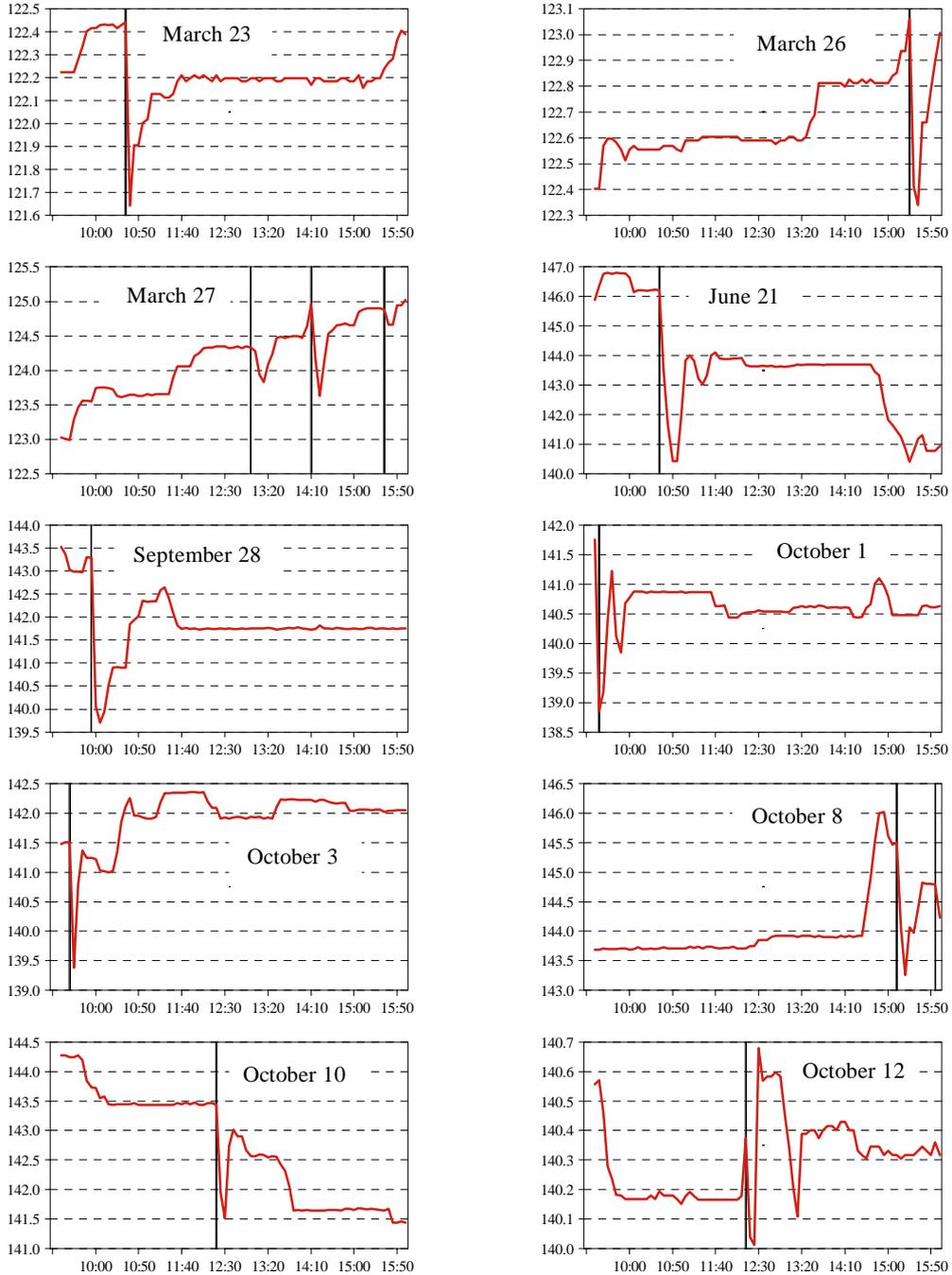
Source: Central Bank of Iceland.

Box 5 Empirical evaluation of the effect of Central Bank interventions on the exchange rate of the króna 1998-2001

GARCH models are commonly used to evaluate the effect that central bank interventions in foreign exchange markets have on exchange rates. Such models enable evaluation of the impact of intervention both on the exchange rate level and on its volatility (see, e.g. Brandner, Grech and Stix, 2001, and Kim and Sheen, 2002).

Such a model for the period from the beginning of 1998 to the end of 2001 was used to evaluate the impact of the Central Bank of Iceland's interventions on the exchange rate of the króna. Since foreign exchange trading in its current form did not begin until mid 1997, the beginning of 1998 was chosen as a starting point to allow some experience of the new trading format to have been built up. It was decided to complete the evaluation at the end of 2001 since no direct interventions were made in 2002. The Bank's only transactions that year were in connection with its pre-announced program to buy back foreign currency which, as discussed in the main article, are not defined as conventional interventions. Accordingly, two trades by the Bank in December 2001 are not included in the empirical evaluation either.

The following EGARCH model was evaluated using daily data from January 1, 1998 to December 31, 2001 (1,363 observations):

$$\Delta \log s_t = (\alpha_0 + \alpha_1 VIK_t + \alpha_2 FLOT_t + \alpha_3 HOL_t)$$
$$+ \delta(\log s_{t-1} - \log s^T)(1 - FLOT_t)$$
$$+ [(\beta_{00} + \beta_{01}VIK_t + \beta_{02}FLOT_t)$$
$$+ \beta_1 CUM_{t-1} + \beta_2 SIZE_{t-1}] \times INT_{t-1} + \varepsilon_t \sqrt{h_t}$$

$$\log h_t = (\omega_0 + \omega_1 VIK_t + \omega_2 FLOT_t + \omega_3 HOL_t)$$
$$+ \theta |\log s_{t-1} - \log s^T|(1 - FLOT_t)$$
$$+ \gamma_1 |\varepsilon_{t-1}/\sqrt{h_{t-1}}| + \gamma_2 (\varepsilon_{t-1}/\sqrt{h_{t-1}}) + \gamma_3 \log h_{t-1}$$
$$+ [(\lambda_{00} + \lambda_{01}VIK_t + \lambda_{02}FLOT_t)$$
$$+ \lambda_1 CUM_{t-1} + \lambda_2 SIZE_{t-1}] \times |INT_{t-1}|$$

where $\Delta \log s_t$ is the percentage change in the exchange rate index on day t (based on the registered exchange rate for the day), VIK_t is a dummy variable which takes the value 0 until the fixed exchange rate bands were widened to ±9% on February 14, 2000 and 1 afterwards, $FLOT_t$ is a dummy variable which takes the value 0 until the fixed exchange rate bands were abolished on March 27, 2001 and 1 afterwards, HOL_t is a dummy variable which takes the value 1 on the first trading day following a holiday, s^T is the central parity of the fixed exchange rate (115.01), INT_t is the Central Bank's intervention on day t in b.kr. (purchases of foreign currency), CUM_t is a dummy variable which is set to 1 if an intervention on day t follows interventions in the same direction on the preceding two days (i.e. interventions in the same direction for three consecutive days) but otherwise to 0, $SIZE_t$ is a dummy value set to 1 if the size of the intervention on day t exceeds the average amount of interventions over the period (approximately 600 m.kr.) but otherwise to 0, and ε_t is an $N(0,1)$ random variable. In order to avoid a simultaneous bias problem interventions only enter lagged. Thus the model does not capture the short-lived impact of interventions (i.e. that die out within the same day that the intervention is performed). However, it can be argued that the longer lasting effects are of primary importance.

The first equation describes the determination of changes in the exchange rate level of the króna over the period. According to the model, changes in the exchange rate are effected by the previous day's deviation from the central parity of the target bands, ($\log s_{t-1}$ - $\log s^T$), while they were in effect. If the index value exceeds the central parity it should reverse back towards it in the long run, i.e. $\delta < 0$ if this effect is present. Such effects are not present after the króna was floated. Effects of interventions are allowed to vary depending upon their size and persistence and whether they were performed before or after the widening of the target bands in 2000 and their abolition in 2001. For example, the effects of relatively small interventions extending over a single day and performed before the widening of the bands in 2000 is β_{00}, while the impact of a comparable intervention after the floating of the króna is $\beta_{00} + \beta_{01} + \beta_{02}$. Similarly, the impact of an intervention lasting for three consecutive days and exceeding the average amount of interventions after

the floating is $\beta_{00}+\beta_{01}+\beta_{02}+\beta_1+\beta_2$. If the intervention managed to strengthen the króna or reduce its weakening, the sum of the parameters in each case should be positive. Finally, the widening of the target bands in 2000 and their abolition in 2001 is allowed to have a direct effect on the exchange rate index, although such an effect is probably not present. Likewise, average exchange rate changes may be different on the first trading day after a holiday.

The second equation describes the determination of exchange rate volatility which is affected by the same variables as changes in the exchange rate level itself. The EGARCH model allows strengthening and weakening of the exchange rate to have differing effects on volatility. If $\gamma_2 > 0$ a depreciation of the króna increases volatility more than an appreciation. This could reflect, for example, a belief among market participants that the Central Bank was more averse to a depreciation in the exchange rate than to an appreciation. Theoretical models indicate that $\theta < 0$ where the impact of underlying economic factors on the exchange rate within the bands decreases as the exchange rate moves closer to the central parity (see, e.g. Brandner, Grech and Stix, 2001). The króna may also be expected to have become more volatile when the bands were widened and ultimately abolished in 2001. International studies furthermore suggest that exchange rates become more volatile when markets open after holidays, due to the accumulation of information on which trading is then based. The impact of interventions on the volatility of the exchange rate index is interpreted in the same way as their impact on the level itself.

The final model is shown in the table, where insignificant parameters have been eliminated (robust Bollerslev and Wooldridge standard errors are given in parentheses).The final model suggests that the exchange rate of the króna weakens on average on the day after a Central Bank intervention to strengthen it. This implies that the intervention has not succeeded in preventing the króna from depreciating. However, the outcome appears more likely to be successful if the intervention is large or lasts for several days. Impact on the volatility of the króna varies, depending upon whether the intervention was made before or after the widening of the bands and their abolition. Prior to the widening of the bands, large interventions apparently managed to dampen volatility, but after they were widened interventions have increased exchange rate volatility on average, although to a lesser degree after the króna was floated. As before, the impact on volatility remains less if the intervention is relatively large.

al monetary measures which gradually squeezed excessive pressures out of the economy and reversed the inflation hike which was partly caused by the weakening of the króna after the monetary policy framework was changed in March 2001.

An alternative way to assess whether the Central Bank's interventions have been successful is to examine whether the Bank profited from them. According to Friedman (1953), central bank interventions in foreign exchange markets are successful if the bank profits by them. If the exchange rate of a currency is below its underlying equilibrium value, for example, and the central bank buys that currency in order to strengthen it, a successful strengthening will also mean that the bank profits on its interventions. On the other hand, Edison (1993) points out that central banks could even profit on intervention without exerting any impact on the exchange rate, if they buy when the price is low and sell when it is high. A central bank's profit or loss on its interventions cannot therefore be used as a criterion of success in influencing the exchange rate.

A reliable assessment of the Central Bank of Iceland's possible profits on its interventions is difficult to make, especially taking into account the risk involved, and it is perhaps not appropriate to make such an evaluation until it has finished building up the foreign reserve that it drew on when defending the króna over the period 2000-2001. However, it is clear that the Bank incurred some exchange rate loss in 2001 when the króna depreciated from the level at which it had bought króna deposits. This exchange rate loss has been recouped and probably more than so as the króna has strengthened again. In addition, króna deposits have been invested at a higher rate of interest, since domestic rates have been higher than those abroad. Thus it can be argued that the Bank has not incurred losses on its interventions and in the sense used by Friedman (1953) they have been successful.

7. Conclusion

The Central Bank's role in the Icelandic foreign exchange market has changed dramatically as the market has evolved and the monetary policy framework has changed. Until mid 1999, when it withdrew from the market completely, the Bank was an impor-

tant market maker. The Bank was the counterparty of most trades and was frequently on both sides of the market. When the Bank returned to the market around mid 2000, after an interval of a year, its role had changed fundamentally. The foreign exchange market had developed considerably and the Bank's participation consisted only of entering it on its own initiative in order to influence the exchange rate. This applied in particular as the second half of 2000 wore on and the króna was under steady downward pressure, and until the fixed exchange rate framework was replaced in March 2001 by a formal inflation target and floating exchange rate. However, the Bank continued to enter the market in order to support the króna until October 2001. Since then it has only traded in the market under special conditions which are not related to the implementation of monetary policy, most recently to strengthen its net foreign position.

The Bank's interventions have had a fairly limited impact on the exchange rate. They did not manage to halt or reverse the weakening trend of the króna, except for a very short time, although there are instances when the Bank managed to rally market makers behind it and thereby succeeded in halting the weakening for some while. Thus the outcome of interventions appears to depend mainly on market conditions at any given time. Empirical evidence also indicates that interventions have tended to amplify volatility rather than dampen it. The limited success need not come as a surprise bearing in mind that the Bank's interventions are in effect more or less sterilised, i.e. the change in liquidity that they cause is almost automatically readjusted through changes in demand for repo contracts at the Bank. Thus the impact on the Bank's base money is virtually non-existent, even though the Bank itself does not make a formal attempt to sterilise the interventions.

These findings are consistent with international experience which suggests that the effects of sterilised interventions on exchange rates are generally fairly limited and short-lived. However, it is important to remember that it is virtually impossible to say what the króna exchange rate would have been if the interventions had not been implemented. After all, central banks still intervene in the market despite no longer being obliged to maintain their currency's exchange rate within specific limits,

although there have admittedly been fewer instances of this among industrialised countries in recent years.

Thus is cannot be ruled out that the Central Bank of Iceland did succeed in slowing down the deprecia- tion trend of the króna, so that the main weakening was not felt when overheating of the economy was at its height. To some extent this would have reduced the risk of the weakening causing an even greater acceler- ation in the inflation rate than turned out to be the case.

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