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Can the authorities manage crises in the financial system?

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There are a number of parallels between the current financial turmoil and the Swedish bank crisis of the 1990s. To cope with financial institutions in distress, effective regulations and institutions need to be put in place. The banks' increasing cross-border activities mean that international cooperation must also be intensified.

Introduction

Since the summer of 2007, there has periodically been considerable turmoil in the financial markets. The fact that financial markets experience upswings and downswings is scarcely remarkable or unusual, and there are almost always some countries in the world experiencing problems in their financial sector. This is a fact of life that we have become used to.

This time, however, there appears to be much greater nervousness than we have seen in a long time. Central banks have followed developments with great interest, and, for instance, the European Central Bank (ECB), the Federal Reserve and the Bank of England have taken a number of well-publicised measures.

This article aims to shed some light on what all the commotion is about this time and to discuss the regulations for managing financial institutions in distress and the challenges facing the authorities – in Sweden and internationally. But before this, it could be useful to say a little about financial crises on the basis of the current turbulence and the bank crisis Sweden experienced at the beginning of the 1990s.

[1] The article is based on a speech by Stefan Ingves at the Swedish Economics Association on 13 March 2008.

The problems began in the subprime market

The recent credit turmoil began with problems on the US mortgage market, in particular in the segment offering subprime loans. These are loans to mortgage customers with lower creditworthiness – often households without a documented credit history and with a lower income than the average household. These loans doubled between 1996 and 2006, although they still comprise a relatively small part of the US credit market. The problems began to affect many borrowers back in 2005, in connection with the rise in interest rates.

When loans were renewed at the higher interest rates, the loan costs for these borrowers rose substantially. And when real estate prices fell in many areas, there was no scope to increase house mortgages so householders could borrow their way out of their problems. This was otherwise a common – albeit dubious – strategy during the years of rising property prices. Many borrowers could no longer make the interest and mortgage payments on their loans. This led in turn to substantial credit losses for many mortgage institutions. But the loan losses did not merely affect the banks and mortgage institutions that had originally issued the loans. The problems came to have a much wider spread.

AND THE PROBLEMS SPREAD AS THE RISKS WERE SOLD ON

The reason why the problems spread is the extensive securitisation of mortgages. This special form of financial engineering has made it possible for lenders to sell credit risk together with the right to the payment streams from the loans to prospective investors around the world. Essentially, this means that a number of loans are combined and put into an investment vehicle created especially for this purpose, which is in turn financed by issuing securities, what are known as mortgage-backed securities. In principle, this is a way of making illiquid assets liquid.

This strategy has become increasingly common among banks and other credit institutions around the world. One can say that they have thus increasingly moved away from their traditional role as monitors of credit risk. Instead they have to a greater degree originated loans, where the inherent credit risks have immediately been distributed to investors in the financial markets willing to take the risks. Their business strategy has changed from focusing on long-term customer relations to repackaging and selling. Having said this, securitisation is not necessarily a bad thing in itself.

What has been new and something of a problem this time has been the way in which the securitised loans have been repackaged and resold

through several stages. The structured credit risk products that were created often included a large portion of subprime loans. The variety of these products has been impressive. Often one product has been included as a component in another product, which in turn has been repackaged and included as a component in a new product. One can equate this to Russian dolls: a large one that contains a smaller one, which in turn contains an even smaller one, and so on. This has been a means of creating assets that suit investors with differing risk appetites, particularly assets with a high return and a corresponding high risk level.

A COMPLICATED STRUCTURE EMERGED

There has also been substantial variation among the special investment vehicles used by banks and other credit institutions for their securitisation. Without going into detail, what these conduits and SIVs and suchlike have in common is that they invest in high-yield assets with long durations, often structured credit-risk products with a subprime content. They have been financed, at least partially, by issuing certificates in the fixed income market for short durations, what are known as asset-backed commercial papers. The special vehicles have thus to a greater or lesser degree been dependent on the liquidity in the market for these securities for their funding.

Even if these special vehicles are in principle independent from the banks, it is common that the banks supply some form of liquidity guarantee. In other words, if a special vehicle for some reason is unable to issue new certificates when the old ones fall due, the bank guarantees the ability to pay, wholly or partly. Such guarantees need not only consist of formal obligations. They may also be of a purely informal nature. This is because the bank may be disinclined to abandon its special vehicle in order to protect its name and reputation. Whatever the case, it means that the financing problems that affect the special vehicles can easily lead back into the bank. What one has regarded as a true sale may in reality not always have been so.

CREDIT RATINGS ATTRACTED INVESTORS BUT WERE MISUSED

The result has been an extremely complicated structure. Many asset classes have arisen, each with their own unique conditions and idiosyncrasies in pricing. This has in turn made it difficult to assess the different products. For this, one has instead relied heavily upon the services provided by credit rating agencies. Using credit ratings as comfort, investors have been persuaded to invest in the products.

Credit ratings are excellent aids that measure the probability of default or the expected loss. But they do not take into account how the risks are otherwise distributed or how risks covary. Unfortunately, many investors appear to have disregarded these limitations. In addition, all of the repackaging, special intermediaries, and more or less visible guarantees have made it difficult to gain insight into where the risks are. In particular the geographical spread appears to have been greater than in earlier episodes of financial turbulence.

UNCERTAINTY INCREASED AND LIQUIDITY DISAPPEARED

When the problems in the subprime market began to surface here and there, this caused great uncertainty. It was quite simply impossible to know who was directly or indirectly exposed to the subprime loans. This led to liquidity waning in parts of the interbank market. It therefore became more difficult and more expensive for the banks to refinance themselves. When many banks experienced problems, a number of central banks chose to take measures to increase liquidity in the interbank market.

The unease in the credit markets has continued during the winter and spring of 2008. Many large and established banks have been gradually forced to write down the book value of their subprime-related assets. This has led to some major financial groups requiring new capital. At the same time, there has been increased uncertainty over international economic activity. This has in turn contributed to major fluctuations on the world's stock markets.

Given the free movement of capital, increased interest rates in the international credit markets of course also affect Swedish interbank rates. But higher interest rates in the interbank market do not by definition mean that the banks will experience liquidity problems. The Swedish banks have had good liquidity throughout the entire period of turmoil. They have not been exposed to subprime-related securities to any great extent. Their solidity was and remains good and their loan losses are at present very small. Nevertheless, the Swedish banks have not been able to entirely escape the effects of these events.

There are similarities between today's financial turmoil and the Swedish bank crisis

The current financial turmoil and the Swedish bank crisis actually have a number of common denominators. Carmen Reinhart and Kenneth Rogoff have pointed to a number of similarities between the US mortgage turmoil and a number of earlier financial crises, including the Swedish bank crisis at the beginning of the 1990s.[2] Some common denominators for the period prior to the outbreak of the crisis include a rapid increase in property and share prices, the fact that the current account deficit was large and growing and that economic growth had declined from an earlier high level. One important difference is that the exchange rate regime has not played a prominent role in the US case.

TOO LOW RISK PREMIUMS AND ABSTRUSE RISKS

It is also possible to find more specific parallels to the Swedish bank crisis – apart from the obvious connection to the real estate market. In both cases, lending has increased rapidly at the same time as the banks have underestimated and therefore not sufficiently priced the credit risks. In Sweden this was linked to the banks – after decades of credit regulation – lacking a developed strategy for managing and pricing credit risk. When deregulation came in the mid-1980s, they were quite simply unused to loan losses. But such tendencies could also be seen prior to the recent market turmoil. For a long time, risk premiums for credit-risk related securities were remarkably low. The uncertainty has led to an increase.

But, there are also other parallels. This includes in particular the arrangements that made the banks' real risk-taking more abstruse. The banks' formal and informal promises of loans to special investment vehicles meant that the problems quickly bounced back into the banks' balance sheets.

In the Swedish bank crisis one can say that the finance companies in some respects played a corresponding role to the special investment vehicles. It was the finance companies that primarily financed the expansion in the construction and real estate markets. The finance companies largely financed themselves in the short term by issuing commercial papers in the fixed income market. When the property market folded, it was a finance company, Nyckeln, which in September 1990 was the first to throw in the towel when it could not renew its financing. Other finance companies then followed suit.

[2] Reinhart & Rogoff (2008).

Many of the finance companies were in fact owned by the banks. And the banks were tied by both formal and informal commitments. The losses therefore soon returned to the bank system. In 1991, it became apparent that the banks had substantial problem loans through their exposures to the real estate market both directly and indirectly through the finance companies they supported. The bank crisis had become a reality.

THE STRUCTURES WERE A SIDE-EFFECT OF REGULATORY ARBITRAGE

It is also interesting that the abstruse structures, which led to the current financial turmoil and the bank crisis in the 1990s, were in both cases partly due to regulatory arbitrage. The most recent wave of securitisation of the banks' credit portfolios was partly propelled by deficiencies in the capital adequacy rules. Through securitisation the banks could easily avoid a lot of expensive capital charges. Since 2004, there is a new capital adequacy regime, Basel II. This is more finely meshed and does not allow the same possibilities to avoid capital charges through securitisation. However, it has not yet been implemented in all countries, such as the United States, for instance.

The Swedish finance companies were in their day the result of regulatory arbitrage. Prior to the abolition of credit regulation in Sweden, the finance companies were often used as a means for the banks to get round the credit restrictions. This "grey" credit market was once substantial and an important source of additional income for the banks.

CREDIT INSURANCES EXISTED THEN AS NOW

One can also observe another similarity, namely the occurrence of financial guarantors insuring credit. One company that sold credit insurance to the Swedish banks in the 1980s and 1990s was Svenska Kredit. Many banks bought insurances against losses from their loans to property companies from this company. When the real estate market crashed, Svenska Kredit was unable to meet all of its obligations and consequently went bankrupt. This in turn fuelled the problems for the banks.

There are parallels to the current monoline insurance companies. These are large insurance companies that specialise in insuring various types of bond loan. Those who have bought the companies' insurances have traditionally been municipalities, federal states and other bond issuers with poorer credit ratings. The insurance has meant that the bond loans have received better credit ratings and it has been possible to sell

them at better rates. In July 2007, the outstanding volume of bonds insured by monolines amounted to a value of USD 3.3 trillion.

In recent years, these monolines have increasingly been used to insure securities issues with a subprime content. This has meant that they have also begun to experience problems. This risks in turn having repercussions for the securities they have insured and ultimately for those who have invested in them.

Of course, there are also some essential differences between the most recent financial turbulence and the Swedish bank crisis. This applies to both the nature and the scope of the crisis. But, as we have seen, there are many and striking similarities in the way people have acted. Or as Voltaire is supposed to have said "While history may never repeat itself – man always does!"

Financial crises arise as a result of imbalances in the balance sheet

So why do financial crises arise? The root of most financial crises can quite simply be found in the imbalance between assets and financing. The simplest way to illustrate this is to look at a stylised bank's balance sheet. On the asset side there is lending to companies and households. These are assets that cannot be realised quickly without a substantial discount. In other words, they are illiquid. The bank's financing on the other hand largely consists of deposits from the general public and short-term borrowing on the interbank and securities markets. Their financing is thus very liquid.

In normal circumstances this is not a problem, as we do not expect all depositors and other financiers to withdraw their money or their financing at the same time. But at the same time, this liquidity transformation makes the bank sensitive to its financiers' confidence in its ability to meet its obligations. Suspicions that the bank has financial problems could very quickly lead to a bank run.

There have been many bank runs in the past. Stockholms Banco, which was founded by Johan Palmstruch in 1656, was hit by a bank run in the 1660s when the depositors lost confidence in the notes issued by the bank. The bank was taken over by the estates of the realm, and is the precursor to the Riksbank, which was founded in 1668. There were countless bank runs in the United States at the end of the 1920s and the beginning of the 1930s. Argentina and Indonesia were hit at the end of the 1990s and the beginning of the 2000s. And as recently as September 2007, the British building society Northern Rock suffered a bank run.

It is clear that even the most recent financial turmoil is a question of a mismatch between assets and liabilities, although the assets and liabilities have come to look slightly different than in the fictitious example. In essence, this is a matter of the same phenomenon, namely lending at long durations that is funded in short durations. The awareness of this inherent instability and the difficulty in seeing where the risks lie meant that liquidity sometimes dried out in parts of the money market. What is new is that banks around the world have become much more dependent on the securities markets for managing risks and financing themselves. In 2007, we had concrete evidence of how sensitive the banks have become to liquidity shocks in these markets. Problems in the securities markets have rarely ever before returned to the bank systems with such force.

The importance of financial stability

When Northern Rock experienced problems, the British authorities took a number of exceptional measures. For instance, the Bank of England granted the building society emergency liquidity assistance. And HM Treasury abandoned the limits of the existing deposit guarantee, extending the guarantee to cover all deposits in Northern Rock without limitation.

The question that many people are probably asking is why so much effort was made for one individual financial institution. Public measures of this type would hardly have been mobilised if it had been a question of an ordinary engineering company or retail chain that was in financial straits. Why are banks so special? One could reply in the same way as John Dillinger, designated by the FBI in the 1930s as public enemy number one, when asked why he robbed banks: "Because that's where the money is." But there is also a more qualified answer involving two specific aspects. Firstly, it concerns the special role played by the banks and the bank system as a whole in the economy. Secondly, it concerns the special contagion risks in the financial system. In a central bank context, these are usually called systemic risks.

Banks and other intermediaries in the credit market who receive deposits from the general public play a central role in the financial system. They contribute, for instance, to the more efficient distribution of capital by acting as intermediaries between depositors and borrowers.

They also create the conditions for the more efficient mediation of payments in the economy. The banks' deposit accounts are of central importance to the use of payment cards, credit cards and credit transfers. Many banks also participate in the system for the settlement of large-value payments supplied by the central bank. The banks and their account systems are therefore a vital part of the payment system.

At the same time, problems that arise in one bank can easily spread to other banks. This spread can occur in different ways. Firstly, there can be a direct contagion, through the exposures the banks have to one another in the payment systems and in connection with foreign exchange and securities trading. Severe chain effects can arise if the customers of a bank that is experiencing problems have their means of payment tied up in the bank. This makes it difficult to make payments to other households and companies. It can lead to liquidity problems that can in turn give rise to loan losses and payment problems for these customers' banks.

Secondly, the banks are often exposed to the same sorts of risk. This increases the probability that, for instance, a macroeconomic shock may affect more than one bank. The contagion of problems between banks can thus also arise as an indirect effect, through expectations that other banks may suffer similar problems to the one first affected, or via more well-founded suspicions of the banks' exposures to one another.

The contagion risks mean that problems in one bank can easily lead to problems for the entire bank system. The costs to society of a crisis affecting the entire bank system can be substantial. It is, of course, difficult to calculate these costs. Some surveys have indicated that an average production loss resulting from a bank crisis could be around 15–20 per cent of GDP.[3] According to some calculations, the collapse of the Swedish bank market cost around 5 per cent of GDP in terms of a loss in output.

Seen from society's point of view, the individual agents' incentives are not sufficient to take protective measures against crises that affect the financial system as a whole. The shareholders can never lose more capital than they have put in and individual depositors find it difficult to monitor a bank with widespread operations. There are, to use economic terminology, considerable adverse externalities. In addition to the consumer protection aspects, this is a decisive motive for having a financial safety net in the form of special regulation, supervision and a deposit guarantee. It is also the reason why central banks have the possibility to provide emergency liquidity assistance. Such emergency liquidity assistance shall in principle only be granted if the institution in question has temporary liquidity problems, but is essentially viable and if there are systemic contagion risks.

It was exactly this risk of domino effects in the rest of the financial system that meant that Northern Rock, which can hardly be said to be of critical significance to the bank system, became the object of a number of measures taken by the British authorities. It was probably similar consid-

[3] Hoggarth & Saporta (2001).

erations that motivated the measures taken in Germany to save IKB and Sachsen Landesbank.

Now one has seen that it was not so easy for the British authorities to manage the problems in Northern Rock. The existing regulations and arrangements did not prove particularly effective. Despite the measures taken, they did not manage to avoid a bank run. This has led to the authorities in the UK drawing up, in an impressively short time, proposals for a number of improvements in the regulatory framework for managing institutions in distress. In February, the Chancellor of the Exchequer announced the decision to nationalise Northern Rock, as there was otherwise a risk that the cost to the taxpayers would be too high.

The regulations for managing institutions in distress are inadequate

For the Riksbank, as a body partially responsible for the stability of the financial system, it is relevant to ask how things are in Sweden. Do we have the regulatory framework required to manage possible future problems? Unfortunately, the answer to that question must probably be no, at least at present.

During the Swedish bank crisis at the beginning of the 1990s, a number of extraordinary measures were taken. These included issuing the bank deposit guarantee. This was a general declaration that the banks' creditors would be protected. In addition, a special crisis management authority was established, Bankstödsnämnden (the Swedish Bank Support Authority). In connection with this, a number of provisions of a compulsory nature were introduced to prevent the possibility of the state being placed in a blackmail situation. For instance, an act was introduced that meant in principle that the Swedish Bank Support Authority could make decisions in the bank through a state compulsory purchase of the shares if the bank's capital adequacy fell below two per cent.

But these temporary provisions, like the general bank guarantee, ceased to apply in 1996. The Bank Support Authority was transformed into the Deposit Guarantee Board (Insättningsgarantinämnden), which was given the task of managing the deposit guarantee and investor protection.

Since then, it is in principle only the general regulations for bankruptcy and liquidation and the system for the deposit guarantee that are available for managing institutions with problems. Unfortunately, it is not particularly appropriate – if even possible – to apply the general insolvency regulations to banks. The regulations on bankruptcy and liquidation are primarily to protect the interests of the creditors. They are not particularly

well-adapted to take into account society's interest in maintaining the stability of the financial system. The primary task of a receiver in a bankruptcy is to safeguard the interests of the creditors. He or she has neither the authority, nor can be expected to have the skills required, to take the measures needed to safeguard the stability of the financial system.

Problems that threaten stability require immediate action. Bankruptcies usually take years to resolve. Some elements of the general bankruptcy procedure, such as freezing balance sheets, may in some cases be directly harmful if applied to a systemically-important institution. For example, the banks' central role in the payment system means that one cannot merely stop payments in one or more of the major banks, as this could have devastating consequences for the financial system. During the bank crisis no banks were declared bankrupt.

The lack of specially-adapted regulations for winding up problem institutions with the capacity to take into account society's need for financial stability was emphasised by the Banking Law Committee (Banklagskommittén. This was a commission of enquiry appointed in 1995 in the wake of the bank crisis to look into the needs for modernised legislation for banks. The Committee also presented a proposal for a new framework to manage banks in distress, called public administration. This proposal has now been under consideration by the Government Offices since 2000.

CUSTODIA WAS A REMINDER OF THE SHORTCOMINGS

Since then, we have received new indications of the shortcomings in the regulations. The course of events at the credit institution Custodia in 2006 indicated worrying difficulties in managing even a relatively small and insignificant problem institution. We are therefore in no way better equipped than the United Kingdom to manage problem institutions and this applies with regard to both small and large institutions.

Fortunately, Custodia was a small company and the problems occurred in a situation where there was relative calm on the financial markets. The stability of the financial system was thus definitely never threatened. But it is regrettable that we still have not managed to create an adequate regulatory framework in this field, more than fifteen years after our own bank crisis.

In countries where they have slightly more experience of bank failures, such as the United States and Canada, they have learned that special institutions and arrangements are needed to manage institutions with financial problems.

One of the most important lessons is that the authorities must be able to intervene as quickly as possible when a bank faces problems. There are several reasons for this. The first is to put pressure on the management and owners of the bank to rectify the situation and hopefully to prevent the situation deteriorating further. The so-called Savings and Loans crisis in the United States in the 1980s became more costly when the authorities failed to take action in time. This meant that in the United States at the beginning of the 1990s they introduced a system with so-called prompt corrective action. This means that the authorities quite simply are obliged by law to intervene at certain specified thresholds. In our opinion, it is desirable that Finansinspektionen (the Swedish Financial Supervisory Authority) should also have a large toolbox of measures that can be taken at an early stage. It should be possible to intensify these measures gradually as problems worsen. Of course, it is not desirable that the only possibility is to withdraw the license of an institution whose capital adequacy falls below the eight per cent level. In Sweden, there is every reason to look more closely into the obligations and powers of authority of Finansinspektionen.

Another motive for the authorities to act quickly is to be able to quickly pay the deposit guarantee. To be able to make the necessary preparations for this, the authorities therefore need to have access to and control over relevant data files at an early stage when an institution gets into difficulties. This has been a problem in earlier cases of compensation from the Swedish deposit guarantee.

If the financial system is threatened, the authorities must also be able to temporarily take control over the bank to maintain vital functions. The banks' central role in the payment system means that payment defaults by one bank can have substantial domino effects. The consequences for the rest of the financial system may then be difficult to overview.

With regard to institutions lacking a long-term survival capacity, it is of course important that they are wound up as quickly and smoothly as possible. There must be several different alternative methods for winding up banks to make it possible to choose the model that is best suited and entails the least cost to society. Of course, it would be best if one could get another bank to take over this institution's activities. But the possibility to carve up the business and sell it in parts could in some cases prove more cost-effective. In certain cases, a reconstruction of the bank may be the most appropriate solution.

If it were to take too long to find a buyer, it might be necessary for the state to take over the bank temporarily. This was what was ultimately necessary in the case of Northern Rock. There is a risk in similar situations that the state could be exposed to blackmail. To minimise the costs to

taxpayers, it is therefore desirable that the state has sufficient strength to negotiate with existing and presumptive shareholders. For instance, there must be legal possibilities for the state to redeem the shares at a price corresponding to the value of the bank in the absence of state measures. It is also particularly important to avoid situations where a bank ends up in a no man's land regarding ownership.

An essential condition for a well-functioning system is that one can attain a balance between all of the interested parties who come forward when a bank is in distress. The various interests include society's interest in financial stability and the depositors' interest in good consumer protection. But there are also the creditors' interest in good protection and fair treatment as well as the taxpayers' and the fee-paying institutions' interest in the cost of the deposit guarantee system being as low as possible. In addition to this, we have the owners' interest in their legal rights and not least society's interest in the administration of justice functioning in the field of economic crime.

All of these interests, and probably more, are entirely legitimate and must of course be taken care of in the legislation. But they must be classified according to their relative significance to society. Otherwise it will not be possible to distribute the roles between the different authorities in the best way when managing problem institutions. There is also a risk of wasting valuable time on managing conflicts between different interested parties instead of managing the institution's problems. In other words, it is necessary to have a bird's eye view when drawing up regulations.

THE REGULATIONS MUST BE FORMULATED TO GIVE THE STATE THE RIGHT TOOLS

The Swedish Ministry of Finance is currently working hard on a proposal for the public administration of banks in distress. The design of the deposit guarantee and Finansinspektionen's powers of authority are also being reviewed. We eagerly await these proposals. Even if the work is carried out on parallel tracks, it is important that the final result is coherent. Otherwise it could be difficult to manage a future crisis in the financial system.

It is also important that the proposals are not toothless. Running a bank is not a right, rather it entails considerable responsibility towards both society as a whole and the customers who have entrusted their savings to the bank. Bank owners are already protected by the financial safety net and insulated against risks in a completely different way to those who own ordinary companies. It would therefore be unfortunate if the result was merely a proposal that entailed the state taking over the man-

agement of a problem institution, fixing it up and then handing it back to the owners in a new, improved version.

Hopefully, the government will dare to take the overall approach required when working on these issues and, in particular, they will take note of the events in the United Kingdom and the initiatives that have come about as a result of the problems with Northern Rock. It is important that the state has the necessary tools. If the current EU legislation puts a spoke in the wheel in various ways, then the joint regulations also need to be reviewed.

The internationalisation of the financial sector requires greater cross-border cooperation

The authorities' crisis preparedness and legal and institutional arrangements for crisis management will thus be less of a purely national affair. The financial sector will be increasingly internationalised, if not globalised. The banks' activities are becoming more cross-border in nature.

The four largest Swedish banks currently have more than half of their total assets abroad, mainly in the other Nordic countries, but also in Germany, Poland and the Baltic states, and, recently, in Russia and the Ukraine. An almost equally large share of their total operating profits originates abroad. For the Nordea Group this share is no less than three quarters.

In recent years, there have also been some much-publicised cross-border acquisitions among several large European banks. There are currently around 50 banks in Europe with substantial operations in several EU countries. There are a number of interacting reasons behind this. The capital adequacy rules have been harmonised, the opportunities to expand in small and mature domestic markets are slight and the economies of scale have increased as a result of, for instance, IT costs accounting for a larger share of the banks' total costs.

When the banks operate across national borders competition increases. This benefits both companies and households, as financing costs fall and the supply of financial services increases. These are efficiency gains which are ultimately beneficial for economic growth.

But at the same time the risk of a bank crisis spreading across national borders increases. This also increases the risk of serious problems arising in several countries at the same time. This makes high demands of crisis management. The exchange of information and the decision making must be coordinated between different authorities. This can be difficult enough to achieve in just one country. The differences between the different authorities' aims, perspectives and working methods can be substan-

tial. In a cross-border crisis it would also be necessary to coordinate the authorities in several different countries. It is not difficult to imagine that this could be very complicated. Apart from involving more authorities, a number of legal and practical complications arise. This can sorely test the coordination of the exchange of information and the decision making.

The Swedish bank's substantial activities abroad have therefore meant that the Riksbank has entered into a number of agreements on cooperation in the event of financial crises with the central banks in the other Nordic countries and in the Baltic states. There is now also an overall agreement on crisis management at the EU level – a Memorandum of Understanding (MoU). This covers central banks, supervisory authorities and finance ministries in all of the member states. Agreements of this nature are valuable because they create orderly forms for cooperation. They create necessary contact networks and, not least, a common parlance, which can be of great importance when managing a crisis. But these MoUs also have shortcomings. They are often worded in a vague and general manner and are not usually legally binding; more a declaration of intent.

But the most serious deficiency is that they do not take into account the conflicts between national interests that may arise in a crisis situation. These should be added to all of the other conflicts which may arise between different interested parties and authorities with different objectives. Conflicts between national interests can be particularly prominent if the socioeconomic costs of a crisis in a cross-border institution are unevenly or unreasonably distributed between different countries. This could in some situations affect the willingness to contribute constructively to an overall solution of the crisis. There is an evident risk that the crisis management can be delayed by political negotiating games. When the stakes are high, there is a risk that many countries will choose to play their cards close to their chest as long as possible. In the worst case scenario, this could lead to crisis measures not being taken in time, which could have devastating results for all those involved.

In September 2007, a Nordic-Baltic crisis exercise was organised around a financial crisis scenario. The central banks, financial supervisory authorities and finance ministries of all of the five Nordic countries and the central banks of the Baltic states took part in this excercise.The exercise brought to light many shortcomings in coordination – both between authorities within individual countries and across national borders. In particular, it showed that measures taken unilaterally by the authorities in one country can easily have devastating consequences for financial stability in other countries. It also further emphasises the importance of con-

tinuing to develop the cooperation and ensuring that national regulations do not form an obstacle to cross-border crisis management.

In a crisis it is essential that the authorities in different countries understand one another's assessments of the situation and preferable that they can reach a common view. This demands common criteria and joint terminology.

It must also be possible to coordinate various measures across borders, such as emergency liquidity assistance and payments of deposit guarantee funds. And it must be possible to distribute the socioeconomic burdens in the wake of a cross-border crisis in a reasonable and preferably fairly predictable manner. Otherwise, there is a risk that conflicts between national interests will make the management of a crisis more difficult and belated.

Another aspect which has come to the fore in the recent financial turmoil is the banks' increased dependence on liquidity in the securities markets for their risk management and funding. Central banks around the world need to examine whether they have the necessary tools to manage coming liquidity crises. The question of when and how liquidity support can be given and how such a decision should be communicated without having a stigmatising effect that counteracts its purpose may require new ways of thinking.

Better regulations and increased cross-border cooperation are necessary

In conclusion, we can observe that the current financial turmoil bears a number of clear parallels to many other financial crises – not least the Swedish bank crisis of the 1990s. The bank crisis was in many ways the wake-up call that made the Riksbank and other authorities realise the serious consequences that a lack of stability in the financial system can have. It led to the Riksbank developing an analysis capacity in the field of financial stability. Ten years ago, the Riksbank published the first of its now regular Financial Stability Reports.

The insights from the bank crisis have also led to the Riksbank strengthening its crisis organisation and developing forms for cooperation between authorities with regard to managing financial crises. But one important element is missing, namely an effective and coherent regulatory framework for managing financial institutions in distress. In our opinion, one should have at least some fundamental requirements for such a system.

Firstly, it should ensure the quickest, most resolute action possible from Finansinspektionen when a financial institution suffers problems.

Secondly, it should be designed so that it is possible to quickly and easily pay the deposit guarantee.

Thirdly, it should give the state sufficient negotiating power towards existing and presumptive shareholders to prevent taxpayers having to bear the cost when a financial institution has been mismanaged.

Without well-functioning arrangements and appropriate legislation already in place it may be very difficult to manage future problems in the Swedish financial system. And it is not sufficient to merely patch up the gaps in the domestic regulatory framework. The real challenges lie in managing cross-border crises. This is becoming increasingly important, particularly in the light of the banks' increasing international operations. It entails challenges that we must tackle jointly on an international level. The regulations must be developed at the European level, at least.

All of these are difficult issues. One does not need to look far beyond narrow authority objectives and short-sighted national interests to realise that new regulatory frameworks and arrangements for cooperation are required if we are to be able to manage future financial crises. But this appears to be an insight that not everyone reaches at the same time. The picture appears to be most clear to the countries that have come furthest in the question of the integration of the financial sector across national borders and which themselves have experience of financial crises. It appears to take other countries longer to realise what new demands arise from the changes in the financial landscape. To achieve this it is necessary to surmount ingrained opinions and other internal resistance. We hope that it will not require a financial crisis of catastrophic proportions before the political maturity and willingness to go further can be achieved on all fronts, both nationally and within the EU.

As John F Kennedy said, "the time to repair the roof is when the sun is shining." When it starts to drizzle it is high time to speed up.

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Why do we need measures of underlying inflation?

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The Riksbank's inflation target is expressed in terms of the annual rate of increase in the consumer price index (CPI). As the target is a so-called flexible inflation target the Riksbank does not always strive to achieve an inflation level of exactly 2 per cent, but the forecast for CPI inflation is normally in the range of 2 per cent seen over the course of a couple of years. But even if the target is defined in terms of the CPI, it may be interesting to analyse different measures of underlying inflation. A characteristic of these measures is that the effects of temporary price fluctuations are reduced. By studying measures of underlying inflation we can therefore get an indication of the more lasting inflation pressures. It may also be interesting to make forecasts for different measures of underlying inflation in order to illustrate how different components of the CPI develop during the forecast period. Measures of inflation that are not directly affected by the Riksbank's monetary policy are of particular interest. To date, the Riksbank has used the CPIX inflation measure for this. In the current situation, however, it is mainly as a result of increasing housing prices and an indexation of excise duties that the CPIX is expected to be below the CPI in the medium to long term. The CPIX is therefore no longer a particularly good measure. We present a better measure for this purpose in this article, the CPI with a fixed interest rate.

The Riksbank's inflation target is expressed in terms of CPI inflation

According to the Sveriges Riksbank Act, the aim of the Riksbank's monetary policy is to "maintain price stability". The Riksbank has defined this more precisely by adopting an operational target for inflation of 2 per cent, measured as the annual change in the consumer price index (CPI).

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At the same time, a specific measure of underlying inflation, the CPIX, has acquired a special status in monetary policy analysis.[2] Many observers have thus assumed that although the CPI is the official target it is actually the forecasts for the CPIX that govern the interest rate decisions of the Riksbank. Giavazzi and Mishkin (2006) argued that by using this procedure the Riksbank created an unnecessary degree of uncertainty. They recommended that the Riksbank should base its monetary policy decisions on the development of the target variable and at the same time felt that this target variable should be the CPIX.

The Riksbank has chosen to continue to define the target in terms of the rate of increase in the CPI. On the other hand, it is now the forecasts for CPI inflation that govern decisions on monetary policy.[3] According to Kuttner (2004), 17 of 21 countries have chosen to define their inflation targets in terms of as broad a measure of inflation as possible. In Iceland, South Africa, South Korea and Thailand the central banks have deliberately chosen to exclude certain prices from the inflation measure relating to the target. The fact that the Riksbank has chosen to continue to allow the inflation target to be defined in terms of the CPI is thus in line with international practice.

The Riksbank follows and regularly reports on the development of a number of different measures of underlying inflation. In this article, we explain what is meant by underlying inflation and outline what characteristics these measures should have if they are to be useful for monetary policy analysis. We also perform a statistical analysis of the forecasting capacity of the various measures of underlying inflation that the Riksbank uses. This is followed by a special review of the CPIX measure of inflation. One conclusion is that the CPIX is unsuitable as a measure for governing monetary policy when the target variable is the CPI. CPIX inflation is expected to be lower than CPI inflation for some considerable time to come for reasons that have nothing do with changes in the repo rate. The article concludes with a presentation of another measure of underlying inflation that better excludes the direct effects of the Riksbank's decisions on monetary policy.

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2 CPIX is calculated as CPI excluding mortgage interest costs and the direct effects of changes in indirect taxes and subsidies.

3 See press release no. 9, 2007, Sveriges Riksbank, and "The Riksbank's Inflation Target – The CPI, other Measures of Inflation and tha Phase – out of the CPIX", speech by Barbro Wickman-Parak 9 June, 2008.

Underlying inflation reflects the lasting inflation trends

Given that the inflation target is defined in terms of the rate of increase in the CPI, what are the reasons for examining various measures of underlying inflation such as the CPIX? Let us begin by taking a closer look at what is meant by underlying inflation and at what the various measures of underlying inflation can be used for.

If we look at the research in this field we can see that there are various reasons for the interest in measures of underlying inflation. The most common is that one wants to see what the long-run, lasting or trend inflation is (see for example Clark, 2001).[4] In the United States, for instance, price changes relating to food and energy are usually excluded for this reason.[5]

Study, for example, what happens if food prices rise permanently as the result of a increased demand on the world market. If this the only thing that happens then CPI inflation, that is, the twelve month change in the CPI, will increase at first. After twelve months, however, the higher food prices will no longer be part of the 12-month figures and CPI inflation will be back at its original level. If, at the point when food prices increase, you are interested in illustrating more long-term inflation trends then you can do one of two things. The first is to exclude price increases that you believe to be temporary from the index you are studying. In the example, this corresponds to the CPI excluding food prices. The second is to produce a forecast for CPI inflation that shows that the higher food prices disappear from the 12-month figures after twelve months.

Studying the development of a measure of underlying inflation can thus be seen as a complement to studying forecasts for CPI inflation. In both alternatives an attempt is made to filter out the "white noise" in the monthly price changes in order to get a clearer picture of the more enduring inflation trends. The "white noise" is filtered out by excluding price changes for goods for which prices fluctuate greatly. In an inflation forecast, the "white noise" can instead be reduced by looking further forward than the twelve months during which a price change affects the annual rate of change. If there are components that say nothing about the long-

[4] Another reason for studying measures of underlying inflation relates to the belief, for a variety of reasons, that changes in the CPI are not a good measure of inflation, see Bryan & Cecchetti (1994) and Bryan, Cecchetti & O'Sullivan (2002). A third reason for studying underlying measures relates to sampling theory. According to this view, the aim is to measure the same thing that the CPI tries to measure but in a more efficient way, see Bryan, Cecchetti & Wiggins II (1997). A fourth reason has to do with the fact that a central bank that aims to pursue a welfare-maximising policy should only try to stabilise sluggish prices, see Woodford (2003).

[5] Mishkin (2008), however, justifies the use of the same measure of underlying inflation by referring to Woodford's research, i.e. the fourth reason in the previous footnote.

term inflation trends then they will not influence the inflation forecast in the longer term either.

Mortgage costs have been excluded for pedagogical reasons

When we speak about underlying inflation we are usually interested in the lasting inflation trends. In the case of the Riksbank there is also a reason that relates to how the Swedish CPI is calculated. The Swedish method for calculating housing costs is directly affected by changes in mortgage costs. The Riksbank's monetary policy decisions thus affect the CPI in a counter-intuitive way. The immediate effect of increasing the repo rate with the aim of curbing inflation is, namely, that CPI inflation increases. In most other countries, housing costs are measured using methods that do not comprise mortgage costs. In the United States and Norway, for example, housing costs for owner-occupied homes are approximated with the measured market rents for similar housing. In the most important inflation measure used by the European Central Bank, HICP, housing costs for owner-occupied homes are not included at all. In the UK, the inflation target is also expressed in terms of the HICP. In Australia, housing costs are measured using the so-called net acquisition method. This means that the price of new houses is included in the CPI with a weight that corresponds to the expenditure for new houses. The Riksbank's decision to highlight the CPIX is thus linked to the fact that housing costs for owner-occupied homes are measured in a special way in Sweden.

Nessén & Söderström (2001) analyse underlying inflation in a model in which the CPI is measured in a way similar to the approach used in Sweden. A decision by the central bank to increase the policy rate drives up mortgage costs and thus also pushes up the CPI initially. Nessén & Söderström find that it may sometimes be optimal to react to a measure of underlying inflation that is not directly affected by mortgage costs even though the inflation target is defined in terms of the rate of increase in the CPI.

Let us reflect a little on what these results mean. In the model, the target is defined in terms of the rate of increase in the CPI and a measure of the stability of the real economy in line with the idea of flexible inflation targeting. It is therefore always optimal to stabilise the *forecast* for CPI inflation around the inflation target. The forecast for CPI inflation is determined by the model's structure and parameters, and by the shocks that have occurred. Some shocks only affect CPI inflation temporarily, that is, they do not affect the more long-term forecast for CPI inflation. If we describe monetary policy in terms of a reaction function, that is, that

monetary policy *reacts* to different outcomes, monetary policy should only react to those factors that determine future CPI inflation. However, these factors are not necessarily the same as the CPI outcomes. We can thus describe the optimal policy in two different ways that essentially entail the same thing. The central bank should stabilise the *forecasts* for CPI inflation around the target, that is, *react* to the measure of underlying inflation that determines future CPI inflation.

Another interesting result in the analysis conducted by Nessén & Söderström (2001) is how the counter-intuitive effect on mortgage costs affects monetary policy. Despite the fact that the direct effect on inflation "goes in the wrong direction" via the mortgage costs, a central bank should still stabilise the forecasts for CPI inflation. If CPI inflation is high, the central bank should not, however, increase the repo rate quite as much as if mortgage costs had no impact, as the "wrong direction" effect would then drive up CPI inflation further. Similarly, when CPI inflation is low, the central bank should not reduce the policy rate so much because this would push down CPI inflation further. The consequence of the fact that mortgage costs push inflation in the wrong direction is thus that the optimal monetary-policy response will be slightly weaker than otherwise, which means that the process of bringing inflation back to the target will take a little longer.

Different measures of underlying inflation provide a relatively similar picture

The Riksbank follows and regularly reports on the development of a number of different measures of underlying inflation in the Monetary Policy Report. These measures vary in character. In some of them, for example, price changes for certain predetermined components that are judged to be more short-term and temporary in nature are excluded from CPI inflation. The CPIX, the CPIX excluding energy and the CPIX excluding food and energy are examples of such measures of underlying inflation. Others are designed so that they use statistical methods to systematically exclude or reduce the significance of product groups with volatile prices. MEDIAN, TRIM85 and UND24 are examples of such measures of underlying inflation.

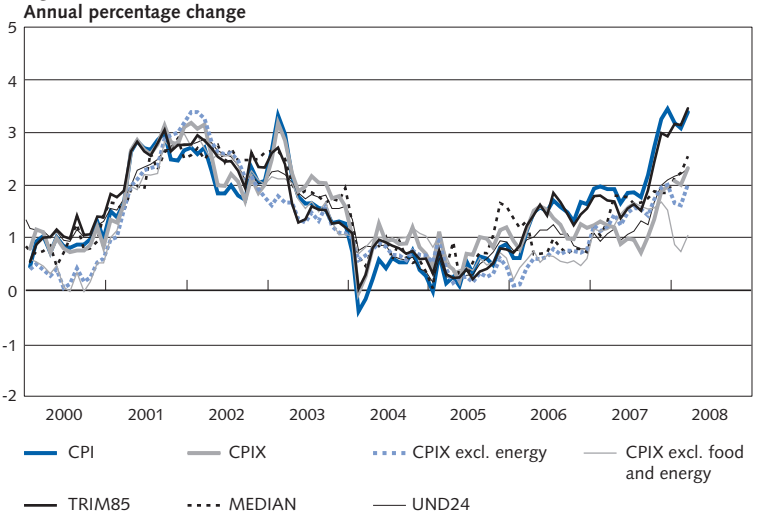
The measured price changes form the starting point in MEDIAN and TRIM85. These are ranked from the price that has fallen most (risen least) to the price that has increased most (fallen least). Simplifying somewhat, we can then view MEDIAN as the median price change, that is, the price change in the middle of the range, in this ranking. TRIM85 is calculated, once again somewhat simplified, by first excluding the 7.5 per cent of

prices that have fallen most and the 7.5 per cent that have risen most. The average price change in the remaining 85 per cent is then calculated.[6] MEDIAN and TRIM85 are thus both similar and yet different to measures such as the CPIX. The similarity lies in the fact that certain price changes are excluded every month. The difference is that in the CPIX the same goods and services are excluded every month, while in MEDIAN and TRIM85 different goods and services may be excluded from the index from one month to the next.

UND24 is calculated in a slightly different way. For each product included in the CPI, the variance in the difference in the rate of change between the respective components and the total CPI for the last 24 months is calculated. The price changes for the various products are weighed together to provide UND24 by using weights based on this variance. The more stable the price of a certain product has been, the greater the weight for this product when UND24 is calculated, and vice versa. This procedure means that a price change for a product or service with a price that has fluctuated greatly over the previous 24 months has little impact on UND24.

In Figure 1, we can see how the various measures of underlying inflation have developed since 2000. Over the period as a whole, the rate of increase for the underlying measures is somewhat more stable than

Figure 1. Various inflation measures
Annual percentage change



Source: Statistics Sweden and the Riksbank.

[6] In practice, the weights are also used when calculating MEDIAN and TRIM85. After the products have been ranked from the lowest to the highest price changes, those products with 7.5 per cent of the total weight sum that have the highest and lowest price changes respectively are excluded when calculating TRIM85. In MEDIAN, the products with 50 per cent of the total weight sum that have highest and lowest price changes respectively are excluded.

the rate of increase for the CPI. One possible interpretation of this is that the underlying measures have to a certain extent filtered out the "white noise". The various measures provide a relatively similar picture of inflation trends, even though there may be significant differences in the case of single years. One example is late 2007, when CPI inflation rose significantly, whereas according to all the underlying measures except TRIM85 inflation increased only moderately. According to most of the measures of underlying inflation, therefore, a large part of the recent increase in CPI inflation is not permanent.

Underlying inflation should have the same average as CPI inflation

According to Roger (1998), an important property of a measure of underlying inflation is that it should be unbiased, that is, the measure should have a mean that in the long term corresponds to the mean of the target variable. This is in practice a considerable problem as most types of statistical processing of the CPI risk changing the mean. This problem is particularly serious when the measure of underlying inflation is used as a rudder for monetary policy even though the target is expressed in terms of the CPI. Forecasts for the underlying measure cannot then be compared directly to the inflation target.

All of the measures of underlying inflation described above have on average increased more rapidly than the CPI since 1995 (see Table 1). This applies particularly to the CPIX. The CPI has on average increased by 1.2 per cent since 1995, while the average increase for the CPIX has been 1.5 per cent. In the period since 2000, the differences have been smaller, which demonstrates that the relation between the measures vary over time. As all of these measures of underlying inflation change the weighting of the components in the CPI, the expected value in the medium term will not be the same as for the CPI if relative price adjustments between the products are expected to occur. For example, the volatile goods prices rise on average more slowly than the stable services prices as a result of higher productivity growth in those sectors that produce goods.

Table 1. Average annual rate of increase in various measures of inflation (per cent).

	CPI	CPIX	CPIX excl. energy	CPIX excl. food and energy	TRIM85	UND24	MEDIAN
1985–	3.2	3.0	3.0	3.3	3.2	2.9	3.2
1990–	2.5	2.4	2.3	2.6	2.4	2.1	2.4
1995–	1.2	1.5	1.4	1.5	1.3	1.3	1.4
2000–	1.5	1.5	1.2	1.3	1.6	1.4	1.5

Sources: Statistics Sweden and own calculations.

Underlying inflation can be used as an indicator of future CPI inflation

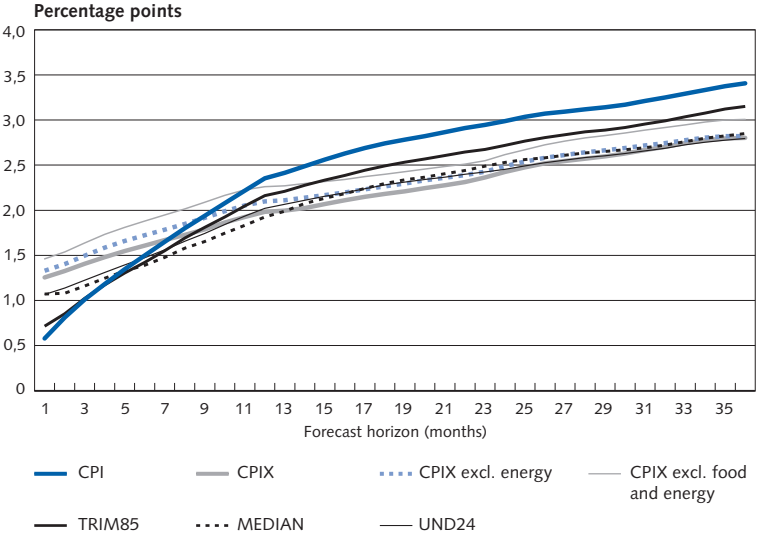
As the various measures of underlying inflation do not necessarily have the same mean as CPI inflation there are problems associated with using them as monetary policy rudders. They may, however, still be of interest as indicators of future inflationary pressures, see for example Wynne (1999). How good then are the latest outcomes of a measure of underlying inflation as a forecast of future CPI inflation? In order to study this, the Root Mean Square Error (RMSE) between the respective measures of underlying inflation and the inflation measured by the CPI over a forward period of 1 to 36 months is compared using the formula:

$$RMSE = \sqrt{\frac{1}{T}\sum_{t}(\Pi_{t+h}^{CPI} - \Pi_{t}^{core})^2},$$

where Π_t^{core} is the underlying inflation in month t, Π_{t+h}^{CPI} is the rate of inflation according to the CPI h months ahead, where h=1 to 36. Monthly data for the period January 1984 to March 2008 has been used, so that T=290 to 255. All inflation measures are expressed in terms of annual percentage change. The results are shown in Figure 2.

We can see in the figure that the CPI has an RMSE of approximately 0.5 percentage points over the course of one month. This means that if we make a "naïve" forecast, that is assume that CPI inflation in a months

Figure 2. RMSE for forecasts of the annual rate of change in the CPI for various forecast horizons from 1984 to 2008
Percentage points



Source: The Riksbank.

time will be the same as the current outcome for CPI inflation, then the RMSE will be 0.5 percentage points over the course of one month. Similarly, if we assume that in 36 months time the CPI will be the same as the latest CPI outcome then the RMSE will be 3.5 percentage points in 36 months time. If instead we allow the current outcome for UND24 inflation to act as a forecast of future CPI inflation we will get an RMSE of approximately 1 percentage point over the course of a month and of slightly less than 3 percentage points in 36 months time.

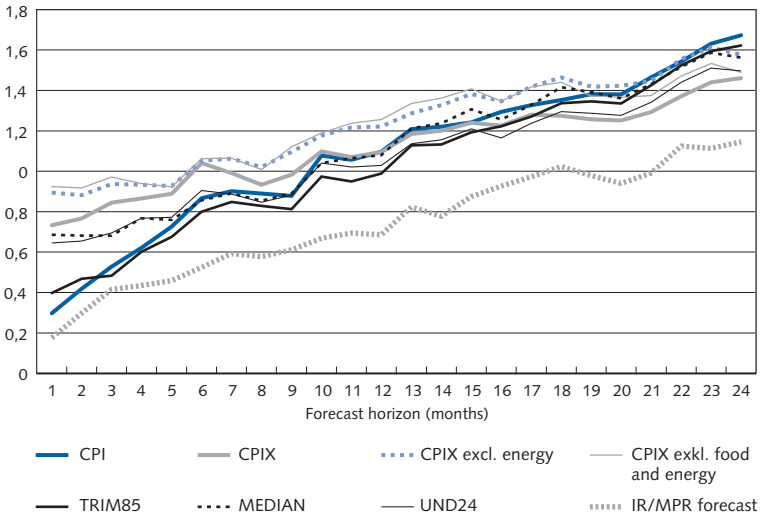
A low RMSE indicates a good forecasting capacity. As can be seen in Figure 2, UND24, MEDIAN, the CPIX, and the CPIX excluding energy are those measures of underlying inflation that have the best forecasting capacity for CPI inflation in the slightly longer term. Today's CPI is worst at predicting future CPI inflation for forecast horizons longer than 12 months. These results indicate that measures of underlying inflation are useful as indicators of more lasting inflation pressures.

However, none of the measures provide better forecasts than the CPI forecasts published by the Riksbank. In Figure 3, the RMSE for the CPI forecasts for various horizons published by the Riksbank from the fourth inflation report in 1998 to the first monetary policy report in 2008 is compared to the RMSE for the various measures for the same months and same forecast horizons. The Riksbank's forecasts are better for all forecast horizons. We could therefore say that the Riksbank's forecasts of CPI inflation represent the best measure of underlying inflation pressures in the economy as they are better at predicting future inflation than any of the other measures of underlying inflation. The advantage of the measures of underlying inflation compared to the Riksbank's forecasts is, however, that they become immediately available when new outcomes are published and that they are not affected by judgments.

Calculating mortgage costs for owner – occupied homes in the CPI

As mentioned above, mortgage costs for owner – occupied homes in the CPI are directly affected when the Riksbank changes interest rates. We would therefore like to show how these costs are calculated and what the effects can be. The mortgage costs in the CPI are affected by the development of house prices and market interest rates. This is a rather complicated process in that certain factors have a rapid impact on mortgage costs while others take a long time. The basic idea behind the Swedish calculation method is to attempt to calculate the mortgage costs that homeowners would have had if they had borrowed a sum equivalent to

Figure 3. RMSE for forecasts of the annual rate of change in the CPI for various forecast horizons from the Fourth Inflation Report 1998 to the First Monetary Policy Report 2008
Percentage points



Source: The Riksbank.

the total purchase price for the property concerned. The index for mortgage costs is calculated as:

Mortgage cost index = Interest rate index × Capital stock index

To produce an index for mortgage costs, Statistics Sweden thus calculates two indexes, one for the average interest rate for all outstanding mortgages (the interest rate index) and one for how the purchase price of the housing stock that the loans finance is developing (the capital stock index). The mortgage cost index is thus affected by the development of interest rates and by the development of purchase prices for the houses in the housing stock.

The interest rate index measures the development of the average interest rate for last mortgage loans in banks, variable-rate loans in mortgage institutions and fixed-rate loans in mortgage institutions with fixed-rate terms of 1, 2, 3, 5 and 8 years.[7] The rates for the fixed loans are included in the calculations as a moving average for the relevant fixed-rate term. For example, a change in the 5-year fixed interest rate is

[7] Loans with fixed-rate terms of 1, 3 and 8 years were introduced into the CPI in 2004. Last mortgage loans in banks, variable-rate mortgages and loans with fixed-rates of 2 and 5 years were already included. Loans with a fixed-term of 8 years have a small weight in the interest rate index (approximately 3 per cent). Loans with a fixed term of 5 years have a weight of 19.5 per cent. Loans with fixed terms of 1, 2 and 3 years have weights of 1.5, 14.2, and 9.7 per cent respectively.

included as a moving average over the last 60 months. This is because a loan with a term of five years is renewed on average every fifth year.

The interest rate index is then calculated as a weighted average of the interest rates included where the weights reflect the actual loan structure of the households. As just over half of all mortgages are made up of last mortgage loans in banks together with variable-rate mortgages, variable-rate loans have a weight of just over 50 per cent in the interest rate index. This means that any changes in the short-term rates have a relatively direct impact on the interest rate index. At the same time, the remaining interest rates are calculated as a moving average over time, which means that changes in these rates only gradually affect the interest rate index.

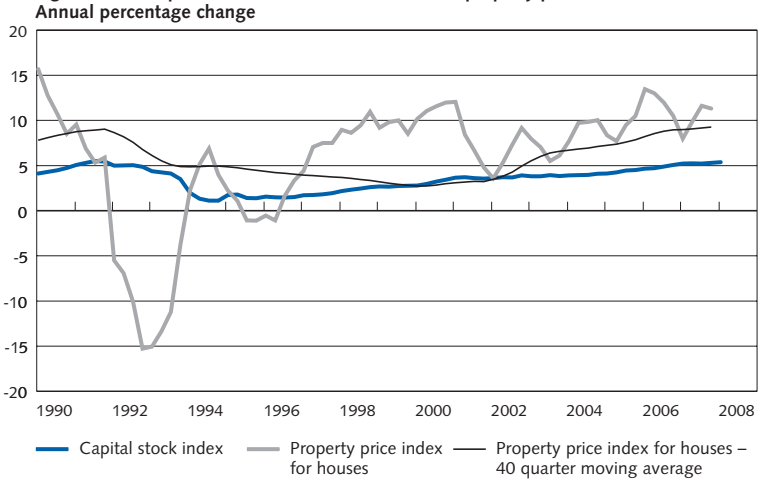
The capital stock index measures the average purchase price for the housing stock financed by mortgages. Statistics Sweden attempts to estimate the change that takes place when houses change owners or new houses are constructed.[8] The difference between the capital stock index and the property price index is that in the latter the price change has a direct impact on the entire housing stock directly, while the effect on the capital stock index occurs when the house concerned changes owner. The result of this calculation method is that there is a considerable time lag before changes in house prices affect the capital stock index.

If we assume that no new construction takes place and that house prices on one single occasion increase by 30 per cent and thereafter remain stable at the new level, and that all properties change owner every 20th year, then the value of the housing stock, and thus the average purchase price, will be adjusted upwards by 1.5 per cent (30 per cent $\times$ 1/20) per year for a period of 20 years. This calculation method means that rising property prices will only affect the capital stock index to the extent that properties change owners, which is a gradual process. Rising property prices thus have a relatively small direct effect on the capital stock index, although the effect is also protracted.

The capital stock has grown at an increasingly rapid rate since the mid-1990s (see Figure 4). The figure also clearly shows that the capital stock index moves sluggishly in relation to property prices.

[8] The rate of price increases for new houses is calculated using the Construction Price Index for new houses.

Figure 4. The capital stock index in the CPI and the property price for houses
Annual percentage change



Sources: Statistics Sweden and own calculations.

The CPIX is expected to increase at a slower rate than the CPI because house prices have risen dramatically

Since 1995, the CPIX has on average increased more rapidly than the CPI, which is mainly due to the Riksbank's interest rate cuts in the late 1990s. Between 1995 and 1999, the repo rate was cut from approximately 9 per cent to around 3 per cent. Interest rates with a fixed term of 5 years also fell by approximately 6 percentage points.[9] The generally lower interest rates reduced CPI inflation but not CPIX inflation. There is now reason to believe, however, that for some considerable time to come the CPIX will instead increase at a slower rate than the CPI even if there is no significant change in the general level of interest rates. This is explained by the way mortgage costs are calculated in the CPI.

Given how the mortgage costs are calculated, the capital stock index will continue to increase relatively quickly over the next few years almost irrespective of what happens with property prices in the near future. When houses that were bought 15 to 20 years ago are sold the average purchase price will increase rapidly as prices are much higher now than when the houses were bought.

In April 2008, the mortgage cost index in the CPI increased by over 21 per cent expressed as an annual rate. As the weight of the mortgage cost index constitutes approximately 4.5 per cent of the CPI, the mortgage cost index contributed approximately 1 percentage point to

[9] See the box "The Riksbank's monetary policy – target and indicators" in Inflation Report 2003:3.

the annual rate of increase in the CPI of 3.4 per cent. This contribution mainly stems from the increase in interest rates but also from the increase in the value of the property stock. If the value of the property stock had remained constant during the period, the contribution would have been approximately 0.2 percentage points lower.

The change in the capital stock index has of course influenced the Riksbank's forecast for the CPI. In the Monetary Policy Update of April 2008, the Riksbank assumed that the capital stock index will increase by an average of approximately 7 per cent per year in the period 2008-2011. This is a somewhat higher rate of change than for the previous year (see Figure 4). This was the most important reason why the CPIX was expected to increase more slowly than the CPI towards the end of the forecast period, as when the CPIX is calculated the entire mortgage cost index is excluded from the change in the CPI. Towards the end of the forecast period the annual rate of increase of CPIX amounts to 1.9 per cent while the CPI increases by 2.2 per cent; a difference of approximately 0.3 percentage points. The average interest rates increase by approximately 1.5 per cent on an annual basis, while the total mortgage cost index increases by almost 9 per cent as a result of the increase in the value of the houses in the capital stock. Despite the fact that mortgage interest rates themselves will increase relatively slowly, the total mortgage cost index will increase fairly quickly due to the increase in the average purchase price for houses in the housing stock.

Tax adjustment is another reason why the CPIX is expected to increase more slowly than the CPI

When calculating CPIX inflation, not only mortgage interest costs but also the direct effects of changes in indirect taxes and product subsidies are excluded from CPI inflation. The CPIX is thus also a constant tax index that attempts to measure what inflation would have been if the indirect taxes had remained unchanged during the measurement period. When the tax adjustment is made, however, at least three complications arise in practice. The first is due to the assumption that all the direct effects of changes in indirect taxes affect consumer prices immediately. The calculation of the CPIX is initially based on the actual prices included in the CPI. The entire effect of the tax increase is then excluded from these actual prices. In practice, however, there is reason to believe that the actual price will not increase by the full amount of the tax increase immediately. This means that too much is excluded from the CPI when calculating the CPIX. The assumption that changes in taxation are immediately passed through to consumer prices means, paradoxically; that the CPIX may fall

when taxes are increased and vice versa, even though no other prices are changed.

The second complication relates to which taxes are taken into account in the adjustment. In this case an adjustment is made for changes in indirect taxes and subsidies, that is, taxes on and subsidies for products, but the prices of consumer goods are also affected by other taxes. When the government, for example, wanted to stimulate demand in certain service sectors, a reduction of VAT or of employers' contributions was discussed. When calculating the CPIX, however, only the effect of a reduction in VAT will be excluded. However, the likely effect on prices of these two alternative ways of stimulating service sectors will probably be the same in the long term. There are other problems relating, for example, to how changes in the property tax are taken into account. The fact that the choice of fiscal policy measure influences the impact on the CPIX means that the decision on which measures should be excluded is arbitrary to a certain degree.

The third complication relates to the indexation of excise duties. For example, taxes on energy, alcohol and tobacco are stipulated in terms of kronor/kWh, kronor/l and kronor/gr respectively. If all prices rise by 2 per cent per year, then the percentage of consumer prices represented by excise duties will decrease over time. In Sweden, therefore, certain excise duties are indexed as a means of maintaining the duty's percentage of the price. The regulations stipulate, for example, that the excise duty on petrol should be indexed with the annual rate of increase in the CPI in June of the previous year. In recent years, however, the duty on petrol has been increased above this level as an element of the so-called environmental tax shift. Other excise duties are also normally indexed with some measure of price trends. However, every increase in excise duties is excluded from CPI inflation when the CPIX is calculated. This means that even in the long term there are tax changes that lead to differences between CPI inflation and CPIX inflation. The overall effect of the indexation of excise duties is estimated to be approximately 0.1 percentage points.

In the longer term, (approximately 3-5 years) when it is assumed that changed interest rates will not affect the mortgage cost component, the assessment at the moment is therefore that CPIX inflation will be approximately 0.3 percentage points lower than CPI inflation: 0.2 percentage points from the mortgage cost component and 0.1 percentage points from the indexation of excise duties. This is the Riksbank's forecast and it is as usual uncertain.[10]

[10] The same assessment was made by the National Institute of Economic Research in a box published in the report The Swedish Economy in Januari 2008.

The expectation that the CPIX will be lower than the CPI is mainly due to the fact that the value of the housing stock has increased over a long period of time and is expected to go on increasing in the future, but is also partly due to the indexation of excise duties. When the Riksbank introduced the CPIX measure, the main purpose was to provide a measure of inflation that was not directly affected by the monetary policy conducted and the direct effects of temporary fiscal policy measures. In the current situation, however, it is mainly other factors, the protracted effects of increasing property prices and the regulations governing excise duties, that lead to the expectation that the CPIX will be lower than the CPI. The CPIX is therefore not a particularly good measure if we want to have a measure of underlying inflation that is not affected by the monetary policy conducted.

A new measure of underlying inflation that better adjusts for the effects of the monetary policy conducted

The Swedish method for calculating housing costs entails certain pedagogical challenges. When the Riksbank raises the repo rate, as we pointed out above, this also increases the CPI initially. It may therefore be a good idea to also present measures of underlying inflation that exclude the effects of changes in the repo rate. However, as also mentioned above, the CPIX is not a particularly good alternative as it excludes more than just the changes in the repo rate. The CPI with a fixed interest rate is probably a better measure.[11] In this measure, only the interest rate index is held constant, which means that changes in the capital stock index have an impact on the mortage cost index and thus affect the CPI with a fixed interest rate.[12]

Keeping all interest rates constant in this way should lead to the CPI with a fixed interest rate having the same long-term mean as the CPI. In the current monetary policy regime it is a reasonable assumption that the nominal interest rate does not have a trend. Even if the repo rate is constant, the effective mortgage rate paid by households may vary some-

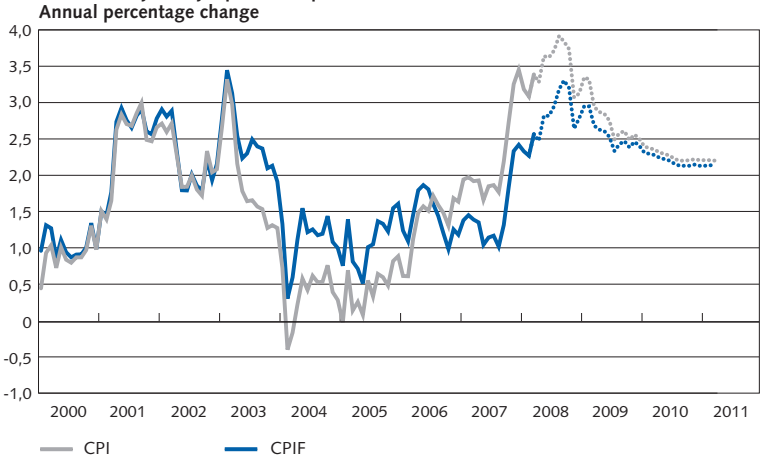
[11] A similar discussion was conducted in the enquiry on a review of the consumer price index (SOU 1999:124)

[12] In the CPI with a fixed interest rate as well, too much is actually excluded from CPI inflation. Ideally, only the effect of changes in the repo rate should be excluded. Short-term interest rates, which constitute over 50 per cent of the interest rate index, are affected relatively directly by changes in the repo rate. Short-term interest rates may also be affected by other factors, however, such as changes in bank margins. In the wake of the recent turmoil on the financial markets, for example, the difference between the repo rate and variable mortgage rates has increased. Mortgage rates with longer terms are also included in the index. These are largely affected by factors other than the Riksbank's decisions on the repo rate even though changes in the repo rate normally also affect interest rates with longer terms. It is, however, not possible in practice to calculate a measure that only excludes the direct effects of changes in the repo rate.

what over time as a result of increasing competition on the mortgage market or changes in risk and term premiums or mortgage terms. This should not, however, entail any major changes in the average interest rate over the course of a few years. It is possible that there may be long-term trends in the real interest rates, but these should also be limited. The Riksbank's forecasts for mortgage rates with different terms are based on the average observed difference over the last few years between the repo rate and variable-rate mortgages being unchanged, and on interest rates for fixed-rate mortgages developing in line with the expectations hypothesis.[13]

Figure 5 presents outcomes and forecasts for the CPI and the CPI with a fixed interest rate. In April 2008, the rate of increase in the CPI with a fixed interest rate was 0.8 percentage points lower than the rate of increase in the CPI as the increase in interest rates over the last 12 months affects the CPI but not the CPI with a fixed interest rate. The delayed effects of rising interest rates will also push up CPI inflation over the next few years, but towards the end of the forecast period the CPI will increase at approximately the same rate as the CPI with a fixed interest rate according to the forecast made in the Monetary Policy Update of April 2008. In this case there is no obvious added value to be gained from publishing forecasts for the CPI with a fixed interest rate, although outcomes may be important for illustrating the fact that it is reasonable to assume that a large element of the currently high inflation is temporary (as the

Figure 5. The CPI and the CPI with a fixed interest rate, outcomes and forecasts from the Monetary Policy Update in April 2008
Annual percentage change



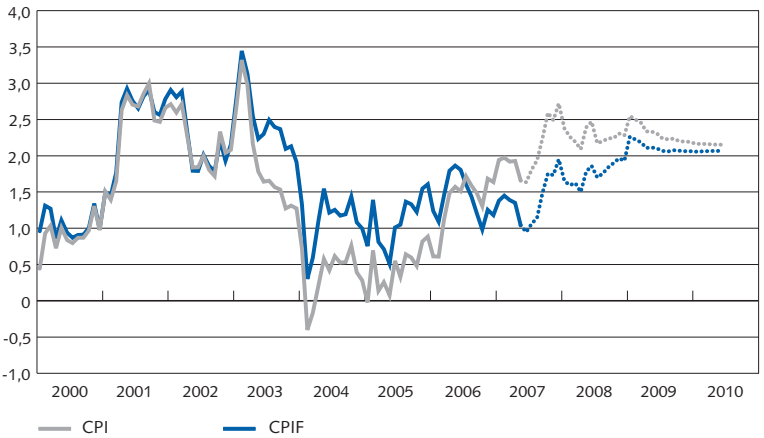
Note. CPIF refers to CPI with a fixed interest rate.
Sources: Statistics Sweden and the Riksbank.

[13] The expectations hypothesis determines the slope of the yield curve as long-term interest rates are determined on the basis of expectations concerning the future level of short-term interest rates.

repo rate is expected to remain more or less unchanged in the Riksbank's latest forecast).

If the repo rate is expected to change significantly during the forecast period, however, the forecast for the CPI with a fixed interest rate will also be of interest in the long term as the mortgage costs of the households will affect CPI inflation throughout the forecast period. A relevant example is from June 2007 (Monetary Policy Report 2007:2) when the repo rate was expected to rise from 3.25 per cent to 4.4 per cent by the second quarter of 2010. In the Riksbank's forecast from this report for mortgage rates with different terms, the forecast for the CPI with a fixed interest rate deviates from the forecast for the CPI two to three years ahead as well, see Figure 6.[14] In this situation it may be instructive to also present the forecast for the CPI with a fixed interest rate as this makes it clear that the only reason that CPI inflation exceeds 2 per cent in 3 years is the delayed effect of interest rate increases. If we look even further ahead this effect will disappear.

Figure 6. The CPI and CPI with a fixed interest rate, outcomes and forecasts from the Monetary Policy report 2007:2 (annual percentage change)
Annual percentage change



Note: CPIF = the CPI with a Fixed interest rate.
Sources: Statistics Sweden and the Riksbank.

The CPIX has served its purpose in monetary policy communication

The special status that the CPIX has had in the monetary policy analyses of the Riksbank is mainly linked to the simple rule for monetary policy

[14] The Riksbank does not publish forecasts for mortgage rates but in this calculation the expectations hypothesis and the average difference between mortgage rates and government bond rates has been used. The result is consistent with the published forecast for the 10-year interest rate for government bonds.

that was launched in Inflation Report 1997:4 and confirmed in the clarification of 1999.[15] This rule stated that if the forecast for inflation, given an unchanged repo rate, deviated from the inflation target two years ahead then there were grounds for considering a change in the interest rate.

This simple policy rule focused on the forecasted level of inflation exactly two years ahead. In the period in which the simple policy rule was launched the Riksbank had significantly reduced the policy rate, which meant that mortgage costs pushed down CPI inflation for a substantial period of time. The cuts in interest rates also affected the forecast for CPI inflation two years ahead, which was the most important horizon according to the simple policy rule. This was an important reason for excluding mortgage costs from the index (the CPIX) on which the monetary policy decisions were based.

However, the Riksbank has altered its working methods somewhat in recent years. The forecast horizon has been extended from two to three years and forecasts for the future repo rate are also published now. In the choice between different forecasts for the repo rate, the entire path forecast for CPI inflation and the development of the real economy now play a part. The alterations made mean that the simple policy rule is no longer applicable. Furthermore, there is no research that supports the idea that a central bank should base its monetary policy on stabilising *the forecasts* for anything other than its target variable. If the target is defined in terms of a certain inflation measure, the policy should be based on the forecasts for this particular measure.

In the light of the changes made it is therefore natural that the CPIX no longer has any special status among the underlying measures of inflation. The Riksbank will continue to monitor the measure, but its main area of use will be as one of many indicators of future CPI inflation. When there is a need to illustrate what degree of current inflation is due to the interest rate changes made by the Riksbank itself, the CPI with a fixed interest rate is a better alternative than the CPIX. This does not mean, however, that the CPI with a fixed interest rate will play the same role in monetary policy communication as the CPIX previously did. The optimal policy is the policy that stabilises the forecast for CPI inflation around the target and there is no single measure of underlying inflation that works in all situations and that always excludes exactly those factors that have no lasting effects on CPI inflation.

[15] See Heikensten (1999).

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Card and cash payments from a social perspective

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The modern market economy depends on the ability to make payments simply and inexpensively. Yet surprisingly little is known about the impact of these payments. In this article, we describe both the fundamental problems and costs of the use of cards and cash in Sweden from a social perspective. We estimate that the cost to society of the use of cards and cash amounts to 0.4% of GDP. Cash payments tend to be more expensive than card payments, and the results indicate that cash is over-used. The choice that the consumer makes between card and cash is largely determined by the size of the payment and the age and education of the consumer. The consumer also appears to be influenced by cost implications. A balanced use of withdrawal fees for cash and transaction fees for cards could therefore result in more efficient use of the payment system in Sweden.

One of the main reasons why money exists is that we need it as a means of payment. After all, the major part of all economic activity in a modern economy requires the buyer to pay the seller. Having inexpensive, simple methods for making payments is important for two reasons. Firstly, lower costs for executing transactions lead to an increased exchange of goods and services in the economy because of the lower cost of buying goods and services. In this way, efficient means of payment serve as a lubricant to the economy. Secondly – and this is an oft-neglected point – payment mediation is an economic activity in itself, which requires real resources. On that basis, efficient means of payment produce direct social benefits that may be substantial.

The physical handling of money, i.e. distributing and storing notes and coins, is expensive and tends to increase the cost of payment. Elec-

tronic payments, in contrast, do not involve physical handling but they do produce other costs, for example for IT networks. This applies equally to payments where buyer and seller do not meet – i.e. remote payments – and payments where the parties meet at the point of sale. In the first case, electronic transfers – such as Internet payments – are the electronic alternative to paper-based giro transfers. For payments at the point of sale, card payments can replace cash.

The fact that the costs involved in producing a payment service are not reflected in a price per payment may make it difficult to make the right – i.e. the most cost-efficient – choice of payment method when we buy something. In other markets, the production cost often determines the price of the product or service concerned, but in the market for payment services, the customer rarely incurs specific charges for the particular payment; cash withdrawals are often free, and we do not pay the bank a fee every time we use our debit or credit card. It is thus not certain that the customer will choose the lowest-cost method of payment. Therefore, it is not certain either than the payment system as a whole is used in the best way.

Despite the fact that payments occupy such a central role in all economic activity, relatively few studies exist that shed light on social costs of different types of payment, or how efficiently the payment market functions. Within the Riksbank's responsibilities for the security and efficiency of the payment system, the Riksbank has now begun to address these issues. In this article, we present some of the results from the Riksbank's research into the payment system: what is the cost of cash versus card payments from a social perspective? How does the public choose between these two payment instruments? What prevents us from using them efficiently?

Common causes of welfare losses in payment system

In the simple world of the textbook, maximum social efficiency arises when goods and services are priced on the basis of the marginal cost of producing them. However, in reality, a large number of factors also come into play, making it impossible – or undesirable – to apply this simple principle without qualification. Negative externalities (harmful environmental impact etc.) and the need to cover fixed costs mean for example that the price should be set higher than the marginal costs.[1] Similarly, in the pres-

[1] For a discussion on marginal-cost pricing in this context, see Laffont (2000).

ence of positive externalities, the price should be set *below* the marginal cost.

One particular type of positive externality is represented by "network effects". These arise when the benefit of a product to a user rises as the number of *other* users of the same product increases. For example, a certain individual's telephone becomes increasingly useful as the number of people it can be used to call increases. In the same way, certain computer programs – such as Word – become more useful as the number of people it can be used to swap files with increases. Payment systems are characterised by network effects such as these. In the case of cash, the network effects are in the main direct and so obvious that they are taken for granted: the value of notes and coins lies in the fact that they are used (accepted) by practically speaking all players in the market. This type of network effect may be referred to as *direct* or *one-sided*.

NETWORK EFFECTS VERY IMPORTANT TO CARD USE

Another type of network effect arises when two different types of players interact via a *platform* (or platform product) connecting them. This type of network effect is usually referred to as *two-sided*. In the case of debit and credit cards, network effects are mainly two-sided. Cardholders do not interact with each other and so do not enjoy any direct benefit from any increase in the number of cardholders. On the other hand, cardholders benefit from any increase in the number of merchants who accept cards. Similarly, the ability to accept card payments becomes more valuable to the merchants if the number of card users increases.

Markets with network effects – both one- and two-sided – may need to pass a certain critical point (or critical mass) for the number of users before the benefit outweighs the cost. After all, the first person to buy a telephone will have no-one to call, and a single cardholder will not be able to use his card if no shop accepts it. Consequently, in markets with direct network effects, the willingness of the first users to pay for the service of product will be low. To get the market moving, the manufacturer may need to sell the product at a loss initially before the number of users has risen to such an extent that the willingness to pay justifies a price that exceeds the costs. The need for a critical mass of users in markets with network effects carries the risk of a low degree of innovation or technology lock-in. This is very much a problem for payment markets that in some cases may be locked into inefficient technology.

SUBSIDIES CAN SOLVE THE NETWORK PROBLEM

A further complication of two-sided markets, such as the card market, is that there may also be a need long term to subsidise one side of the market. For example, a situation is conceivable where the consumers' willingness to pay falls short of the production cost but where the merchants' willingness to pay is far higher than the production cost. If in the example above marginal-cost pricing is applied to both sides separately, the consumers will not buy the card product/card services and the card systems will not be able to get established in the market. One possible solution to this problem is to allow the merchants with a high willingness to pay to subsidise the consumers in order to create a demand for cards/card services on both sides of the market. This type of logic has created the situation in which payment services exist where one side does not pay anything at all for the product, i.e. the entire cost is borne by the side where the willingness to pay is high. Cards and card payments are frequently quoted as examples of payment services of this kind, but the same kind of arrangement also exists in other markets. For example, Adobe Acrobat software is available in a simple version that only reads PDF files and is free, and as a full version – in which the user can create PDF files – that has to be bought.

As for all products, the production costs are the basis of efficient pricing of payment services, i.e. if the prices charged for a product accurately reflect its production cost, the price will contain all the information that the consumer needs to make a choice that will result in the optimal use of the resources of society. In certain cases, however, an adjustment for externalities is necessary, and in cases where positive network effects are present, the price should be set at below the production cost. In the case of negative externalities, e.g. negative external environment effects, the price should be set at above the production cost. Nevertheless, for the payment system as a whole, it may be reasonable to demand that it should cover its own costs, which in practice means that the "side" of the market that benefits most from the system should subsidise the other "side". Even if subsidies of this kind from one side of the market to the other may be socially optimum, it is very difficult to decide how large these subsidies should be.[2] Incorrect pricing may have the effect that the market does not develop quickly enough, that a relatively less efficient payment instrument is over-used and that a more efficient instrument is under-used. In the example of the card market, this may result in too few payment terminals (if merchants' fees to the banks are too high) or too

[2] Press release from European Commission, 19 December 2007, reference IP/07/1959.

few customers with cards (if transaction fees to the cardholders are too high). In that scenario, cards will be under-used and cash over-used.

AGREEMENTS ON FEES BETWEEN BANKS

Where externalities exist, there is a possibility that the market prices will not be the social optimum and that the networks will be too limited. In the card market, the banks have tried to address this problem by entering into multilateral agreements on fees between card-issuing and acquiring banks. These inter-bank mediation fees are generally often justified by the argument that the payer's bank must be compensated for the work and costs connected with the payment. Another way of expressing this is that an optimal balance of network effects is best achieved by having the card acquiring bank – and therefore, ultimately, the merchants – pay these costs, rather than having the cardholders pay them. This argument holds good if difficulties in persuading individuals to become card users justify their being subsidised by the merchants. The European Commission previously accepted this argument but recently changed its policy and decided to ban MasterCard from charging what are known as multilateral interchange fees for cross-border payments by charge and credit cards for private individuals – if it cannot demonstrate that the fees promote innovation for the benefit of all users.

Is the problem of pricing relevant to the cash and card markets in Sweden?

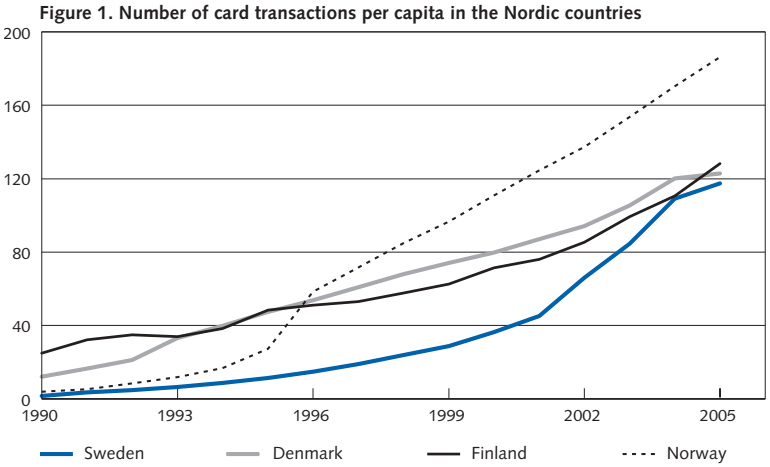
In the case of cash, network-related problems – such as for small-scale networks – are not relevant, as notes and coins issued by the Riksbank are traditionally broadly accepted as a means of payment.

On the other hand, there are examples in the card market of situations where network effects may have hampered the development of innovative products. One such situation arose in 1998 when three of Sweden's major banks jointly issued the *Cash Card* product. *Cash Card* was Sweden's first electronic cash system and was intended to be used as a substitute for physical cash. The system worked by having a prepaid value stored in a microchip on a plastic card. A digital value corresponding to the transaction amount was transferred from the microchip to another microchip in a terminal during the transaction. The launch of the new electronic cash system failed, although the three issuing banks collaborated in building up a common infrastructure and technical standards, as well as on marketing activities. Electronic cash never reached a sufficient critical mass of users, and the system was abandoned in 2004.

However, standard debit and credit card payments quickly succeeded in passing the critical mass threshold in Sweden. Both sides of the market are now well established. Not only density of terminals but also the number of cards per capita in Sweden are, from an international perspective, high. In 2006, there were 20,107 payment terminals per million inhabitants in Sweden. The corresponding figure for the average of EU countries was 15,356. The Swedish public on average holds more than 1 card per person. The number of cards issued per capita totalled 1.53 in Sweden, compared to 1.38 for the EU average. [3] If anything, these figures indicate that the acceptance of card payments is as high among individuals as among merchants.

However, a comparison with the other Nordic countries suggests that far too few card payments are made in Sweden. In terms of both the number of terminals and cards per capita, the Nordic countries are very close to each other. On the other hand, this infrastructure appears to be used less intensively in Sweden than in the rest of the Nordic region, even if the differences – above all, vis-à-vis Denmark and Finland – have narrowed considerably since 2001. The number of card transactions per capita in Sweden in 2005 – the last year for which this statistic is available for all the Nordic countries – totalled 117.[4] The corresponding figures for Denmark, Finland and Norway in the same year were 123, 128 and 186, respectively.[5] Figure 1 shows the trend of card use in the Nordic countries since the early 1990s.

Figure 1. Number of card transactions per capita in the Nordic countries

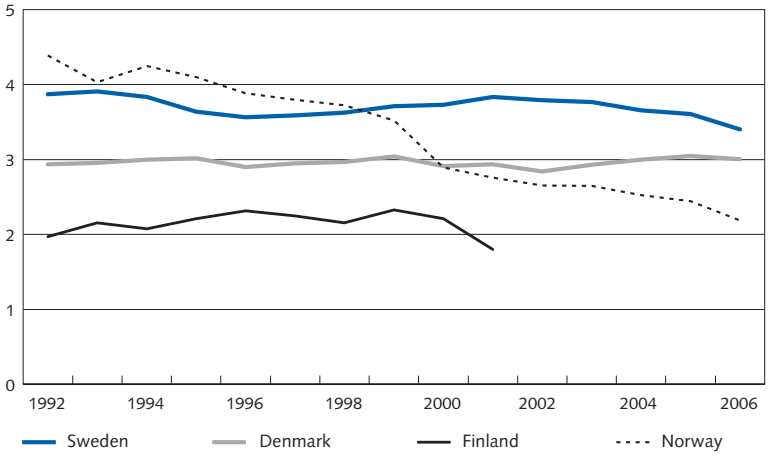


Sources: ECB and Norges Bank.

[3] Blue Book (2006), European Central Bank.
[4] Statistics on card transactions refer only to card transaction made with bank-issued cards.
[5] Sveriges Riksbank, The Swedish Financial Market in 2007.

Because card and cash payments are interchangeable, the lower level of card use by Swedes reflects, at the same time, a more widespread use of cash. In 2001, the last year for which Finland reported its own money supply figure (before joining the euro), its cash use, measured as the ratio of cash in circulation to GDP, was 1.8%. In Denmark and Norway, cash use by this measure totalled 2.9% and 2.8%, respectively. The corresponding figure in Sweden was 3.8%. The difference vis-à-vis Denmark has narrowed in recent years, but has remained stable or has even risen slightly vis-à-vis Norway. Figure 2 illustrates cash use in the Nordic countries since the start of the 1990s.

Figure 2. Cash use, measured as ratio of cash in circulation to GDP in the Nordic countries
Per cent



Sources: ECB and Norges Bank.

As we explained in the introduction, handling cash is expensive. The fact that cash is used more in Sweden than in the other Nordic countries could therefore indicate that the Swedish payment system is being used less efficiently. Logically, the next question is, in that case, why is cash overused in Sweden? Experience from both Sweden and Norway indicates that the demand for payment services is price-sensitive, i.e. the fees that above all banks but also in some cases merchants charge for a payment considerably influence the consumer's choice of payment method – see Humphrey et al. (2001) and Nyberg and Guibourg (2003).[6] In Norway, the number of electronic payments – including card payments – rose very

[6] Cash is the most common means of payment in the shadow economy. If Sweden were to have a more extensive shadow economy than the other Nordic countries, the demand for cash in Sweden would be higher than in the other Nordic countries. However, there is nothing to suggest that this is the case. On the contrary, the shadow economy appears to be roughly equal in the Nordic countries. Therefore, the explanation for the different level of demand for cash in the different countries is probably to be found elsewhere. For more information on the correlation between the shadow economy and the demand for cash, see Guibourg and Segendorf (2007b).

sharply when the banks increasingly started using cost-based transaction charges. Previously, the Norwegian banks had financed their payment services via cross-subsidisation, net interest and float income.[7] This raises the question as to whether incorrect pricing for card and cash payments may lie behind the less efficient use of the payments instruments in Sweden.[8]

How are card and cash payments priced in Sweden?

Guibourg and Segendorf (2007a) analyse the Swedish banks' costs for various payment services, and demonstrate that the difference in costs are only to a minor extent reflected in the fees paid by businesses and private individuals for various services.[9] In the case of card and cash payments, it appears that the banks almost exclusively charge fees to retailers. With few exceptions, the Swedish public do not pay charges to the banks for cash withdrawals and only pay an annual fee for their cards. Instead, the banks cover their card and cash payment costs via fees to retailers for daily takings (cash takings) and transaction fees for card payments. In some cases, cardholders also receive a bonus on the purchase amount, and in the case of charge and credit card transactions consumers regularly benefit from an interest-free credit period of around a month. Both the non-charging of fees and the provision of a bonus mean that the bank subsidises the consumer's card transactions. As we explained above, a subsidy of this kind on only one side of the market may be justified if (two-sided) network effects exist.

CASH IS MORE EXPENSIVE

The costs to Swedish banks – both variable and unit – of cash withdrawals exceed their costs for card payments. If we look at the revenue side, we find that in 2002 an average large Swedish banking enterprise made an annual profit in the card market (SEK 460 million) equal to the loss it incurred on its cash distribution operation (SEK 466 million). It may thus be concluded that cash distribution is being subsidised by the profits made in the card market.

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[7] According to information from Norges Bank, the rapid growth was attributable to a combination of successful pricing and merging of different card systems. "Net interest" refers to the difference in borrowing and lending interest rates. "Float income" is the interest income the bank earns on money "in transit" between different accounts. If it takes more than 24 hours from when the account of the paying party is debited and the account of the beneficiary party is credited, the bank can invest the money and earn interest on it.

[8] Guibourg & Segendorf (2007a).

[9] Ibid.

So retailers pay fees to the banks for both cash and card payment services, but do not price these services explicitly vis-à-vis their own customers.[10] The costs that retailers incur are instead passed on to the consumers in the form of general mark-ups on the prices of goods. In this way, retailers do not, either, send signals to their consumers about the costs of one method of payment or another

THE CUSTOMER CHOOSES

In the transaction, it is the customer who decides which means of payment he or she wishes to use. Since the customer rarely meets any explicit pricing signals, either from the bank or from the merchant, he or she can be expected to decide on the basis of non-monetary costs, such as the time and trouble involved.

It is clear from the above-mentioned studies that the banks would gain from increased use of cards by their customers, at the expense of cash. However, this does not automatically imply that society as a whole would benefit from a trend of this kind. To ascertain what is good for society, we should instead consider the social costs that arise as a result of card and cash payments.

Cost to society of card and cash payments

What distinguishes a cash payment from other types of payment is that no intermediaries are involved in the transaction itself. The payment is concluded immediately when notes and coins are handed over. A card payment on the other hand is not concluded immediately when the buyer hands his card to the seller. When a card is inserted into a terminal, information is transferred from the buyer's card to the terminal and onward to the shop's (the merchant's) bank. This starts a relatively complex process in which information and payments are transferred in several stages, with several intermediaries being involved. Ultimately, the transfer of information results in money being moved from the paying party's bank account to the beneficiary's account. The payment is not considered as finalised until the banks have debited and credited the accounts of the respective parties.

[10] The agreements that retailers enter into with the card issuer prohibit them from "discriminating" between different types of card, such as credit card and debit card, or between cards and cash. "Discrimination" here refers to retailers charging a special fee for card payments or charging customers different prices depending on their choice of means of payment. Nevertheless, there are individual merchants who charge a fee for card payments below a certain amount. Under a decision by the Swedish Competition Authority "discrimination" was permitted until the beginning of the 2000s, but this option was rarely used and the Authority then changed its decision after the EU Commission declared in 2001 that card issuers were entitled to prohibit "discrimination".

Card payments require an infrastructure of terminals and systems for transferring information about the payment. An infrastructure of this kind generally represents a major fixed cost. On the other hand, the cost that is directly attributable to an individual card payment is minor and arises when the payment information is processed and transferred in the system.

Cash payments do not need any infrastructure for the payment itself to be executed. On the other hand, handling cash requires an infrastructure for transport of cash between banks, post offices, retailers and users. This, too, involves fixed costs as well as costs attributable to an individual payment that arise before, during and after the actual handing over of the cash. What is common to both cards and cash is that several parties are involved in the production of both types of payment.[11]

An analysis of costs within a particular market should distinguish between private costs for the parties involved and social costs. The latter consist of the total costs to society, and reflect the real use of resources in the production of payment services. When a good or service is produced in a production chain, the social costs cannot be estimated simply by adding up the private costs of the parties involved. This is partly because, at a certain stage of production, private costs include fees to cover costs at an earlier stage of the production process.[12] For example, part of the fees paid by the business proprietor for transport of cash covers the transport company's production costs. Simply adding up these costs would result in double counting. The social costs comprise only the real costs of production, that arise at every stage of production, i.e. the added value of the production stage (assuming that the economic profit is zero).

COSTS OF CASH PAYMENTS

Handling cash demands an extensive infrastructure that entails substantial costs and the involvement of many intermediaries. The Riksbank's costs arise mainly when notes are issued, i.e. printing costs, storage costs etc. The banks buy the notes and coins they need from the Riksbank. These notes and coins are then handled by various private operators. In the case of the cash deposits – where the cash surpluses of the banks are stored – costs include rent of premises, insurance, security, machinery, personnel and IT systems. Transport companies move and distribute the cash, and

[11] For a more detailed account of the card and cash market, see Bergman, Guibourg and Segendorf (2007) and The Swedish Financial Market, Sveriges Riksbank (2007).

[12] In the case of cash, the calculation of private financial costs also include seigniorage costs – the interest income that banks, retailers and the public lose via their holdings of cash. However, these costs are deducted in the estimation of social costs, since seigniorage consists only of transfers that are made from banks, retailers and the public to the central bank.

their costs include, alongside personnel and transport costs, the costs of logistics and security.

Private costs

Cash handling at bank branches includes both the withdrawal and depositing of cash by customers.[13] These transactions involve costs relating to premises and personnel, i.e. costs that are mostly fixed relative to the number of cash withdrawals. ATMs also involve high fixed costs, but there are also substantial variable costs, in particular for filling the machines and for the fees known as interchange fees[14] paid by the banks to each other. Banks also incur costs for cash takings, in terms of foregone interest and administration, as well as for transport of cash between bank branches and cash deposits.

Swedish users do not pay fees for cash withdrawals. The only explicit costs to the public are the fixed annual fees that are charged for cards that may be used for withdrawals from ATMs. Nevertheless, the user incurs implicit costs, namely foregone interest income on his average cash holding, plus the time cost for the withdrawals. Cash users also incur a cost in the form of the time taken to carry out a cash payment (time of queuing at the shop's cash register etc.).

Retailers incur costs, including personnel time costs for cash payments at the cash register, as well as the extra time taken for other administration of cash, such as counting, sorting notes and coins, helping with daily takings and ordering cash. Retailers also pay fees to both banks and transport companies for depositing and transporting daily takings.

The total private cost of handling cash is the total of the costs that arise in all these stages. Bergman, Guibourg and Segendorf (2007) estimated that the total private cost connected with handling cash in 2002 was SEK 10.8 billion, corresponding to 0.5 per cent of GDP in that year. Just over 70 per cent of gross private costs arise at banks and retailers, and are fairly evenly shared among them.[15]

Social costs

The social costs only take account of the value added in each production stage, and are calculated as the total of private costs in each production stage, less the fees paid to the previous production stage. By this

[13] After this point, any reference to the banks' costs includes the costs incurred by Svensk Kassaservice (the Swedish Cashier Service).

[14] The bank of which the cardholder (the person making the withdrawal) is a customer pays a fee – an interchange fee – to the bank that owns the ATM, unless the first-mentioned bank itself owns the ATM. Interchange fees will be dealt with in more detail later.

[15] M.Bergman, Guibourg G. and Segendorf B., (2007).

measure, the social costs amounted to SEK 6.6 billion, 0.3 per cent of GDP. Nearly half of the social costs arose on the banking side. Roughly the same proportion was incurred in all by retailers, transport companies and the public, distributed fairly evenly across the three categories. The respective shares of total social costs accruing to the Riksbank and the cash deposits are minor.[16] According to the above-mentioned study, the number of payments made with cash totalled 1.4 billion per year. As a result, it is calculated that a cash payment cost society on average SEK 4.6 in 2002.

COSTS OF CARD PAYMENTS

The costs of card payments vary from user to user and bank to bank, depending on the type of card used. Credit card payments are more expensive to both issuing banks and users.[17] The card issuers have to pay higher costs for credit card payments because they allow the users credit for a period that the banks themselves have to finance.[18] As a result, the banks charge higher fees to the sellers (the merchants) for credit card payments. To the cardholders, the picture is more ambiguous. Annual fees for credit cards may be higher than for debit cards, but generally fees are not charged per transaction, neither for debit nor credit cards. In addition, those who pay by credit card sometimes receive a bonus on the purchase price and it is fairly common for no fee to be charged for at least the first year.

In addition to fees to the banks, retailers also have to bear the costs of terminals and personnel. As for cash payments, personnel costs are a function of the average time taken for a card payment to be performed. Customers who pay by card also have to pay a cost for the time at the cash register. The cost is the same for credit and debit card payments, as they both use the same technology. Otherwise, card payments generate costs for the transfer of information on payments between the card-issuing bank and the merchant's bank, plus costs relating to settlement and clearance of payments between the banks involved.

In the above-mentioned study, the social costs for payments by card were estimated at SEK 1.9 billion, corresponding to 0.1 per cent of GDP in 2002. The gross private costs totalled SEK 4.3 billion, or 0.2 per cent of

16 Bergman, Guibourg and Segendorf (2007).

17 All cost data is from Bergman, Guibourg and Segendorf (2007)

18 There are two types of credit card: pure credit cards, where the cardholder pays either the whole amount or part of the debt after 30 days and pays interest on the remaining balance of the debt, and "charge cards", where the entire debt is paid after 30 days without any interest charge to the cardholder. Charge cards are the type of card that is used most frequently in Sweden. Debit card payments are most common in Sweden. With these, the transaction amount is deducted immediately from the cardholder's account at the time of the transaction.

GDP. Nearly half of total social costs arose at the banks, while the share accruing to retailers was approximately a third.

Our discussion has so far centred on where the costs arise. If we also take payments between the operators into account, such as fees for services, we gain an idea of the proportions in which they ultimately bear these costs. We can then see that retailers bear nearly half of the costs, while the banks' share is less than a quarter. Retailers pay high transactions fees to the banks for card payments, fees that are in turn decided by the fees that the banks involved pay to each other.

In 2002, the number of card payments amounted to 589 million.[19] The cost to society of each card payment thus totalled on average SEK 3,0 about 35 per cent less than the corresponding cost of a cash payment. Table 1 summarises the social costs, in total and per transaction, for both payment instruments.

Table 1. Social costs, in total and per transaction, of card and cash in 2002

	Total social costs *SEK million*	Volume *million transactions*	Unit cost social *SEK*
Cash	6 560	1 424	4.6
Cards	1 780	589	3.0
– of which			
– Debit cards	1 540	509	3.0
– Credit cards	240	80	3.0
Total	**8 340**	**1 989**	

Source: Bergman, Guibourg and Segendorf, 2007.

Cost-efficiency in the choice between cards and cash

What does this say about the socially optimal use of cards and cash, respectively? At first glance, card payments – with a social unit cost 35% lower than that for cash payments – ought to replace cash totally. But it is not quite so simple, because there are major differences in the production technologies used by the two payment instruments. Card payments require an extensive infrastructure of terminals, computers and lines of communication, which involves a high proportion of fixed costs. A cost is also associated with processing payments, but this cost is constant, irrespective of the transaction amount – meaning that the cost of the payment is the same whether the card is used to pay for a purchase amounting to SEK 50 or 50,000.

In the case of cash payments, the conditions are partly reversed. Cash payments involve a good deal of physical handling – transport,

[19] The Swedish Financial Market (2007), Sveriges Riksbank

counting, storage of notes etc. The larger the transaction amount, the more expensive the actual cash payment is, as a larger transaction amount will require a larger amount of handling. In payments of small amounts, the "variable" cost is lower for cash than for card payments. As a result, from the social viewpoint, cash may be preferable for small payments. But what does this mean in practice, from the perspective of the socially optimal use of cash?

Bergman, Guibourg and Segendorf (2007) calculate a "social break-even value", which is the transaction amount below which cash payments are the socially most efficient option. The calculation is performed by expressing the cost to society of a cash and card payment, respectively, as functions of the transaction amount. In payments of very small amounts, the fixed unit cost dominates. Because this is higher for card payments than for cash payments, paying by cash is (on average) socially the most efficient option for small payments. As the transaction amount rises, so too does the total unit cost for cash payments, while the cost of a card payment on the other hand is not affected by the amount. Therefore, the social break-even point is found at the transaction size where the total social unit costs are equal for both payment methods. The result of the calculation indicates a break-even point of SEK 69.[20] This means that, according to the costs that prevailed in 2002, the socially optimal option typically was to use cash for purchases up to a value of SEK 69. Above that amount, card payments were generally preferable, even though the actual costs for the two payment methods may of course vary considerably from one specific payment to another.

Costs to consumers of card and cash payments

In Sweden, a high proportion of the merchants accept both cash and card payments. It is therefore primarily the consumer who chooses the instrument of payment. Demand for payment instruments is determined in the same way as demand for other goods and services, in other words by the consumers' preferences and their private incentives, i.e., the costs that arise from the consumer's choice.

Both card payments and ATM cash withdrawals require the customer to have a card, and an annual fee is normally charged to the customer for such cards. However, when making the transaction, the customer will already have borne the annual card fee. This is, thus, a sunk cost and, consequently, should not affect the choice between cash and card. Other-

[20] For a more detailed description of the method of estimation, see Bergman, Guibourg and Segendorf (2007).

wise, a Swedish consumer does not incur any explicit variable costs, either from the bank or the merchant. On the other hand, costs arise in the form of queuing time at the cash register and implicitly a cost in time for future ATM cash withdrawals when the person draws on his cash balance.

Bergman, Guibourg and Segendorf (2007) also calculated the private costs to consumers of paying by card and cash, respectively, using the figures for 2002. As for the social costs, these costs are also expressed as functions of the transaction amount. As before, the calculation is based on specific assumptions and therefore may be assumed at best to apply to a "typical" transaction. Depending on the circumstances, the costs, and so the break-even point, vary for every individual payment.

For an average payment, it was calculated that the private break-even point for consumers was around SEK 125. Below this point, it is in private terms cheaper to use cash, while above it, using a card is cheaper. It should be noted that the private break-even point is nearly double that of its social equivalent. As a result, if consumers chose between card and cash on the basis of their private incentives, this would lead to over-use of cash and thus to a welfare loss.

How do Swedish consumers choose between card and cash payments?

In order to study how the consumers choose the method of payment, the Riksbank conducted a questionnaire-based survey *inter alia* of how consumers chose between card and cash in their most recent transaction.[21] As well as being asked about their actual choice of means of payment, individuals were questioned on the size of the purchase. Other background variables taken into account in the survey were age, education, income and gender. By comparing consumers' actual choices with the break-even points calculated, it is possible to start discussing the efficiency of the payment system in Sweden.

Bergman, Guibourg and Segendorf (2007) used data from this survey to estimate the actual break-even point in the choice between card and cash payments. To be more precise, the transaction amount at which it was equally likely that an individual would choose a card or a cash payment was estimated. The results indicated that a typical consumer does not choose to use a card until the purchase amount exceeds SEK 123.[22] This is very near the private break-even point. Against that background, it appears that a typical consumer makes the choice on the basis of his

[21] Synovate Temo 2006.

[22] The typical consumer is defined as a 41-year-old man with upper secondary education and with an annual household income of SEK 350,000–400,000, living in a two-person household.

private incentives and, so, deviates from the social optimum. This results in over-use of cash. However, certain background variables – such as level of education and, above all, age – considerably affect the outcome. The break-even point at which a 60-year-old individual chooses card ahead of cash does not arise until purchases of SEK 179, while the corresponding break-even point for a 20-year-old consumer occurs at transaction amounts as low as SEK 60. The choice of young people thus appears to be very close to what is the social optimum.

Private incentives can deliver more cost-efficient payments

The Riksbank's studies of the card and cash market suggest that there is an over-use of cash and a corresponding under-use of cards, from a social perspective. Welfare losses therefore arise in these markets. Because developments in technology have made card transactions more efficient and because the study is based on conditions in 2002, it is probable that the break-even point prevailing today is lower than the estimated one, which implies even greater welfare losses.

On the other hand, the choice of payment instrument by Swedish consumers appears to follow from their private incentives. The problem is that these incentives are not compatible with what is the social optimum. However, the behaviour of the consumers could be changed by structuring private incentives so as to coincide with what is socially efficient. This could be achieved for example by introducing fees on cash withdrawals. An illustrative calculation based on 2002 figures indicates that quite small withdrawal fees – in the order of SEK 0.15 per SEK 100 withdrawn – would be sufficient. In order not to encourage small withdrawals, a fixed fee may be justified, for example SEK 1.5 if a normal withdrawal is around SEK 1,000.[23]

To prevent this from providing excessive incentives for using cards for small payments, consideration could also be paid to the possibility of introducing a fixed transaction fee of, for example, SEK 0.25 – 0.50 per card payment. However, higher fees for card payments alter the private break-even point, and so such fees must be offset by higher withdrawal fees. On that basis, card fees at the above-mentioned level require withdrawal fees of SEK 5–8.5 per withdrawal for the break-even point to remain at the optimal level of around SEK 70. For a typical customer, the annual cost would rise by SEK 300–500. If competition is operating

[23] In 2006, the average withdrawal was just under SEK 900, but a withdrawal fee would probably lead to an increase in this average.

effectively, however, higher transaction fees ought to give the consumers offsetting revenues via higher interest on transaction accounts or, alternatively, reduce other fees, such as annual card fees, so that the consumers' total costs remain stable..

Of course, it is up to the market operators themselves to decide how to price their services. There may be commercial and other issues to be considered, and so the above-mentioned calculations should only be regarded as illustrative. Transaction-based fees also involve costs in themselves, which speaks against their introduction. In addition, the use of cards as an instrument of payment is age-related, in that the choice of the young generation is very close to the optimum. This may be interpreted as indicating that – all else being equal – time itself may play a part in reducing welfare losses. If, on the other hand, the desire is to create a more efficient payment system quickly, transaction fees may be a way of aligning the private incentives to better match the social costs involved in the production of the two payment services.

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Stress tests: Objectives, challenges and modelling choices

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Abstract

Stress tests have become an integral tool for banks' risk management practices as well as for financial stability assessments by central banks. But there has been no debate about the objectives of stress tests, even though an understanding of those is essential when building and evaluating stress testing models. This paper identifies three main objectives: validation, decision making and communication. And it shows that different objectives lead to different and possibly conflicting priorities for model design. In the light of this discussion modelling choices are assessed and two main challenges for stress testing models are discussed: data limitations and the endogeneity of risk.

Keywords: stress tests, objectives, macro feedbacks, endogenous behaviour, liquidity risk, non-linearities

Introduction

The initiation of the Financial Stability Assessment Programmes by the International Monetary Fund (IMF) and the World Bank in 1999 brought stress tests to the forefront of financial stability modelling. Most major central banks in the world have now their own financial stability (FS) stress testing model or are in the process of developing one. Stress tests are also an integral part of banks' risk management practices. This widespread use of stress tests has lead to an emergence of a rough consensus about the model structure of stress tests. For FS stress tests there also seems a broad agreement that the value added from stress tests is derived

* The views expressed in this paper do not necessarily represent those of the Bank for International Settlements (BIS) but only those of the author. The bulk of the paper was written when on secondment to the European Central Bank (ECB) ECB and is based on a presentation for the Stress Testing Workshop at the Riksbank in June 2007, where participants provided helpful comments. I am also grateful for very detailed comments from Claus Puhr, Kasper Roszbach, Matthias Sydow, Iman van Lelyveld and Staffan Viotti which improved the paper considerably. Contact details: Mathias Drehmann, Bank for International Settlements, Centralbahnplatz 2, 4002 Basel, Switzerland, mathias.drehmann@bis.org.

from "an integrated forward looking perspective, a focus on the financial system as a whole and a uniform approach to the assessment of risk exposures across institutions" (p.3, IMF and World Bank, 2003). Therefore, a best practice guide to building stress testing models should be easily established.

This is not the case. As any other model, stress tests can only capture reality in a stylised fashion. Model builders therefore have to make choices on what is essential, what can be represented in a reduced form fashion and what can be ignored. To do this, it is necessary to understand the ultimate objective of the model. It is surprising that there has been little to no debate about this issue. In the first section of the paper I, therefore, provide an overview over different objectives. And I show how they translate into different model requirements which can sometimes be conflicting. In the light of this discussion, I explore how objectives shape modelling choices. One of the key objectives of FS stress tests is to capture the impact of severe (yet plausible) shocks on the whole financial system. So far, this has not been possible as modellers face two important challenges: data limitations and the endogeneity of risk. These issues are discussed in the third section of the paper, where I will also highlight possibilities to start addressing these challenges.

A first distinguishing factor when discussing stress testing objectives is whether they are run for *internal* or *external* purposes. This already implies different model requirements. Whereas *external* models have to focus on the target audience, *internal* models have to be understood and accepted by senior management. As the background and risk management culture differs across institution – especially when comparing commercial and central banks – stress testing models have to reflect these variations. For internal purposes, two broad objectives can be distinguished. The first is *validation*, when stress tests are used to assess for example the robustness of capital models. But, the ultimate internal objective is *decision making*. For private banks, stress testing results may feed into capital decision or business planning and central bank use them as input into the supervisory dialog or for assessing FS vulnerabilities. But for many non-supervisory central banks, the main objective is not internal but external *communication*.

Communication, decision making and *validation* all lead to different model requirements. For the latter two, model accuracy and forecast performance are essential. Whilst these characteristics are important they may not be overriding priorities for communication, which requires primarily that the model is transparent and suitable for storytelling. Unfortunately, transparency, the suitability for storytelling, model accuracy, forecast performance and other priorities cannot always be achieved

equally well within the same model. For example, it is well known that simple models such as autoregressive specifications may even outperform the true model with respect to forecast performance (see Clements and Hendry, 1998). But, autoregressive specifications are certainly not granular enough for policy evaluation or communication. Understanding these trade-offs for different model specification is not easy and ultimately depends on the objective. This is not only important for modellers when designing the stress testing framework but also for policy makers. It is not enough to call for more stress testing but it is also important to know what should ultimately be achieved with the stress test results.

Notwithstanding that objectives are different for different stress tests current models share very much a common structure. As pointed out by Summer (2007) this structure is rooted in the quantitative risk management framework. The quantitative risk management framework can be characterised as a model chain starting with a specific shock to systematic risk factors (e.g. stock market returns or macroeconomic variables), followed by a modelled data generating process which captures how systematic risk drivers interact between each other and across time, and finally a model computing how systematic risk drivers impact onto the specific risk measure for exposures (e.g. value at risk). Without undertaking a full survey of the literature (for this see Sorge and Virolainen, 2006 or ECB, 2006) , the main theme throughout my discussion in Section 2 is that different model choices are available, but that data availability and the main objective are the key determinants in choosing an appropriate set-up at each point along the model chain.

However, any stress testing modeller will meet important challenges. Most of them are well understood (see ECB, 2006), but because of their complexity, limited progress has been made. In Section 3, I discuss the two biggest problems: data and the endogeneity of risk. I argue that data limitations imply that stress testing models are not always econometrically robust, something which should be reflected when communicating the results, e.g. by confidence intervals or by reporting results with different assumptions. That said stress tests can also be used to address data limitations. This is actually frequently done, for example, when modellers do not observe sufficient data to econometrically model the link between risk factors and outcome they may just set values to extreme levels. If the objective is validating the robustness of the capital model, this may be sufficient. If it is communication, it may not as such a stress test does not reveal key parts of the transmission from shock to impact.

It seems to me that when policy makers call for more stress testing they implicitly call for modelling risk endogenously. Endogenous risk is due to endogenous behavioural reactions by agents in the economy

including the policy maker. Modelling endogenous behaviour is an important step in addressing issues currently not captured in any satisfactory fashion. For example, current stress tests assume that banks will be passive in light of the stress event and not change their exposures. And central banks are also assumed to act in a mechanical fashion. I discuss, further, how endogenous behaviour can lead to liquidity risk and macro feedbacks. Finally, the endogeneity of risk can imply non-linearities in the model of the data generating process, something often mentioned by policy makers without further specifying what it really means.

The aim of the Section 3 of this paper is not only to highlight these problems but also to point to possible solutions. But it is apparent that modelling the endogeneity of risk is the key challenge for improving stress testing models. The remainder of the article is structured as follows. Section 1 discusses the objectives of stress testing. Section 2 elaborates on the common structure of current stress testing models and explores how objectives shape modelling choices. Section 3 highlights important challenges and some possibilities to address them. Section 4 discusses the possible next steps and Section 5 concludes.

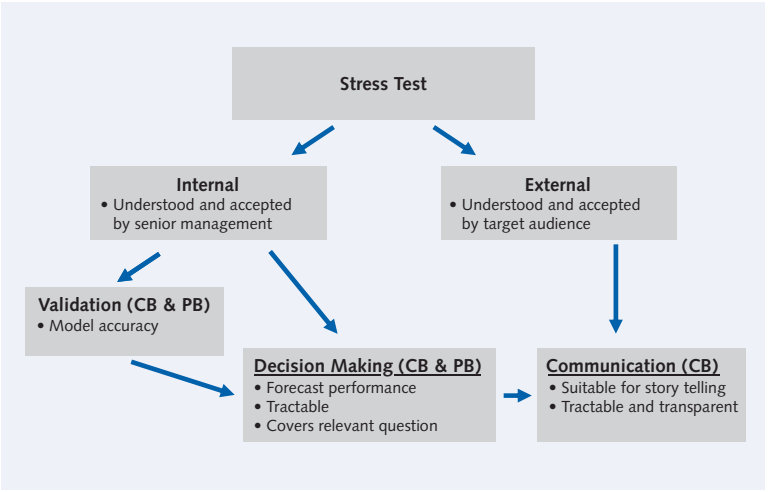
1 Objectives of stress tests

It is clear that the objective should be the guiding force in shaping the design of any model. In the context of macro models Smith (1998, 2007) provides an excellent discussion about different objectives and how different objectives can imply conflicting priorities when building a model. This also applies to stress testing models. A stylised summary of objectives for private banks (PB) and central banks (CB) is given in Figure 1, which also shows the model requirements different objectives imply.

Whilst many empirical models in the academic literature are built to evaluate economic theory, stress tests are always forecasting exercises. However, the focus of the forecasting exercise is not the mean expected outcome over a specific horizon but the impact of a severe, yet plausible stress event. The results of these forecasting exercises are then used *internally* or *externally*, with different implications for model design. For *external* use the model has to be understood by the target audience. If it is mainly used for *internal* purposes the model structure has to reflect the (risk) management culture of the organisation. Otherwise it is not taken seriously by senior management and thus the model will be ineffective. It is obvious that risk management cultures are different for different institutions, and hence models across institutions should differ as well. As indicated in the introduction, PBs and CBs differ significantly in this respect. This can explain some of the difficulties which arise in discussions

between these two parties. PBs approach stress testing from a risk management perspective which is based on finance theory, mathematics and statistics. The majority of senior central bankers on the other hand have a macroeconomic background and therefore require that stress tests take fundamental macroeconomic forces into account. Given different objectives and the state of the macro-finance literature, it is clear that these approaches are not easily integrated and/or comparable, which explains some of the problems for the implementations of stress tests under Basel II. But this point should also be kept in mind, when PBs and CBs engage in discussions about stress testing.

Figure 1. Objectives and model requirements



For internal purposes, stress tests are often used as *validation* tools (van Lelyveld, 2006; CGFS, 2005). For example, historical stress tests can offer insights whether the 99th confidence interval indicated by a capital model may be correct or not. Here model accuracy is at a premium. But the ultimate objective, even for stress tests run for *validation* purposes, is always *decision making*. For example, PBs draw heavily on stress tests when setting capital, trading limits or the risk appetite of the bank (e.g. see BCBS, 2006, CGFS, 2005, or CRMPG II, 2005). For these exercises, similar models are often used as for the day-to-day risk management to ensure comparability of results. Therefore, the forecast performance of the model is essential. However, if the stress test is used for long term business planning it may be more important that the model covers the relevant ques-

tions and is tractable so that senior management can actively engage in analysing different scenarios.[1]

Similar to PBs, CBs use stress tests to guide their own policy *decision making* when for example judging the relative importance of different FS vulnerabilities (Haldane et al. 2007). Stress tests can also feed into the supervisory *decision making* process. At a very simple level, FS stress tests can act as a cross-check of PBs' individual stress test results. The IMF and the World Bank (2003) see this as an important benefit of country wide stress tests as they provide a benchmark which is based on a consistent methodology and hence easily comparable. But the use of FS stress tests can go further than that. Given their structure, most stress tests simulate the riskiness of individual PBs before aggregating the results to the system level. The first stages can, therefore, provide some indications about weak PBs. Hence, the stress test can be potentially an additional off-site supervisory tool, which can be used for internal as well as external purposes, e.g. when deciding where to focus supervisory attention or when engaging with PBs in the supervisory dialog. Again different *decision making* processes imply different priorities for model design. For analysing FS it may be most important that the model captures the broad picture of vulnerabilities, whilst for supervisory purposes model accuracy and forecast performance for stress tests run at portfolio level are essential.

The main objective, especially for non-supervisory CBs, is not internal but external *communication* about risks and vulnerabilities to influence risk taking by private agents. Indeed, stress testing results appear in financial stability reports of most CBs (for an overview see Cihak, 2007). Clearly, external *communication* is shaped by internal *decision making*. But model requirements can be different. For FS-stress test to have an impact, the underlying model has to be tractable and transparent so that it can be understood by the target audience such as risk managers in PBs. Most importantly, it has to be suitable for story telling to help illustrating and quantifying the possible unwinding of vulnerabilities, the transmission mechanism from shock to impact and likely ramifications for the financial system. Forecast performance may not be the most important aspect for this objective.

Unfortunately, different priorities can be conflicting. As already discussed in the introduction, simple autoregressive specifications may even outperform the true model with respect to forecast performance – at least for artificially generate data (see Clements and Hendry, 1998). But, autoregressive specifications are certainly not granular enough for policy

[1] Business planning is often based on analysing a set of future scenarios. In essence these are stress testing exercises. However, the horizon is generally much longer (up to 10 years) and tools are often more rules of thumb than full statistical models.

evaluation or *communication* as they do not allow for any story telling or counterfactual policy analysis. A model may also not be able to cover the relevant policy question and be tractable at the same time – something which is important to ensure transparent *communication*. Take an example from the area of macro modelling.[2] Whilst macro models used for monetary policy are now relatively concise and hence tractable, macro models used for fiscal policy decisions often remain large and complex. Policy questions asked of these models can require the modelling of different taxes, tariffs or a wide range of fiscal indicators. Hence, models have to be detailed at the micro level and broad at the same time. Therefore, models are still very much in the spirit of first generation macro models with hundreds of equation, where it can well be the case that a small change in one leads to unreasonable system dynamics. Nor is the forecast performance necessarily good for such large models. However, the model enables the (fiscal) policy maker to undertake thought experiments which highlight transmission channels if certain policy parameters are changed. Whilst the ultimate point estimates may not be accurate such a model based analyses can provide valuable information for the policy debate. It is a reoccurring theme throughout the remainder of the paper that different objectives may lead to different priorities in model design, something which has to be kept in mind when discussing and comparing stress testing models.

2 Modelling choices

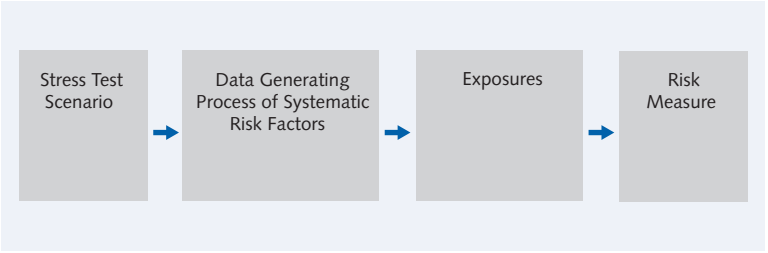
2.1 STYLISED BUILDING BLOCKS OF CURRENT STRESS TESTING MODELS

A consensus view seems to have emerged about the structure of stress tests which is summarised in Figure 2 (see e.g. Bunn et al., 2005, or Sorge and Virolainen, 2006). As Summer (2007) points out, this model structure is essentially rooted in the quantitative risk management framework (see McNeil et al., 2005).

From a modelling perspective the starting point of the quantitative risk management framework are exposures. These could be the trading book of a PB or in the context of FS stress tests the total credit risk exposures of the banking system. It is assumed that the value of these exposures in the future at time *T* is driven by a set of exogenous systematic risk factors. The main part of the stress testing model embodies the data generating process, which captures the interdependence of different risk

[2] For a detailed discussion see Smith (2007).

Figure 2. Schematic view of building blocks of current stress testing models



factors between each other and across time. Finally, the model captures the impact of systematic risk drivers on a risk measure for the exposures at time *T*. Once the model is in place, different stress tests scenarios can be run. The main objective of the stress test (and data availability) guide modelling choices along the way. The underlying issues will be exemplified in the next section without giving a full survey of the literature. Rather than following the flow of Figure 2, the discussion follows the sequence of questions when setting up a stress testing model. Therefore it starts with a short discussion about exposures, proceeds to risk measures and the data generating process and ends with a short exploration of stress testing scenarios.

2.1 EXPOSURES

It is evident that the objective is guiding the choice of exposures which should be considered. For PBs, this is generally not a difficult question as the exposures modelled in stress tests are the same as the ones PBs base their capital models on, i.e. the banking and/or the trading book. For FS stress tests the ambition is generally to model the "whole financial system". But model and data limitations make this often impossible. The starting point for many FS stress tests is therefore to assess the most important risks for the financial system. In some sense this is a circular question: Without a full FS measurement model it is impossible to know which risk type is most important for FS. Given PBs hold capital buffers it is not necessarily the case that the most important risks for commercial banks (or other financial intermediaries) are the most important ones from a system perspective.

The more practical approach for most FS stress tests is to start with the banking system because of its pivotal role in the transformation of savings into investments and, hence, its position in transmitting FS shocks back to the real economy. Within the banking system, stress testing mod-

els usually confine themselves to domestic credit risk (see ECB, 2006).[3] On the one hand, this is due to the fact this risk type is considered to be the most important one by size of exposures. On the other hand, the focus on domestic rather than international credit exposures is driven by data availability and a desire to keep focused, even though international credit risk has been modelled as well (see Peseran et al., 2006).

Given different data availabilities some stress tests also model market risk exposures of the trading book (Boss et al., 2006), the insurance and pension sector (van den End, 2007) or counter party credit risk in the interbank market (e.g. see Elsinger et al, 2006). The surprising conclusion of the latter study is that counterparty credit risk is of second order importance. Results for pure contagion models seem to support this view (see Upper, 2007). For model builders these results suggest that for a first order approximation it is not necessary to model counterparty credit risk. And it may be useful to concentrate modelling efforts on other areas. That said, counter party credit risk models are relative straight forward to incorporate. Once the matrix of interbank exposures is known (or derived by maximum entropy from data on banks' balance sheets as commonly done), a clearing mechanism ala Eisenberger and Noe (2001) is simple to implement.

An important question is whether to consider liabilities. So far, most stress tests focus on assets, even though including liabilities is essential when aiming to model liquidity risk, which I will discuss in Section 3.2.2. But the liability side of the balance sheet is also important when looking at net-interest income, which remains the most important source of profits for commercial banks even though it has been declining in recent years. De Bandt and Oung (2004), Bunn et al. (2005) and Boss et al. (2008) capture net-interest income in a reduced form fashion, whilst Drehmann et al. (2007) derive a structural model. Their model reveals interesting dynamics about the system and confirms that the maturity missmatch between assets and liabilities can be an important source of vulnerability for PBs.

2.2 THE RISK MEASURES

As pointed out the objective determines the exposures modelled, which in turn determine the choice of risk measure to a large extent. But even for the same exposures, different risk measures used as summary variables of the stress test can be useful for different objectives.

[3] Even when only domestic credit exposures are modelled, it is not necessarily the case that these are only driven by domestic risk factors. Pesaran et al. (2006) show that for large internationally active firms national and international macroeconomic factors are important systematic risk factors.

A basic issue is whether to use a risk measure based on a market-to-market perspective or an accounting perspective. Whereas the market-to-market perspective provides a long term view of banks' health based on economic fundamentals, an accounting perspective assesses whether there could be future regulatory or liquidity constrains (e.g. when there are significant losses in the short run but sufficient profits in the long run so that the bank is fundamentally sound but capital adequacy is threatened over a 1 year horizon).[4] The choice of perspective should be aligned with the accounting standards in the country. This is obvious for PBs. But it should also be the case for FS stress tests to enhance *communication* and to ensure comparability of results of private and public players.

The ultimate choice of the risk measure is linked to the objective and whether results are used internally or externally. The focus for PBs is the optimal risk return trade-off, and risk measures used are for example capital adequacy or future profitability. So stress test results are expressed in similar terms. Given a different perspective, risk measures for FS stress tests could and maybe should be different. CBs use a host of different measures in practice. The choice is often guided by data limitations, for example when only loan loss provisions rather than credit risk write-offs or firm specific data are available. More sophisticated stress tests can look not only at losses but at net profits, the number of PB defaults or possible lender of last resort injections to recapitalise the banking system (for an overview of different measures see Cihak, 2007).

FS stress tests often normalise losses by capital to assess whether the banking system is robust or not. This is problematic for two reasons. First, banks generally make positive profits which act as the first buffer against any losses. Hence, the risk of the stress scenario is possibly overestimated, if profits are not stress tested as well (which is rarely the case). Second, banks set capital against all risks including market, credit, operational, business and reputational risk. All these risks impact on profits and losses, but are normally not stress tested, even though they may also crystallise in severe scenarios. Hence, the buffer indicated by capital maybe too large. Presentations of the results should highlight these uncertainties.

Another key problem for FS stress test is that representing the financial system with aggregate variables may be misleading. Take for example average capital adequacy for a banking system. Two different stress tests may result in average capital adequacy ratios which are well above minimum requirements, even though in one case all banks are solvent whilst in the other a major player defaults. From a FS perspective these scenarios are clearly different. Stating all individual results, on the other hand, may

[4] For a detailed discussion on this issue see Drehmann et al. (2007).

not be too useful either. First, this may be resisted because of confidentiality agreements. But second, even presenting interquantile ranges or anonymous minima and maxima may distort the message. For overall FS, it is not just the capital adequacy but the size of the affected institution which is key. A failure of a very small player can be generally absorbed by the financial system whilst a large player can create financial instability leading to severe real losses. A possible solution could be to not derive the simple average but the (size) weighted average, which so far is – surprisingly – not done.

The ultimate variable of interest from a welfare perspective is the real economy and hence GDP. Measuring the impact of shocks on banks' capital adequacy is in essence only a proxy variable for this. Stress tests have not successfully tackled this problem because of formidable technical challenges. As will become apparent in Section 3.2.3, current models which capture the feedbacks from the financial sector back to the real economy are in a highly reduced form and therefore not too useful for *communication,* nor is it clear how robust they are. Hence, they are of limited use to achieve objectives for either CBs or PBs.

2.2.1 The horizon of interest

Related to the ultimate risk measure used is the question over which horizon the stress test should be run. Some guiding principles are given by the regulatory framework which specifies a ten day horizon for market risk and a one year horizon for credit risk. Early FS stress tests also used a one year horizon but it has been acknowledge that the emergence of severe credit risk losses takes time to trickle through the system. By now CB practitioners therefore often use a three year horizon. However, Drehmann et al. (2007) show for one stress test scenario that, while credit risk losses take three years to fully impact on banks' balance sheets, the maximum loss occurs after less than two years, if interest rate risk and net-interest income are modelled appropriately.

Ultimately, the horizon chosen requires a trade-off between the time a vulnerability needs to crystallise and the realism of the modelled behavioural responses by market participants and policy makers in times of stress. The shorter the horizon, the more realistic it is to assume that participants do not or cannot react for example by reducing exposures – hence the ten day focus for market risk. However, this may not be sufficient for severe stress to emerge. In essence this question is linked to the problem of endogeneity of risk, which I will discuss in Section 3.2. But the horizon is also important to assess the key systematic risk drivers which should be captured by the model. It is for example obvious that for a ten

day horizon macro factors will not play an important role as they fluctuate at a much lower frequency. Overall, there is no golden rule for the optimal horizon to consider in a stress test. And again, this question has to be decided by the ultimate objective of the stress testing exercise.

2.3 SYSTEMATIC RISK FACTORS AND THE MODEL OF THE DATA GENERATING PROCESS

The choice of exposures, the risk measure and the time horizon will determine the set of risk factors which should be sensibly considered. By now there is a large literature on this issue, especially in the context of FS stress tests (see ECB, 2006, or Sorge and Virolainen, 2007). Therefore, I limit my discussion at this point to highlight that the way risk factors are modelled should be driven by the objective of the stress tests and the availability of data. For explanatory purposes I do this for credit risk only. CreditRisk+ is a model heavily used by financial institutions and CBs. Model developers admit that the single risk factor specification for CreditRisk+ is driven by the lack of data on default correlations (see Credit Suisse, 1997). Further, they argue that *"no assumptions are made about the cause of default. This approach is similar to that taken in market risk management, where no assumptions are made about the causes of market price movements. This not only reduces the potential for model error but also leads to…an analytical tractable model"* (Credit Suisse, p.7, 1997).

The objective of CreditRisk+ is risk management and capital adequacy. Hence, the forecast performance and computational speed implied by an analytical tractable model are at a premium. Given the statement above, it is apparent that the ability to tell stories how a change in a risk factor may ripple through the economy and finally impact on defaults of exposures is not considered to be important for the model.

An unspecified risk factor is not well suited for story telling and conflicts with objectives for stress testing models most central bankers implicitly have in mind.[5] Further, it is extremely difficult to link the data generating process of the single risk factor with observable variables. Hence, stress test scenarios, based on historical data or a hypothetical scenario, are hard if not impossible to implement in a robust and realistic fashion. This is one of the key problems PBs face when trying to implement stress test for Pillar II purposes of Basel II.

[5] Even though central bankers generally do not approach it this way, it should be pointed out that stress tests are possible in a model with unobservable risk factors as well. These stress tests would assess changes in the underlying data generating process. A stress test in the case of CreditRisk+ could for example be an increase in the volatility of the unobserved factor.

Since the main policy instruments of CBs in the FS arena is primarily *communication* and because of a more macroeconomic background, stress tests used by policy makers generally specify macro economic factors as systematic risk factors. Models considering aggregate variables such as write-offs or non-performing loans as their risk measure only assume macroeconomic variables (e.g. GDP, interest rates, exchange rates) as systematic risk factors (see e.g. Bunn et al., 2005 or Basu et al., 2006). Models which look at firm specific probabilities of default to construct loss distributions for credit portfolios sometimes assume that macroeconomic factors are the only important systematic risk drivers (Pesaran et al., 2006, Jacobsen et al. 2005 or Castren et al., 2007). Other papers taking firm specific defaults as inputs into their risk measures follow Wilson (1997a,b) and consider firm specific and macroeconomic variables as key explanatory variables (see e.g. Boss, 2002). While macro factors are informative about the level, firm specific factors help to better predict the cross-sectional distribution of default risk (see Carling et al., 2007). Therefore, it would seem best to consider both. However, questions then have to be asked how firm specific factors change during stress. Some, such as size, are likely to be unaffected, whilst others such as profitability or leverage certainly vary.

The choice of systematic risk factors is closely connected to the model of the data generating process. Credit risk models specify the data generating process differently. Models range from calibrated distributions of the unobserved factor (see e.g. CreditRisk+, 1997), autoregressive processes for each underlying macro variable (see e.g. Wilson 1997 a/b, or Duffie et al., 2007), reduced form vector autoregressive macro models (see e.g. Pesaran et al., 2006) or structural macro models (see e.g. Haldane et al. 2007). All these models have different benefits in terms of forecast performance, computational simplicity and speed, tractability and ability to tell stories which means that modellers have to find the right-offs, which suit their main objective.

If *communication* is the main objective for a FS stress test, unobservable factors may not be the first modelling choice as they are unsuited for storytelling. In contrast, using general equilibrium structural macroeconomic models to forecast the impact of shocks on credit risk may be very good in highlighting the key macroeconomic transmission channels. However, macro models are often computationally very cumbersome. As they are designed as tools to support monetary policy decisions they are also often too complex for stress testing purposes. For example, it may not be straight forward to undertake simple stress tests such as a 40% drop in house prices as the model requires that only deep parameters (e.g. preferences or productivity) are shocked. This may speak to reduced form vec-

tor autoregressive macro models, which could provide an optimal trade-off between complexity, ability to tell stories and forecast performance.

It should be pointed out that from a stress testing perspective it is certainly hard to use autoregressive processes as model for the data generating process. By design, such an approach does not capture the interdependence of systematic risk factors. Hence, it constraints the set of sensible stress test scenarios which could be undertaken with the model. Therefore, when setting out the model of the data generating process the desired stress test scenarios should also be kept in mind. Obviously this depends on the ultimate objective as well.

2.4 THE STRESS TEST SCENARIO

Stress test scenarios can fully determine the changes of all systematic risk factors up to the end of the stress test horizon. This is the case when undertaking a historical stress test and all risk factors are changed in line with previously observed changes in the stress period. Classical examples for such stress test scenarios in the context of market risk are the LTCM crisis or 9/11 (see CGFS, 2005).[6] But scenarios often contain only factor changes for one or two risk factors during a specific time period and the model of the data generating process then determines the change of all other risk factors conditional on the stress scenario. This is for example a scenario which would be impossible to run if the data generating process is model by autoregressive processes for each systematic risk factor. Often, these stress tests are referred to as hypothetical stress tests and common examples in are an increase in oil prices or a drop house prices. Furthermore, some stress tests not only specify the initial stress scenario but also make assumptions on the data generating process. For example, market stress tests often assume a correlation break down in stressed conditions. Other stress tests change model parameters to judge the impact of new products (e.g. see Bunn et al., 2004). Berkowitz (2000) is one of the few who looks at stress tests from a more conceptual perspective. He argues that all scenarios can be categories as one of the four types:

1) simulating shocks which are suspected to occur more frequently than historical observations suggest;
2) simulating shocks which have never occurred;
3) simulating shocks that reflect the possibility that statistical patterns could break down in some circumstances;

[6] Historical stress tests generally require some manipulation as well. For example, modellers have to decide whether to use relative or absolute changes of the respective systematic risk factors considered in the stress. Further, they have to come up with ways to model new financial products.

4) simulating shocks that reflect structural breaks which could occur in the future.

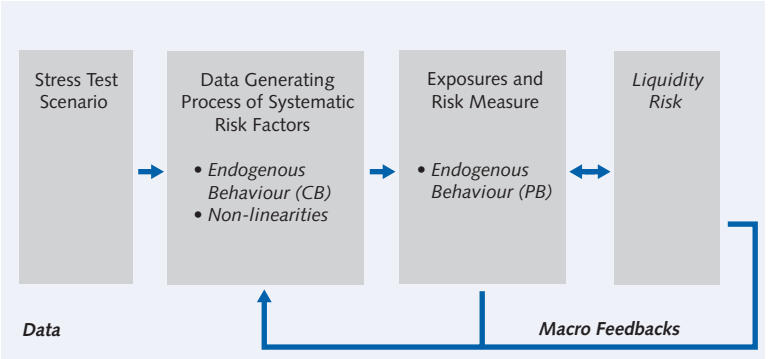
Within the model framework, these stress tests essentially imply that the modeller believes that the true data generating process is different from the one embedded in the model. This is certainly a key aspect of stress testing. However, Berkowitz' view on stress testing is too narrow. His implicit objective is assessing the robustness of capital. However for *validation, decision making* or *communication*, running single scenarios using the data generating process embedded in the model can provide fruitful insights. It has long been known that even experts have problems of correctly assessing the impact of a low probabilities event on one variable (e.g. see Kahnemann and Tversky, 1972) let alone on a portfolio of correlated exposures. It is, therefore, hard to intuitively understand what a severe adverse shock to unidentified risk factor would mean not only for losses (which are given by the model) but also for wider economic conditions. But understanding these are essential for *decision making*. It is much easier to conjecture the impact of a shock similar to the LTCM crisis in 1998. Given that such a scenario can be intuitively grasped it is easier linked to setting the risk appetite of a PB or just deriving possible reactions as contingency plans if such a scenario were to unfold.

This discussion highlights what is obvious: the objective needs to inform the choice of stress testing scenarios. This should be the main reference point in deciding whether to run a historical stress test or a hypothetical stress test, to draw the scenario randomly from the data generating process or specify it and change the data generating process at the same time.

3 Challenges

So far I tried to show that modelling choices have to be driven by objectives. However, any stress testing modeller will meet important challenges. Most of them are well understood (see ECB, 2006), but because of their complexity, limited progress has been made. Figure 3 extends the schematic representation of stress tests from Figure 2 to indicate where these challenges lie along the modelling chain. Data problems are an overarching issue, which I discuss first. Then I look at the endogeneity of risk which arises because of endogenous behaviour by PBs and the CB, liquidity risk and macro feedbacks. In the end I will briefly touch on non-linearities which can be a result of endogenous behaviour.

Figure 3. Challenges for stress testing models



Note: Words in italics indicate challenges for stress testing models.

3.1 DATA

Data are rare, especially for severe stress episodes. This is a long standing problem for FS stress tests. As has been seen already, data availability is often an important consideration in what exposures to model and which risk measure to adopt. It should be stressed that full data availability would not solve all problems. For example, very few stress tests endogenise cyclical variations in loss given default (LGD) because of data problems. It is well known that LGDs are cyclical (see Altman et al., 2005) even though recent research has highlighted that the underlying relations are complex and the ultimate amount recovered is highly contract specific (e.g. see Davydenko and Franks, 2008). An all encompassing model should take these issues into account. However, the desire to incorporate every contractual detail would inevitably lead to an enormous model with millions of underlying data points and hundred of equations. Such a model would likely have limited forecast performance and would be rather intractable and therefore not suitable for any objective.

One frequently cited reason for the lack of data is a result of rapid innovation in financial markets, with a multitude of players and products emerging continuously. Historically stress often emerges after periods of market liberalisation or around financial innovations, with the recent turmoil providing an excellent example. Innovations are nearly impossible to capture by models as they can change the endogenous relationships within the system and hence parameters used to model the data generating process.

Rather than arguing that a lack of data and changing financial systems invalidate stress testing models, I argue the opposite: stress tests are well suited to address these problems as long as users are aware of the assumptions made. Going back to LGDs. As long as cyclical LGDs do not

change the dynamic properties of the data generating process[7] but only the level of losses in case a debtor defaults, it may for example be sufficient for risk management purposes to "stress test" a portfolio credit risk model by assuming that LGDs are as low as the lowest historical observation or even lower. In practice this is often done as such a stress test can provide some comfort about the level of capital. This may already be sufficient, depending on the objective. However, when communicating the results it should be kept in mind that numbers generated by such a stress testing model are not accurate point estimates but only provide an assessment about possible downside risks.

The same can be done for new financial instruments where no data are available, especially not during stressed conditions. For example, Bunn et al. (2004) assess the impact of buy-to-let mortgages on FS. In the early years of this decade, buy-to-let mortgages were a new financial product in the UK, mentioned frequently as a possible FS risk. As no historic default series were observed, the authors just assumed that buy-to-let mortgages were up four times more sensitive to changes in house prices than normal mortgages. By running several stress test scenarios, this exercise showed that even with extreme assumptions buy-to-let mortgages hardly posed a FS threat to the UK.

Whilst stress test can address some of the problems posed by a lack of data and a changing FS system, the underlying problem remains: standard parametric econometric techniques require sufficient data which is often not given. This can lead to large errors in the econometric specification of the data generating process. Therefore, a lack of data will limit the forecast performance of any stress testing model – especially as the focus of stress tests are the tails of the distribution.

As a first step, model outputs should therefore not only present point estimates. Even though this is generally not done, error bands could either be based on standard statistical techniques (see Hanson and Schuerman, 2006, or Drehmann et al., 2006) or on judgement (see Haldane et al., 2007). The lack of model robustness also implies that many assumptions have to be made. These can significantly alter the results. As a second step, this means that models should be run under different assumptions as Cihak (2007) rightly stresses. And it is also important that this has to be made transparent to the broader audience of the model results.

However, modellers may want to consider different econometric methods. It is for example surprising that Bayesian methods are not more frequently used for risk management models. Such an approach seems

[7] Apriori feedbacks cannot be excluded. In the case of mortgages, for example, higher LGDs are linked to lower house prices and lower house prices in turn may induce higher mortgage defaults in subsequent periods.

especially useful in an environment where people's priors deviate from observable data as is for example the case for low default portfolios. Alternatively, Segoviano and Padilla (2007) successfully deal with limited data by using non parametric models based on entropy. Their model provides robust estimates even for data series with less than 20 data points.

3.2 THE ENDOGENEITY OF RISK

Danielsson and Shin (2002) discuss endogenous and exogenous risk by reviewing the problems of the Millennium Bridge in London. The Millennium Bridge is a foot bridge over the Thames. After the opening weekend, it had to be immediately closed down because of safety concerns. When designing the bridge engineers had assumed a limited number of pedestrians which would walk with different rhythms so that the resulting vibrations would cancel each other out. In essence they assumed risk to be exogenous. However, an unexpected large number crowd wanted to see the bridge for the opening weekend. Given the flexible design of the bridge small oscillations emerged. In turn these lead people to sway in step, increasing the amplitude of the oscillation and amplifying the original shock in an ever increasing feedback loop. This story highlights how small exogenous shocks can have a disproportional impact because of an endogenous behavioural response.

In financial systems, the endogeneity of risk can emerge for several reasons. Below I discuss endogenous behaviour by PBs, the CB, macro feedbacks and liquidity risk in more detail. Endogenous behaviour will also give rise to non-linearities which are discussed in the last sub-section. Developing models which are able to capture the endogeneity of risk is possibly the most important challenge risk management models and stress tests need to meet. Once risk is endogenous, it is well known that standard risk management models break down (see e.g. Danielsson, 2002).

3.2.1 Endogenous behaviour

Endogenous risk is essentially due to endogenous behavioural reactions by agents in the economy including the policy maker. This is also true for macro feedbacks and liquidity risk. Given their importance it is however worth to discuss them separately. As shown in Figure 2, stress tests are a chain from an exogenous shock via the data generating process to the impact on banks' balance sheets. Exogenous behavioural responses are important at several stages (see Figure 3).

First, in standard stress tests exposures only change because some default occurs and/or their market value changes. Implicitly, PBs are sit-

ting on their initial portfolio allocation during the stress event without trying to hedge losses or realign their portfolio. Over a one to three year horizon, this is clearly unrealistic. Most modellers are aware of this problem. But the model structure hides this issue. Once the maturity structure of PBs balance sheets is taken into account, endogenous behaviour has to be addressed. Drehmann et al. (2007) model assets and liabilities as well as their respective maturity structure to capture interest rate risk in the banking book. A large part of the book has a maturity below one year. Hence, even for a one year stress test, the question has to be addressed what the PB (and depositors) is doing once assets (and liabilities) mature or can be repriced.

An ideal model would consider full portfolio optimisation. This has been done by the operations research literature discussing stochastic programming models for dynamic asset and liability management.[8] But even the latest papers can only undertake this modelling exercise for tradable assets funded with a simple cash account (see Jobst et al., 2006). Drehmann et al. (2007) therefore use a simple rule of thumb. They assume that PBs as well as depositors are passive, i.e. that they continue to invest in the same assets with the same risk characteristics as before.[9] Clearly, rules of thumb are not ideal. However, it is a first step in modelling endogenous behaviour. De Bandt and Oung (2004) follow a different strategy. Rather than building a structural model, they establish a relationship between the demand and supply for credit and the state of the economy. Hence, balance sheet adjustments by PBs are accounted for in a reduced form fashion.

Second, when talking about endogenous behaviour, it is crucial to consider the policy makers as well. If the model of the systematic risk drivers is reduced form, then the (average past) CB policy response is already embedded in the data generating process. To clarify this, assume that the events of the summer 2007 are run as a historical stress test scenario using the observed changes in market prices. The latter are, however, a result of the stress event as well as CBs liquidity interventions. Hence, by re-running this scenario, a similar CB reaction is implicitly assumed. Market participants may reasonably expect this in the future if a similar scenario would unfold again. However, if this stress test is run by a central banker aiming to explore the robustness of the system with and without policy interventions, this is obviously a problem.

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[8] For an overview over this literature see Zenios and Ziemba (2007).

[9] Drehmann et al. also have to make an assumption about the re-investment of positive profits. The modelling framework is generally flexible enough to also look at rules of thumb where balance sheets are increasing or portfolio realignment occurs. Alessandri and Drehmann (2007) base a full economic capital model on the same set-up.

Reduced form macro models representing the data generating process share a similar problem as past interest rate decisions are embedded in the data generation process. If a structural macro models is used to capture the dependence of macro risk factors, most stress tests do not model the behaviour explicitly but rely on an estimated Taylor rule, i.e. they assume that the CB mechanically sets interest rates to minimise deviations in inflation and output. It is well known that this assumption imposes problems in generating severe stress scenarios. For example, a severe shock to the housing market would lead to a reduction of the interest rate, which dampens the impact of the initial shock on banks balance sheets as interest rates are an important driver for corporate and household defaults. Without additional shocks to inflation, it is therefore very hard to generate consistent scenarios where interest rates rise whilst house prices fall, even though this was the case for example in the early 1990s recession in the UK, which was a stress event for PBs.

No easy answers can be given how best to start modelling endogenous behaviour. However, it is already important to be aware of the problem. A first step could be to explore rules of thumb for both policy makers and PBs. In practice this would force PBs to start thinking not only about their behavioural responses but also what other market participants would do. The latter step is important for understanding systemic risk in general and liquidity risk in particular.

3.2.2. Liquidity risk

Liquidity risk crystallizes because of an endogenous behavioural response by agents. In the classic paper on liquidity risk by Diamond and Dybvig (1983), agents run because other agents run.[10] The modern literature on bank runs (Goldstein and Pautzner, 2005) establishes that behaviour by depositors is not driven by sun-spots but by negative information. It is not only funding liquidity risk but also market liquidity risk which can affect the overall stability of the financial system. Markets may be illiquid because of informational frictions as is the case in the classical markets for lemons (Akerlof, 1970). And market liquidity more broadly may dry up because of behavioural responses by agents when they for example withdraw their money from weak performing funds (see Vayanos, 2004) or if there is a negative feedback loop between funding and market liquidity

[10] In lack of a common definition, I mean by market liquidity the ability to sell assets at fair value with immediacy and by funding liquidity the ability to satisfy the demand for money (see Drehmann and Nikolaou, 2008).

risk (see for example Gromb and Vayanos 2002 and Brunnemeier and Pedersen 2006).[11]

Market participants would argue that such spirals have happened, for example during the LTCM crisis or more recently during the turmoil in the summer 2007. Rather than aiming to embed these spirals into the model themselves, market practitioners use these events as historical stress tests. If these scenarios are indeed representative of market liquidity dry ups and the main objective of the stress test is to assess the robustness of capital, this may be a valid strategy. Said that, such an approach cannot reveal much about the underlying transmission mechanism and hence it is less well suited for FS stress tests.

Therefore, and because PBs are generally illiquid before they are insolvent, some FS stress tests aim to incorporate liquidity risk (see Jenkinson, 2007). However, making empirical progress on these questions remains difficult. First, to measure liquidity risk, not only assets but also liabilities and off-balance sheet items and their respective maturities have to be considered. This expands the universe of necessary data considerably. PBs own approaches rely on vast amounts of confidential data which are changing continuously and rapidly, especially during stress. This limits their use from an FS perspective. Second, data on behavioural responses by depositors and counterparties in the interbank market are also rare. Therefore, liquidity stress tests are based on rules of thumb rather than on empirical relationships. Using bidding data from open market operations, Drehmann and Nikolaou (2008) are so far the only study which measures funding liquidity risk with data available to CBs. They are able to capture the recent turmoil but data restrictions imply that they can measure liquidity risk only over a one week horizon. It remains unclear how their approach could be incorporated into a model with a much longer horizon. The more general problem is that the link between shocks to solvency, modelled by current stress tests, and liquidity is even less clear.

3.2.3 Macro feedbacks

There is strong evidence that system wide solvency and liquidity crises in the banking system lead to significant costs in terms of loss of GDP (e.g. Hoggarth et al., 2002). But so far, linking the real and the financial sector has proven to be difficult. Christiano et al. (2007) for example build on the financial accelerator literature (see Bernanke et al. 1999) and include

[11] The intuition behind these spirals is as follows. Assume a severe drop in asset prices which induces higher margin calls. If the funding liquidity of PBs is constrained, higher margin calls can only be satisfied by selling assets. This lowers asset prices further if many PBs have to raise cash because of a lack of market liquidity. In turn this raises margin calls, leading to increased funding liquidity demands and so forth. Whilst such a spiral is theoretically understood it is very hard to model empirically. For a survey on asset market feedbacks see Shim and von Peter (2007).

an aggregate banking/financial sector in a dynamic stochastic general equilibrium model. They find that this sector is a source of shocks which can account for a significant portion of business cycle fluctuations. But the sector is also an important amplification mechanism.

Whilst this is an interesting macro model, it is of limited use for FS stress tests. As has been vehemently argued by Goodhart in many publications (see e.g. Goodhart et al. 2006) and should also be clear from the discussion on risk measures above, it is important to model heterogeneous actors within the financial system. A single financial sector will mask many of the important relationships. For example, different PBs may have different preferences. Hence, they may take different risks and the most risky ones are likely to fail first. Further, aggregate (funding) liquidity conditions are set by the CB. As long as it does not make any massive policy mistakes, the level of aggregate liquidity is not an issue even in crises. But the distribution of liquidity across institution certainly is, as an institution short of liquidity will fail. Given interbank markets such a failure may induce contagion to other banks – i.e. counter party credit risk– with different ramifications for the real economy depending on how many and which banks fail.

From many private discussions I know that most modellers at CBs intend to extend the model set-up depicted in Figure 2 by implementing a feedback loop from the risk measure – i.e. banks' losses – back to the model of the data generating process. If a large structural macro model is used as a model of the data generating process, an intuitive possibility could be to link the risk premia and availability of investment funds to the capital adequacy of banks. There is indeed empirical evidence that investment is a negatively related to conditions in the banking sector (see Peek and Rosengreen, 2000, or Dell'Ariccia et al. 2005). But I am not aware of any stress testing model which links the banking sector and the real economy. The only successful approaches so far are reduced-form models, which are different in nature than the standard stress testing model set-up depicted in Figure 2.

These models are essentially large scale vector autoregressive models (VAR) and based on the same idea of linking the standard set of macro factors with risk measures of the financial system.[12] Aspaches et al. (2006) use a cross country approach and proxy financial sector risk by bank defaults and bank profitability. Jacobsen et al. (2005) do not explicitly model banks but set-up a panel VAR modelling macro factors and the likelihood of default for Swedish companies. They find that macro feed-

[12] Hoggarth et al. (2005) develop a macro VAR model which includes write-offs by PBs as a risk measure. In contrast to the other papers cited above they find little evidence of feedbacks.

backs can have important implications and that sometimes monetary policy and FS objectives can conflict. De Graeve et al. (2007) follow the approach of Jacobsen et al. (2005) but use PDs for the German banks directly. They show that a negative monetary policy shock impacts significantly on the robustness of the banking sector, but only once the feedback from bank PDs back to the macro economy is allowed for.

Whilst these models are of limited use for PBs, they provide CBs with some quantitative indications about the importance of macro feedbacks. However, given their highly reduced form nature, there are not well suited for *communication.* Furthermore, the endogenous response by the policy maker is already embedded in the model, which is not desirable if the model is used to analyse counterfactual policy experiments.

3.2.4 Non-linearities

Policy makers frequently argue that non-linearities will emerge during stress (e.g. see Haldane et al., 2007, ECB 2006).[13] Conceptually, it is not entirely clear what policy makers really mean by this and it is therefore worth to disentangle various aspects. On the one hand, non-linearities are a result of endogenous behavioural responses. On the other hand, models may not capture them because they are econometrically misspecified.

Standard parametric econometrics generally imposes a log-linear specification on the model of the data generating process. This is also done for macro economic models. Given their objective is to forecast the mean outcome around the equilibrium, results may be acceptable as mistakes made may be not too large.[14] This cannot be expected for extreme stress events. Stress testing modellers therefore have to assess where significant non-linearities can arise. For example, given the binary nature of default the link between systematic risk factors and credit risk is often modelled in a nonlinear fashion for example as a probit specification (see Wilson 1997 a/b) or based on a Merton type model (see Drehmann, 2005, or Pesaran et al., 2006). Drehmann et al. (2006) show that even for probit specifications non-linearities may not be sufficiently well captured. Accounting for the non-linear nature of the data generating process, they show that stress test results are significantly different. It is a question, however, whether tackling this type of non-linearities is of high importance, especially if the objective is *communication*. Modelling non-linearities in the underlying data generating process will not reveal any

[13] Mathematically, a model has non-linearities if the impact of a three standard deviation shock is not simply three times the impact of a one standard deviation shock.

[14] A log-linear specification can mathematically be interpreted as first order Taylor approximation of true data generating process (see Jordà, 2005). But for severe stress events in the tail of the distribution such an approximation cannot hold.

more about the transmission mechanism from shock to impact. Clearly, it will change the level of different stress test scenarios,[15] which is important if the objective is risk management.

Non-linearities may also arise because of jumps or switching between multiple equilibria. This can be a result of endogenous behavioural reactions and is presumably really what policy makers care about. Jumps and multiple equilibria are central to models about funding and market liquidity discussed above. One possible avenue to explore, is modelling these endogenous non-linear reaction with a structural model. As the previous discussion highlights this is difficult. Another possibility could be to capture them by models with regime shifts. So far, I am only aware of one model. Bruche and Gonzalez-Aguado (2008) use a latent, unobserved factor model to capture the dynamic join distribution of default probabilities and recovery rates in the US. In terms of forecast performance, they find that this model outperforms models based on observable macro factors. But as pointed out before, such a modelling approach is not well suited for *communication* but could be useful for *decision making*. It seems a fruitful avenue for future research to assess how important regime shifts are and whether they could be practically incorporated into risk management and stress testing models.

4 What's next?

Modellers have to cope with a lack of data, as this cannot be changed at least within the medium run. The endogeneity of risk, however, is an area where progress can be made. So far all stress testing models essentially follow the set-up depicted in Figure 2, except the highly reduced-form models discussed to capture macro feedbacks back to the real economy. The only exception is the work stream by Goodhart et al. (2004, 2005, 2006 a,b)[16] who theoretically derive general equilibrium models with incomplete markets where agents are heterogeneous and default can occur. As stressed by Goodhart et al., both of these features are essential when aiming to model FS. The model by Goodhart et al. goes well beyond the standard stress testing models as all agents, in all markets, in all states of the world are fully optimising over quantities, prices and defaults. The model is therefore able to address some of the problems discussed above, most importantly endogenous behaviour. Modelling defaults in a general equilibrium framework is one of the key challenges for their set up. In the classic Arrow-Debreu model it is implicitly assumed

[15] For univariate models, non-linearities will also not change the rank ordering of different scenarios.
[16] The theoretical model to assess financial stability is based on Tsomocos (2003a,b).

that all agents honour their obligations, and thus there is no possibility of default. Hence, Goodhart et al. follow Shubic and Wilson (1977) and treat default as the repayment rate which is endogenously chosen by agents. In this sense defaults are partial and voluntary. Even though Tsomocos and Zicchino (2005) show that there is a an equivalence between a general equilibrium model with incomplete markets and a model where default is endogenous, this model structure makes it already hard to communicate with senior CB management or PBs as they see default as an exogenous event. *Communication* is also not fostered by the complexity and intractability of the model.

Ultimately, calibrating and finding computational solutions for the model are the major difficulties. So far this has only been tried for the UK (Goodhart et al., 2006b) and Colombia (Saade et al. 2006). In both cases, it was only possible to implement a highly stylised model with three different banks[17], two states of the world (stress and no stress) and two time periods. Even in this case, calibration proves difficult. As Saade et al. (2006) explain, some parameters such as policy variables are observed, some can be calibrated using econometric methods (e.g. the income elasticity) and others such as the occurrence of the stressed state or default penalties are arbitrarily imposed. Saade et al. replicate the Columbian banking crisis in 1997–1999. For some model variables (such as the volume of mortgage loans) the model seems to perform well. For others, such as GDP, projections are far off true developments.

An alternative is therefore to extend the model set-up in Figure 2 to the model depicted in Figure 3. The most ambitious project in this regard is currently undertaken by the Bank of England (see Jenkinson, 2007). As a starting point it takes the structure of the standard Bank of England stress testing model (see Bunn et al. 2005 and Haldane et al., 2007) which covers the macro economy, credit risk and banks net interest profits. Following the Austrian central bank's model (see Boss et al. 2006), the basic structure is extended to include market risk exposures of banks and counter party credit risk. Additionally, interest rate risk is modelled structurally along the lines of Drehmann and Alessandri (2007). The aim is to also cover macro feedbacks as well as market and funding liquidity risk. Because of a lack of data, robust estimates for the latter may not be possible and hence these channels may be very much based on rules of thumb. Nonetheless, the model breaks important new ground and will certainly highlight interesting FS channels. First model results suggest for example that the distribution of systemic risk, if measured as the aggre-

[17] In the model there is a one to one relationship between a class of households and a PB. Hence, there are also three different types of households.

gate loss distribution of the banking system, may be bi-model (see Jenkinson, 2007).[18]

Such a model may be the only possible solution to deal with the limitations of current stress tests. However, an important drawback for this approach is that it does not break with the modular structure inherent in all current stress testing models. This implies that there will be most likely empirical as well as theoretical inconsistencies across modules.[19] Given piece-wise estimation it is also likely that model errors add up with important implications for the robustness of the model. There is also a clear danger that such a model will become so complex and non-transparent, that only a few highly specialised economists are able to understand the dynamics of the model if parameters are changed. Lack of model robustness and high degree of complexity may ultimately limit its usefulness for external *communication*, which is an important consideration as this is the main objective of FS analysis for a non-supervisor CB.

That said, engaging in a model building process is already an important step in deepening the understanding of FS and its system dynamics. Limitations of these models will certainly remain. But an overall FS model can already provide useful inputs into the policy debate and help communication efforts, as long as these limitations are made transparent and model results are presented carefully.

5 Conclusions

In this article I look at the objectives, challenges and modelling choices stress tests. I argue that for model builders as well as model users it is essential to understand the main objective of the stress tests. Different objectives highlighted are *validation*, *communication* and *decision making*. Sometimes these objectives imply different and possibly conflicting priorities for model design. The main building blocks of stress tests are then discussed in the light of different objectives and the article concludes with a discussion about the key challenges for current stress testing models and how they could be addressed. The endogeneity of risk is the main issue for standard risk management models as it challenges the fundamentals of the current model set-ups which assume a chain from an exogenous shock via the data generating process to the impact on banks' balance sheets.

Finally I want to point out that a successful stress testing model is not only designed with a clear objective in mind, but suitable instruments

[18] It should be pointed out that this result relies on an extreme assumption for market risk.

[19] An easy to make mistake would for example be to treat interest rates as I(1) variable in one module but I(0) in another.

are identified with which the objective can be achieved. Summer (2007) highlights, that PBs understand their objectives and instruments much better than CBs. PBs ultimate objective is to maximise shareholder value by taking and managing risks so that an optimal risk return trade-off is achieved. Stress tests contribute to this objective by deepening the understanding of risks. And if issues are identified, the PB has clear instruments to address problems for example by raising more capital, setting limits or reducing exposures. Instruments for CBs to address FS issues are more ambiguous. In general, interest rates are set to ensure price stability. During the recent financial turmoil CBs have successfully used open market operations to address FS issues. However, by design these instruments are focused narrowly at providing liquidity for a specific horizon (e.g. one week), to ensure the appropriate implementation of the monetary policy stance. No other issues, such as the building up of FS vulnerabilities, can be addressed. Therefore, the main instrument used to address FS is *communication* with financial institutions.

There is however a question how much this can ultimately achieve. For example, the most recent turmoil should give some pause for thought. Notwithstanding that the asset-backed commercial paper market was not specifically highlighted as possible vulnerability, CBs around the globe had identified complex financial products, high leverage and trading in illiquid markets as FS risks before the turmoil (see IMF 2007; Bank of England 2007; ECB 2007; and Geithner 2007). And publications demonstrate that these calls were acknowledged by the banking industry (see CRMPG 2005; and IFRI-CRO Forum 2007). Nonetheless the crisis occurred. Can we conclude that communication had no impact? Would the crisis have been worse without FS reports? Maybe CB warnings were not acted upon this time. But given that CBs made valid attempts to identify the vulnerabilities, their reputations should be enhanced. But does this mean that the private sector will be more responsive in the future? Finding answers on these questions is not easy. Ultimately, I remain doubtful about how much communication can achieve given considerable uncertainties and the incentives for risk taking by PBs. For communication to become more than "cheap talk" it seems essential to develop reliable measures of FS and link those to policy instruments such as regulations. As Summer (2007) points out, the link between stress tests as a measure of FS and concrete policy instruments is so far uncharted territory. I hope that the continued development and use of stress tests with all their benefits and limitations will foster this debate. This, and capturing the endogeneity of risk in stress testing models, is certainly needed.

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