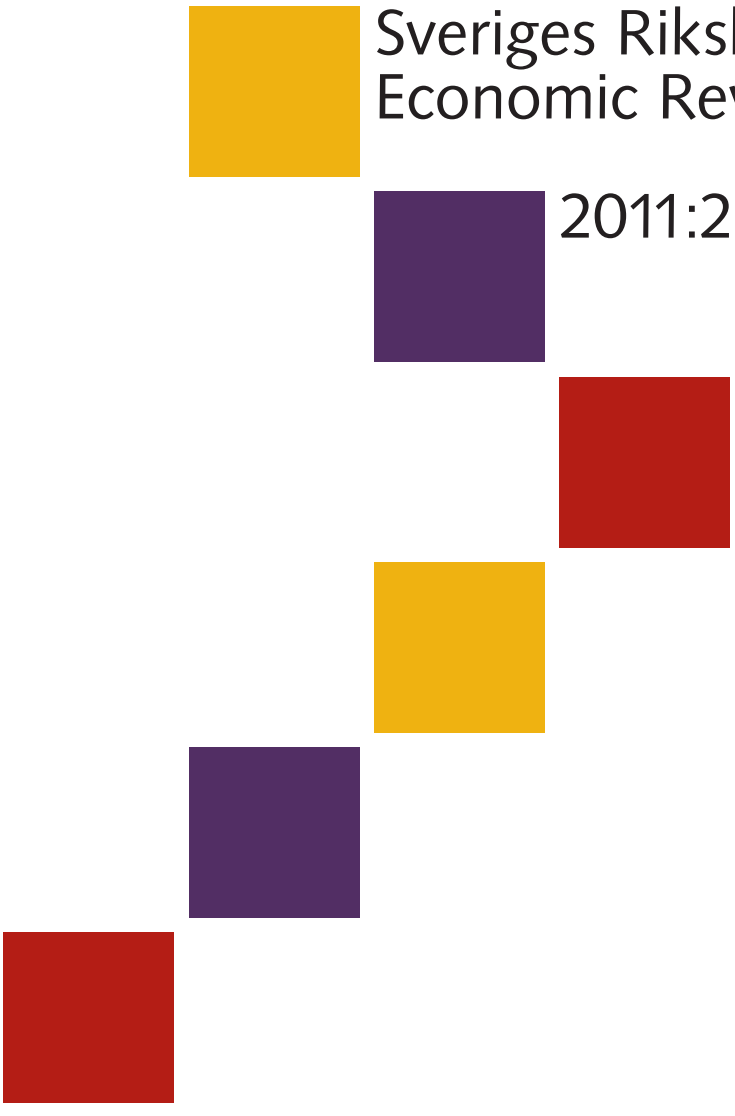

Sveriges Riksbank Economic Review

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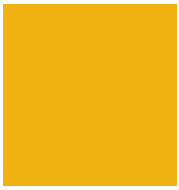

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Dear readers,

In this issue of *Sveriges Riksbank Economic Review* we publish four articles relating to various issues in the fields of monetary policy and financial stability.

- Henrik Lundvall and Andreas Westermark analyse why the natural interest rate, that is the real interest rate that is compatible with normal resource utilisation, varies over time and how it may be affected by shocks of the type noted during the financial crisis.
- In their article, Gudrun Gunnarsdottir and Sofia Lindh address the need to take measures to develop the market for corporate bonds in Sweden. The authors analyse the results of interviews and the Riksbank's survey on the funding of Swedish non-financial companies and note that the market for corporate bonds will become more important if, as expected, the banks' supply of corporate loans declines, partly as a result of the new Basel III regulations.
- Johannes Forss Sandahl, Mia Holmfeldt, Anders Rydén and Maria Strömqvist present an index that aims to reflect the degree of stress on those markets that are important sources of funding for Swedish banks, companies and households.
- Dale Gray and Andreas Jobst describe how the theory of price-contingent contracts (option theory) can be used to analyse how risks spread between banks and the financial system, and between the financial system and the central-government's balance sheet. In their article, the authors use empirical examples of the effects of the financial crisis in the United States, the euro area and Sweden.

If you have any views or comments on the journal, please contact us at the email address pov@riksbank.se

We hope you enjoy this issue!

Claes Berg and Kerstin Mitlid

Contents

corporations' financing. Steps to develop the market may thus now be relevant. A more efficient corporate bond market may be a positive development for the Swedish financial markets. It could improve the efficiency of financial intermediation, better determine the price of credit risk in different maturities and increase the diversification options for Swedish corporations' financing. Further work is however needed to be able to develop an efficient Swedish corporate bond market.

We have developed an index for financial stress that is intended for use as a tool in analysing developments on the financial markets. The starting point for our index is the financial markets that are important sources of funding for banks, companies and indirectly also for households. The four stress indicators we have chosen are directly or indirectly related to the funding costs prevailing in each respective market. The stress indicators are equally weighted and normalised on the basis of the reference period January 1997 to July 2007. The tests presented in this article show that the choice of historical reference period and weighting may affect the analyses of the way the index develops. As the index is an average value of various indicators, it may provide an overall picture of the degree of financial stress on the financial markets. However, this may need to be supplemented with further information to provide a more complete picture. For instance, the analysis of sub-components may increase understanding of the symptoms of financial stress.

This article introduces a new framework for macroprudential analysis using a risk-adjusted balance sheet approach that supports policy efforts aimed mitigating systemic risk from linkages between institutions and the extent to which they precipitate or amplify general market distress. In this regard, the systemic contingent claims analysis ('Systemic CCA') framework helps quantify the magnitude of general solvency risk and government contingent liabilities by combining the individual risk-adjusted balance sheets of financial institutions and the dependence between them. An example of Systemic CCA applied to the US financial sector delivers useful insights about the magnitude of systemic losses

and potential public sector costs from market-implied contingent liabilities. Stress tests using this framework are presented. Applications to European banks and the stress testing of systemic risk are also described. Finally, the banking and sovereign risk analysis is applied to Sweden, and joint banking sector and sovereign stress testing applications are shown. The paper concludes with new directions for a framework of integrated stress testing of banking and sovereign risk, with macrofinancial feedbacks, and monetary and fiscal policy analysis. Future research would ideally explore directions in using CCA-based economic output value and Systemic CCA to promote economic growth and financial stability, as well as the relationship to fiscal and debt management dynamics.

What is the natural interest rate?

Henrik Lundvall and Andreas Westermark[1]

The authors work at the Monetary Policy Department, Sveriges Riksbank.

What real interest rate should a central bank aim for if it wishes to attain a normal level of resource utilisation? In modern monetary policy theory, the real interest rate that is consistent with a normal level of resource utilisation is usually called the 'natural interest rate'. One way of determining whether monetary policy is expansionary or contractionary is to compare the actual real interest rate with the natural interest rate. One important characteristic of the natural interest rate is that its level varies over time. This article analyses how different types of macroeconomic disturbances of the type that were seen in the financial crisis can impact the natural interest rate in a theoretical model of the economy.

The **nominal interest rate** is the compensation that a borrower pays to a lender in addition to the borrowed amount. It is measured as a proportion of the borrowed amount and is expressed as a percentage. For example, banks often offer loans and savings at nominal interest rates.

The **real interest rate** can be calculated as the nominal interest rate over the loan's maturity minus expected inflation over the same period. The real interest rate shows the purchasing power a borrower must relinquish to gain access to the loan, and is the most relevant factor for households and firms when they decide to borrow money.

The **policy rate** or **repo rate** is the nominal interest rate at which banks can borrow from or invest in the Riksbank over the short term. The policy rate can also be calculated in real terms by adjusting for expected inflation, which is more relevant when analysing the development of the real economy.

The **natural interest rate** is the real interest rate that would prevail if resource utilisation in the economy was normal today and was expected to remain normal in the future.

What do we mean when we say that a certain monetary policy is expansionary or contractionary? Most of us would probably agree that an expansionary monetary policy means that the central bank holds the policy rate at a low level so as to increase resource utilisation. Conversely, a contractionary policy means that the policy rate is set at a relatively high level, which, in normal cases, leads to the dampening of resource utilisation.

But what would be a more precise definition of the concepts of 'expansionary' and 'contractionary' monetary policies? Is it possible to determine an exact cut-off point for the

1 We have received assistance from many of our colleagues, and would particularly like to thank Lars E.O. Svensson and Ulf Söderström.

interest rate, below which a certain monetary policy can be characterised as expansionary and above which it can be said to be contractionary? In modern monetary policy theory, such a cut-off point exists for the *real* interest rate, that is, the nominal interest rate minus expected inflation. This cut-off point is usually called the 'natural real interest rate' or, more succinctly, the 'natural interest rate'. One important characteristic of the natural interest rate is that its level varies over time as a result of macroeconomic disturbances affecting the economy. In theory, the level of the natural interest rate must first be established, before it can be determined whether a certain monetary policy is expansionary or contractionary.

The aim of this article is to discuss what is meant by the term 'the natural interest rate'. Its starting point is a description of the economy that forms the mainstream of current research on monetary policy, sometimes known as New Keynesian theory. In the article, we describe some central relationships in a simple version of a New Keynesian model, and, on the basis of these relationships, discuss the concept of the 'natural interest rate'.[2] The appendix includes a brief mathematical description of the model. The article also includes a section with examples showing how the natural interest rate is affected by a number of different macroeconomic disturbances.

The natural interest rate and monetary policy

According to modern macroeconomic theory, a central bank normally wants to control both the rate of inflation and the level of resource utilisation in the economy. A central bank that conducts inflation targeting and tries to hold inflation stable around an inflation target usually has two reasons for influencing resource utilisation, the first of which is directly linked to the task of maintaining price stability. Resource utilisation affects firms' costs, and the costs are decisive when firms price their products. For a central bank aiming to stabilise inflation around an inflation target, it is thus very important to also stabilise resource utilisation so that the general cost level rises at a rate that is compatible with the inflation target.

In addition to the target of stabilising inflation, the central bank may also consider the stabilisation of the real economy to be part of its objective. This need not conflict with the task of maintaining price stability: given that households and firms trust that the central bank returns inflation to target in the long term, there is normally scope for trying to find a balance in the short and medium term between the target of stabilising inflation and the ambition of stabilising the real economy. Such trade-offs are relevant when the economy is affected by macroeconomic disturbances driving inflation and resource utilisation in

2 The concept of a natural interest rate was introduced by Knut Wicksell in a series of theoretical works published around 1900. By the 'natural interest rate', Wicksell meant a real equilibrium interest rate that was independent of the actual bank interest rates and which was determined by the real disturbances affecting the economy. A central bank wishing to hold prices stable should take action aimed at holding the actual bank interest rates level with the natural interest rate. In recent decades, this concept has become an important component of what is known as New Keynesian theory, although the meaning of the concept has partly changed. Wicksell's influence on modern monetary policy theory is considered to be highly significant by a number of researchers, and, consequently, the term 'Neo-Wicksellian model' is occasionally used instead of 'New Keynesian model'. See Wicksell (1898) and Woodford (2003), particularly chapters 1 and 4.

opposite directions, for example supply shocks. Another reason for the central bank to influence resource utilisation may thus be that the stability of the real economy is seen as a monetary policy target in itself.

Under an inflation-targeting regime, monetary policy is normally a matter of finding a path for the policy rate that gives good forecasts for inflation and resource utilisation. 'Good forecasts' mean a forecast for inflation that deviates as little as possible from the inflation target, and a forecast for production and employment that deviates as little as possible from a normal level of resource utilisation.

NORMAL RESOURCE UTILISATION AND THE NATURAL INTEREST RATE

Resource utilisation is thus one of the most important macroeconomic variables for a central bank. But how can the level of resource utilisation be measured, and what is meant by the expression 'a normal level of resource utilisation'?

One frequently used measure of resource utilisation is the output gap, which measures the difference between the actual output level (actual GDP) and the potential output level (potential GDP). When actual GDP is equal to potential GDP, the output gap is zero and resource utilisation is said to be normal. If the output gap is positive, so that actual GDP is higher than potential GDP, resource utilisation is said to be higher than normal, while, conversely, a negative output gap means that resource utilisation is lower than normal.[3]

So what is meant by the 'potential output level', and how can it be that the actual output level can differ from the potential level? In New Keynesian theory, potential GDP is usually defined as the level of output that would arise if all prices and wages were fully flexible. Full flexibility means that all prices and wages are adjusted immediately to changes in economic conditions.

However, there is a lot of evidence that suggests that prices and wages change relatively infrequently – they are sluggish. So, why is it reasonable to define potential GDP as the level that would prevail if all prices and wages were flexible? According to the theory, the sluggishness is the reason that actual GDP generally differs from its potential level. In a market economy, prices and wages play a central role, in that they convey information from one firm to another, and between firms and households. Prices convey information to households regarding firms' marginal cost levels: different firms' relative prices signal differences between their relative production costs. If prices are sluggish, there is a risk that households will get the wrong signals concerning relative costs and will thus demand too much of those goods that are comparatively expensive to produce. This could lead to the misallocation of resources within individual firms and industries, and in the economy as a whole. This latter situation will be the case if the economy's average price or wage level is not adjusted fast enough when the economy is affected by aggregate disturbances.

3 However, there are several other measures of resource utilisation in addition to the output gap. Examples of other measures are the hours gap, which measures the deviation between the actual number of hours worked and the potential number of hours worked, and the unemployment gap, which specifies the difference between the actual level of unemployment and unemployment when prices and wages are flexible.

If, on the other hand, prices and wages are fully flexible, no such mismanagement of the economy's total resources will arise. For this reason, we let potential GDP be equal to the level of output that would arise if price and wage levels were flexible. This level of output is also occasionally called the 'natural output level'.[4] However, if an economy reaches its potential output level and has a normal level of resource utilisation, this does not mean that this economy will always grow in accordance with the economy's long-term growth rate. For example, productivity and demand shocks will affect an economy with flexible wages and prices, thus diverting the economy from its long-term growth rate.

One price that is of particular interest for monetary policy is the return on savings – the interest rate. When firms and households decide to borrow or save money, the real cost or return is determined by the real interest rate. The real interest rate corresponds approximately to the nominal interest rate minus the inflation that is expected to occur during the period which the money was lent. As prices of goods and services in general change fairly infrequently, inflation is relatively sluggish. Of course, the sluggishness of price and wage formation means that the rate at which prices increase – inflation – changes more slowly than would have been the case had all prices and wages been flexible. Just as sluggishness in price and wage formation creates a gap between actual GDP and potential GDP, the same sluggishness creates a gap between the actual real interest rate and the interest rate that would apply if all prices and wages were flexible. Consequently, to the natural or potential output level there is a corresponding concept of a natural interest rate, that is, the real interest rate that would arise if prices and wages were fully flexible and resource utilisation was normal. The natural interest rate can be regarded as the interest rate that would prevail if there was no need for monetary policy to stabilise the real economy.

Before we discuss the question of which factors determine the natural interest rate, there may be reason to comment on the definition of the term we are using here. In the theoretical literature on monetary policy, the potential output level and the natural interest rate are determined by the equilibrium of flexible prices and wages. In the empirical literature, other definitions of the term 'potential output level' are often used. Naturally, by analogy with such alternative definitions of the output gap, alternative definitions of the level of the real interest rate that is compatible with a normal level of resource utilisation can be made.

WHAT DETERMINES THE NATURAL INTEREST RATE?

The interest rate is determined by demand and supply in the credit market. To understand which factors influence this market, it is helpful to start by examining a stylized model, in which a representative household decides how much money to save (or borrow), and how much to use for consumption. In modern macroeconomic theory, it is assumed that the

4 Misallocation of resources can arise for many other reasons than just nominal constraints. However, when discussing monetary policy, it is natural to focus on these nominal constraints, since these are the causes of misallocation that the central bank can affect.

household's choice will be forward-looking – the household will choose consumption and savings to maximize the payoff from consumption today and in the future. To understand households' behaviour, two basic assumptions are made regarding how consumption is valued over time.

The first basic assumption concerns how the household values variations in consumption. Let us assume that the household has a given amount of consumer goods at its disposal, and that the household must determine how this consumption is to be allocated over time. Will the household allocate its consumption evenly over time, or will it consume large amounts in certain periods and less in others? It is reasonable to assume that an increase of consumption is valued relatively highly if the initial level of consumption is low, while an equally large increase is worth less if the level of consumption is high. An optimising household will thus plan its consumption so that the value of consumption increases today and tomorrow are equal. This means that households prefer consumption that is fairly equal across time to consumption that varies across time. In other words, the household has a basic desire to consume approximately the same amount in all time periods.

An example of this is pension savings. After retirement, income drops significantly for most households, and, to avoid an old age spent in relative poverty, it is very common for households to save a portion of their income during their working years. Another example is that households often build up a certain savings buffer that can be used in times when expenses are unexpectedly high. The assumption of consumption smoothing has been an important part of macroeconomic theory since the 1950s, when Modigliani and Brumber (1954) and Friedman (1957) launched their hypotheses on life cycle savings and permanent income.

The second basic assumption is that households gets a higher payoff from consumption early on, rather than consumption taking place at some point far in the future. Quite simply, households value consumption taking place today or tomorrow slightly higher than equivalent consumption taking place in one year's time.[5] It could be said that the value of consumption declines the further ahead in time it takes place.[6]

The two assumptions of the household's preferences that we have described determine the choice between consumption and saving. The household's preference for smooth consumption means that the household has reason to save during periods in which its income is unusually high and to cut back on saving (or borrow money) during periods

5 In theoretical models, this is captured by the size of the household's subjective discount factor. A higher value for the discount factor means that households value consumption today and in the future more equally.

6 It is possible to describe these two assumptions in a more technical manner. If households choose current and future consumption to maximise

$$\sum_{t=0}^{\infty} \beta^t u(c_t),$$

in which β is a subjective discount factor and $u(c_t)$ is the households' benefit from consuming c_t, then β captures the households' time preference, and the degree of concavity in u captures the households' aversion for variation of consumption over time. If β is less than one, households are impatient, which is to say that they value consumption today higher than consumption in the future.

in which income is unusually low. By using the credit market, the household can thus sever the consumption level from the income level at any point in time. However, the household's impatience is a force pushing in the opposite direction, as this impatience means that the household does not necessarily have reason to fully equalize consumption across time. Instead, consumption is allowed to decline somewhat over time. As we have seen, consumption taking place today is valued slightly higher than that taking place in the future.

If the household's preferences suggest that consumption will decline over time, the return on saving (positive interest) creates a counteracting incentive. If the household chooses to postpone a little of today's consumption to a later point in time, the household will be compensated via interest and will later be able to consume a little more than it has refrained from consuming today. All other factors being equal, the higher the interest rate is, the greater the reason for the household to postpone some of its consumption. Thus, there is a relationship between consumption and interest rates. In an economy where GDP and consumption grow over time, the rate of growth will have a significant impact on the real interest rate. As consumption grows, households have incentives to borrow to smooth consumption over time. If growth increases, households have incentives to borrow more, in turn driving up the real interest rate. In normal New Keynesian models, the conclusion of this analysis is that the real interest rate is primarily determined by the growth in consumption expected by the representative household and by the strength of the household's interest in consuming today rather than at a later date. The household's expected growth in consumption is, in turn, closely linked to the expected growth rate of GDP.

Because a single household is small relative to the size of the credit market, changes in that household's saving decisions have no impact on the equilibrium interest rate. However, the interest rate is affeced if changes occur that cause many households to simultaneously change their balance between consumption and saving. Assume, for example, that news of macroeconomic developments leads the average household to expect higher future rises in income than have previously been the case. As households prefer to spread consumption evenly over time, the average household thus has reason to decrease its current saving level. Households cut back on their saving and immediately start to adjust their consumption to the higher expected income. The result is that net demand for loans increases, which, in turn, leads to a rise in the interest rate. If the average household becomes more optimistic regarding future growth rates, this will lead to an increase in the natural interest rate.

If uncertainty over its future income increases, it is reasonable for a household to increase its buffer of saved funds, so that these savings can be used in case future income should be particularly low. Intuitively, we can regard this scenario as an example of the average household's impatience. In this case, many households simultaneously become less impatient. The result is that savings increases and the natural interest rate falls. This example is a reasonable interpretation of the changes in households' saving patterns that

arose during the deep recession of 2008-2009, when households' saving, as a proportion of disposable income, rose sharply.

The natural interest rate thus primarily depends upon the growth in consumption expected by the average household, and on households' impatience. Households' expected growth in consumption is, in turn, closely linked to the expected growth rate of GDP. According to theory, there is thus a close connection between macroeconomic developments (growth in GDP) and fluctuations in the level of the natural interest rate.

SLUGGISH PRICES GIVE THE CENTRAL BANK POWER: THE MONETARY POLICY TRANSMISSION

The natural interest rate is thus the price of saved funds that would have arisen had all prices and wages been flexible. However, as actual economies are characterised by sluggishness in price and wage formation, there is no reason to expect that the actual real interest rate should coincide with the natural real interest rate. Instead, in actual economies, the short-term real interest rate is determined by the central bank. In this section, we first summarise how the central bank determines the real interest rate. Following this, we discuss what happens if and when the central bank chooses to set the real interest rate at a level differing from the natural interest rate.

The framework for the implementation of monetary policy takes different forms in different countries. In Sweden, the Riksbank controls the interest rate by determining the terms and conditions for the banks' overnight deposits in and loans from the Riksbank. These terms and conditions, in turn, set the limits for the interest rate charged by the banks to each other when they lend money to each other overnight. By way of repo transactions and what are known as fine-tuning operations, the Riksbank ensures that this interest rate lies close to the repo rate determined by the Riksbank's Executive Board. By controlling the interest rate charged by the banks to each other when they need to borrow money or invest a surplus, the Riksbank indirectly influences the interest rates offered by the banks to their customers, namely households and firms.

In the previous section, we mentioned that inflation is a sluggish variable. One consequence of this is that the central bank's control of the nominal interest rate also means that it controls the real interest rate, as the sluggishness of price and wage formation means that inflation changes relatively slowly. When the central bank adjusts the real interest rate, by adjusting the policy rate, the total demand in the economy is affected. In an actual economy, this takes place through several channels, for example through firms' investment decisions and by influencing the exchange rate. In this article, we focus on the channel that depends on households' choices between consumption and saving.

To briefly describe how changes in the real interest rate influence resource utilisation and inflation, we can consider an example in which inflation risks being above target and the central bank thus decides to raise the interest rate. Assume that resource utilisation is normal to start with, but that the private sector has inflation expectations that are clearly above the inflation target. This could, for example, be due to expectations of high future

wage increases, which, in turn, are influencing the cost situation in the business sector. When inflation expectations are high, actual inflation also risks being above target. Normal resource utilisation means that the actual real interest rate initially coincides with the natural interest rate. To prevent inflation from rising above target, the central bank raises its interest rate. This higher real interest rate changes the conditions for households' choice between consumption and saving: saving becomes more profitable, at the same time as it becomes more expensive to borrow money. When households cut down on consumption, demand in the economy decreases. This makes firms decrease production, which means that their demand for labor and equipment also declines. In turn, this leads to a gradual decrease in the rate of wage increases. The rate of price increase for existing capital also declines. When firms realize that cost pressure is easing off, they adjust their prices accordingly: inflation becomes lower than it would have been if the central bank had left its interest rate unchanged.

By raising the real interest rate above the natural interest rate, the central bank has caused a drop in economic activity. The lower level of demand has led to a lower level of resource utilisation: firms have reduced both their labour force and their demand for equipment. A low level of resource utilisation has, in turn, led firms' costs to increase at a lower rate than would otherwise have been the case, and the rate of price increase has thereby been dampened.

However, the central bank's ability to influence the real interest rate is only short-term. The average real interest rate over longer periods is determined by other factors than monetary policy, for example by the economy's long-term growth rate, household impatience and any taxes on capital. The conclusion is thus that the central bank can allow the actual real interest rate to deviate from the natural interest rate for shorter periods, but, in the long run, the central bank finds itself forced to act so that the actual real interest rate, on average, is fairly close to the natural interest rate.

THE NATURAL INTEREST RATE AND THE OBJECTIVE OF MONETARY POLICY

The attitude monetary policy should take towards changes in the natural interest rate obviously depends on the aims of the central bank. In general, it can be said that the greater the emphasis placed by the central bank on stabilising resource utilisation, the greater reason it has to adjust the actual real interest rate to changes in the natural interest rate. This is a consequence of the definition of the term: we have defined the natural interest rate as the real interest rate that corresponds to a normal level of resource utilisation. In many cases, an inflation target also justifies adjusting the actual real interest rate to fluctuations in the natural interest rates. An actual real interest rate above the natural interest rate implies a downward pressure on firms' cost levels, as resource utilisation would then tend to fall below a normal level. This kind of contractionary policy thus leads to a lower inflation rate. Similarly, an expansionary monetary policy, in which the actual real interest rate is held below the natural interest rate, leads to rising cost levels. Inflation will then tend to rise.

However, in earlier sections, we have mentioned that various types of macroeconomic disturbances tend to drive resource utilisation and inflation in different directions. In general, under such circumstances, there is reason for the central bank not to adjust the actual real interest rate fully to changes in the natural interest rate. For example, if inflation increases at the same time as resource utilisation decreases, a short-term conflict will arise between the target of stabilising inflation and stabilising resource utilisation. If the central bank only took consideration of the target of stabilising the real economy, fully adjusting the actual real interest rate to changes in the natural economy would be justifiable. But when consideration is also taken of the target of stabilising inflation, there is reason to allow the actual real interest rate to be higher than the natural interest rate for a time. On one hand, such a policy would contribute to holding resource utilisation below a normal level for a longer period than would otherwise be the case. On the other hand, this contractionary monetary policy would also contribute towards preventing inflation from rising too far above target.

In practice, it is difficult to estimate the level of the natural interest rate, just as it is difficult to estimate the potential level of output.[7] When the level of economic activity changes, it can take time before the central bank (and other analysts) can determine which underlying circumstances have changed and what the consequences will be for future economic development. Resource utilisation can then fall below or rise above normal levels before monetary policy can react. In addition, it can take time to return resource utilisation to normal levels using monetary policy. It is thus difficult to prevent resource utilisation from occasionally lying above or below normal levels.[8]

Changes in the natural interest rate – some examples

An economy is continually affected by different types of disturbances. This, in turn, affects important macroeconomic aggregates such as consumption and GDP. The aim of this section is to explain, with the help of a relatively simple macroeconomic model, how some of these disturbances affect the natural interest rate. The purpose is to describe, in an intuitive manner, the relationship between the real economy and the natural interest rate. To this aim, we use a variant of a model presented by Gali (2008). We have attempted to select disturbances that could have caused the deep recession of 2008 and 2009. The model is simple and cannot explain every aspect of the crisis. Consequently, we do not attempt to relate the analysis included in the following section to any empirical evidence.

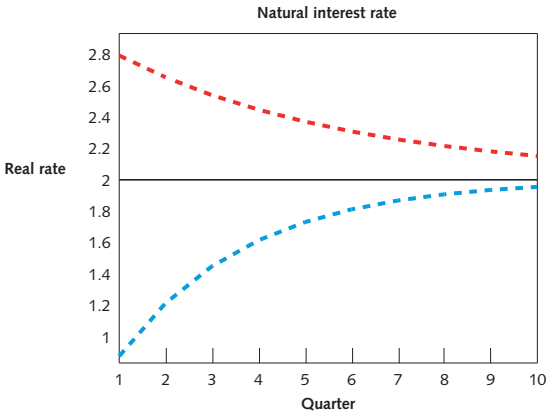
7 See, for example, Justiniano & Primicieri (2010) and Laubach & Williams (2003).

8 For these reasons, there may be reason to differentiate between the natural interest rate that applies if resource utilisation is initially at a normal level, and the natural interest rate that applies if resource utilisation is initially below or above a normal level. In the latter case, we are thus interested in the level of the real interest rate that, if implemented, would be expected to return the economy to its potential GDP and growth rate within one or two quarters. This distinction is related to the difference made in the theoretical literature between an unconditional and a conditional output gap. See also Adolfson, Laséen, Lindé & Svensson (2010).

UNEXPECTED CHANGES IN PRODUCTIVITY

Productivity varies over time and can have major effects on economic developments. When making assessments of the level of resource utilisation and the natural real interest rate, it is important to attempt to determine the extent to which positive or negative productivity disturbances have been temporary or permanent. In practice, productivity can be affected by many factors – for example, variations in the size of the capital stock or in how well the capital stock and the labour force's capacity is being utilised (labour hoarding). In the model used here, productivity disturbances are changes in total factor productivity.[9] Disturbances in production technology can be divided up into temporary and permanent disturbances.[10] We will now examine examples of how a negative productivity disturbance affects the economy, and analyse the difference between temporary and permanent negative disturbances.

Figure 1. The effect on the natural interest rate of unexpected changes in productivity



The red dashed line shows the effect on the natural interest rate of a temporary and unexpected negative change, while the blue dashed line shows the effect of a permanent and unexpected negative change. The scale on the vertical axis is the yearly interest rate in percent.

The black line in Figure 1 shows the natural interest rate when the economy in the model grows along a balanced growth path with an annual real growth rate of 2 per cent. Growth is driven by gradual and permanent improvements in the productivity of the labour force. The level of the interest rate can be related to the households' choice between consumption and saving. As the economy is growing by 2 per cent per year, household consumption is also growing by 2 per cent per year, which, in turn, leads to an interest rate level that is constant over time. The interest rate level will then depend on the long-term

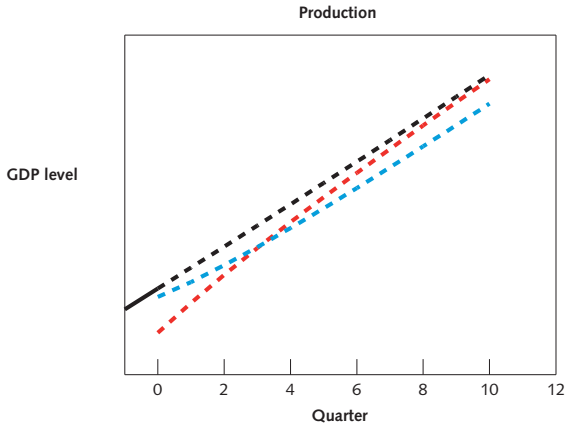
9 A change of the total factor productivity means that the output level changes, even though the use of labour, capital and other inputs remain constant.

10 In this section, we use a simple New Keynesian DSGE model, similar to the model described in chapters 2 and 5 in Gali (2008) (see appendix). The economic environment is very simple: we analyse a small, open economy in which the labour force is the only factor of production.

growth rate and on household impatience. A long-term growth rate higher than 2 per cent will mean that the interest rate will rise. As households prefer a smooth consumption level over time, a higher expected growth rate means that household demand for loans will increase: by borrowing money today, households can immediately start to translate their expected future increase in income into higher consumption. This increased demand for loans will, in turn, drive up the real interest rate.

The blue and red lines in Figure 1 show the effect on the natural interest rate of a negative disturbance to productivity impacting the economy. The red line shows the effect of a temporary disturbance that lowers the economy's potential growth rate for a limited period.[11] The effect on the economy's potential output level is shown in Figure 2. Initially, GDP develops according to the solid black line. Before the temporary disturbance affects productivity, firms and households expect the potential GDP level to continue to grow according to the dashed black line. Instead, in period 1, labour productivity falls quite steeply, and, consequently, the potential level of GDP also falls, as shown by the red line in Figure 2. However, this fall in GDP is temporary, and, after the disturbance in period 1, the potential growth rate becomes slightly higher than 2 per cent. In the long term, the economy is expected to recover from the entire fall in output level.

Figure 2. Impact on potential output level of an unexpected change of productivity



The black dashed line shows private-sector expectations, in period zero, of the potential output level ten quarters ahead. The blue and red dashed lines show expectations in period one, following a temporary (red line) and permanent (blue line) disturbance to productivity.

The real interest rate is a forward-looking variable, and consequently, to understand the results of the model, it is important to understand how the households in the model form expectations of future developments. When households make their consumption and savings decision, they base their choice on the real return they expect to receive today and in the future. We also assume that households understand how the model economy works.

11 Potential output level here refers to the production level in an economy with flexible prices.

Households have what are known as rational expectations. After a productivity disturbance has taken place in the first period, the households realise that GDP and consumption will grow faster than 2 per cent for a number of years, as the economy gradually returns to the long-term growth path. This higher expected growth rate means that households have a strong incentive to borrow against future income, which, in turn, initially pushes up the interest rate. When the economy later approaches the long-term growth rate, consumption growth is more in line with the long-term growth rate, which, in turn, means that the natural interest rate approaches its long-term level of 2 per cent.

If, instead, the economy is impacted by a negative, permanent productivity disturbance, the effect on consumption and interest rates will be quite different. The blue dashed line in Figure 2 illustrates that the initial fall in output is smaller[12] than when the disturbance is temporary. However, the growth rate continues to be comparatively low for a couple of years, with no expectation of reaching the old growth path. After a couple of years, the potential growth rate again reaches about 2 per cent, but the potential output level is permanently lower than households and firms had expected before the disturbance occurred.

The effect on the natural interest rate (the blue dashed line in Figure 1) is a direct consequence of households' expectation that the growth rates of GDP and consumption will be lower than 2 per cent for the next few years. The lower expected growth rate means that households' incentive to borrow against future income becomes weaker, which, in turn, pushes the interest rate down. Eventually, the interest rate gradually rises back towards its original equilibrium level, as the potential growth rate returns to 2 per cent.

The conclusion of this analysis is thus that the effect on the natural interest rate of a disturbance to productivity depends on whether the disturbance is expected to have temporary or permanent effects. We have used a highly stylised model. In a more realistic model, for example one including capital, the effects on the natural interest rate will be slightly different.[13]

FISCAL POLICY: INCREASED GOVERNMENT SPENDING

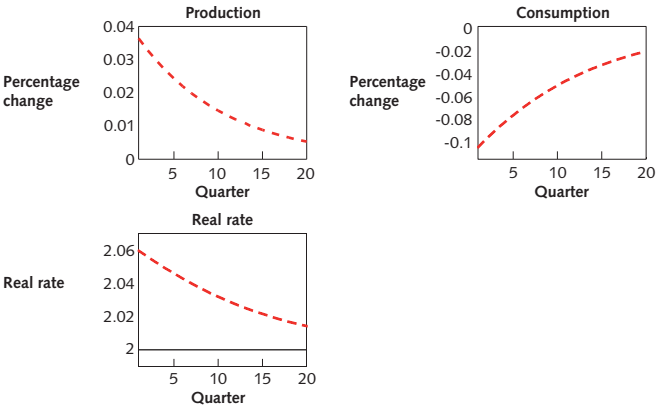
When a government formulates its fiscal policy, one of its objectives may be to stabilize resource utilisation. So how is the natural interest rate affected by an increase in public expenditure? In the simple model we are studying here, it has been assumed that the public sector uses a portion of output for government spending. Household consumption is equivalent to GDP minus government spending and net exports. An increase in government spending is modelled as an unexpected increase in the proportion of total output utilised for government consumption. The disturbance occurs in period 1, and entails an increase in the public sector's share of GDP, and also that this share is expected

12 This less severe initial fall is due to the fact that the permanent disturbance initially is fairly small. The disturbance does not reach full effect until several quarters later.

13 See also Jonsson (2002).

to be higher than normal for a number of years. However, over time, government spending as a share of GDP falls back to the level prevailing before the disturbance occurs.

Figure 3. Effects on potential GDP, consumption and the natural interest rate of an unexpected change in government spending



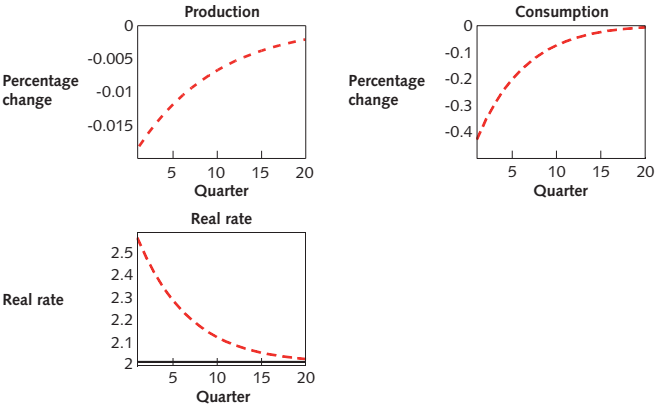
The vertical axis in the figure for GDP and consumption shows the percentage deviation from the long-run output and consumption levels. The scale on the vertical axis in the figure for the real interest rate is in percent per year.

The effects on Swedish GDP, consumption and the real interest rate of an increase in government spending are shown as the red dashed line in Figure 3. The upper left figure shows how the output level changes in relation to the long-run output level of the economy (steady state in the stationary model). The increase in government spending leads to an increase in aggregate demand, contributing to an increase in GDP. The utilisation by the public sector of a larger portion of total output means that private consumption becomes lower in relation to the initial position, as the increase in public expenditure via increased taxes reduces the private sector's scope for consumption. However, as the disturbance dissipates, both public and private consumption return to the levels expected before the disturbance occurred. One consequence of this is that private consumption is initially low in relation to its long-term level. Households' willingness to smooth consumption thus pushes up the demand for loans, in turn also pushing interest rates up. After a while, the increase in government spending goes down, and consumption and the natural interest rate thus return to their long-term levels.

LOWER FOREIGN GDP

In this section, we analyse the effects on the domestic economy of an unexpected fall in foreign GDP. The international financial crisis and its effects on Sweden's foreign trade have dramatically illustrated the Swedish economy's dependence on foreign countries. The effects of a fall in foreign GDP on Swedish GDP, consumption and the real interest rate are shown as a red dashed line in Figure 4.

Figure 4. Effects on potential GDP, consumption and the natural interest rate of an unexpected change in foreign GDP



The vertical axis in the figure for GDP and consumption shows the percentage deviation from the long-run output and consumption levels. The scale on the vertical axis in the figure for the real interest rate is in percent per year.

When output falls abroad, foreign demand for domestically-produced goods also falls. This leads, in turn, to a fall in domestic output and consumption.[14] As in the case of a disturbance of government spending, this lower current consumption means that households expect more rapid growth in their consumption in the future. Households' willingness to maintain a smooth level of consumption thus pushes demand for loans upwards for a period, and thus also pushes the natural interest rate upwards. There is an indirect positive relationship between the natural interest rate abroad and the natural interest rate in Sweden – falling output abroad pushes down consumption abroad, which, in turn, increases the natural interest rate abroad. Conversely, a fall in the natural interest rate abroad entails a fall in the natural interest rate in Sweden.

INCREASED PRECAUTIONARY SAVING

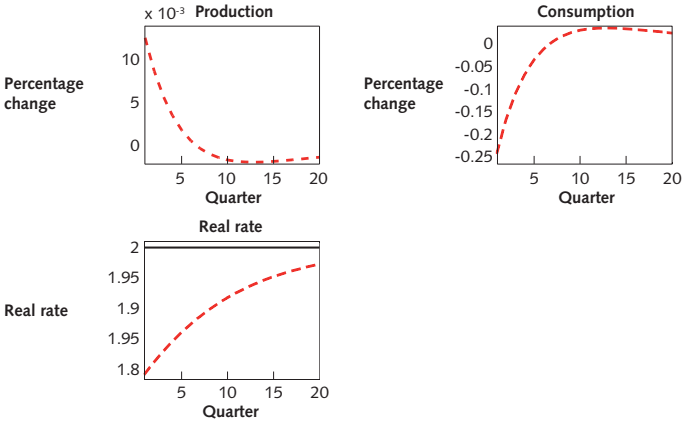
In times of economic uncertainty, there may be reason for households to increase their savings. For example, consumption fell sharply during the international crisis of 2008, when the economic situation was more uncertain than normal. Recessions normally also entail lower demand for labour, which can impact individual households via unemployment, temporary dismissals and other risks affecting income from work.[15] Here, we carry out

14 Among other factors, the mechanism described here depends on households' preferences: if the model's parameters assume other values, the effect on domestic production, consumption and thus the real interest rate can be the reverse.

15 The models we have used for our analysis in this section do not allow any formal analysis of how uncertainty affects decisions by households and firms. The method most frequently used to analyse monetary policy models entails linearising the model's equations around the model's steady state. One characteristic of this linear model is that agents only take account of the expected future values of the stochastic variables affecting their decisions; uncertainty concerning these variables that are captured by second-order terms or higher are not taken into account. On the other hand, the effect of households temporarily becoming more patient can be analysed.

a simplified analysis of such risks by studying the effects of a reduction in household impatience.

Figure 5. Effects on potential GDP, consumption and the natural interest rate of an unexpected fall in households' willingness to consume today



The vertical axis in the figure for GDP and consumption shows the percentage deviation from the long-run output and consumption levels. The scale on the vertical axis in the figure for the real interest rate is in percent per year.

A temporary fall in households' willingness to consume today temporarily pushes consumption down. As consumption propensity is low in times of crisis, households will wish to increase their saving. In turn, the reduced net demand for loans will push the real interest rate down.

Concluding remarks

How monetary policy affects the economy depend on the relationship between the level of the actual real interest rate and that of the natural interest rate. The usual starting point is that monetary policy is characterised by its effect on resource utilisation. We call a monetary policy 'contractionary' if, in the medium term, it is expected to result in resource utilisation below the normal level, while a monetary policy that leads to resource utilisation above the normal level is called 'expansionary'. In this perspective, the definition of what constitutes a normal level of resource utilisation is central to the question of how monetary policy should be assessed. Here, we have used the New Keynesian definition of normal resource utilisation. The potential or 'natural' output level and growth rate are those that would prevail if all prices and wages were fully flexible. The sluggishness of price and wage formation normally give rise to a difference between actual GDP and the actual growth rate, on one side, and natural GDP and the natural growth rate on the other. These differences imply deviations in resource utilisation from its normal level.

Just as nominal sluggishness gives rise to differences between actual and natural GDP, a difference also arises between the actual real interest rate and the real interest rate that

would arise if prices and wages were flexible – the natural interest rate. In other words, the natural interest rate is the interest rate that is compatible with a normal level of resource utilisation. If the central bank equates the actual real interest rate with the natural interest rate, resource utilisation can be expected to be normal. An actual real interest rate that is lower than the natural interest rate means that actual GDP will be higher than natural GDP, so that resource utilisation will be higher than normal. When the central bank sets the actual real interest rate below the natural interest rate, monetary policy can thus be said to be expansionary. Conversely, an actual real interest rate above the natural interest rate leads to resource utilisation being lower than normal. Monetary policy is then contractionary.

It could be asked in which way the definition of the natural interest rate contributes towards a constructive discussion on monetary policy. After all, whether a particular announced monetary policy is expansionary or contractionary can be determined through an examination of the forecast for resource utilisation and inflation included in the announced policy.

The definition of the natural interest rate is reminiscent of an important insight supplied by New Keynesian theory. The level of the real interest rate that is compatible with a normal level of resource utilisation varies over time. The efforts of a central bank to normalise resource utilisation in a given situation is thus not the same thing as that central bank's efforts to bring the interest rate to a certain average, constant level. The level of the real interest rate that is compatible with a normal level of resource utilisation is, instead, highly dependent on the currently prevailing macroeconomic circumstances.

A problem is the significant difficulties associated with each estimation of the natural interest rate. It is often difficult to rapidly and correctly identify the disturbances affecting the economy. As we have seen above, a change in productivity (for example) can have completely different effects on the natural interest rate, depending on whether this change is temporary or permanent. A closely-related difficulty is formed by what is known as model uncertainty. Results from the scientific literature indicate that different economic models give different predictions of how the natural interest rate is affected by different disturbances. Empirical studies of the natural interest rate in other countries also seem to produce quite varied views of the natural interest rate.[16]

Another important aspect deals with the difference between the real interest rate at present and the private sector's expectations of future real interest rates. New Keynesian theory usually assumes that all households and firms take conscious and fully-informed decisions. One result of this is that expectations of future developments play an important part in most economic decisions. Instead of only talking about the natural interest rate, it is thus often appropriate to consider the expected path for the natural interest rate.

16 See, for example, Andres, Lópes-Salido & Nelson (2008), who estimate the natural interest rate for the United States and compare with other studies.

Appendix. Permanent output disturbances in Gali's model

In this appendix, we describe how permanent productivity disturbances or shocks can be added to a model that closely follows Gali (2008).[17] In a model with permanent productivity disturbances and a growing technology trend, such as the one we analysed in section 2, certain variables such as output and real wages, for example, will increase over time. The growing variables are 'detrended' by dividing the variables that grow over time in the model by the (growing) level of technology Z_t. This lets us calculate, for example, output Y_t in terms of what is known as output in efficiency units Y_t / Z_t, which is constant over time.[18] The difference between the model in Gali and a model with permanent disturbances in technology is that the consumers choice between consumption and saving – what is known as the Euler equation – is modified. Without permanent technology shocks, this is:

$$c_t = E_t(c_{t+1}) - \frac{1}{\sigma}(r_t - \rho_t), \qquad \text{(A1)}$$

where c_t is aggregate consumption in period t, $E_t(c_{t+1})$ consumers' expectations in period t of consumption in the next period, r_t the real interest rate, σ (the inverse of) the intertemporal substitution elasticity and ρ_t a parameter that captures individuals' subjective time preference. In a model with permanent technology shocks[19], the Euler equation instead becomes:

$$c_t = E_t(c_{t+1} + z_{t+1}) - \frac{1}{\sigma}(r_t - \rho_t), \qquad \text{(A2)}$$

where $z_{t+1} = \log\frac{Z_{t+1}}{Z_t}$. Individuals also decide how to allocate time between leisure and work. Specifically, individuals choose leisure and work so that the price of leisure – real wages – is equal to the marginal rate of substitution between work (which provides more consumption) and leisure:

$$w_t - p_t = \sigma c_t + \varphi n_t, \qquad \text{(A3)}$$

where w_t is wages, p_t the price level, n_t hours worked and φ (the inverse of) the elasticity of the number of hours worked with regard to changes in real wages – the Frisch elasticity.

17 See Gali (2008), chapters 2 and 5.

18 In a model without capital, the (non-logarithmic) production function is $Y_t = A_t Z_t N_t$, in which A_t is a technological process with a constant trend, Z_t is a technological process with a growing trend and N_t is hours worked. As GDP has a growing trend but hours worked are constant in the long run, we rewrite the production function in terms of efficiency units as $Y_t / Z_t = A_t N_t$.

19 In a standard model, the (non-logarithmic) Euler equation (compare with (7) in Gali) is given by $(C_t)^{-\sigma} = \beta E_t\left[(C_{t+1})^{-\sigma} R_t\right]$ where C_t is aggregate consumption, β households' subjective discount factor and R_t the real interest rate. As consumption grows over time, we rewrite this as $(C_t / Z_t)^{-\sigma} = \beta E_t\left[(C_{t+1} / Z_{t+1} * Z_{t+1} / Z_t)^{-\sigma} R_t\right]$ We allow the discount factor to be time-varying and let $\rho_t = -\log\beta_t$.

Capital is ignored in the model, and output y_t is then given by:

$$y_t = a_t + n_t, \tag{A4}$$

where a_t is a temporary output shock.
Firms maximise their profits, and set prices and determine employment so that labour costs – the real wage – are the same as workers' marginal product:

$$w_t - p_t = a_t - n_t, \tag{A5}$$

In addition, the economy is open and the model thus includes foreign trade. Aggregate consumption then consists of goods produced both in the country and abroad. In the model, households also have the possibility of investing in domestic and foreign bonds. In normal New Keynesian models, individuals' choice of foreign and domestic assets gives an interest rate parity condition in terms of nominal exchange rates and interest rates. As we are analysing a model with flexible prices and wages, we instead obtain an interest rate parity condition in terms of the relationship between changes in the real exchange rate q_t, the real interest rate differential between Sweden and the rest of the world, and a risk premium that depends on the net asset position b_t towards the rest of the world:

$$E_t q_{t+1} - q_t = (r_t - \rho_t) - (r_t^* - \rho^*) + \varepsilon^b b_t, \tag{A6}$$

where r_t^* is the real interest rate abroad and ε^b describes the sensitivity of the real exchange rate to changes in the net asset position.[20] The net assets depend on yesterday's net asset position and net exports x_t:

$$\kappa b_t = b_{t-1} + x_t,$$

where κ is a constant. In turn, net exports depend on gross exports which closely follow foreign GDP, y_t^*, and gross imports which are determined by domestic consumption and the real exchange rate:

$$x_t = y_t^* + (\eta - \frac{1}{1-\alpha})q_t - c_t, \tag{A7}$$

where α is the share of imports and η is the degree of substitutability between domestically produced goods and imported goods. The resource constraint of the economy is given by

$$y_t = (1-\alpha)(1-\bar{g})c_t + \alpha(1-\bar{g})y_t^* + \alpha(1-\bar{g})\left[\frac{\gamma}{1-\alpha} + \eta\right]q_t + \bar{g}\, g_t, \tag{A8}$$

20 In the model, we use the Euler equations at home and abroad so that (A6) becomes
$E_t q_{t+1} - q_t = \sigma(E_t c_{t+1} - c_t) - \sigma(E_t y_{t+1}^* - y_t^*) + \varepsilon^b b_t$.

where g_t is government spending, γ is elasticity between imported goods and $\bar{g}$ is the average share of government spending out of GDP. The model then consists of the equations (A2)-(A8).

The two productivity shocks follow the processes:

$$z_t = \rho_z z_{t-1} + \eta_t^z,$$

$$a_t = \rho_a a_{t-1} + \eta_t^a,$$

where ρ_z and ρ_a are the degree of persistence in the shocks and η_t^z and η_t^a are innovations. Foreign GDP, government spending and individual's subjective time preference follow the processes:

$$y_t^* = \rho_y y_{t-1}^* + \eta_t^y,$$

$$g_t = \rho_g g_{t-1} + \eta_t^g,$$

$$\rho_t = \rho_\rho \rho_{t-1} + \eta_t^\rho,$$

where ρ_y, ρ_g and ρ_ρ are the degree of persistence in the shocks and, η_t^y, η_t^g and η_t^ρ are innovations.

When calculating the effects of the different shocks, we set the intertemporal substitution elasticity $1/\sigma$ to 1 (in the case of productivity shocks) or 0.3 (in other cases), labour supply elasticity $1/\sigma$ to 1 and the import share α to 0.4, elasticity between imported goods γ to 1 and the proportion of government spending $\bar{g}$ to 0.2. In addition, we set the risk premium parameter ε^b to 0.01, the degree of substitutability between domestically-produced goods and imported goods η to 4 and κ to 0.9999 (in the case of productivity shocks) or 0.995 (in the other cases). We set the persistence parameters in both productivity shock processes to $\rho_a = 0{,}8$ and $\rho_z = 0{,}7$. We also determine the long-term growth rate and households' time preference so that the real equilibrium interest rate is two per cent over the long term. The persistence parameter in the shock processes to foreign GDP is 0.86, in government spending 0.9 and in individuals' subjective time preference 0.8.

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Markets for Swedish non-financial corporations' loan-based financing

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This study aims to describe the Swedish non-financial corporations' debt-financing markets and discusses the future development of them. Numerous media reports and articles from financial analysts in the last couple of years have argued that structural changes are taking place. Corporations in Europe are said to be moving away from taking bank loans towards issuing corporate bonds, a development which started during the recent financial crisis.

This trend has not been clearly seen in available statistics for the Swedish debt markets following the crisis. However, Swedish banks and financial institutions have started preparing for a growing demand for Swedish corporate bonds. At the same time, many Swedish corporations have shown interest in expanding into the corporate bond market. However, numerous issuers, investors and intermediaries state that the Swedish corporate bond market is underdeveloped. They argue that transparency and liquidity in the market is poor. Also they argue that the available statistics for corporate bonds and loans are insufficient.

The new Basel III banking regulations are expected to increase the price for bank loans to corporations and to decrease the supply. Due to these changes, the Swedish corporate bond market may become more important for Swedish corporations' financing. Steps to develop the market may thus now be relevant. A more efficient corporate bond market may be a positive development for the Swedish financial markets. It could improve the efficiency of financial intermediation, better determine the price of credit risk in different maturities and increase the diversification options for Swedish corporations' financing. Further work is however needed to be able to develop an efficient Swedish corporate bond market.

1 We would like to thank Anders Nordberg, Daniel Sachs, David Forsman, David Kjellberg, Lars Nyberg, Lena Strömberg, Mia Holmfeldt and Sofia Kåhre for their useful comments, as well as the Swedish debt market participants that we have interviewed.

Changing markets

The majority of Swedish non-financial corporations' debt financing comes from bank loans. Apart from bank loans, Swedish corporations also use the money and bond markets locally and globally to obtain funding. The debt financing situation for Swedish non-financial corporations is therefore affected by the development of the credit markets. During the recent financial crisis, banks around the world became less willing to lend to corporations (Chui et al., 2010). Due to that fact, issuance activity in the global corporate bond markets increased substantially during the crisis. It increased especially in 2009 as corporations looked for alternative financing for bank loans (Fitch, 2010). Swedish corporations, for example, issued large amounts of corporate bonds in the euro market in 2009. Banks' lending to corporations has now recovered from the crisis.[2] On the other hand, new regulations may affect the loan market again in the near future. This will affect Swedish corporations and may lead to some structural changes in their debt financing.

Corporations are important for a country's economic prosperity and their access to financing is crucial for their operations. Efficient financial markets are therefore important for a country's economy, corporations' risk management, market efficiency and even the financial stability of the country. As an example, the absence of an efficient local debt market may force corporations to depend on borrowing from foreign lenders. This would imply a higher degree of currency risk since earnings and investments would not be denominated in the same currency as borrowing. Alternatively, companies may only have access to more short-term loans in the local currency, causing a higher degree of interest rate and refinancing risk for them (BIS, 2007).

Structural changes expected in Swedish non-financial corporations' debt financing will impact the Swedish financial markets. Therefore it is important to follow these changes.[3] With the above as a background, we wanted to investigate further the Swedish corporations' debt financing markets and obtain a better picture of the market situation.

In the first section, we map the markets for Swedish corporations' debt financing. This includes a description of instruments and an overview of statistics for the Swedish debt markets, i.e. bank loans and fixed-income instruments. In the second section, we analyse the debt markets. Issues discussed are new regulations that may impact Swedish corporations' debt financing, possible structural changes to debt financing, and market actors' views of debt financing and future developments. The analysis is mainly built on interviews with market participants and a survey which was sent out to corporations

2 Although, the growth of lending has not returned to pre-crisis levels yet.
3 Hereafter, we refer to Swedish non-financial corporations when we say Swedish corporations.

in March 2011.[4] Finally, we discuss how the Swedish corporate bond market can be developed.

Mapping the debt markets

SWEDISH NON-FINANCIAL CORPORATIONS' DEBT FINANCING

When discussing Swedish non-financial corporations' debt financing, we are referring to bank loans, corporate bonds and commercial paper. In this section, we give a basic description of these instruments, including a cost comparison of bank loans and corporate bonds.

Bank loans

A bilateral loan is provided to a borrower by one lender. Smaller corporations usually use bilateral loans as their main debt-financing source. According to the market participants, these are often called relationship loans. This is due to the fact that the lending banks have built customer relationships with the corporations over the years. The corporations then often feel secure in obtaining funding from their bank, based on their past relationship.

A syndicated loan is provided to a borrower by more than one lender. This enables large corporations to get credit in excess of a single bank's loan limit. Syndicated loans are traded on the secondary market and therefore have some resemblance to corporate bonds (Altunbas et al., 2009).

In addition to traditional term loans, corporations often have credit facilities in place, which are loan programmes that are drawn on by request. Some of the credit facilities are only meant to be used in cases of emergency, while others are used as overdraft facilities.

Fixed income securities

A corporate bond is a debt instrument issued to investors in the bond market, with a maturity of a year or more. There is a minimum size limit for issuing in the bond market (often 250 to 500 million kronor on the Swedish market). Issuing corporate bonds is thus more attractive to larger and medium-sized corporations. Usually, when a Swedish corporation issues a large bond, this is a syndicated bond, with two to five banks participating in the issuance.[5]

4 As the purpose of this study was to obtain a broader picture of the Swedish markets for bank loans and corporate bonds, we met with several market participants to help form our views. We interviewed banks, corporations and investors. We met with NASDAQ OMX Stockholm, where corporate bonds are registered. We met with representatives for the initiative to develop the Swedish corporate bond market, and with Svenskt Näringsliv (Confederation of Swedish Enterprise), which is to participate in developing the corporate bond market. We also attended seminars at which the bank loan and corporate bond markets were discussed by market participants and regulators. In addition, we sent out a survey in March 2011 to a number of Swedish corporations to get a better understanding of the markets. The survey results were published separately on the Riksbank's homepage in September 2011 (Sveriges Riksbank, 2011).

5 According to interviews with the Swedish banks.

A commercial paper is a short-term debt instrument issued in the money market, with a maturity of less than a year. It is thus similar to a corporate bond but with shorter maturity.

Cost of taking bank loans versus issuing bonds

The Swedish non-financial corporations mainly look at the cost of financing when deciding on a financing source. On the other hand, for various reasons, it is generally difficult to compare the cost of taking bank loans or issuing bonds. For example, there is not much public information available on the prices that individual Swedish corporations pay for their debt financing.

The interest rate cost of a corporate bond is a market price, but the interest rate cost of a bank loan usually differs depending on the corporation's business relationship with the lending bank. If the company also does other business with the bank, such as foreign exchange deals, swaps, deposits etc., the bank often takes this into account when pricing a loan. If the corporation does a lot of business with the bank, it can get a very good price. Larger, well rated, Swedish corporations can, for example, often get a lower price for their bank loans than the lending bank can obtain for its own funding on the market.[6]

With a bond, you pay the same interest rate over the lifetime of the bond, which is negotiated at the beginning, fixed or floating rate plus issuance fees. For a bank loan, on the other hand, the interest rate cost plus other costs can be variable, depending on when you take the loan and how much of the loan programme or credit facility the corporation uses.

Another factor that lenders usually look at when determining the price of a loan or a bond is the credit quality of the corporation. Credit rating agencies give corporations, and sometimes the debt, an official credit rating. This is usually preferred by bond investors – however, it is costly to attain for corporations.[7] With bank loans the lending bank itself estimates an internal credit rating for the corporation. These two ratings can differ. Banks may take other things into consideration compared with the rating agencies, such as the size of the corporation and the relationship history the bank has with it.

The administrative costs are more extensive when issuing bonds, compared to taking bank loans. As an example the documentation requirements are higher.[8] The cost of listing

6 According to interviews with the Swedish banks and corporations.

7 The yearly cost of having a credit rating from one rating agency is about 2 million Swedish kronor. In addition, someone needs to take care of the dialogue with the rating institution, which is an additional cost (according to interviews with market participants).

8 When taking a bank loan, the corporation has to sign a loan document. Banks do not charge for loan documentation, but the documentation cost is associated with having an external lawyer examine the contract. To issue a bond, the corporation needs to have a bond programme in place. One can, for example, have a European medium term note (EMTN) programme for the euro market or a domestic programme for the Swedish market. Having an EMTN programme costs about 1 million Swedish kronor a year, while having a Swedish programme costs up to 100 thousand Swedish kronor a year. The corporation then needs to have a prospectus for the bond programme and to issue a form of pricing supplement when issuing. The prospectus needs to be updated once a year. The cost of this is about half a million Swedish kronor a year. When issuing a bond, the corporation usually has to undertake a road show to introduce the company to investors. Road shows are usually included in the total price for the lead bank. On the other hand, it takes time and effort for the corporation to do the road show (according to interviews with market participants).

bonds on exchange is however not high, but one has to comply with IFRS standards to be able to list the bonds. About 95 per cent of the Swedish corporate bonds are listed on an exchange, which is often a requirement from investors.[9]

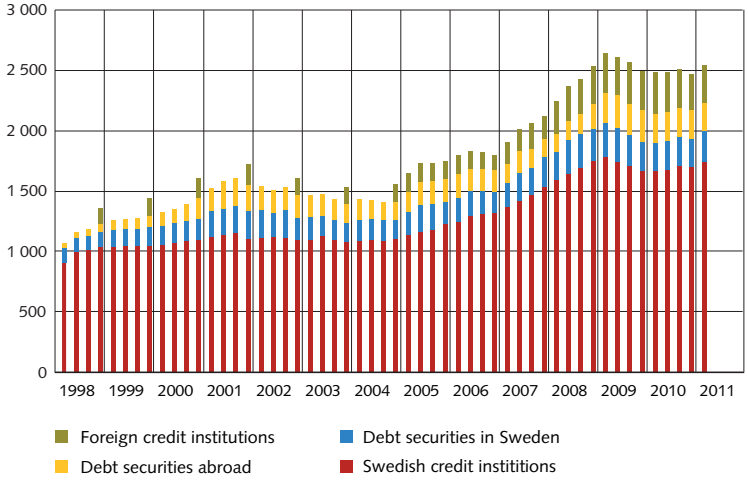
According to market participants, bank loans have generally been less costly for Swedish corporations in recent years, compared to issuing corporate bonds. This may explain why bank loans are a more popular debt financing source for corporations.

THE DEVELOPMENT OF SWEDISH CORPORATIONS' DEBT FINANCING

In this section, we focus on statistics available for Swedish corporations' debt financing.

Strong tradition and favourable prices have led to bank loans being the major debt-financing source of Swedish corporations. This is shown in the statistics from Statistics Sweden where bank loans count for about 80 per cent of the corporations' debt financing (see Chart 1). According to Statistics Sweden, Swedish credit institutions are the major lender to Swedish corporations as shown by the red columns in Chart 1. On the other hand, it is noticeable that, from 2008, outstanding market financing has increased (as represented by the yellow and blue columns in Chart 1), while outstanding bank loans decreased in 2009.

Chart 1. Outstanding debt financing of Swedish corporations
SEK billions



Source: Statistics Sweden.

According to Statistics Sweden, Swedish corporations are defined as non-financial corporations operating in Sweden. The statistics in Chart 1 include the total debt financing of the corporations, both Swedish parent companies and foreign companies' affiliates and subsidiaries operating in Sweden. Foreign affiliates and subsidiaries of Swedish corporations are therefore excluded.

9 Listing is not needed for private placement bonds (according to interviews with market participants).

Chart 1 does not include all loan-based funding as it does not show trade credits and so-called foreign direct investment loans (FDI).[10] Many Swedish corporations are part of international groups. Their borrowing within their own groups is referred to as FDI loans. These loans stand for an increasing part of the Swedish non-financial corporate sector's total financing[11], which means that their financing from abroad has been increasing. The chart therefore underestimates the foreign financing part.[12]

Statistics from Statistics Sweden do not always correspond with the information we have received from the Swedish banks and other secondary sources regarding the debt markets. The biggest disagreement seems to be on how much of the loan market is made up of syndicated loans and bilateral loans, and how much of the lending that comes from foreign banks.

In 2011 the Riksbank received the Swedish Parliament's approval to collect the data it requires directly from all market participants, even if these do not fall under the supervision of Finansinspektionen (the Financial Supervisory Authority).[13] This should improve the quality of the statistics for corporate debt in the near future.[14]

Swedish corporations' bank loans

The outstanding amount of bank loans to Swedish corporations amounted to 2001 billion Swedish kronor at the end of 2010.[15] Of this, 85 per cent of loans are given by Swedish credit institutions, according to Statistics Sweden. The majority of these loans are in Swedish kronor and euros.

There was a large increase in loans to corporations during the years 2003 to 2007, both in Sweden and in other Nordic countries, due to favourable conditions on the markets.[16] These loans will mature in the near future, particularly in the years 2011-2013, as can be seen in Chart 2.

10 Trade credits are the non-financial companies' foreign accounts receivable and accounts payable and they constitute a small share of the total financing.

11 According to estimations made by Sveriges Riksbank, FDI loans amount to about a quarter of total corporate financing.

12 According to Sveriges Riksbank.

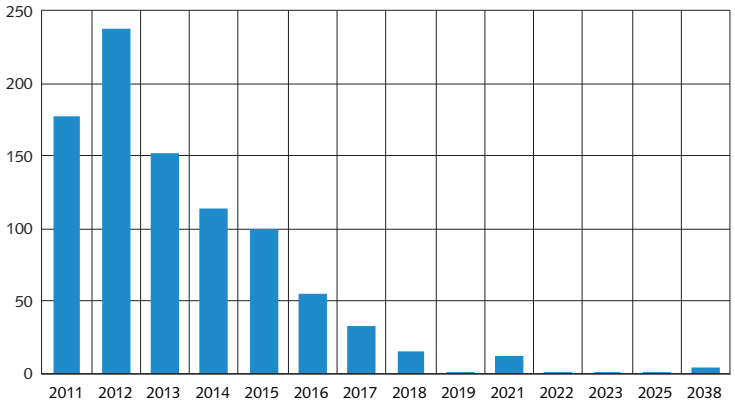
13 www.riksdagen.se. Sveriges Riksbank Act (1988:1385), amended as of 1 July 2011.

14 We have compared statistics from Statistics Sweden, Bloomberg, Dealogic and the Swedish banks. These data sources do not match each other, as these institutions may not have the same access to data or may use different definitions for Swedish corporations. Statistics Sweden, for example, obtains statistics from the Swedish banks on their lending to Swedish corporations, but does not have complete information on foreign bank lending to Swedish corporations (only a sample). Swedish corporations are not required to report their borrowing to any data source.

15 According to Nordea, 75 per cent of loans in the Nordic market are syndicated, while 25 per cent are bilateral. Statistics Sweden does not agree with this, stating that bilateral loans form the majority of loan financing for Swedish corporations (90 per cent of Swedish financial institutions' lending). On the other hand, no information is available from Statistics Sweden on the proportion of syndicated loans held by foreign financial institutions. Results from the corporate financing survey in March 2011 indicate that syndicated loans account for 38 per cent and bilateral loans for 62 per cent of the total Swedish loan market, based on a sample (Sveriges Riksbank, 2011).

16 According to interviews and reports from the Swedish banks.

Chart 2. Maturities of syndicated loans of Swedish corporations and their subsidiaries
SEK billions[17]



Source: Dealogic.

Swedish corporations' fixed-income financing

The Swedish kronor corporate bond market is small in an international comparison and is mostly dominated by large corporations. Those corporations are well known in the market and have no problem getting the financing they need, even in foreign currency markets. Outstanding amounts issued by Swedish non-financial corporations only account for about 6 per cent of the total Swedish kronor bond market.[18]

Outstanding commercial paper issued by Swedish non-financial corporations amounted to 61 billion kronor at the end of December 2010.[19] Nearly all of the issued commercial paper was issued in Swedish kronor. This market is important for corporations' short-term financing, but we do not focus especially on that market in this study. We, instead, focus on more long-term financing, which constitutes a much larger share of corporations' financing. In addition, there is not much data available on the corporate commercial paper market.

The largest and most developed market for corporate bonds in the world is the US market, where there is a strong tradition that corporations issue bonds rather than depend mainly on bank loans.[20] The euro market is not as well-developed as the dollar market and the tradition of taking bank loans rather than issuing bonds in the market is strong, as it is in Sweden (ECB, 2007). The euro market, on the other hand, has a size advantage over the

17 It is important to note that Dealogic does not cover all loans in the market since no one is required to report to them. It also does not cover small loans; therefore bilateral loans are not many in Dealogic. Chart 2 is therefore just an indication of the maturity profile of Swedish corporations. Swedish corporations will also need to renew their credit facilities which are not included in Chart 2.

18 According to Statistics Sweden.

19 According to Statistics Sweden.

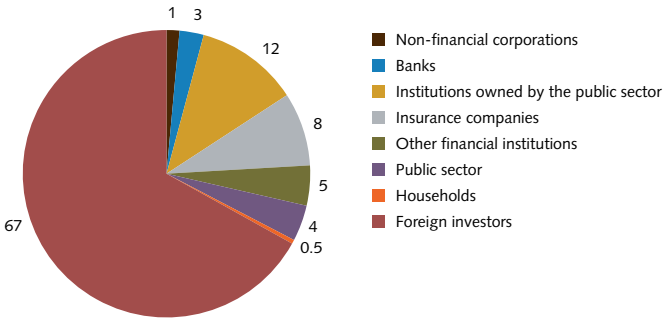
20 In the US, a largely low transparent secondary market in corporate bonds has been converted with careful regulatory and industry oversight, into a largely transparent one in the last few years. The TRACE system has been developed where individual trade information is published. Dealers have an obligation to report corporate bond deals to TRACE under a SEC-approved set of rules. This system may help the fact the US corporate debt financing is 70 per cent bond market financing against 30 per cent in bank loans. The US corporate bond market also has a strong investor base through its well-developed large money market fund market (González-Páramo, 2007).

Swedish corporate bond market, with a greater investor base, which often makes it a more liquid market than the Swedish kronor market.

The outstanding amount of bonds issued by Swedish corporations was 376 billion Swedish kronor at the end of December 2010. The majority of Swedish corporate bonds is issued in foreign currency, around 60 per cent of the outstanding total amount. The rest is issued in Swedish kronor.[21] The largest Swedish corporate bond issuers, issuing in both foreign currency and Swedish kronor, are Vattenfall, TeliaSonera, Volvo, Vasakronan and Atlas Copco. They account for more than half of the bond issuance. In total, there are about 70 Swedish corporate bond issuers.[22] Hence, it is evident that bond issuance by Swedish corporations is dominated by very large, often global corporations. Many major bond issuers have also ties to the Swedish government. They may therefore get a better credit rating, which enables them to get a better price and to have access to more investors in the markets.[23] The majority of the Swedish corporate bond issuers, on the other hand, do not have a credit rating.

The largest investor group in Swedish corporate bonds is foreign investors. They count for 67 per cent of holdings at the beginning of 2011, as can be seen in Chart 3.[24] Institutions owned by the public sector and insurance companies are the next largest investor groups in Swedish kronor corporate bonds. Retail investors (households) are not a large investor group, as the tradition in Sweden has been that private investors take credit risk in the equity market rather than in the bond market. In addition, it often requires larger amounts to be able to invest in corporate bonds.

Chart 3. Investors in Swedish corporate bonds at the beginning of 2011
Per cent



Source: Statistics Sweden.

21 According to Statistics Sweden. According to Bloomberg, 50 per cent is issued in euros, 33 per cent in Swedish kronor and 17 per cent in other currencies.
22 According to Bloomberg.
23 The ten largest Swedish corporate bond issuers according to Bloomberg are: Vattenfall 22 per cent (government owned), TeliaSonera 12 per cent (partly government owned), Volvo 11 per cent, Vasakronan 5 per cent (bought from the government in 2008, now owned by the Swedish pension funds AP fonderna), Atlas Copco 5 per cent, Investor AB 4 per cent, Ericsson 4 per cent, Sandvik 3 per cent, SCA finans 3 per cent, Akademiska hus 3 per cent (government owned).
24 According to Statistics Sweden.

The possibility for investors to invest in Swedish corporate bonds through funds has increased in recent years. Although, many institutions only offer those funds to larger investors. As an example, in Nordea's Institutionella Företagsobligationsfond, one has to invest at least one million Swedish kronor to be able to buy into the fund. Other fund companies, such as SEB Funds, Swedbank Robur, Öhman's and Case, offer corporate bond funds to retail investors, with minimum investing amount varying from 1 to 1 000 kronor.[25] Although there have been improvements, the market needs to develop further in order to make it available to more investors.

About 100 corporate bonds were listed on the NASDAQ OMX Stockholm (both issued by Swedish and foreign corporations) in 2010.[26] Listing has usually only been done to fulfil requirements of investors. There is not much trading on the exchange and the transparency of the market is poor. Trading of Swedish corporate bonds is mostly over the counter trading (OTC).[27]

Recent development of Swedish corporations' bonds

2009 was a record issuance year for Swedish corporate bonds, particularly in terms of bonds issued in foreign currency. In 2009, the euro market was very attractive to corporations in terms of pricing, and investor demand for corporate securities was good. The Swedish kronor market did not take off to the same extent as the euro market. Increased funding assistance by Svensk Exportkredit during the crisis may have impacted this (SEB, 2009) (Nordea, 2009-2011).

In 2010, the investment activity of corporations was low in Sweden and Europe. Swedish corporations had, in general, good capital bases. Many of them had for example prefunded the large bond maturities in 2010 and had positive earnings. Therefore the financing need of Swedish corporations was low, and issuance volumes were lower in 2010 compared to 2009, looking both at Swedish kronor and foreign currency financing of Swedish corporations (SEB, 2010). Swedish corporations' capital bases are still strong, although the level of issuances this year is already higher than in 2010, according to Bloomberg.

Although the issuance volumes of Swedish corporations decreased in 2010, some corporations issued bonds for the first time, such as Corem Property, Sagax, Kungsleden (real estate companies), Bonnier (media) and Mjölby-Svartådalen Energi (energy).[28] Some of these newcomers are so-called high-yield issuers.[29] According to market participants, high-yield issuance in Swedish kronor has increased substantially since 2008. Before there were no high-yield issues at all. The Swedish high-yield market is still very small, but it is

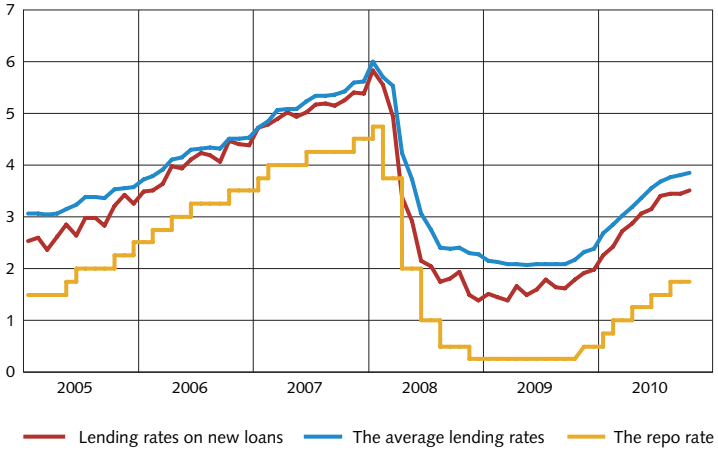
25 www.e24.se, "Företagsobligationsfonder endast för den insatta." June 2009.
26 According to NASDAQ OMX Stockholm.
27 Over the counter (OTC) trading means that the bonds are traded directly between a buyer and a seller instead of via organised exchange.
28 According to Bloomberg.
29 High-yield bonds are bonds rated below investment grade (rated BBB- or higher by credit institutions). High-yield bonds have a higher risk of default but, typically, they pay higher yields than higher-quality bonds in order to make them attractive to investors.

developing. In 2010 these amounted to 17.4 billion kronor.[30] As a comparison, the high-yield markets in the euro area and in Norway have been established for many years, as there has been more investor interest in high-yield bonds in these regions.

One reason for the increased issuance of high-yield bonds is that corporations with low ratings argue that the prices for their bank loans have increased and they are therefore seeking financing alternatives by issuing bonds.[31] To support this, Chart 4 shows that the increased average lending rates to Swedish corporations cannot only be explained by the recent increases to the Riksbank's repo rate.

The high-yield market has been expected to keep expanding during 2011, as investors search for yield in the low interest-rate environment. However, the increased financial turmoil during the summer has impacted this development, as investors prefer safe investments with low risks in uncertain times. In addition, in a longer perspective the demand for high-yield bonds may decrease if major central banks start hiking rates to a greater extent.

Chart 4. Swedish banks' lending rates to Swedish corporations
Per cent

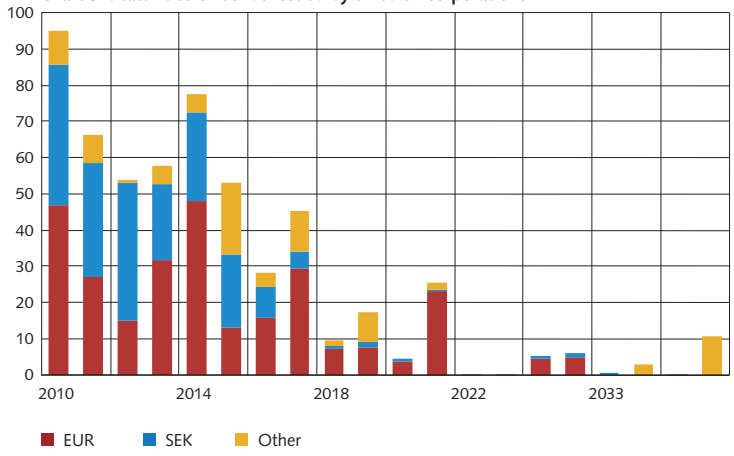


Source: Statistics Sweden.

Looking at Bloomberg's statistics in Chart 5, we see that there are relatively large bond maturities for Swedish corporations in the coming years, especially in 2014. On the other hand, the maturities in 2010 were the largest in a long time. However, it did not cause problems in the market, as many corporations had, as previously mentioned, prefunded the upcoming maturities during 2009.

30 Dagens Industri, February 2011.
31 According to news reports and Sveriges Riksbank (Sveriges Riksbank, 2011).

Chart 5. Maturities of bonds issued by Swedish corporations



Source: Bloomberg.

Alternative debt-financing sources for Swedish corporations

In addition to traditional bank loans and fixed income securities, Swedish corporations have had access to alternative financing sources or assistance. This support comes, for example, from Svensk Exportkredit (SEK), Exportkreditnämnden (EKN) and Proventus Capital Partners.

SEK's mission is to secure access to financial solutions for export companies. SEK's services include export credits, lending, structured financing, project financing and leasing, as an example. SEK has been of assistance to Swedish corporations, especially during the crisis, when it increased its lending to Swedish corporations substantially. According to SEK, its outstanding loans to Swedish corporations amounted to 49.6 billion kronor, while its loans to Swedish corporations' subsidiaries amounted to 17.6 billion kronor at the end of September 2010.[32] In addition, SEK lends to foreign corporations that buy Swedish exports, which further helps Swedish corporations' operations.[33]

EKN is commissioned by the Swedish government to promote Swedish exports and the internationalisation of Swedish companies. It does so by insuring export companies and banks against the risk of non-payment in export transactions, thereby enabling them to conduct more secure export transactions. EKN, for example, provides guarantees for export payments. During the crisis, it is also guaranteed credit/loans to corporations often issued by SEK, with which it works closely. EKN takes 75 per cent of the risk in such loans.[34] EKN has been criticised by the banks, who claim that it takes "normal" business away from the market by offering these guarantees, as it provides corporations with lower interest rates than are available on the market.[35]

32 These are both direct loans and loans via buying bonds issued by these companies.
33 www.sek.se and Svensk Exportkredit's quarterly reports.
34 As an example, Ericsson obtained a loan in 2009 from SEK with a guarantee from EKN for 4.6 billion kronor (625 million dollar).
35 Svenska Dagbladet, "Statliga EKN får från kritik", 28 July 2010.

Proventus Capital Partners has been active in the corporate market from 2005 and announced in May 2011 that they were launching a new structure. Proventus will be lending 5.3 billion Swedish kronor to medium-sized Nordic corporations that need financing, for example for acquisitions and restructuring. Institutions such as Fjärde AP-fonden, Folksam and Länsförsäkringar are co-investors with Proventus Capital Partners.

Analysis of the debt markets

NEW REGULATIONS AFFECTING SWEDISH CORPORATE DEBT FINANCING

Basel III

The Basel III banking regulations will require banks to hold more capital of better quality and at the same time improve liquidity. The regulations will be introduced step by step over the coming years, starting in 2013. However, due to market pressure, the banks may be forced to comply with the rules earlier. It is difficult to estimate the effects of the regulations, as they impact different parts of the banks' operations and also due to the long implementation period from 2013-2019. According to the Riksbank, the four major Swedish banks already have sufficient capital to fulfil the new capital requirements.

However, analysing the effects of the new liquidity rules is more challenging. The banks have to improve their Net Stable Funding Ratios[36]. This can be done in many ways, for example by changing the conditions for deposit accounts, by reducing commitments and assets requiring stable funding, and by extending short-term funding to long-term funding. With greater liquidity buffers, banks will generate a lower return than they would if they had kept other assets instead. Also, by increasing the maturity of their funding, banks usually have to pay higher interest rates for their borrowing. The banks can pass on the increased costs to their customers, for example by increasing lending spreads or charging higher fees for their services. The Swedish banks may also choose to decrease the lending or try to lower the maturities on the loans they provide and to decrease the size of credit lines.

Depending on how the banks will act, the new regulations may impact corporations directly with lower corporate loan supplies, higher borrowing rates and increased refinancing risk. Alternatively, the banks' shareholders may accept a profitability that corresponds to the lower risk. That implies that the banks do not have to pass on the new costs fully to the customers.

36 The Net Stable Funding Ratio (NSFR) requires a bank's stable funding to be greater than the bank's need for stable funding. The NSFR specifies the percentage of different types of debt that are considered to be stable and the percentage of the various assets that are considered to need stable funding. For example, securities issued with a maturity of more than one year and deposits with a maturity of more than one year are classified as 100 per cent stable funding, while loans from financial firms maturing in less than one year are not considered to provide any stable funding (Sveriges Riksbank, 2010).

Solvency II

Through their significant holdings of financial assets, insurance companies, particularly life insurance companies, form an important part of the financial system. The Solvency II regulations will likely enter into force in the spring of 2014. These regulations may significantly change the investment strategies of insurance companies. They may, in turn, impact financial markets (Sveriges Riksbank, 2010).

The current solvency capital requirement of life insurance companies is mainly based on the size of the companies' commitments. Under the new Solvency II regulations, the capital requirement will be based on the insurance risk existing in the insurance companies' operations and on the risks arising when these companies invest in financial assets. It is presently unclear how large the solvency capital requirement will be for the insurance companies under Solvency II. If their capital base is less than the new solvency capital requirement, they will have to reduce their risk. They can do that by increasing investments in financial assets with the lowest capital requirement, which are government bonds and covered bonds. At the same time, they can reduce their holdings of other financial assets. According to a Bank of International Settlements (BIS) report, Solvency II will make it more difficult for insurance companies to play their traditional role as global providers of long-term risk capital. The proposed changes will, for example, tend to make it more expensive for them to hold low-rated corporate bonds (BIS, 2011).

At present, the Swedish insurance companies hold about 8 per cent of bonds issued by Swedish corporations, corresponding about 25 per cent of outstanding Swedish kronor bonds. There is still uncertainty regarding Solvency II but at present, the rules do not encourage insurance companies to invest larger amounts in corporate bonds. At the same time, many say increased investment by insurance companies is crucial for the further development of the Swedish corporate bond market. In addition, according to the proposed regulations, it may be better for some corporations not to have a credit rating. This is because it will be more advantageous for insurance companies to invest in non-rated companies than in corporations with lower ratings than BBB, i.e. companies with high-yield bonds.[37]

Markets in Financial Instruments Directive (MiFID)

The European Commission has proposed to increase the transparency of the corporate bond market within the framework of MiFID. According to the proposal, the key rationale for transparency is to provide investors with access to information about current trading opportunities, to facilitate price formation and to assist firms in providing the best execution for their clients. It will provide information that enables users to compare trading

37 Danske Markets, June 2011. Companies can then, for example, have the rating institutions give them a secret rating, just to know at what level they would be rated. If this level is not satisfying, they can choose not to be rated publicly.

opportunities and results across trading venues. Post-trade transparency is also used for portfolio valuation purposes (European Commission, 2010).

MiFID is set to be adopted in Sweden in the next few years. Post-trade transparency is to be increased by making the International Securities Identification Number (ISIN) codes, coupons, maturities, ratings, issuers, currencies, prices, volumes and so on of all trades public. Although, some exceptions to the rules may be made. By implementing the MiFID regulations, the hope is that more issuers and investors will be interested in the Swedish corporate bond market, resulting in increased liquidity.

However, not everybody agrees that increasing transparency will only be a positive development. In a small market like the Swedish corporate bond market, it may, instead, be inhibiting. This is because the number of issuers and investors and the size of the bonds are small. So, with these regulations, it may be possible to figure out more information than is needed for the market to function well according to some. This is an argument mostly made by banks. They are worried that the increased transparency might reveal market makers' positions. This may result in unfavourable prices for the market makers, who may become unwilling to take on some positions. Today, market makers often have a head start when it comes to see what happens in the market. If all have access to market information and volumes at the same time, the risks for those who buy and sell on their own behalf increases (Nyberg et al. 2006). This may, in turn, lead to fewer being interested in being market-makers, which could decrease liquidity in the market.

There are therefore different views on how the proposed MiFID regulation will affect the Swedish corporate bond market.

STRUCTURAL CHANGES TO THE SWEDISH CORPORATIONS' DEBT FINANCING?

Based on the above overview of Swedish non-financial corporations' debt financing, it is clear that some structural changes may be forthcoming in the near future. The Swedish corporations will be facing large maturities on both the loan and the bond markets. And with the Swedish economy recovering, they may want to invest more. This implies that the corporations probably will have large financing needs in the nearest future, even though their capital base now is strong. At the same time, the supply of loans to corporations may become more limited or at least more expensive under the Basel III regulations. A new period of global financial turmoil may also cause banks to hold back on lending to corporations.

The Swedish banks are well-capitalised. They should therefore not need to decrease the loan supply to Swedish corporations to a large extent in order to comply with the Basel III regulations, although they may want to decrease the maturities of the loans.[38] However, the price for the loans may increase with the new regulations.

38 Swedish banks have stated that they should not have problems in extending the loans given to corporations when they mature.

Nevertheless, it needs to be kept in mind that foreign banks also stand for a certain share of Swedish corporations' bank loans.[39] On average, foreign banks' capital positions may not be as strong as those of the Swedish banks (Peters, 2011). There is therefore a risk that the foreign banks may not be able to continue lending as much as previously to corporations outside of their country, according to the Swedish banks. If foreign banks, on the other hand, renew the loans, they will, at least, be likely to demand a higher price for the loans due to the new regulations and because Swedish corporations often do not do any other business with them. If lending from foreign banks decreases or becomes too expensive, Swedish corporations will likely turn to the Swedish banks instead. There will then be a risk that demand will exceed the Swedish banks' ability to lend to the corporations. The corporations may therefore need to seek other financing sources.

When bank loans became limited during the crisis, corporations started issuing corporate bonds to a greater extent as an alternative financing source to bank loans (European Commission, 2010). Under the upcoming regulations, the change from loans to bonds for corporations may thus become more permanent with less supply of and increased prices for the loans (unless some other financing source, such as equity, is more attractive).[40] We believe bank loans will, on the other hand, remain the number one debt-financing source of corporations, especially credit facilities.[41]

No clear trend has yet been seen in statistics for suggesting that Swedish corporations are moving from taking bank loans to issuing bonds, even though there has been some increased interest in high-yield Swedish corporate bonds. There have, however, been numerous news reports discussing this trend in the last couple of years. Swedish banks and financial institutions have, on the other hand, started preparing for a growing demand for Swedish corporate bonds as the implementation of the Basel III regulations gets closer. For example, during the spring, some of the major Swedish banks have expanded their departments responsible for managing corporate bond issuance. In addition, a few smaller financial institutions have developed departments focusing on the corporate bond market.[42]

39 Nordea, SEB and Statistics Sweden disagree on how large the share held by foreign banks is, as they disagree on how large the syndicated loan market is. As an example, Nordea says syndicated loans form 75 per cent of the total Nordic loan market, while Statistics Sweden indicates that they form no more than around 23.5 per cent of the total Swedish market with the rest being bilateral loans. Nordea and SEB say that foreign banks stand for about 50 per cent of the syndicated lending (or about 37.5 per cent of total lending), while Statistics Sweden says this is only 15 per cent of total lending (excluding FDI loans). Dealogic's statistics indicate that foreign banks stand for a share closer to 50 per cent of syndicated loans.

40 Corporations may see an advantage in issuing corporate bonds over equity, for example to keep control over their company as equity holders, or, get voting rights for their shares (Veckans affärer, "Hotet mot Börsen," June 2011).

41 According to interviews with the Swedish banks and corporations.

42 According to interviews with the Swedish banks. Smaller financial institutions, such as ABG Sundahl Holding, Carnegie, Catella, and Proventus, have also developed their departments focusing on corporate bonds (Bloomberg and Affärsvärlden, February 2011).

MARKET PARTICIPANTS' VIEW OF SWEDISH CORPORATIONS' DEBT FINANCING AND ITS FUTURE DEVELOPMENT

In this section, we present the views of Swedish corporations, banks and investors on the current debt-financing situation of the corporations and on its future development. We will focus particularly on the development of the Swedish kronor corporate bond market. That market is more accessible than foreign markets to Swedish corporations of all sizes but, of course, corporations can also choose to issue bonds in foreign bond markets.

Swedish corporations' view of bank loans and bonds

Based on interviews with a number of corporations in 2010 and 2011, we have drawn the conclusion that their view on debt-financing sources and the financing situation depends on their size. This is also in line with the results we obtained in the Riksbank's corporations' financing survey (Sveriges Riksbank, 2011).

During the financial crisis, medium-sized and smaller corporations found it more difficult to obtain debt financing.[43] Many of those say it is still more challenging to get funding than before the crisis, especially when it comes to getting longer-term funding. Some even say that they have seen the price of bank loans rising recently.

Consequently, a few medium-sized corporations have issued bonds for the first time recently or are planning to expand into the market to attain a more diversified financing structure and due to the increasing prices. Smaller corporations have less knowledge of the upcoming regulatory changes to the financial markets and the Swedish corporate bond market. Therefore, they show less interest in this area.

On the contrary, very large corporations state that the price offered for bank loans today is very good and that the banks have not yet adjusted to the new Basel III regulations. They say that they have no problems in obtaining funding at present. It is important to note, however, that the largest corporations have full access to both the loan and bond markets in Sweden and internationally, which smaller corporations may not have.

In the Riksbank's financing survey (Sveriges Riksbank, 2011), a number of corporations said that increased prices for bank loans could push them to search for alternative financing sources, such as the issuance of corporate bonds. Due to the cost issues mentioned above, medium-sized corporations may now have the greatest incentive to expand into the corporate bond market. The larger corporations already often have access to this market, while the smaller companies may consider it is too costly to participate in. However, corporations of all sizes generally believe that financing through bank loans will always remain as the main debt-financing source. It is very important for them to have credit facilities in place to have access to secure funding when needed.

43 According to Statistics Sweden, small companies have fewer employees than 50. Medium sized companies have employees from 50 to 250 and large companies have 250 employees or more. Other estimates could also be used to categorize companies such as the size of the company's balance sheet.

Many of the companies that, in the survey, said they have interest in expanding into the corporate bond market also mentioned that they see some limitations to the Swedish market. Examples of such limitations are low transparency, limited volumes, low liquidity and vulnerable market. Corporate bond contracts in Sweden are also difficult to understand as there are no standardised contracts available.

All of the corporations we interviewed were positive towards taking steps to develop the Swedish corporate bond market.[44] They believe that the initiative to develop the market has to come from all market participants: issuers, investors and intermediaries. They see increased transparency in the corporate bond market as an improvement. They suggest that credit analysis could be done just like equity analysis to attract more investors. They think a well-functioning Swedish corporate bond market could, for example, be important to decrease corporations' currency risk, as the foreign exchange swap market often does not function that well. In addition, medium-sized and smaller corporations often do not have access to foreign bond markets, so a well-functioning Swedish market would be a good financing alternative for them. The overall view is that now would be a good time to start up the Swedish corporate bond market with the upcoming banking regulations. Some corporations, for example, are worried about being too dependent on bank loans.

A few of the corporations we interviewed or which participated in the survey stated that they believe that banks are negative towards developing the corporate bond market, due to how profitable corporate loans have been for them in the past. They believe the banks are an important factor in pushing ahead with this development since they have central functions when issuing bonds.

Swedish banks' views of bank loans and corporate bonds

We met with some of the Swedish banks and discussed the Swedish corporate debt-financing situation and asked if they believe corporations will start using the corporate bond market more for their financing.

The banks' views vary, but all of them said that, at present, it is generally less expensive for corporations to borrow from banks than to issue corporate bonds. That is the main reason why corporations continue to prefer bank loans over corporate bonds. A lot of work also comes with issuing in the bond market, which the corporations may want to avoid (bond programmes, road shows, getting a credit rating, etc.). Economies of scale also matter as, proportionally, it is more expensive to issue a smaller-sized bond than a larger-sized bond. Consequently, issuing in the market may not be attractive for smaller corporations.

It needs to be kept in mind that, over the years, banks have earned well from providing bank loans to corporations, and may want to hold on to that business for as long as they can. This may affect their view regarding this trend. The banks may, nevertheless, become more interested in the market if it develops and liquidity increases. The banks will

44 Note that all of the corporations we interviewed are already participants on the bond market.

then see some profit prospect in the market through bid ask spreads and more corporate clients. In addition, they may be able to profit from taking care of the issuance of bonds for corporations, at the same time as they decrease the risk on their balance sheets by providing fewer loans to corporations. The reason for this is that corporate bonds have no balance sheet impact for banks.

However, the banks do point out the fact that the price situation for corporations may change after the new Basel III regulations have been implemented. At this point, the banks will have to preserve more capital per loan, the available liquidity pool for bank lending will decrease, and funding costs for corporations will increase (Nordea, 2010). Consequently, the difference in the cost of taking bank loans and issuing bonds may get smaller for corporations in the near future, which may make them evaluate their financing options. As mentioned earlier, the banks have already started preparing for this change by enhancing their units that focus on corporate bonds.

Investors' views of the Swedish corporate bond market

Many investors see an opportunity to invest in Swedish corporate bonds, as this is associated with less risk than the equity market, but a decent return can still be had. Some Swedish insurance companies may be interested in buying more corporate bonds instead of investing in equity. However, in some cases, their investment policy needs to be changed for that to be possible.[45] The new Solvency II regulations for insurance companies will, on the other hand, likely restrict this development. At present, there is, on the other hand, a lot of uncertainty over how the regulations will affect insurance companies' investment decisions.

Retail investors could also become more interested in investing in corporate bonds if there were more corporate bond funds available for them to invest in. However, for more investors to be interested in the Swedish corporate bond market, the market would need to become more transparent and liquid, and the supply in the market would need to be higher.[46] Investors should follow the development of the financial markets and follow new opportunities for investment when new asset classes appear and evaluate the risk that they are taking on both in bonds and equity investments (Nordea, 2010).

DEVELOPING THE SWEDISH CORPORATE BOND MARKET

This section will mainly focus on the development of the Swedish kronor corporate bond market, of which both Swedish and foreign issuers are a part of (although foreign issuers are a minority).

45 From discussions with a number of insurance companies.
46 Corporate finance conference, IVA, 7 September 2010.

Increased interest in the market

As stated above, the Swedish corporate bond market is underdeveloped. Statistics are not complete and transparency regarding price and turnover is poor,[47] liquidity is low, investors mainly buy and hold the securities, there is no trustee function to protect the rights of both issuers and investors in corporate bonds,[48] and there are very diverse terms between bonds

In the past, there has not been much incentive to develop the market as corporations, banks and investors have been very set in their ways. Developing the market has, on the other hand, been a topic in Sweden for more than a decade. An article in Affärsvärlden from 1999, for example, discussed how corporations should start to consider using market financing to a greater extent, as international banks were decreasing the supply of loans. Increased corporate bond issuance in Sweden was also discussed in the Riksbank's second Financial Stability Report from 1999, stating that this diversification of corporations' financing is a positive development.

Based on the Riksbank's survey and our interviews, there now seems to be increased interest from investors, issuers and even banks in further developing the Swedish corporate bond market as the implementation of the new Basel III regulations approaches. The MiFID regulations will then increase the transparency of the market, which may increase investor interest in it. But the problems in the market will not be solved on their own. There needs to be a joint push by all market actors, including corporations, investors, financial institutions and even regulators, to start up the market. If more corporations, for example, ask to issue in the market, this will help the developing process. History, on the other hand, shows that developing the market can be a long process.

A better-functioning corporate bond market in Sweden could improve the efficiency of financial intermediation in Sweden. It would provide more financing alternatives and diversification for the Swedish corporations that mostly need Swedish kronor financing (and perhaps decrease the foreign exchange risk and currency mismatch of corporations). Corporations may also receive more long-term financing from the market, which would provide a more stable working environment for them and less refinancing risk, especially at a time when the banks may try to decrease the maturities of their loans to corporations due to new regulations.

47 Turnover statistics are missing. Euroclear sees the turnover flows but, legally, it cannot publish the data. Market makers can then only see price and turnover for their own bonds.

48 A bond trustee is an independent third party who can play a critical role in acting as a bridge between the borrower and holders of its debt securities during the life of a loan capital issue. The Bond Trustee shall exercise the discretions provided in the Loan Agreement. About 95 per cent of the issues for example on the Norwegian bond market have a Bond Trustee. Benefits for borrowers of having a bond trustee are that they can relate to only one single legal entity as creditor, and discuss any necessary confidential matters and disclose price sensitive information to the Bond Trustee. The Bond Trustee also protects the borrower from bondholders making arbitrary proceedings as an example. The benefits for the investors of having a Bond Trustee are that they then have professional monitoring of the terms and conditions of an issue to protect their interest. Legal action can be taken by the Bond Trustee as a class action on behalf of all bondholders. In a default situation the Bond Trustee will be able to take possession of assets and negotiate on behalf of all bondholders (Norsk Tillitsmann, 2006).

With a larger, more efficient market, a better price for credit risk can be determined from actual bonds available on the market. That, in turn, could lead to a more efficient pricing of derivatives in Sweden. Foreign issuers and investors may then also become more interested in the Swedish market, which could increase the investor base for Swedish corporate bonds. In addition, with increased market financing of corporations, credit losses of banks may be reduced since corporate bonds have no balance sheet impact for banks. The banks may also benefit from a greater number of credit opinions regarding the borrowers on their books, as investors will need information about what they are investing in (Fitch, 2010).

On the other hand, it needs to be taken into account that markets may often suffer from irrational behaviour, especially in times of crisis. Smaller and less liquid markets such as the Swedish corporate bond market may be more vulnerable than larger markets in such times. It can therefore be argued that pushing corporations into such a market is not necessarily a positive thing. However, if companies expand their options and gain access to both bank loans and the corporate bond market, they should not be worse off than they would be if they only had access to one source of debt funding.

Initiatives taken to develop the Swedish corporate bond market

In the last couple of years, an initiative from market participants has been taken to develop the Swedish corporate bond market.[49] The initiative suggested five steps that can be taken to improve the Swedish corporate bond market:

1. *Increase transparency*: At present, the pricing of portfolios is impaired by the lack of *available* prices in the market. To improve this, the initiative suggests that a certain level of post-trade transparency is introduced, which will lead to better market statistics, improve the possibilities to launch a Swedish corporate bond index and improve liquidity over time. One argument is also that MiFID is likely to lead to increased transparency being forced in any event.
2. *Improve corporate governance through self-regulation:* The corporate bond market is in need of common structure and standardisation.
3. *Establish a trustee function*: The trustee would, for example, manage corporate restructuring cases for the investors (see footnote 48).
4. *Modernise and adapt investment policies*: Today's investment policies, for example for life insurance companies, often limit investment in corporate bonds.
5. *Open up the corporate bond market for more issuers/investors*: For more corporations to be able to issue in the market, the minimum amount for issuance needs to be decreased. The minimum amount for trading also needs to be

49 Daniel Sachs (CEO of Proventus Capital Partners) and Erik Thedéen (former head of NASDAQ OMX Stockholm) started the initiative to develop the corporate bond market in Sweden (Upprop: Fem steg till en bättre obligationsmarknad).

decreased.[50] More banks and fund companies then need to offer these investments to retail investors on exchanges, as is done in the equity market.

As a consequence of the above market initiative, the Confederation of Swedish Enterprise (Svenskt Näringsliv) has decided to investigate the Swedish corporate bond market. They are to explore why the market is underdeveloped and how it can be developed.[51]

Much work remains

At present, it is clear that the Swedish corporate bond market is underdeveloped. Transparency is poor and the available statistics for both bank loans and corporate bonds are not sufficient. On the other hand, it is likely that new regulations will have an impact on corporations' financing structures in the near future. To what extent we can expect structural changes is however unclear. Due to the changing environment, the corporate bond market could become more important for Swedish corporation financing. Steps to develop the corporate bond market may therefore now be important. Developing the corporate bond market will improve the Swedish bond market, giving a clearer picture of the credit risk in the market. This will lead to the improved functioning of the financial markets, with more correct pricing of derivatives as an example. Corporations will gain better access to long-term financing in Swedish kronor and gain access to more investors, which will provide them with an opportunity to diversify their financing. The banks' credit losses may then decrease. From our study, it is, on the other hand, evident that a lot of work will be needed to improve the Swedish corporate bond market.

50 The corporation needs to issue a bond for at least 250-500 thousand Swedish kronor. Investors need 500 000 kronor to participate in a primary market auction and 10 000 to buy corporate bonds on the secondary market. (Dagens Industri, February 2011).

51 The investigation will be done by Daniel Barr, head of the Bank Support Department at the Swedish National Debt Office.

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An index of financial stress for Sweden

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We have developed an index for financial stress that is intended for use as a tool in analysing developments on the financial markets. The starting point for our index is the financial markets that are important sources of funding for banks, companies and indirectly also for households. The four stress indicators we have chosen are directly or indirectly related to the funding costs prevailing in each respective market. The stress indicators are equally weighted and normalised[2] on the basis of the reference period January 1997 to July 2007. The tests presented in this article show that the choice of historical reference period and weighting may affect the analyses of the way the index develops. As the index is an average value of various indicators, it may provide an overall picture of the degree of financial stress on the financial markets. However, this may need to be supplemented with further information to provide a more complete picture. For instance, the analysis of sub-components may increase understanding of the symptoms of financial stress.

Difficult to assess the health of the financial system

The financial system is important as it provides fundamental services to the real economy. For instance, the financial system can facilitate economic growth through the efficient allocation of capital to companies and households. A particularly important part of the system is the markets where banks, companies and ultimately households have access to capital and manage their risks. Shocks to the system, which affect the functioning of some part of it may ultimately cause large costs to society. However, it is often difficult to determine how smoothly the financial system is functioning. One reason is that there are several sub-markets which can develop in different directions. This makes it difficult to assess the functioning of the system as a whole. One way of forming an overall impression of whether there are disruptions on markets is to construct and study an index for financial stress. This can provide an overall picture of developments on the financial markets, which

1 We are grateful for the assistance provided by Johanna Eklund and Lena Strömberg at the beginning of the project and for help and comments from Meredith Beechey, Gudrun Gunnarsdottir, Gunnar Blomberg, Johanna Fager Wettergren, Mattias Persson, Kasper Roszbach, Jonas Söderberg, Kristian Tegbrink and Maria Wallin. The views expressed in the article are the authors' own views and should not necessarily be regarded as representing the Riksbank's views on these issues.

2 This normalisation has taken the form of deducting the historical average from the individual observations. The results have then been divided by the historical standard deviation. The method is described in Appendix 2.

also makes it easier to compare different periods of stress. In this article we present such an index for Sweden.[3]

The following two sections present earlier literature and discuss how financial stress can be defined and measured. After that we present our index and the reasons for the choice of markets included. This is followed by a description of the data and the choice of historical reference period as well as the method used for weighting indicators. We also test how sensitive the index is to alternative choices of historical reference period and weighting method. The final section presents our conclusions. Our conclusion is that the index can provide indications of financial stress, but that changes in the index may also occur for other reasons. We also report the conclusion that the analysis of the development and level of the index may be affected by the choice of historical reference period and by the weighting method.

DEFINING FINANCIAL STRESS

It is difficult to define the concept of financial stress, and there is no real unequivocal or generally accepted definition for it. Illing and Liu (2006) discuss stress in the financial system in terms of a shock that may have negative effects on the real economy. Hakkio and Keeton (2009) instead define it as a period that is characterised by at least one of the following five circumstances: uncertainty over the fundamental value of financial assets, uncertainty over other investors' behaviour, information asymmetries, substantially increased demand for assets with very low risk (flight-to-quality) and substantially increased demand for assets with very good liquidity (flight-to-liquidity). Balakrishnan et al. (2009) also consider that financial stress is characterised by a number of circumstances similar to Hakkio and Keeton (2009), but also expressly take into account potential concern for the financial health of the bank system. Balakrishnan et al. (2009) also define financial stress as a period when the financial system is strained and its capacity to fulfil its mediation function is impaired.

EARLIER LITERATURE ON STRESS INDICES

Indices that show financial stress are quite common in academic research. An index can be constructed in different ways and contain different indicators. One simple method of weighing together indicators into one index is to normalise them and give them equal weight. This is how Danmarks Nationalbank's index is constructed (Hansen, 2006). This index aims to measure the risk premium in euro-denominated assets. The index uses indicators in the form of four differences between interest rates on high-risk and relatively risk-free assets, three measures of volatility and the difference between the yield on bonds

3 Sveriges Riksbank regularly publishes two stress indices, one for Sweden and one for international circumstances. You can read about the two indices in the Economic Commentary "How has the stress on the financial markets developed? – An index-based discussion" published on 28 October 2009 and in the Box "Financial stress index" in the report "Financial Stability 2009:2" published on 26 November 2009.

and equity. Österholm's (2009) index for the Swedish market, which is used to measure the effect of the financial crisis in the late 2000s on the real economy, is also normalised and equally weighted.

Another means is to allocate weight to the indicators included in the index according to how much they contribute to systematic risk, that is, the risk that affects the entire financial system. One method of estimating this is to make a principal component analysis of the indicators, where the first component can be interpreted as the market's systematic component.[4] This method is used by Hakkio and Keeton (2009), who have a financial stress index for the American market. The index contains eleven indicators[5] which represent flight-to-quality, flight-to-liquidity and the uncertainty over fundamental values and other investors' behaviour.

A further means is to give the indicators different weights on the basis of a specific criterion. Illing's and Liu's (2006) Canadian index contains variables for the equity market, bond market and currency market, as well as the bank sector. They primarily choose to weight the indicators on the basis of the relative size of their respective markets as a percentage of the total credits in the economy.

In addition to the three named methods, there are a number of other possible ways of calculating the weights for the indicators in a stress index. For example, the European Central Bank's (ECB) (2009) global stability index is weighted on the basis of the indicators' variance.

A stress index for Sweden

The aim of our stress index is to try to reflect the degree of financial stress in a simple and comprehensive way. In this article we define financial stress as a disruption that impairs the financial markets' ability to act as an efficient intermediary between lender and borrower or buyer and seller. By efficient, we mean that there is good market liquidity and an even distribution of information between the agents in the market. Furthermore, financial stress may entail or lead to higher risk premiums and increased volatility. Our stress index is intended to function as an overall measure of these types of symptoms of financial stress.

When constructing a stress index, several considerations need to be made. These include which stress indicators to include, how to make these indicators comparable and how to weight them together into an index. We have chosen to include a total of four components from the capital market and the foreign exchange market. By normalising the indicators we relate them to their respective average levels during a reference period (January 1997 to July 2007) and make them comparable. We then allocate them equal weights in our index. This section describes the considerations we had when constructing the index.

4 This is assuming that the first component is an approximately equally-weighted linear combination of the indicators.

5 Examples of indicators in their index are the TED spread (the difference between the interest rate on a non-secured interbank loan and the interest rate on a treasury bill), the 2-year swap spread (the difference between the interest rate on the fixed leg of an interest rate swap and the interest rate on a government bond), the risk premium on corporate bonds and implied volatility on the equity market.

STARTING POINT IS THE CAPITAL AND FOREIGN EXCHANGE MARKETS

One of the financial system's most important functions is to mediate capital, which can make it easier for companies and households to generate economic growth. The market that makes this funding possible is the capital market. It is therefore important that this market is not subjected to shocks that prevent it from functioning efficiently. As the capital market is central to the financial system, it forms a natural starting point for a financial stress index. The capital market can be divided up into the equity market and the credit market (consisting of the shorter money market and the longer bond market). Moreover, the foreign exchange market is important, as banks and companies to a great extent obtain funding in foreign currency.

We have chosen to use a few broad indicators as a base, to create a general and simple stress index. The index uses three stress indicators from the capital market – volatility in the equity market, the TED spread, a bond spread – and one indicator from the foreign exchange market – volatility. These indicators are described in more detail below.

The equity market

The equity market is an important source of funding for companies, either through IPOs or new issues where companies acquire their own capital. In addition to this, the equity market gives analysts and other interested parties important and useful information on investors' assessments and pricing of risk.

Choice of indicator for the equity market: volatility

There are several ways of measuring financial stress on the equity market. One of the most common is volatility. When investors are uncertain of the value of a share, they tend to react more strongly to new information when pricing the share than they would otherwise have done. This leads to increased volatility. If a price change is not supported by the company's ability to make a profit, the ensuing high volatility may be a sign of financial stress.

There are several theoretical models explaining the effects of volatility on the cost of equity capital. One of the most common is the Capital Asset Pricing Model (CAPM), which briefly states that the capital cost is positively related to the volatility. According to this theory, it becomes more expensive for companies to fund themselves on the equity market when volatility increases. Moreover, empirical studies show that periods of high volatility coincide with falling equity prices (see, for instance, Poon and Granger, 2003). The volatility thus becomes a natural starting point for the analysis of stress in the equity market.

There are different methods of measuring volatility. The most common entails calculating the historical volatility, measured as the standard deviation in price changes during a particular period of time. One disadvantage of this measure is that it is retrospective and thus not necessarily representative of the companies' capital costs at

the time of the measurement. Another method is to derive it from option prices and thus obtain an implied volatility that is based on market pricing of expected volatility.

The US equity market has the Chicago Board Options Exchanges index VIX, which measures 30-days' implied volatility on the S&P 500 index via option prices. The Swedish equity market does not have an index for implied volatility corresponding to the VIX index. We have therefore constructed one for the Swedish equity market.[6]

The credit market

The credit market can be divided up into two parts on the basis of the maturity of the loan: the short-term money market and the long-term bond market. The stress indicators on the credit market are calculated as the difference between the interest on a risky and a (relatively) risk-free asset. They thus represent the extra return that an investor requires over and above the risk-free interest in order to take a risk.

The money market

The money market includes loans with maturities up to one year. Both banks and companies seek short-term funding through the money market, for instance, through interbank loans or borrowing via certificates. As the money market constitutes an important source of short-term funding for banks and companies, disruptions to this market may rapidly lead to consequences for the financial system.

Choice of indicator in the money market: the TED spread

We have chosen to use the 3-month TED spread as an indicator of stress on the money market. The TED spread is the difference between the interest rate on an unsecured interbank loan (Stibor[7]) and the interest rate on a treasury bill with the same maturity. The spread thus shows the extra return that an investor requires to lend to a bank rather than lending to the state.

An investor who gives an unsecured interbank loan risks losing the deposit. There is also a risk that investors will need the money they have deposited before the loan matures. A treasury bill, on the other hand, is in principle free of both credit and liquidity risk as there is very little probability that the state will default on its payments and the bill is also very easy to convert into cash. Thus, the interest rate on a an unsecured interbank loan should be higher than the interest rate on a treasury bill. The TED spread thus compensates the investor for credit and liquidity risks. Something else that affects the spread is that investors want high-quality collateral in uncertain times, which increases the demand for, and leads to lower interest rates on, safer government securities (flight-to-quality and flight-to-liquidity). The TED spread thus also includes such effects of changes in supply and demand.

6 See the Chicago Board Options Exchange (1999) for a technical description of the construction of the index, Demeterfi et al. (1999) for a derivation of the theoretical grounds for the index and also Dahlman and Wallmark (2007) for an application to the Swedish equity market.

7 Stockholm Interbank Offered Rate.

Times of financial stress may be linked to increased credit and liquidity risks, at the same time as a flight-to-quality and a flight-to-liquidity arise. At such times Stibor tends to rise at the same time as the interest rate on treasury bills tends to fall. Both of these variables can in this way contribute to the TED spread increasing, which makes it a good indicator of periods of financial stress.

The bond market

On the bond market, banks and companies borrow money for longer periods than one year. Together with bank loans, the bond market represents many companies' most important source of credit. Moreover, mortgage loans and other forms of consumer credits are funded via the bond market. This makes the market important for how demand develops in the economy.

Choice of indicator for the bond market: bond spread

We have chosen to represent the degree of financial stress in terms of an interest rate differential also for the bond market. In the same way as higher volatility in the equity market makes it more expensive for a company to fund itself in the equity market, a higher interest rate in the bond market makes it more expensive and more difficult to obtain funding there. We have chosen to use the difference between the interest rate on covered bonds and government bonds as an indicator of stress in the bond market.[8] In the same way as for the TED spread, periods of financial stress may be linked to a higher bond spread both because interest rates on covered bonds rise and because interest rates on government securities fall.

The credit risk relating to covered bonds can, unlike that for most corporate bonds, be regarded as very low. The value of covered bonds arises from the issuer's debt-servicing capacity and the collateral, which is mostly mortgage loans. These bonds constitute a central asset category in the Swedish financial system. This means that covered bonds, despite their very high credit quality, are regarded as a good indicator of the price of risk in the bond market in Sweden.

The foreign exchange market

Swedish banks and companies obtain a substantial part of their funding in foreign currency. It is therefore important for the Swedish economy that banks and companies have access to capital markets in other currencies on reasonable terms. This requires both smoothly-functioning foreign capital markets and a smoothly-functioning market for managing the financial risks that accompany borrowed capital in foreign currencies. If this risk management does not function efficiently, the access to foreign currency can deteriorate or

8 Covered bonds were introduced into Swedish legislation in 2004. For the period prior to this, mortgage bonds are used instead.

the cost of this capital can increase. It is therefore valuable to include an indicator for the foreign exchange market in the financial stress index.

Choice of indicator for the foreign exchange market: volatility

When banks and companies choose to obtain funding in foreign currency, they take a foreign exchange risk. One means of managing this risk is to use derivative instruments. However, uncertainty over future exchange rates may lead to the price of such derivatives rising, which in turn may make it more expensive and more difficult for banks and companies to obtain funding in foreign currency.

There are several ways of estimating the uncertainty over future exchange rates. One means of estimating the price of foreign exchange risks is to use implied exchange rate volatility. We use implied volatility for the Swedish krona's exchange rate against the US dollar and the euro in the stress index. The reason for the choice of these two currencies is that Swedish banks and companies mainly use these currencies when obtaining funding in foreign currency.

DATA

The stress index is calculated on daily observations from 1 January 1997 to 30 June 2011 (see all of the indicators in Table B3). Where there are no observations, the previous data point has been used. All data has been gathered from EcoWin, except for the statistics for the index on implied volatility in the equity market, which have been gathered from Bloomberg and NASDAQ OMX. When calculating market weights, data on banks' and companies' funding has been gathered from Statistics Sweden (SCB).

The volatility on the foreign exchange market has been calculated as the mean value of the implied volatility for the Swedish krona relative to the US dollar and the euro respectively. As there is no data for the euro available prior to 1999, the volatility on the foreign exchange market between 1997 and 1999 is solely based on the krona's exchange rate against the US dollar.

Panel A in Table B1 shows the correlations between the indicators. The correlation is calculated for the entire period (1997-2011) and for two sub-periods, the historical reference period between January 1997 and July 2007 and the period between August 2007 and December 2009, which is characterised by the financial crisis of the late 2000s.

The indicators are mostly positively correlated, which is natural as the different parts of the financial system are affected by one another and by the same events. However, the TED spread in the historical reference period is negatively correlated with all of the other variables – although this changes during the crisis period when the TED spread is positively correlated with all variables.

METHOD

There are several methodological deliberations to make when constructing the index. Although advanced methods may have statistical advantages, they may also in general be more difficult to understand and interpret. We have therefore chosen to use a simple method where the indicators are allocated equal weight. A technical specification of the calculation of the index is contained in Appendix 2.

The stress indicators have been normalised to be able to express them in the same units and thus make them comparable with one another. The normalised stress indicators are then weighed together into an index. The index is also normalised, so that it has the mean value 0 and the standard deviation 1. The interpretation of the level of the index will thus be that when the value is equal to zero the index is equal to its historical mean value, and consequently the financial stress level should be regarded as low. This does not mean, however, that there cannot be individual markets that experience stress at the same time as other markets are stable. It is therefore interesting to also examine the level of the different components in the index to obtain a more detailed picture of the situation on the financial markets.

The Y axis in the figure shows the standard deviations from the historical mean value for the series. The standard deviation is a measure of variability for the distribution. In a normal distribution, one standard deviation covers around 68 per cent of the outcomes, two around 95 per cent and three standard deviations cover 99.6 per cent. One can thus say that when a series exceeds three standard deviations, it is an extreme situation that occurs very rarely, according to the normal distribution.[9]

Historical reference period

In general, the stress index is based on deviations from historical mean values. We use more than ten years' data, from January 1997 to the end of July 2007, to calculate the mean value used in the index. During this period Sweden experienced both upswings and downswings in its economy, which is necessary for the historical mean value to be representative. The period after this, up to the end of June 2011, is then compared with this historical mean value.

The choice of using data starting in the year 1997 can be discussed. Normally, longer time series entail more data points and thus better statistical properties. At the same time, the question arises of how relevant some historical data can be regarded to be for the current situation. The choice of time period should therefore be based on two factors: access to data and relevance of accessible data. As the method of the index is based on normalisation, it is very important that the historical mean values and standard deviations required for this are based on a period that can be regarded as representative.

9 Financial data, of the type used in the stress index often do not follow the normal distribution, but instead tend to show a greater number of observations, which according to the normal distribution would be attributed a very low probability. This means that the normal distribution probably underestimates the probability of very unusual events. Thus, the probabilities implied by the normal distribution for certain outcomes should only be regarded as very indicative.

All of the indicators are limited by access to data to a different extent (see Table B3). Our index for implied volatility on the equity market has been calculated from the year 1992, which was the first year that NASDAQ OMX could supply data from. The TED spread and bond spread are accessible for slightly longer periods, from 1986 and 1990 respectively. However, the volatility in the foreign exchange market is based only on implied volatility in the exchange rate USD/SEK prior to 6 January 1999, because the implied volatility in EUR/SEK is not available prior to this date.[10]

The TED spread is an example of when one might discuss the relevance of the available data. Data for calculating the TED spread is available from 1986. However, one could argue that the TED spread for the period around the changeover to a floating exchange rate cannot be regarded as relevant to the index.[11] This is because interest rates tend to be more volatile under a fixed exchange rate regime than under a floating exchange rate regime, which may make it difficult to compare the interest rate differentials in different regimes.

It is interesting to check whether the conclusions would have altered significantly if we had chosen a different historical time period. We have therefore compiled a test where we calculate the index on the basis of two alternative time periods. The first alternative reference period is January 1992-July 2007, which means that it also includes the 1990s crisis in Sweden. The second is January 1992-June 2011, which means that it also includes the financial crisis of the late 2000s. Data on volatility in the foreign exchange market are not available prior to 29 December 1995. The extended history is therefore only based on the other three components prior to this point in time in the index.

Weighting of the indicators in the index

The advantage of weighing together the submarkets into one index is that this provides a collective overview of the level of stress on the market, as the significance of the individual factor is reduced. In our stress index we allocate equal weight to all stress indicators. In other words, the index is equally weighted. One justification for giving all of the sub-markets the same weight is that the index then becomes simpler and easier to understand. There are two main objections to using an equally-weighted index. The first is that the variables are not independent of one another (see Table B1). Equal weights can thereby risk overweighting an individual common factor among the indicators. The second is that it is debatable whether all sub-markets are of equally great significance for the economy.

To examine what effect the choice of weighting method may have on the results and to show the possible reasoning as to how the index can be constructed, we test two methods that offer alternatives to equal weighting. In the second alternative weighting (alternative method 1), we take into account the covariance between the indicators and carry out a principal component analysis, where the first component represents the market's systematic

10 Implied volatility in USD/SEK is available from 29 December 1995.
11 Sweden switched to a floating exchange rate in 1992.

component. We also use a weighting method based on the relative size of the sub-markets in the economy (alternative method 2).

Alternative method 1: Weighting based on the covariance matrix

If the different sub-components are correlated and affected by a common factor, an index based on the components being allocated equal weight can lead to the degree of stress being overestimated or underestimated. One means of managing this is to use a principal component analysis (PCA). A PCA is a mathematical method whereby a number of correlated variables are converted into a number of uncorrelated variables that are known as principal components. These independent components capture similar movements or variations in the series examined. The first principal component captures as much of the variations in the data material as possible, and each ensuing component captures as much as possible of the remaining variations. If the series follow a common pattern, for instance a general market trend, the first principal component should be able to explain most of the common variation in the data material.[12] This first component therefore comprises our index and represents the common systematic risk in our variables. The first component uses around 63 per cent of the variation in the variables (see Table B2), which means that some information is lost in this method. The advantage is that the weights take into account the correlation between the variables, as the method uses the covariance matrix to calculate the weights. This means that the systematic risk is not overvalued in the index, which is a risk with the method using equal weights. However, one problem with applying the principal component analysis to indicators in the stress index is that these may have non-linear relationships to one another. As the method is based on linear relationships between the variables, the estimation of weights may disregard important information and thus be less suitable in this particular context.

Alternative method 2: Market weights

The second alternative method involves allocating the respective markets' weights based on their relative significance for the economy. One way of measuring the significance of a market is to take its size into account. However, one difficulty with this weighting is determining how to measure the size of a particular market. When calculating the weights we have used the banks' and companies' funding as a starting point.

With regard to the equity market, we have chosen to use the market value of equity in companies listed on Swedish marketplaces. This leads to a relatively large weight for the equity market, around 41 per cent in June 2011 which forms the end of the observation period, as a result of the non-financial companies' considerable dependence on this form of funding.

The weight of the money market is calculated by adding the total certificate borrowing of the Swedish MFIs in Swedish krona to the total value of their deposits in Swedish krona

12 Several important assumptions are made in a principal component analysis, such as linearity and independence. For further information on PCAs, see Campbell et al. (1997).

with other MFIs, which gives a weight of 11 per cent at the end of the observation period. For the bond market we have chosen to use MFIs' total issued securities in Swedish krona, deducting certificate borrowing (which is included in the money market) and adding the total of the outstanding amount of bonds issued by non-financial companies on the Swedish bond market and the non-financial companies' debts abroad in Swedish krona. As a large percentage of bonded borrowing is in foreign currencies, the weight for the bond market amounts to around 16 per cent at the end of the observation period.

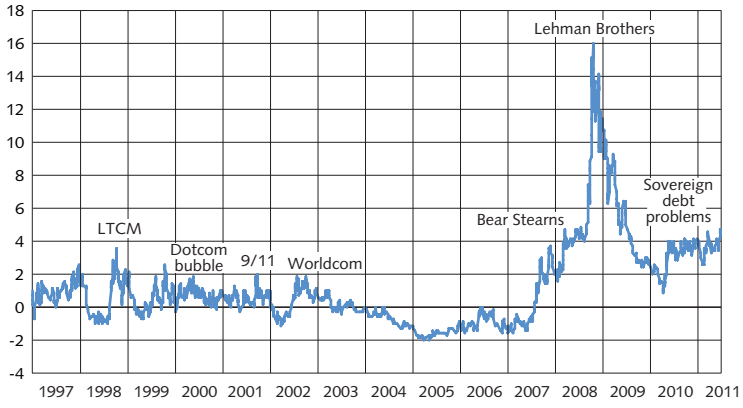
For the foreign exchange market we have chosen to base the weight on the MFIs' and non-financial companies' funding in foreign currency. This constitutes a large part of the total funding and of both the money market and bond market borrowing. The weight for the foreign exchange market is therefore around 31 per cent in the index at the end of the observation period.

One problem with this approach is that the markets with weights based on market value are given a lower weight during periods of stress. For example, as mentioned earlier, equity markets with falling equity prices often have a high volatility. This means that the value of the equity market falls, and its weight in the index declines, despite its importance for the economy remaining unchanged. Another problem arises if there are substitute markets that can replace the markets on which the index is based. One example of this is that the repo market can to some extent replace the unsecured interbank market, which is not captured by this index.

ANALYSIS OF THE INDEX

Figure 1 shows the equally-weighted index during the period January 1997 to the end of June 2011.

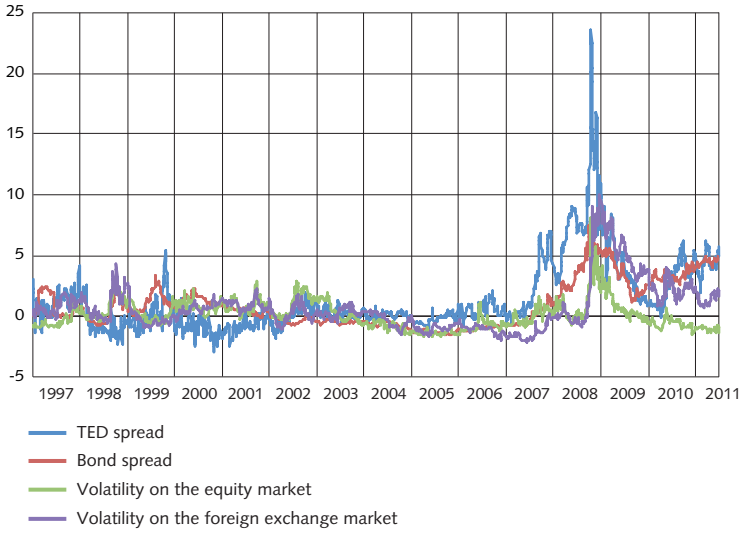
Figure 1. Stress index, January 1997-June 2011
Standard deviations



Source: The Riksbank.

The stress index captures a number of periods of increased global financial unrest, for example the LTCM crisis in connection with Russia's financial collapse in autumn 1998, the dotcom bubble of 2000, the terror attack in the USA on 11 September 2001 and the Worldcom scandal in 2002. From the middle of 2003, the index reflects the period of calm with low uncertainty and abnormally low risk premiums that prevailed until the autumn of 2007, when the financial crisis of the late 2000s began. The index reached a peak after the fall of Lehman Brothers in September 2008 and began to return to lower levels in 2009. Since the first half of 2010 the index has once again risen, parallel to the sovereign debt problems in several European countries.

Figure 2. Stress indicators, January 1997-June 2011
Standard deviations



Source: The Riksbank.

To be able to analyse developments in the index, one must take into account the respective stress indicators. Figure 2 shows the development of the normalised stress indicators. For instance, we can see in the figure that all of the indicators contributed to a sharp rise in the index during the financial crisis of the late 2000s. Initially, it was only the TED spread that contributed to this increase, while there were only moderate increases in equity volatility on the equity market and the bond spread. However, as the crisis worsened the bond spread and share volatility began to increase. Volatility in the foreign exchange market also increased after September 2008 and remained at a high level for the rest of the year.

It is important to note that our stress index does not necessarily reflect financial stress. The symptoms of stress the index attempts to measure may be caused by other circumstances. A deviation in price from the historical mean value may be justified and may arise while the market is functioning efficiently. For example, the difference in the interest rate between a risky bond and a risk-free bond may rise above the historical average because the credit risk has risen. This could have the consequence that the index implies

financial stress, despite the actual market not being stressed. And a deviation from the historical mean value can for example also occur without an increase in the credit risk. This could then be a sign of financial stress. In practice, these two factors tend to covary, which can contribute to difficulties in separating them from one another. A further complication is that it is very difficult to assess what should comprise a normal level for the financial stress index. In our measure we use deviations from historical mean values as a base, but in actual fact this is not certain and the historical average level can be said to be normal.

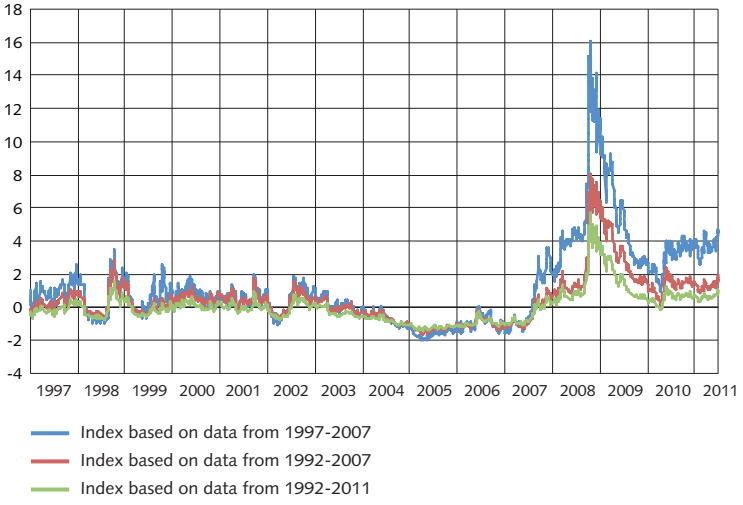
Market pricing of risk is also affected by the investors' willingness to take risk, that is, risk aversion. The investors' risk aversion determines what compensation they will demand to take on a particular risk in addition to the compensation for the actual risk. This further compensation is often called a risk premium. When risk aversion increases, the market demands higher compensation to take on the same risk. When analysing the stress index and the stress indicators included in it, it may be of great importance to distinguish between the risk and the price of the risk.[13]

Sensitivity to the choice of historical reference period

The three stress indices in Figure 3 follow one another closely over time. However, on a couple of occasions a tangible difference arises between the two alternative indices and our primary index. These are the middle of 2008 and then the first half of 2010, when our primary index increases much faster than the two alternative indices. This is largely due to the two alternative indices being partly based on a time period that includes the 1990s crisis. This means that the mean values and standard deviations for the two alternative indices are higher, which lowers the normalised values of the sub-components.

13 See, for example, Hull et al. (2005) and Espinoza and Segoviano (2011) who discuss this problem.

Figure 3. Stress index with different historical reference periods, January 1997-June 2011
Standard deviations



Source: The Riksbank.

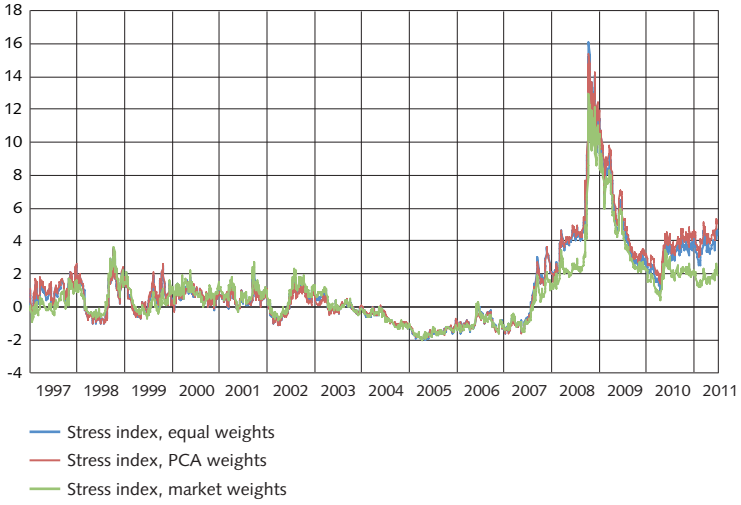
The two alternative indices are also in general slightly lower than the one based on 1997 to 2007. The index based on the time period 1992 to 2011 has the lowest level, because it is based on a time period that includes both the 1990s crisis and the late 2000s financial crisis.

Sensitivity to choice of weighting method

Figure 4 shows the stress index constructed using a PCA together with the equally-weighted and the market-weighted indices. The PCA index shows roughly the same development as the equally-weighted index, despite the weights not being of equal size.[14] However, not all of the information from the indicators is used; the first principal component represents only around 63 per cent of the total variation in the Swedish indicators (see Table B2). All in all, a weighting with a PCA does not have any significant effect on the development of the index compared with using equal weights.

14 The weights in the PCA are obtained from the condition that the total of the squared coefficients for each component totals 1.

Figure 4. Stress index, three weighting methods
Standard deviations



Source: The Riksbank.

Figure 4 also shows the equally-weighted index compared with an index that is weighted with market weights that change over time. The index with market weights deviates from the equally-weighted index on two occasions, namely in the middle of 2008 and since the first half of 2010. The reason for this is that on these two occasions it is primarily the TED spread and the bond spread that contribute to the increase in the index. These two indicators have been allocated relatively small weights in the market-weighted index. They therefore do not affect the index as much as the volatility on the equity market and volatility on the foreign exchange market. Otherwise, the indices follow one another fairly well.

Stress index – an overall picture of the financial markets

We have developed an index that is intended to function as a tool for analysing developments on the financial markets. We have based our index on the financial markets that are important funding sources for banks, companies and ultimately households. The stress indicators we have chosen are directly or indirectly related to the funding costs prevailing in each respective market. In times of financial stress these components tend to be affected, which may make it more expensive, and possibly more difficult, for banks, companies and households to obtain funding.

The indicators included in the stress index are normalised so that the level of each indicator at each point in time is related to the average level and the standard deviation during a reference period (January 1997 to July 2007). The indicators have then been weighed together into an equally-weighted index. In this article we test how the index is affected by alternative historical reference periods and alternative weighting. Our conclusion is that the development of the index is affected to some extent over time. The

differences in the way different variations of the index develop have however been few and temporary.

The construction of the index is simple and is intended to be easy to understand. Each change amounting to one unit in the index corresponds to a movement equivalent to a standard deviation, calculated on the basis of the historical reference period. When the level of the index is zero, the total of the four stress indicators correspond to the total of their historical mean values. However, there are a couple of aspects to take into account in the analysis of the index.

Firstly, the total of the four stress indicators may correspond to the total of their historical mean values without each stress indicator being equal to this mean value. This means that the analysis of the stress index may need to be supplemented with other information, such as the development of each individual stress indicator.

Secondly, it is not certain that the historical reference period (January 1997 to July 2007) is representative of any form of normal level. On 30 June 2011 the level of the stress index was 4.4. This can be compared with 4.5 on 30 June 2008 or -1.6 on 30 June 2005. However, it is not certain that the level of financial stress was lower on the dates 2005 and 2011 than the date 2008. What can be regarded as a normal level may change over time as a result of, for instance, structural changes in financial markets and changes in regulation. The level that our current construction implicitly regards as normal through the choice of historical reference period may thus need to be adjusted in the future and should not be unreservedly accepted.

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Appendix 1. Tables

Table B1. Correlations

Panel A: Indicators	TED spread	Bond spread	Volatility on the equity market	Volatility on the foreign exchange market
Total period (Jan 1997-Jun 2011)				
TED spread		0.68	0.29	0.48
Bond spread			0.31	0.69
Volatility on the equity market				0.52
Volatility on the foreign exchange market				
Historical reference period (Jan 1997-Jul 2007)				
TED spread		-0.11	-0.16	-0.14
Bond spread			0.45	0.50
Volatility on the equity market				0.63
Volatility on the foreign exchange market				
Crisis period (Aug 2007-Dec 2009)				
TED spread		0.60	0.68	0.19
Bond spread			0.62	0.65
Volatility on the equity market				0.59
Volatility on the foreign exchange market				

Table B2. Principal components based on the period January 1997-June 2011

Principal component	Value	Percentage		
PC 1	2.51	0.63		
	TED spread	Bond spread	Volatility on the equity market	Volatility on the foreign exchange market
Own vectors (loadings), PC 1:	0.50	0.55	0.40	0.54

Table B3. Variables included

	Source	Available from	Mean value	Standard deviation
3-month rate Treasury bills	EcoWin	03-01-1983	3.27	0.91
3-month interbank rate (STIBOR)	EcoWin	30-12-1986	3.46	0.90
5-year bond spread	The Riksbank	01-01-1990	44.50	18.76
30-day implied volatility index for OMXS30	The Riksbank	02-01-1987	26.36	8.42
3-month implied volatility, USD/SEK	EcoWin	29-12-1995	10.64	1.48
3-month implied volatility, EUR/SEK	EcoWin	06-01-1999	6.06	1.36

Note. The mean values and standard deviations are for the historical reference period (January 1997-July 2007) or from the date when they became available and until the end of July 2007.

Appendix 2. Technical specification of the calculation of the index

STAGE 1. CALCULATION OF THE HISTORICAL MEAN VALUE AND STANDARD DEVIATION FOR EACH RESPECTIVE STRESS INDICATOR IN THE INDEX

Based on a historical reference period, the arithmetical mean value is calculated as:

$$\overline{x} = \frac{1}{n} \times \sum_{i=1}^{n} x_i \qquad \text{Equation 1}$$

where n is the number of observations of the stress indicator. In our index the observation x_1 corresponds to the stress indicator's value as of 1 January 1997 while x_n corresponds to the stress indicator's value as of 31 July 2007. The historical standard deviation is calculated as:

$$s = \sqrt{\frac{1}{n} \times \sum_{i=1}^{n} (x_i - \overline{x})^2} \qquad \text{Equation 2}$$

STAGE 2. NORMALISATION OF THE STRESS INDICATORS

Each observation of the respective stress indicator is normalised using the historical mean value and the standard deviation. The observations are normalised as follows:

$$x_i^{norm} = \frac{x_i - \overline{x}}{s} \qquad \text{Equation 3}$$

STAGE 3. WEIGHTING OF THE INDICATORS

The stress indicators are weighed together into an index as follows:

$$index_i = w_a \times x_{i,a}^{norm} + w_b \times x_{i,b}^{norm} + w_c \times x_{i,c}^{norm} + w_d \times x_{i,d}^{norm} \qquad \text{Equation 4}$$

where w is the weight allocated to the respective indicators and the index a, b , c and d designate our four stress indicators. In our equally-weighted index $w_a = w_b = w_c = w_d = 0.25$.

STAGE 4. NORMALISATION OF THE INDEX

The index needs to be normalised so that the level of the index can be interpreted as the number of standard deviations from the mean value. Normalisation is carried out in accordance with Stages 1 and 2, with the difference that x is replaced by $index$.

Modelling systemic financial sector and sovereign risk

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This article introduces a new framework for macroprudential analysis using a risk-adjusted balance sheet approach that supports policy efforts aimed mitigating systemic risk from linkages between institutions and the extent to which they precipitate or amplify general market distress. In this regard, the systemic contingent claims analysis ('Systemic CCA') framework helps quantify the magnitude of general solvency risk and government contingent liabilities by combining the individual risk-adjusted balance sheets of financial institutions and the dependence between them. An example of Systemic CCA applied to the US financial sector delivers useful insights about the magnitude of systemic losses and potential public sector costs from market-implied contingent liabilities. Stress tests using this framework are presented. Applications to European banks and the stress testing of systemic risk are also described. Finally, the banking and sovereign risk analysis is applied to Sweden, and joint banking sector and sovereign stress testing applications are shown. The paper concludes with new directions for a framework of integrated stress testing of banking and sovereign risk, with macrofinancial feedbacks, and monetary and fiscal policy analysis. Future research would ideally explore directions in using CCA-based economic output value and Systemic CCA to promote economic growth and financial stability, as well as the relationship to fiscal and debt management dynamics.

I. Introduction

The complex interactions, spillovers and feedbacks of the global crisis that began in 2007 remind us how important it is to improve our analysis and modelling of financial crises and sovereign risk. This article provides a broad framework to examine how vulnerabilities can build up and suddenly erupt in a financial crisis, with potentially disastrous feedback effects for sovereign debt and economic growth. The article discusses lessons from the crisis and new directions for research on modelling financial crises and sovereign risk. It shows how risk management tools and contingent claims analysis (CCA) can be applied in new ways to measure and analyse financial system and sovereign risk. A new framework ("Systemic CCA") is presented, which can help the measurement, analysis and management of financial sector systemic risk, tail-risk, and associated government implicit and explicit guarantees (contingent liabilities).

This article begins with a brief overview of the crisis of 2007-2011 which describes key features and market events, the actions of the authorities, and feedbacks from the markets to the real economy. This is followed by a section on what has been missing in the measurement and analysis of financial crises and sovereign risk. This includes a discussion of the need for better measurement and analysis of risk exposures, balance sheet risk, interconnectedness and contagion. Conceptual frameworks that can better analyse risk exposures and risk-adjusted balance sheets are presented. The article shows how risk management tools and contingent claims analysis (CCA) can be applied in new ways to the financial system, to economic sectors and to the national economy. CCA is a valuable tool to improve systemic financial sector and sovereign risk management. Next, a new framework ("Systemic CCA") is presented, which can help the measurement, analysis and management of financial sector systemic risk, tail-risk, and associated government implicit and explicit guarantees (contingent liabilities). An example of the Systemic CCA for the US financial sector, as well as similar applications of the model in the context of the European and Swedish banking sector, are provided. The next section shows how this can be used to analyse potential (non-linear) destabilising feedback processes between the financial sector and the sovereign balance sheet. Finally, the systemic risk dynamics are interlinked with important new measures of risk-adjusted economic output value via the CCA balance sheets and put-call parity relationships.

II. Key features of the global financial crisis and shortcomings of traditional analysis

A. KEY FEATURES AND STAGES OF THE CRISIS, 2007-2011

The crisis can be divided into four stages: Stage 1 – Buildup of vulnerabilities; Stage 2 – Run on shadow banking system; Stage 3 – Lehman bankruptcy and global financial crisis/great recession; and Stage 4 – Sovereign debt crisis.

In the first stage of the crisis, the surge in new credit created from securitising subprime mortgages in the US contributed to the upward spiral of higher house prices, and eventually to speculation and a bubble in the housing market. Poor regulation meant discipline in mortgage lending eroded from a loosening of lending standards. As initial low "teaser" rates expired and adjustable rate mortgage interest payments increased, many households could not afford to pay their mortgages. Eventually, the surge of house prices slowed and many borrowers defaulted.

Structured finance and regulatory rules created incentives for regulatory arbitrage which allowed for a reduction in the capital cushion across the financial system. This strategy of creating such off-balance sheet vehicles was part of the "originate and distribute" model that allowed banks to hold less capital than if the assets were held on-balance sheet. The structured assets placed in these off-balance sheet vehicles were financed by very short-term funding, in large part by commercial paper.

While the crisis started with a credit shock from defaults by subprime borrowers in the United States in mid-2007, there are additional features which amplified the subprime credit shock and turned it into such a serious crisis. The second stage of the crisis in 2007 can be thought of as a *run on the shadow or parallel banking system*. The conditions needed for a run are: (i) a negative credit shock from subprime borrowers; (ii) illiquid structured credit without transparent values, (iii) very short-term funding of longer maturity assets (maturity transformation); and, (iv) the lack of a lender of last resort to key institutions in what had grown into a very sizable "parallel banking system" (outside the US banking sector) (Loeys and Cennella, 2008).

The build-up in leverage, financed by wholesale short-term funding, was a key contributing factor to the severity of the crisis. The leverage in securitised products does not come from the products themselves but from how they are funded (collateralised debt obligations, CDOs, themselves merely redistribute risk). By 2007, short-dated funding of longer maturity assets outside of the regulated banking system in the US economy were about USD 5.9 trillion (Loeys and Cennella, 2008).[1] Overall, this maturity transformation outside of the banking world amounted to 40% of total maturity transformation in the US financial system in 2007. Yet there was no official lender of last resort to this "parallel banking system." The vulnerabilities were building from 2003 to 2007, but didn't erupt into a full-blown crisis until mid-2007, when lenders stopped providing short-dated funding to SIVs, conduits, and ABCPs.[2] This was similar to a run.

The third stage of the crisis began in September 2008, when financial markets and the rating agencies decided Lehman Brothers was near bankruptcy. The US Treasury tried to arrange financial support but decided not to participate in a bailout. Lehman declared bankruptcy on 14 September 2008, which was the largest bankruptcy in the history of the world.[3] Prime money market funds (MMFs) that held the USD 4 billion Lehman commercial paper and USD 20 billion short-term debt had to write down these assets when Lehman went bankrupt. This led one money market fund to "break the buck"[4]– shaking confidence in the supposedly safe prime MMFs and prompting intense redemption pressures from institutional investors. Falling confidence induced a precipitous pull-back from MMFs, engendering a downward spiral in confidence in the financial system. World stock markets plunged, wiping out USD 1 trillion in market value. The crisis rapidly spilled over internationally. Several banks in the UK, Belgium and other countries were taken over by their governments. Depositors started a run on an Icelandic bank, the Icelandic króna fell by over 60%, and the three largest Icelandic banks had to be nationalised, triggering a

1 This USD 5.9 trillion was composed of: (1) broker-dealers funding through repos and customer deposits (USD 2.2 trillion); commercial paper issued by ABS issuers and finance companies (USD 1.4 trillion); (3) auction rate securities (USD 900 billion); and repo funding by hedge funds (USD 1.3 trillion). Overall, this maturity transformation outside of the banking world amounted to 40% of total maturity transformation in the US financial system in 2007.

2 SIV is special investment vehicle and ABCP is asset-backed commercial paper.

3 The Finance Crisis and Rescue, page 7, Rotman School of Management, October 2008.

4 'Breaking the buck' refers to closing with a net asset value of less than one U.S. dollar.

sovereign debt crisis. Bank lending to Eastern Europe and the Baltics led to distress in some EU and Nordic banks in 2009.

Extensive government support via liability guarantees, capital injections and economic stimulus packages was initiated to counteract the sharp recession caused by the spillovers from the crisis globally. Many governments significantly increased their borrowing, raising sovereign debt levels simultaneously with declines in tax revenues, higher expenditures and increasing fiscal deficits.

The fourth stage of the crisis, which emerged in 2010, is the sovereign debt crisis. This appeared first in the euro area (Greece, Portugal, Ireland), before morphing into wider concerns about UK and US debt sustainability. Sovereign debt and fiscal issues and banking sector risks are intertwined. Banking risks spilled over, increasing sovereign risk via increased contingent liabilities to banks (this was particularly extreme in Ireland). As sovereign credit risks rise, the value of government support to banks becomes more uncertain, and sovereign spreads can spill over, increasing bank borrowing costs. Large scale banking rollover and refinancing needs and high sovereign borrowing needs occurred simultaneously in 2010 in many countries. By August 2011, there was serious concern about sovereign risk in Italy, Spain and also France, triggering concern about the viability of the euro area single currency.

B. SHORTCOMINGS OF TRADITIONAL ANALYSIS

Traditional macroeconomic and banking models do not adequately measure risk exposures of financial institutions and sovereigns and cannot be used to understand the transmission and amplification of risk within and between balance sheets in the economy. Traditional macroeconomic analysis of the government and central bank is almost entirely flow or accounting balance-sheet based. Sovereign debt analyses focus on debt sustainability (stocks, flows and debt to GDP). A fundamental point is that accounting balance sheets or a flow-of-funds do not indicate risk exposures, which are forward-looking.[5] A risk exposure measures how much can be lost over a forward-looking time horizon with an estimated probability. There has been extensive work on linking the default risk of corporations with macroeconomic models (for example, Schuermann et al., 2006). However, a key risk exposure that macroeconomists have frequently left out of their models is default risk in the financial sector. As pointed out by Charles Goodhart, "the study of financial fragility has not been well served by economic theory. Financial fragility is intimately related to probability of default. Default is hard to handle analytically being a discontinuous, nonlinear event so most macro models [and their underlying] transversality assumptions exclude the possibility of default."[6] Default risk models and risk-adjusted balance sheets of financial institutions are needed to analyse financial fragility and contingent liabilities.

5 Robert C. Merton (2002) pointed out that "Country risk exposures give us important information about the dynamics of future changes that cannot be inferred from the standard 'country accounting statements,' either the country balance sheet or the country income flow-of-funds statements".

6 Charles Goodhart on the occasion of a presentation at the IMF (2005).

Sovereign default risk models are needed and should be used together with the financial sector risk models. Models that *integrate* credit, market and liquidity risks into financial and sovereign crisis models in one framework were not used in the run-up to the global crisis. Also, risk appetite changes in markets, at the global or regional level, affect spreads across corporations, banks and sovereigns. Risk appetite changes are a key crisis component that is not built into traditional approaches (but which is an integral part of the risk-adjusted balance sheet/CCA models).

What are needed are better frameworks to model macrofinancial risk transmission, macroeconomic flows, and financial and sovereign risks together in an integrated way. To mitigate and manage financial sector risk and sovereign risk, new risk analytic tools and broader regulatory frameworks are needed.[7] Recent work has shown that financial sector risk indicators, such as the systemic expected losses or system default risk from CCA, have significant predictive power for GDP and the output gap (see Garcia et al., 2008 and forthcoming). This is most likely due to a credit channel process and a risk appetite channel. When CCA risk indicators for banks are low, i.e. low probability of default, then credit growth is higher, which boosts economic growth, and risk appetite is high. When banks are distressed and expected losses are high (default probabilities are high), then credit growth, GDP growth and risk appetite are likely to decrease as a result.[8]

Policymakers did look at certain aspects of interconnections in the financial sector, but, in light of the financial crisis, it is clear they lacked the correct data, analytical tools or authority to take appropriate action. Going forward, more attention needs to be paid to the linkages between financial sector risk exposures and sovereign risk exposures and their potential interactions and spillovers to other sectors in the economy or internationally. There should be more emphasis on the use of system-wide stress-testing approaches to evaluate vulnerabilities and the potential impact of self-fulfilling negative market dynamics. Improvements are needed in modelling destabilisation processes and what Robert Merton calls "destructive feedback loops" caused by situations where a guarantor provides a guarantee, the obligations of which the guarantor may not be able to meet precisely in those states of the world in which it is called on to pay.[9]

In summary, the financial crisis that began in 2007 has its roots in excessive leverage and maturity transformation in the shadow banking system, which led to large scale risk transmission and spillovers and, ultimately, large scale risk transfer to the sovereign. What is needed, going forward, is much better macrofinancial risk analysis, more use of risk-adjusted balance sheets (for financial institutions and sovereigns), improved systemic risk monitoring (which necessitates broader and more detailed data collection), and policy tools

7 This is similar to what some central bankers call a "macroprudential approach" to financial stability.

8 Garcia et al. (2008) find that including CCA financial sector risk indicators in monetary policy models (in the Taylor rule), interest rate reactions to the financial risk indicator leads to lower inflation volatility and lower output volatility in an application to Chile.

9 Robert C. Merton, Keynote speech, ECB, December 1, 2008. "Observations on Risk Propagation and the Dynamics of Macro Financial Crises: A Derivatives Perspective."

to help mitigate systemic risk. While there are many new ways to integrate risk-adjusted balance sheets with macroeconomic and financial stability models, this article will focus on their use in financial sector and sovereign risk analysis.

III. Contingent Claims Analysis (CCA)

Contingent Claims Analysis (CCA) represents a generalisation of the option pricing theory (OPT) pioneered by Black and Scholes (1973), as well as Merton (1973), and, thus, is forward-looking by construction, providing a consistent framework based on current market conditions rather than on historical experience.[10] When applied to the analysis and measurement of credit risk, it is commonly called the Merton Model.

CCA determines the risk-adjusted balance sheet of firms, based on three principles. They are: (i) the values of liabilities (equity and debt) are derived from assets; (ii) liabilities have different priority (i.e. senior and junior claims); and, (iii) assets (such as the present value of income flows and proceeds from asset sales) follow a stochastic process. Assets may be above or below promised payments on debt which constitute a default barrier. When there is a chance of default, the repayment of debt is considered "risky," to the extent that it is not guaranteed in the event of default. Risky debt is composed of two parts, the default-free value of debt, and deposits minus the "expected loss to bank creditors" from default over a specific time horizon, which can be expressed as the value of a put option.

The value of assets may be above or below promised payments on debt which constitute a default barrier at a given point in time. A CCA framework is a risk-adjusted balance sheet concept. It is an integrated framework relating bank asset values to equity value, default risk and bank funding costs. This concept of measuring credit risk has a wide spectrum of applications. CCA can help central banks analyse and manage the financial risks of the economy. The basic analytical tool is the risk-adjusted (CCA) balance sheet, which shows the sensitivity of the enterprise's assets and liabilities to external "shocks." At the national level, the sectors of an economy can be viewed as interconnected risk-adjusted balance sheets with portfolios of assets, liabilities and guarantees—some explicit and others implicit. Traditional approaches have difficulty analysing how risks can accumulate gradually and then suddenly erupt in a full-blown crisis. The CCA approach is well-suited to capturing such "non-linearities" and to quantifying the effects of asset-liability mismatches within and across institutions. Risk-adjusted CCA balance sheets facilitate simulations and stress testing to evaluate the potential impact of policies to manage systemic risk.

The following sections provide a description of CCA for individual banks, measures of market-implied contingent liabilities, systemic CCA, and CCA applied to the measurement of spillover effects between banks and sovereign default risk.

10 Although market prices are subject to market conditions not formally captured in this approach, they endogenise the capital structure impact of government interventions.

A. CCA FOR INDIVIDUAL BANKS

In order to understand individual risk exposures (and associated public sector contingent liabilities) in times of stress, CCA is first applied to construct risk-adjusted (economic) balance sheets for financial institutions.

In its basic concept, CCA quantifies default risk on the assumption that owners of equity in leveraged firms hold a call option on the firm's value after outstanding liabilities have been paid off. The concept of a risk-adjusted balance sheet is instrumental in understanding default risk. More specifically, the total market value of firm assets, A, at any time, t, is equal to the sum of its equity market value, E, and its risky debt, D, maturing at time T.[11] The asset value follows a random, continuous process and may fall below the value of outstanding liabilities, which constitutes the bankruptcy level ('default threshold' or 'distress barrier') B.[12] B is defined as the present value of promised payments on debt discounted at the risk-free rate. The value of risky debt is equal to default-free debt minus the present value of expected loss due to default. These uncertain changes in future asset value, relative to promised payments on debt, are the driver of credit and default risk. Indeed, default happens when assets are insufficient to meet the amount of debt owed to creditors at maturity.

In this framework, market-implied expected losses associated with outstanding liabilities can be valued as an implicit put option, with its cost reflected in a credit spread above the risk-free rate that compensates investors for holding risky debt. The put option value is determined by the duration of the total debt claim, the leverage of the firm, and the volatility of its asset value (see Appendix 1).

In the traditional way of analysing bank balance sheets, a change in accounting assets results in a one-for-one change in book equity. The traditional bank accounting balance sheet has accounting assets on the left and liabilities consisting of book equity and the book value of debt and deposits on the right. When assets change, the full change affects book equity.

Traditional bank accounting balance sheet

Assets	**Liabilities**
Accounting assets	Debt and deposits
(cash, reserves, loans, credits, other exposures)	Book equity

In conventional definition of credit risk, the concept of "expected losses" refers to exposures on the asset side of the bank's balance sheet, such as loans, mortgages, and non-cash claims (derivatives and contingent assets). This traditional expected loss is frequently calculated as a probability of default (PD) times a loss given default (LGD) times the exposure at default (EAD). The expected losses of different exposures are aggregated (using certain assumptions regarding correlation, etc.) and used as an input into loss distribution calculations which are, in turn, used for the estimation of regulatory capital.

11 We identify contingent liabilities based on the standard Black-Scholes-Merton (BSM) framework of capital structure-based option pricing theory (OPT). See Merton, (1974).

12 Moody's KMV CreditEdge defines this barrier equal to total short-term debt plus one-half of long-term debt.

In the risk-adjusted (CCA) balance sheet context, however, changes in assets are directly linked to changes in the market value of equity *and* the expected losses in an *integrated framework*. A decline in the value of assets increases expected losses to creditors and leads to a less than one-to-one decline in the market value of equity; the amount of change in equity depends on the severity of financial distress, the degree of leverage, and the volatility of assets. The amount of increase can be very high when banks are in severe financial distress. While expected loss in this case also relates to the total debt and deposits on the full bank balance sheet, the underlying "exposure" is represented by the default-free value of the bank's total debt and deposits. The expected loss to creditors is a "risk exposure" in the risk-adjusted balance sheet.

Risk-adjusted (CCA) balance sheet

Assets	**Liabilities**
Market value of assets (A)	Risky debt (D)
(cash, reserves, value of "risky" assets)	(= default-free value of debt and deposits minus expected losses to bank creditors)
	Market value of equity (E)

The risk-adjusted bank balance sheet and the traditional accounting bank balance sheet can be reconciled if uncertainty about the default risk is ignored. The accounting balance sheet can be "derived" from the special case of the risk-adjusted balance sheet—the case in which uncertainty is set to zero (i.e. the bank's assets have no volatility). With zero volatility on the balance sheet, the expected loss to bank creditors goes to zero and equity becomes book equity. The "risk exposure" becomes zero (Gray et al, 2007 and 2008; Gray and Malone, 2008).

The risk-adjusted balance sheet of the banks can quantify the impact on the bank borrowing cost of higher (or lower) levels of equity, the impact of changes in global risk appetite, and of government guarantees:

- Lower levels of the market value of equity are directly related to higher bank funding costs. There is increasing interest in indicators that use the market value of equity as a measure of financial fragility.[13]
- The impact of changes in global or regional risk appetite on the values of bank expected losses to creditors, bank funding costs, and bank equity can be measured. Lower risk appetite causes investors to flee from "risky" investments to safer forms of investment – this raises borrowing costs around the world for corporate, sovereign and household borrowers etc. As the CCA framework quantifies the impact of changes in risk appetite, stress test scenarios can include stressing changes in global or regional risk appetite (see Appendix 2).

13 For example, Haldane (2011) states that "market-based metrics of bank solvency could be based around the market rather than book value of capital…..e.g., [the] ratio of a bank's market capitalisation to its total assets. …Market-based measures of capital offered clear advance signals of impending distress beginning April 2007…..replacing the book value of capital by the market value lowers errors by half. Market measures provide both fewer false positives and more reliable advance warnings of future banking distress."

- During the crisis, implicit and explicit government guarantees had an important impact on reducing bank borrowing costs (and shifting risk to the sovereign balance sheet) which can be measured in the CCA framework.

It is important to measure expected losses to bank creditors in order to understand the drivers of changes in bank funding costs and in financial stability. Higher bank borrowing costs lead to higher lending rates for corporates and households, to credit rationing, and lower credit growth. This can have a negative impact on economic output, which can, in turn, feed back, causing further distress in the banking system. Higher expected losses to creditors raise bank borrowing costs. Lenders may cut off credit and induce severe liquidity problems that can spread through the whole financial system. Bank creditors can incur losses which might contribute to financial instability. Higher expected systemic losses can transfer risk to the government via guarantees and the costs of resolving failed banks.

STRESS TESTING USING CCA

For stress testing, three different methods can be used to model the macrofinancial linkages affecting individual expected losses. Macro variables and changes in risk appetite can be linked to CCA balance sheets and used for stress testing in several ways. In the first model ("satellite model"), the historical sensitivity of expected losses to creditors (or other CCA risk indicators) is estimated from several macroeconomic variables (such as short-term and long-term interest rates, real GDP and unemployment) and bank-specific variables (net interest income, operating profit before taxes, credit losses, leverage and funding gap) using some econometric approach, such as a dynamic panel regression specification (IMF, 2010b, 2010c, 2011b, 2011f, and 2011g). In the second model ("structural model"), the value of implied assets of each bank is adjusted by forecasts of operating profit and credit losses as updated inputs into the calibrated bank CCA model in order to determine changes in expected losses, funding costs, the CCA capital ratio (i.e. market value of equity to market value of assets) and other useful outputs (IMF, 2011c, 2011d, 2011f and 2011g). The third way to link macro variables is to estimate the historical relationships of the macrofactors to changes in the bank market value of assets (which is done in Moody's KMV Global Correlation and Portfolio Manager models).

B. MEASURING MARKET-IMPLIED CONTINGENT LIABILITIES FROM THE FINANCIAL SECTOR

The implicit put option calculated for each financial institution from equity market and balance sheet information using CCA can be combined with information from credit default swap (CDS) markets to estimate the government's contingent liabilities. If guarantees do not affect equity prices in a major way (especially when firms are in distress), implicit guarantees reduce default risk, so that the price of insuring against default, which is expressed as CDS spreads for contracts at different maturity tenors, captures only the expected loss *retained* by the financial institution – and borne by unsecured senior

creditors. Thus, the implied CDS spread is generally higher than the actual CDS spreads due to the impact of explicit and implicit guarantees.

Hence, the scope of market-implied guarantees affecting firm valuation can be defined as the difference between the total expected loss (i.e. the value of a put option derived from the firm's equity price) and the value of an implicit put option derived from the firm's CDS spread, which reflects expected losses associated with the default net of any financial guarantees. This allows one to measure the time pattern of the government's market-implied contingent liabilities and the retained risk in the banking sector (see Appendix 1).[14]

C. MEASURING SYSTEM-WIDE CCA ('SYSTEMIC CCA')

In order to assess systemic risk (and the underlying joint default risk), however, a simple summation of implicit put options would presuppose perfect correlation, i.e. a coincidence of defaults. While it is necessary to move beyond "singular CCA" by accounting for the dependence structure of individual balance sheets and associated contingent claims, the estimation of systemic risk through correlation becomes exceedingly unreliable in the presence of "fat tails".[15]

The Systemic CCA framework (Gray and Jobst, 2010 and forthcoming; Gray and others, 2010; IMF, 2011g) extends the risk-adjusted balance sheet approach in order to quantify the systemic financial sector risk jointly posed by the interlinkages between institutions, including the time-varying dependence of default risk. Under this approach, the magnitude of systemic risk depends on the firms' size and interconnectedness in a multivariate framework. This methodology models the joint market-implied expected losses of multiple institutions with "too-big-to-fail" properties as a portfolio of individual contingent claims (with individual risk parameters).[16] By accounting for the dependence structure of individual bank balance sheets and associated contingent claims, this approach can be used to quantify the contribution of specific institutions to the dynamics of the components of

14 For a more detailed exposition, see Gray and Jobst (2010a and forthcoming) and IMF (2010a). While this definition of market-implied contingent liabilities provides a useful indication of possible sovereign risk transfer, the estimation of the alpha-value depends on a variety of assumptions that influence the assessment of the likelihood of government support, especially at times of extreme stress during the credit crisis. The extent to which the put option values differ from the ones implied by CDS spreads might reflect distortions stemming from the modelling choice (and the breakdown of efficient asset pricing in situations of illiquidity), changes in market conditions, and the capital structure impact of crisis interventions, such as equity dilution in the wake of capital injections by the government, beyond the influence of explicit or implicit guarantees.

15 Correlation describes the complete dependence structure between two variables correctly only if the joint (bivariate) probability distribution is elliptical—an ideal assumption rarely encountered in practice. This is especially true in times of stress, when default risk is highly skewed, and higher volatility inflates conventional correlation measures automatically (as covariance increases disproportionately to the standard deviation), so that large extremes may even cause the mean to become undefined. In these instances, default risk becomes more frequent and severe than suggested by the standard assumption of normality—i.e., there is a higher probability of large losses and more extreme outcomes.

16 The Systemic CCA framework can be decomposed into two sequential estimation steps. First, the market-implied potential losses (and associated change in existing capital levels) are estimated for each sample bank using an advanced form of contingent claims analysis (CCA). Then, these individual estimates are aggregated in a multivariate set-up in order to derivate estimates of joint expected losses and changes in capital levels.

systemic risk (at different levels of statistical confidence),[17] how this systemic risk affects the systemic expected losses and government's contingent liabilities, and how policy measures may influence the size and allocation of this systemic risk over time.

Systemic CCA generates estimates of expected and unexpected losses from systemic financial sector risk, as well as measures of extreme risk. These estimates are based on the multivariate density of each bank's individual marginal distribution of market-implied expected losses and their dependence structure within a system of financial institutions. Accounting for both linear and non-linear dependence and its effect on joint expected losses can deliver important insights about the joint tail risk of multiple entities. Large shocks are transmitted across entities differently than small shocks. As opposed to the traditional (pairwise) correlation-based approach, this method of measuring "tail dependence" is better suited to analysing extreme linkages of multiple (rather than only two) entities, because it links the univariate marginal distributions of expected losses (and associated liabilities) in a way that formally captures both linear and non-linear dependence in joint tail risk behaviour over time.[18]

In addition, the Systemic CCA framework can be used for stress testing. By modelling how macroeconomic conditions and bank-specific income and loss elements (net interest income, fee income, trading income, operating expenses and credit losses) have influenced the changes in the financial institution's market-implied expected losses (as measured by implicit put option values), it is possible to link a particular macroeconomic path to financial sector performance in the future.

D. ADAPTING CCA TO THE SOVEREIGN AND FRAMEWORK FOR INTERACTIONS AND FEEDBACK BETWEEN THE FINANCIAL SECTOR AND THE SOVEREIGN

The CCA approach can be adapted to the sovereign, but the procedure for doing so generally depends on whether one is dealing with an emerging market sovereign, which may possess significant foreign debt, usually denominated in hard currency, or a developed country sovereign, in which most or all debt is issued in local currency (see Gray et al., 2007, Gapen et al., 2008, Gray and Malone, 2008, Gray and Jobst, 2010a, and IMF, 2010a). Our application of the sovereign CCA focuses on developed country sovereigns, especially European sovereigns, such as Greece. The value of sovereign debt can be seen as having two components, the *default-free value* (promised payment value) and the *expected loss* associated with default in the event the assets are insufficient to meet the promised payments. The value of sovereign assets at time horizon *T*, relative to the promised payments on sovereign debt (the sovereign debt or distress barrier), is

17 The contribution to systemic (joint tail risk) is derived as the partial derivative of the multivariate density relative to changes in the relative weight of the univariate marginal distribution of each bank at the specified percentile.

18 As an integral part of this approach, the marginal distributions fall within the domain of Generalized Extreme Value Distribution, GEV (Coles et al., 1999; Poon et al., 2003; Stephenson, 2003; Jobst, 2007). Sample banks in each jurisdiction based on the multivariate distribution (MGEV) of joint CDS spread movements defined by a non-parametric dependence function (Gray and Jobst, 2009 and 2010; Jobst and Kamil, 2008). As opposed to a simple copula approach, this method does not generate a single, time-invariant dependence parameter.

the driver of these expected losses. There is a random element to the way the sovereign asset value evolves over time. The application of the sovereign CCA model to developed country sovereigns requires us to infer the value of sovereign assets—because the value of sovereign assets is not directly observable—based upon measures of expected losses on sovereign debt derived from the *full term structure of sovereign spreads.* See Appendix 3 for details.

The previous discussion and illustration of Systemic CCA points out the importance of measuring the government's contingent liabilities to banks and accounting for the dependence structure of the portfolio of such contingent liabilities using a framework that can capture time variation. The full set of interlinked risk exposures between the government and financial sector should be analysed in a comprehensive framework.

A stylised framework starts with the economic (i.e. risk-adjusted) balance sheets of the financial sector (portfolio of financial institutions) and is then linked to, and interacts with, the government's economic balance sheet.[19] For example, distressed financial institutions can lead to large government contingent liabilities, which, in turn, reduce government assets and lead to a higher risk of default on sovereign debt. Table 1 below shows the key linkages between the financial sector and the government. The economic balance sheet items in italics reflect the risk exposures of the government to the financial sector. The government has provided financial guarantees associated with expected losses due to default, it may have provided asset guarantees, it may have injected capital and have an equity stake in the banks. All of these form the government's risk exposures to the financial sector. Note that these risk exposures consist of portfolio financial institutions. These, in turn, affect the economic value of the government's assets and may affect the government's own default risk and borrowing spreads. Risk interactions and feedbacks can be analysed with this type of framework.

19 There are three types of accounts for any entity, including a financial institution or a government: flow/income accounts; accounting balance sheets; and economic risk-adjusted balance sheets. All three need to be analysed. In the economic risk-adjusted balance sheets of financial institutions or governments, assets always equal liabilities (which include equity). In simple terms, Assets + Guarantees – Equity – (Default-free Debt – Expected Loss due to Default) = 0.

Table 1. Linkages between the financial sector and sovereign balance sheets

FINANCIAL SECTOR	GOVERNMENT
ASSETS	
Assets/loans + Liquid assets/reserves + *Asset guarantees*	Present value of fiscal surplus and guarantee fees + *Equity (government-owned)* + Other assets
LIABILITIES	
– *Equity (non-government)* – *Equity (government-owned)*	– Credit owed to central bank – *Asset guarantees*
– Default-free debt and deposits + (1-α) **Expected Losses (EL) due to default*	– α* *Expected Losses (EL) due to default*
– Present value of guarantee fees	– Default-free sovereign debt + *Expected Losses (EL) due to sovereign default*
ASSETS MINUS LIABILITIES	
0	0

Source: Gray et al. (2010).

Negative feedback effects could arise in a situation in which the financial system is outsized compared to the government, and distress in the financial system triggers a large increase in government financial guarantees. These contingent liabilities to the government due to guarantees, can lead to a rise in sovereign spreads. Banks' spreads depend on retained risk, which is lower given the application of government guarantees, and also on the creditworthiness of the sovereign (as a result of fiscal sustainability and debt service burden), as investors view the bank's risk and sovereign risk as intertwined. Concern that the government balance sheet will not be strong enough for it to make good on guarantees could lead to deposit withdrawals or a cutoff of credit to the financial sector, triggering a destructive feedback in which both bank and sovereign spreads increase.[20] In some situations, this vicious circle can spiral out of control, resulting in the inability of the government to provide sufficient guarantees to banks and leading to a systemic financial crisis and a sovereign debt crisis.

Fiscal, banking and other problems can cause distress for the government, which can transmit risk to holders of government debt. Holders of sovereign debt have a claim on the value of the debt minus the potential credit loss, the value of which is dependent on the level of assets of the sovereign.[21] A sudden stop in access to foreign funding (inability to rollover short-term debt and to borrow) can dramatically increase credit spreads for the sovereign and for banks. A vicious spiral of increasing bailout costs for banks, possible currency devaluation, and the inability of the sovereign to borrow can lead to the default of both banks and the sovereign.

20 The Iceland crisis of 2008 is a case in point.

21 See Gapen et al. (2005), Gray et al. (2007), Gray and Malone (2008), and Gray and Jobst (2010b) for more detail on sovereign CCA models.

IV. Applications

This section describes three applications of CCA and Systemic CCA with examples of stress testing. The first example summarises the findings from the recent US FSAP (IMF, 2010b), where the Systemic CCA approach premiered as an IMF stress-testing approach. The subsequent cases illustrated the application of CCA to the banking systems in Europe and the Swedish banking sector, with a particular focus on spillover effects between banks and the fiscal conditions.

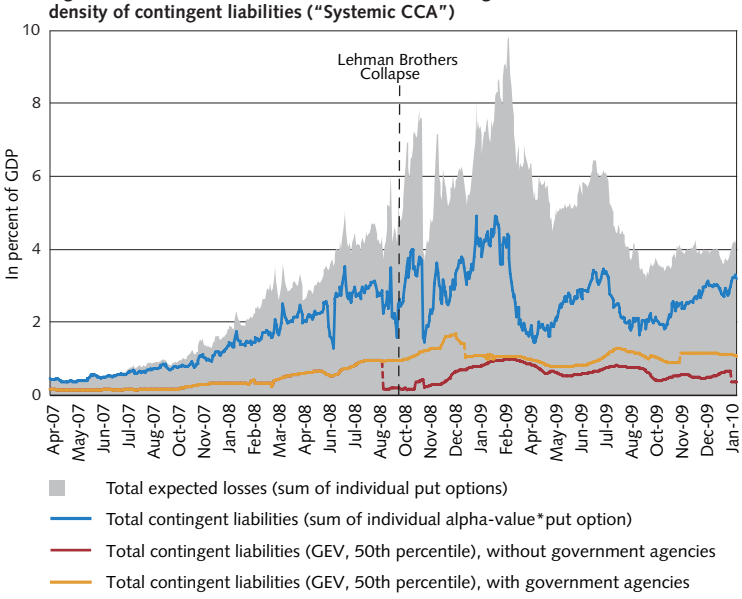
A. APPLICATION TO THE US FINANCIAL SECTOR

This section describes the results from applying the Systemic CCA framework to the financial sector of the United States (IMF, 2010b and 2010c). It uses market and balance sheet information about commercial banks, investment banks, insurance companies and special purposes financial institutions (the 36 largest institutions), using daily data from 1 January 2007 to late January 2010.[22] We apply the enhanced version of the Merton model (see above) with implied asset volatility derived from equity options to determine the CCA-based risk-adjusted balance sheets and one-year CDS spreads as the basis for calculating associated market-implied contingent liabilities.

Figure 1 shows total expected losses (area) and government contingent liabilities (line) for all 36 institutions; both are highest between the periods just after Lehman's collapse in September 2008 and the end of July 2009. The analysis suggests that markets expected that, on average, more than 50 per cent of total expected losses could have been transferred to the government in the event of default. A simple summation of expected losses and contingent liabilities, however, ignores the fact that the realisation of defaults does not happen concurrently, i.e. it does not capture intertemporal changes in the dependence structure between this 'portfolio' of financial institutions.

22 Key inputs used were the daily market capitalisation of each firm (from Bloomberg), the default barrier estimated for each firm based on quarterly financial accounts (from Moody's *KMV CreditEdge*), the risk-free rate of interest (at 3 per cent), a one-year time horizon, and one-year credit default swap (CDS) spreads (from *Markit)*. Outputs were the expected losses (i.e. the implicit put option value over a one-year horizon) and the contingent liabilities (i.e. alpha*implicit put option).

Figure 1. United States: financial sector – total contingent liabilities and multivariate density of contingent liabilities ("Systemic CCA")

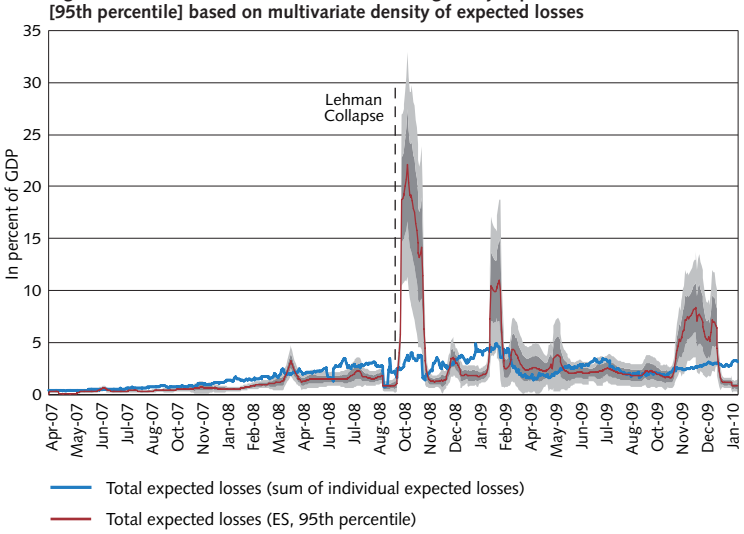


Note. Sample period: 3 January 2007-29 January 2010 (743 obs.) of individual put option values (i.e. expected losses) of 36 sample banks, insurance companies, and other financial institutions.

Source: IMF (2010c).

The median of the joint distribution is much lower than the simple summation of individual contingent liabilities, which underscores the importance of accounting for the dependence structure when measuring systemic risk. With the dependence structure included, the median value of joint contingent liabilities is much lower than the total contingent liabilities obtained from summation. There are two 50th percentile lines in Figure 1. The solid line shows results for the case where government-sponsored financing agencies were de facto nationalised (which warranted their exclusion from the sample on 8 September 2008, which is marked by the sharp drop in the line before Lehman Brothers declared bankruptcy a little more than a week later). Controlling for the time-varying dependence structure between sample firms, the expected joint contingent liabilities peaked at about 1 per cent of GDP at the end of March 2009, averaging 0.5 per cent of GDP over the sample period. The second, dashed, 50th percentile line shows the case where these government-sponsored financing agencies are left in the sample (note that daily equity prices were still available but it can be argued that information may be much less informative).

Figure 2. United States: financial sector – average daily Expected Shortfall (ES) [95th percentile] based on multivariate density of expected losses



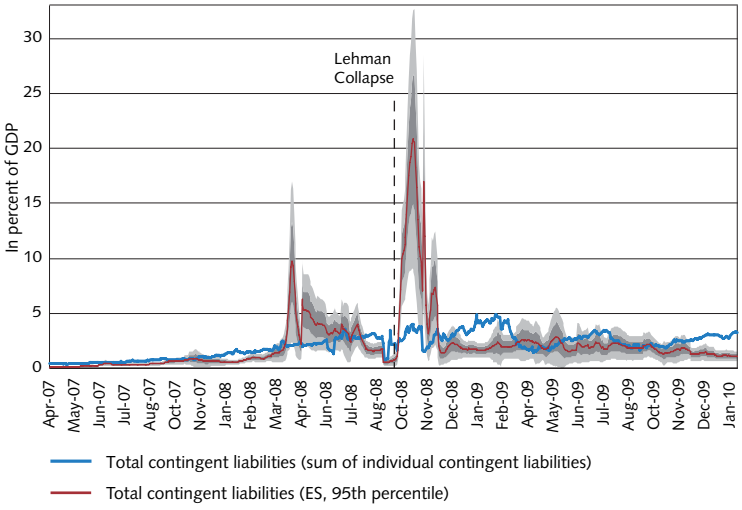
Note. Sample period: 3 January 2007-29 January 2010 (743 obs.) of individual put option values (i.e. expected losses) of 36 institutions. The red line shows the expected shortfall (ES) for the entire sample at a 95th percentile threshold within a confidence band of one and two standard deviations (grey areas).

Source: IMF (2010c).

After the collapse of Lehman Brothers, the extreme tail risk in the system increased sharply. The point estimates of the 95th percentile expected shortfall of extreme risk jumped to more than 20 percent of GDP in the months after the Lehman collapse (see Figure 2). The shaded bands show the one and two standard deviation bands around the estimate. In other words, during this period of exceptional systemic distress, market prices implied a minimum loss of 20 per cent of GDP with a probability of 5 per cent over a one-year time horizon. The magnitude of such tail risk dropped to under 2 per cent of GDP during the course of 2009.

The joint tail risk measure of contingent liabilities shows spikes in April 2008 and October 2008, indicating a high government exposure to financial sector distress. After controlling for the market perception (via CDS prices) of the residual risk retained in the financial sector, we find that the potential tail risk transferred to the government exceeded 9 per cent of GDP in April 2008 (in the wake of the Bear Stearns rescue) and almost reached 20 per cent of GDP in October 2008 (see Figure 3). The red line shows the 95th percentile expected shortfall within a confidence band of one and two standard deviations (grey areas). This spike in April 2008 is absent in the earlier chart showing expected losses (Figure 3), illustrating the distinction of expected losses and contingent liabilities for the purpose of systemic risk measurement. The bailout of Bear Stearns led to expectations of public support and induced highly correlated expectations of government support across numerous institutions, while residual risk outside anticipated public sector support was considered less susceptible to co-movements in asset prices.

Figure 3. United States: financial sector – average daily Expected Shortfall (ES) [95th percentile] based on multivariate density of contingent liabilities ("Systemic CCA")



Note. Sample period: 3 January 2007-29 January 2010 (743 obs.) Contingent liabilities (alpha*expected losses) of 36 sample institutions. The red line shows the expected shortfall (ES) for the entire sample at a 95th percentile threshold within a confidence band of one and two standard deviations (grey areas).

Source: IMF (2010c).

The systemic risk from contingent liabilities was considerable during the credit crisis. For the whole period from 1 April 2007 to 29 January 2010, the average contingent liabilities at the 50th and the 95th percentile levels amounted to 0.5 per cent and 1 per cent of GDP respectively.

This model is also used for forward-looking stress testing. The historical sensitivity of the bank-expected losses to macro variables is estimated (nominal and real GDP growth, real consumption, output gap, unemployment rate, housing prices, 3 month LIBOR-treasury rate spread). Secondly, for each bank, the baseline/adverse scenarios of implicit expected losses are extrapolated based on their joint historical sensitivity derived from a dynamic factor model. The baseline scenario used the IMF World Economic Outlook for 2010, and the adverse scenario assumed slower GDP growth, unemployment at 10 per cent and a further fall in house prices. The multivariate density of both expected losses and government contingent liabilities is then estimated using the marginal distributions of forecasted implicit put option values and their dependence structure for each quarter until the end of 2014 according to the Systemic CCA model. Results are shown in Table 2 below (IMF, 2010b and 2010c).

Table 2. United States – FSAP stress test results: systemic expected losses and market-implied contingent liabilities

Systemic CCA of financial sector – average systemic risk from expected losses and contingent liabilities, forecasting period, 2010 Q1-2014 Q4
(in USD billions unless indicated otherwise)

	50TH PERCENTILE	VAR (95%)	ES (95%)
Baseline scenario			
Market-implied contingent liabilities	31	92	180
Market-implied expected losses	75	219	429
Adverse scenario			
Market-implied contingent liabilities	41	130	382
Market-implied expected losses	97	308	910

Source: IMF (2010b and 2010c).

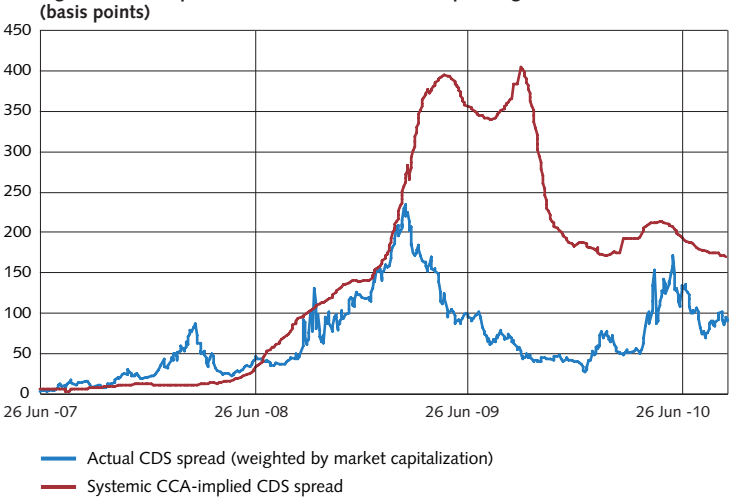
Stress test results for expected losses show the median of projected expected losses under the baseline scenario of USD 75 billion, USD 219 billion at the VaR 95 per cent level, and Expected Shortfall (ES) is higher.[23] For the adverse scenario, losses are USD 97 billion and VaR 95 per cent level USD 308 billion. Stress test results for market-implied contingent liabilities under the baseline are USD 31 billion, and USD 92 billion at the VaR 95 per cent level. For the adverse scenario, contingent liabilities are USD 41 billion, and USD 130 billion at the VaR 95 per cent level.

B. APPLICATION TO EUROPEAN BANKING SECTORS

The CCA model was applied to banks in the euro area. The CCA-implied CDS spread is generally higher than actual CDS spreads due to the impact of explicit and implicit guarantees. This is illustrated in Figure 5 for the top six banks in Europe. The gap between the CCA-implied spread and the actual CDS was largest in 2009 following the actions of authorities to guarantee bank senior debt.

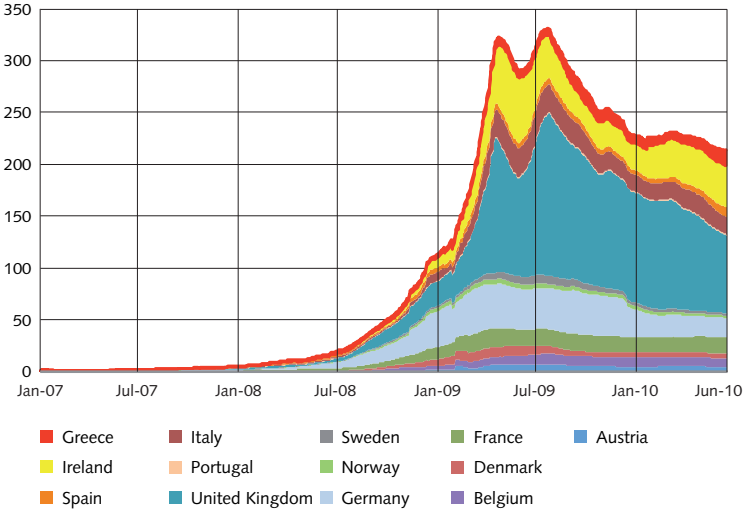
23 VaR (Value at Risk) is a widely-used risk measure. VaR is defined as a threshold value such that the probability that the loss over the given time horizon exceeds this value. ES (Expected Shortfall) is the expected value of the tail loss beyond the specific VaR level.

Figure 4. CCA implied CDS vs. actual CDS for Europe's largest six banks (basis points)



Source: IMF staff estimates.

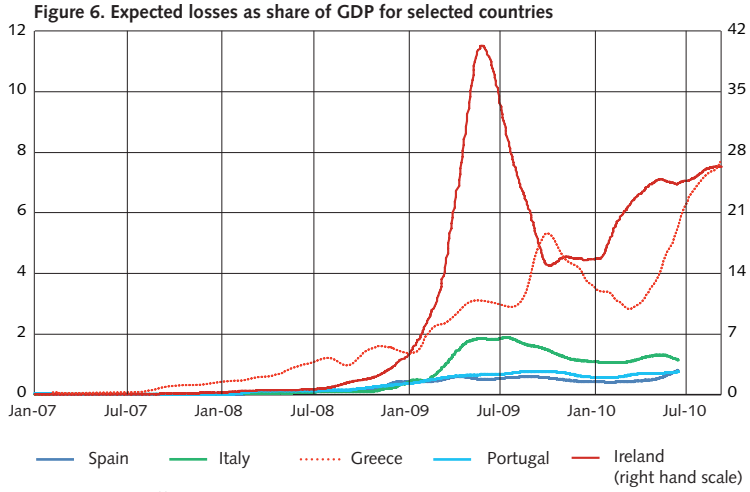
Figure 5. European banking system expected losses EUR billions, Jan. 2007-June 2010



Note. Sample period: 1 March 2005-18 June 2010 (1,075 obs.) of individual put option values. Sample institutions are 37 large commercial banks from the euro area plus Denmark, Sweden, Norway and the United Kingdom as shown above. The time series shows the 50th percentile of the multivariate density generated from extreme value univariate marginals (Generalized Extreme Value Distribution (GEV)) and a non-parametrically identified time-varying dependence structure of sample banks within each country.

Sources: IMF staff estimates, Gray and Jobst (2010).

Figure 6. Expected losses as share of GDP for selected countries



Source: IMF staff estimates.

The CCA model was applied to the banking systems in 13 euro area countries. The CCA model for the largest banks in each country was calibrated, and the Systemic CCA model estimates for each national banking sector were subsequently aggregated by applying the aggregation mechanism of Systemic CCA once again. The time pattern of the expected losses (50th percentile) is shown in Figure 5. While the UK is largest contributor in absolute terms, given the size of the system, this amount, if scaled by GDP, becomes much smaller when compared to Ireland, for instance. Figure 6 shows that the expected losses (as a percentage of GDP) are less than 2 per cent of GDP in Italy, Spain and Portugal, while in Greece they are 6 per cent of GDP. In Ireland, the range is from 20 to 40 per cent of GDP (right hand scale, RHS, is expected losses as a share of GDP for Ireland only).

An example of stress testing using systemic CCA for banking systems in the 13 European countries is shown in Table 3. First, historical sensitivity of the bank median expected losses to macro variables was estimated (real GDP growth and unemployment rate). Second, for each country banking sector, the baseline/stress scenario of median expected losses was projected, based on its historical sensitivity derived from a dynamic factor model. Stress scenario projections were based on an annual decrease of 1.5 percentage points in GDP growth and an increase in unemployment of 1.5 and 1.0 percentage points respectively. The results show that, under the baseline, losses fall to EUR 114 billion for the first year and then to EUR 89 billion in the second year. However, under the stress scenario, the expected losses are EUR 165 billion for the first year and EUR 219 billion in the second year.

Table 3. Stress testing systemic risk of European banking systems

EURO AREA BANKING SECTOR STRESS SCENARIOS	MEDIAN EXPECTED LOSSES, EURO BILLION
Estimation Period (Historical)	
Pre-crisis December 2005 to September 2008	6
Sept 15 to December 30 2008	47
January 1 to March 2010	135
Sovereign Crisis: March 1 to July 2010	123
Projection Period 1st year (2010 Q3-2011 Q2)	
Baseline Scenario	114
Stress Scenario	165
Projection Period 2nd year (2011 Q3-2012 Q2)	
Baseline Scenario	89
Stress Scenario	219

Source: IMF staff estimates.

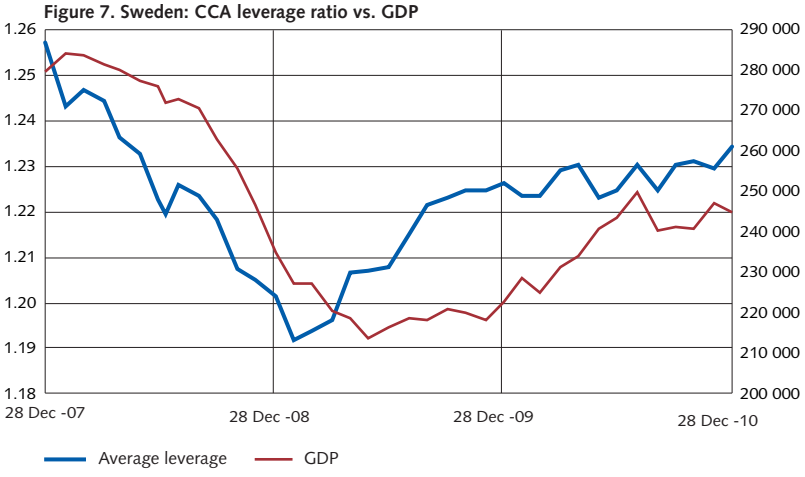
C. APPLICATION TO SWEDEN

CCA models for each of the four banks were first calibrated, and then expected losses for each were estimated. The CCA model for each bank used equity market and balance sheet information (including some inputs from Moody's KMV Credit Edge for each bank) to calibrate the key parameters of the CCA model (bank asset level, asset volatility, bank debt distress barrier, skew, kurtosis, and a volatility adjustment parameter).[24]

One key CCA risk indicator is the ratio of market capitalisation to the market value of assets. All banks show the same pattern, with a low point reached in early 2009. What is very interesting is how this indicator leads GDP. This is common – financial sector indicators of this type contain forward-looking information and relate to credit and risk appetite channels that affect GDP. See Figure 7, showing how the CCA leverage ratio (equity/assets) for the four banks leads GDP.

24 The four banks are Swedbank, Svenska Handelsbanken, Nordea, and Skandinaviska Enskilda Banken (SEB).

Figure 7. Sweden: CCA leverage ratio vs. GDP

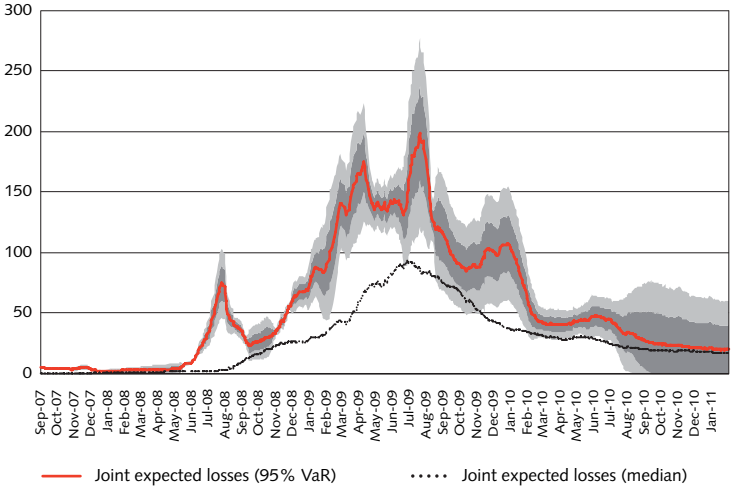


Source: IMF (2011d).

THE SYSTEMIC CCA METHODOLOGY FOR THE FOUR LARGEST COMMERCIAL BANKS IN SWEDEN

Over a sample period from September 2007 to January 2011, we estimate the magnitude of expected losses for all banks, and quantify the individual banks' contributions to systemic bank distress. Figure 8 shows the estimation results of the Systemic CCA-derived multivariate density of expected losses (i.e. the full value of the implicit put option). This is the median of the multivariate distribution of losses and the 95 per cent VaR (tail risk). The risk horizon is one year. July and August 2009 defined peak events (5 per cent chance of losses of SEK 200 billion over the coming year).

Figure 8. Sweden: banking sector – total sum and multivariate distribution function of expected losses (50th percentile and 95th percentile)
SEK, billions

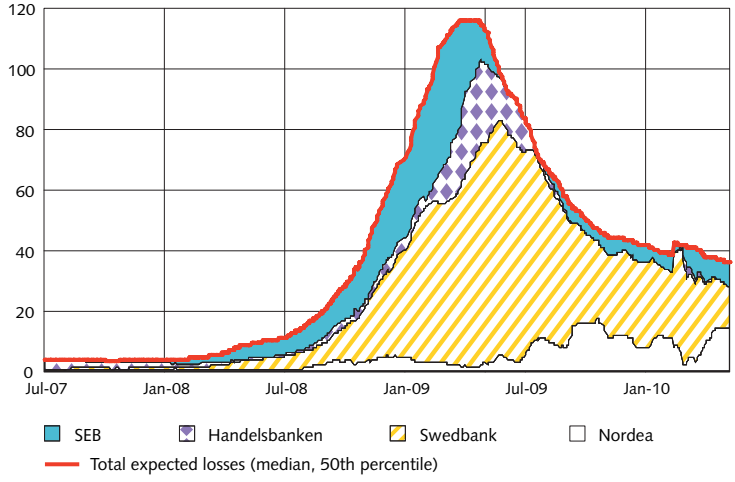


Note. Sample period: 1 January 2007-11 February 2010 of individual of individual put option values. The red line shows the daily Value-at-Risk (VaR) estimate for the entire sample at the 95th percentile within a confidence band of one and two standard errors (grey areas). The multivariate density is generated from univariate marginals, which conform to the Generalized Extreme Value Distribution (GEV) and a non-parametrically identified time-varying dependence structure.

Source: IMF (2011d).

The contribution of each bank to the median expected losses, 50th percentile, is shown in Figure 9. It clearly shows that Swedbank was the largest contributor, suggesting that the dynamics of market prices have anticipated the rising risk profile of Swedbank.

Figure 9. Sweden: individual contribution to daily Value-at-Risk (VaR) point estimates of expected losses ("Systemic CCA") at the 50th percentile
SEK, billions



Source: IMF (2011d).

The results of the balance sheet stress tests were used to estimate changes in bank assets. Bank-by-bank profits before loan losses, and bank-by-bank loan losses, adjusted for taxes and dividends, give the changes in bank assets for the stress test scenarios for each year from 2011 to 2014. In addition, the global market price of risk (a measure of global risk appetite) was projected for baseline and adverse (based on historical relationships to GDP, see Appendix 2 for details). Thus the changes in bank assets (and associated change in bank asset volatility) and the scenarios for the market price of risk form inputs to the CCA bank models, while the outputs are the expected losses to creditors and the market value of equity for each bank annually over the 2011 to 2014 period, from the base date of end 2010 (IMF, 2011c).

The simple sum of expected losses to bank creditors increases in the adverse scenario. They increase from SEK 89 billion at the end of 2010 to nearly 180 billion under the adverse scenario. This is significantly lower than the sum of expected losses, which peaked at SEK 375 billion in 2009.

APPLICATION OF CCA TO SWEDEN SOVEREIGN

In order to calibrate the sovereign risk-adjusted balance sheet, the implied value of sovereign assets and sovereign asset volatility needs to be calculated from observable information (the procedure is described in Appendix 3). The inputs are the sovereign debt default barrier and the term structure of the sovereign CDS spreads on 30 December 2010. The sovereign default barrier is the present value of the promised principle and interest payments on Swedish sovereign debt discounted at the risk free rate (3 per cent was used).

It is informative to see the evolution of the term structure of sovereign CDS spreads over the crisis. Before the crisis, one-year spreads were 8 basis points (bps) and 10-year spreads were 11 bps. During the crisis, on 9 December 2008, the one-year spreads were 120 bps, while 10-year spreads were 158 bps. The spreads have dropped down and, as of 30 December 2010, the five-year spreads were 30 bps.

The time patterns of principal and interest payments on Swedish sovereign debt from Bloomberg were used to estimate the sovereign debt default barrier, which was SEK 629 billion at the end of 2010. Using the CDS spreads and the debt default barrier, the procedure described above yields an implied sovereign asset equal to SEK 1 006 billion. Using end-2010 FX reserves of USD 37.9 billion (equal to SEK 256 billion), the PV of the primary fiscal surplus 2011 to 2016 (using data from the IMF) is estimated at SEK 457 billion, and implicit contingent liabilities to the financial sector are SEK 75 billion. The remainder (other assets) is estimated to be SEK 351 billion. Now we have all the components to estimate the impact on sovereign spreads from changes in financial sector contingent liabilities and changes in risk appetite in the stress test scenarios. Table 4 shows the results of a joint banking system and sovereign stress test with a baseline scenario (WEO 2010 forecast) and adverse (lower growth) scenario. The higher banking-system expected losses translate into higher contingent liabilities and higher sovereign spreads. The higher market price of risk increases both bank expected losses and sovereign spreads.

Table 4. Joint banking system and sovereign stress testing

	BANKING SYSTEM EXPECTED LOSSES (SUM) SEK, BILLIONS		SOVEREIGN SPREAD, FIVE YEAR, IN BASIS POINTS	
Historical				
Pre-crisis	8		10	
2008	60		145	
2009	190		130	
End 2010	89		30	
Projections	BASELINE SCENARIO	ADVERSE SCENARIO	BASELINE SCENARIO	ADVERSE SCENARIO
End 2011	85	180	29	45
End 2012	83	150	28	85
End 2013	80	120	27	77
End 2014	77	98	26	70

Sources: IMF staff estimates and IMF (2011c).

V. Further extensions going forward: integrating macrofinancial stress testing and policy analysis

Going forward, the type of analysis described above could be extended to integrate financial sector and sovereign risk analysis with macrofinancial feedbacks to perform stress testing and policy analysis, as well as monetary and fiscal policy analysis. This framework links some of the important components of financial sector systemic risk analysis to sovereign risk analysis to help evaluate fiscal policies and link the financial sector risk

indicators to GDP and output gap and thus link into the monetary policy models. The fact that CCA financial risk indicators have predictive power for GDP and output gap means that this framework is useful for macrofinancial linkages and feedback as well as monetary policy models. Such integrated risk models could stress test shocks to banking and sovereign balance sheets and evaluate the policy responses on capital requirements of banks, guarantees, fiscal policy and macroprudential regulation, all within one framework. Using economy-wide CCA can also provide new measures of economic output – the present value of risk-adjusted GDP (see Gray et al. (2010) for details).

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Appendix 1. The Contingent Claims Analysis (CCA) approach—standard definition

In the first structural specification of CCA, commonly referred to as the Black-Scholes-Merton (BSM) framework (or in short, the "Merton model") of capital structure-based option pricing theory (OPT) (Black and Scholes, 1973; Merton, 1973 and 1974), total value of firm assets follows a stochastic process and may fall below the value of outstanding liabilities. Thus, the asset value $A(t)$ at time t describes a continuous asset process so that the physical probability distribution of the end-of-period value is

$$A(T-t) \sim A(t)\exp\left\{\left(r_A + \sigma_A^2/2\right)(T-t) + \sigma_A\sqrt{T-t}\tilde{z}\right\},$$

for time to maturity T-t. More specifically, $A(t)$ is equal to the sum of its equity market value, $E(t)$, and its risky debt, $D(t)$, so that $A(t) = E(t) + D(t)$. The term r_A is the risk free rate of interest, σ_A is the volatility of the sovereign asset, z is the stochastic term equal to standard normal distribution mean zero standard deviation of one. Default occurs if $A(t)$ is insufficient to meet the amount of debt owed to creditors at maturity, which constitutes the bankruptcy level ("default threshold" or "distress barrier").

The equity value $E(t)$ is the value of an implicit call option on the assets, with an exercise price equal to default barrier. It can be computed as the value of a call option $E(t) = A(t)\Phi(d_1) - Be^{-r(T-t)}\Phi(d_2)$, with $d_1 = \left[\ln\left(A(t)/B\right) + \left(r + \sigma_A^2/2\right)(T-t)\right]\left(\sigma_A\sqrt{T-t}\right)^{-1}$, $d_2 = d_1 - \sigma_A\sqrt{T-t}$, asset return volatility σ_A, and the cumulative probability $\Phi(.)$ of the standard normal density function. Both the asset, $A(t)$, and asset volatility, σ_A, are valued *after* the dividend payouts. The value of risky debt is equal to default-free debt minus the present value of expected loss due to default,

$$D(t) = Be^{-r(T-t)} - P_E(t).$$

Thus, the present value of market-implied expected losses associated with outstanding liabilities can be valued as an implicit put option, which is calculated with the default threshold B as strike price on the asset value $A(t)$ of each institution. Thus, the present value of market-implied expected loss can be computed as

$$P_E(t) = Be^{-r(T-t)}\Phi(-d_2) - A(t)\Phi(-d_1),$$

over time horizon $T–t$ at risk-free discount rate r, subject to the duration of debt claims, the leverage of the firm, and asset volatility.[25] Since the implicit put option $P_E(t)$ can be decomposed into the risk-neutral probability of default *(PD)* and the loss given default *(LGD)*,

$$P_E = \Phi(-d_2)\left(1 - \frac{\Phi(-d_1)}{\Phi(-d_2)}\frac{A(t)}{Be^{-rT}}\right)Be^{-r(T-t)} = PD \times LGD,$$

There is no need to introduce the potential inaccuracy of assuming a certain loss given default (LGD). The risk-neutral default probability is RNDP. We can use the equations above to see that the spread can also be written as

$$s = -\frac{1}{T}\ln(1 - RNDP \times LGD).$$

Another important factor that drives spreads of banks (as well as corporates and sovereigns) and affects bank funding costs is the change in global risk appetite. The *market price of risk* (MPR, see Box 1) is an important parameter in *CCA* formulas, which changes when global risk appetite changes. It is a barometer of the level of risk appetite and is used to translate from the real to risk-neutral default probability. In the *CCA* model developed by Moody's KMV, the market price of risk is empirically calculated. It uses the capital asset pricing model, together with the *CCA* model, to estimate the market price of risk (MPR) as, $\lambda = \rho_{A,M} SR$,
where λ is the market price of risk, $\rho_{A,M}$ is the correlation of the bank's asset return with the global market and is the global market Sharpe ratio. Appendix 2 provides the derivation and the details.

The market-implied expected losses calculated for each financial institution from equity market and balance sheet information using the *CCA* can be combined with information from credit default swap *(CDS)* markets to estimate the government's contingent liabilities. The put option value $P_{CDS}(t)$ using credit default swap *(CDS)* spreads reflects the expected losses associated with default net of any financial guarantees, i.e., residual default risk on unsecured senior debt and can be written as

$$P_{CDS}(t) = \left(1 - \exp\left(-\left(s_{CDS}(t)/10{,}000\right)\left(B/D(t) - 1\right)\left(T - t\right)\right)\right)Be^{-r(T-t)}.$$

25 Note that the above option pricing method for $P_E(t)$ does not incorporate skewness, kurtosis, and stochastic volatility, which can account for implied volatility smiles of equity prices. More advanced option pricing techniques have been incorporated in the CCA (Gray and Jobst, forthcoming; IMF, 2011g).

The linear adjustment $(B/D(t) - 1)$ is needed if outstanding debt B trades either above (below) par value D, which decreases (increases) the CDS spread $s_{CDS}(t)$ (in basis points) due to an implicit recovery rate of the CDS contract at notional value and below (above) the recovery rate implied by the market price $D(t)$. This negative (positive) difference ("basis") between the CDS spread and the corresponding bond spread represents the ratio between recovery *at face value (RFV)*, which underpins the CDS spread calculation, and recovery *at market value (RMV)*, which applies to the commensurate bond spread.[26] $P_{CDS}(t)$ above is derived by rearranging the specification of the CDS spread

$$s_{CDS}(t) = -(T-t)^{-1} \ln\left(1 - P_{CDS}(t) / Be^{-r(T-t)}\right) \times \left(B/D(t) - 1\right) \times 10,000$$

under the risk-neutral measure, assuming a survival probability

$$1 - \bar{p} = \exp\left(-\int_0^t h(u)\,du\right) = \exp(-ht)$$

at time t with cumulative default rate p, and a constant hazard rate $s(t)_{CDS} \approx h$. Then $P_{CDS}(t)$ can be used to determine the fraction

$$\alpha(t) = 1 - P_{CDS}(t) / P_E(t)$$

of total potential loss due to default, $P_E(t)$, covered by implicit guarantees that depress the CDS spread below the level that would otherwise be warranted for the option-implied default risk.[27] In other words, $\alpha(t) P_E(t)$ is the fraction of default risk covered by the government (i.e. its contingent liability) and $(1 - \alpha(t)) P_E(t)$ is the risk retained by an institution and reflected in the CDS spreads. Thus, the time pattern of the government's contingent liability and the retained risk in the financial sector can be measured.

26 We approximate the change in recovery value based on the stochastic difference between the standardised values of the fair value CDS (FVCDS) spread and the fair value option-adjusted spread (FVOAS) reported by *Moody's KMV* (MKMV). Both FVOAS (FVCDS) are credit spreads (in bps) over the London Interbank Offered Rate for the bond (CDS) of a particular company, calculated by MKMV's valuation model based on duration (term) of t years (where t=1 to 10 in one-year increments). Both spreads imply an LGD determined by the industry category. In practice, this adjustment factor is very close to unity for most of the cases, with a few cases where the factor is within a 10 per cent range (0.9 to 1.1).

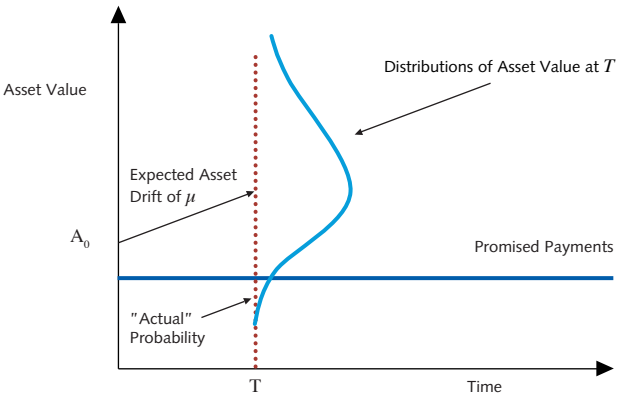
27 Note that the estimation assumes a European put option, which does not recognise the possibility of premature execution. This might overstate the actual expected losses inferred from put option values in comparison with the put option derived from CDS spreads.

Appendix 2. CCA with the market price of risk

MODELLING DEFAULT RISK

Let us start with the evolution of bank assets over time horizon t relative to the promised payments on the debt (default free value of the debt and deposits). The value of assets at time t is $A(t)$. The asset return process is $dA/A = \mu_A dt + \sigma_A \varepsilon \sqrt{t}$, where μ_A is the drift rate or asset return, σ_A is equal to the standard deviation of the asset return, and ε is normally distributed, with zero mean and unit variance. The probability distribution at time T is shown in Figure A1(a) below.

Figure A1 (a). Modelling default risk



Default occurs when assets fall to or below the promised payments, B_t. The probability of default is $A_t \leq B_t$ so that

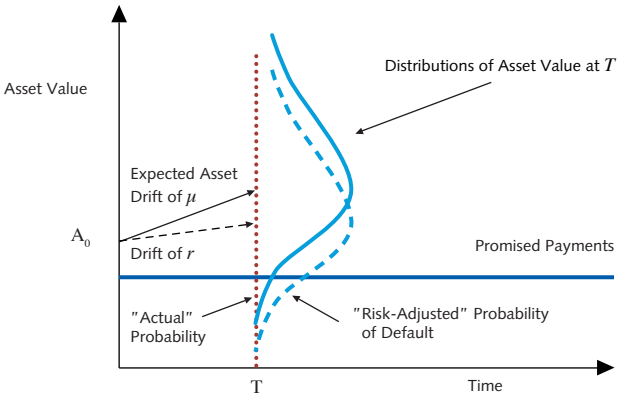
$$\Pr(A_t \leq B_t) = \Pr\left(A_0 \exp\left[\left(\mu_A - \sigma_A^2/2\right)t + \sigma_A \varepsilon \sqrt{t}\right] \leq B_t\right) = \Pr\left(\varepsilon \leq -d_{2,\mu}\right).$$

Since, $\varepsilon \sim \Phi(0,1)$ the "actual" probability of default is, $N(-d_{2,\mu})$ where $d_{2,\mu} = \left[\ln\left(A_0/B_t\right) + \left(\mu_A - \sigma_A^2/2\right)t\right]\left(\sigma_A\sqrt{t}\right)^{-1}$. The "actual" probability of default is the area below the line (promised payment, i.e. the default barrier).

Shown in Figure A1 (b) below is the probability distribution (dashed line) with drift of the risk-free interest rate, *r*. The risk adjusted probability of default is $N(-d_2)$. The area below the distribution in Figure A1 (a) is the "actual" probability of default. The asset-return probability distribution used to value contingent claims is not the "actual" one but the "risk-neutral" probability distribution, which is the dashed line in Figure A1(b) with expected rate of return *r*, the risk-free rate. Thus, the "risk-neutral" probability of default is larger than the actual probability of default for all assets which have an actual expected return (μ) greater than the risk-free rate *r* (that is, a positive risk premium).[28]

28 See Merton (1992, pp.334-343; 448-450).

Figure A1 (b). Actual vs. risk-neutral default probabilities



These two risk indicators are related by the *market price of risk*, λ:

$$\Phi\left(-d_{2,\mu}\right)=\Phi\left(-d_2-\lambda\sqrt{t}\right)$$

The market price of risk reflects investors' risk appetite. It is the "wedge" between the real and risk neutral default probability. It can be estimated in several ways. One way is the use of the capital asset pricing model (CAPM) model to estimate the market price or risk is shown in Box 1 so that:

$$\left(\mu_A-r\right)/\sigma_A=\lambda$$

where $\rho_{A,M}$ is the correlation of the asset return with the market and SR is the market Sharpe Ratio.

Box 1. Market price of risk (MPR)

A two moment CAPM is used to derive the market price of risk (developed and used in Moody's KMV model). This CAPM states that the excess return of a security is equal to the beta β of the security times the market risk premium $\mu - r$, so that

$$\mu_A - r = \beta(\mu_M - r)$$

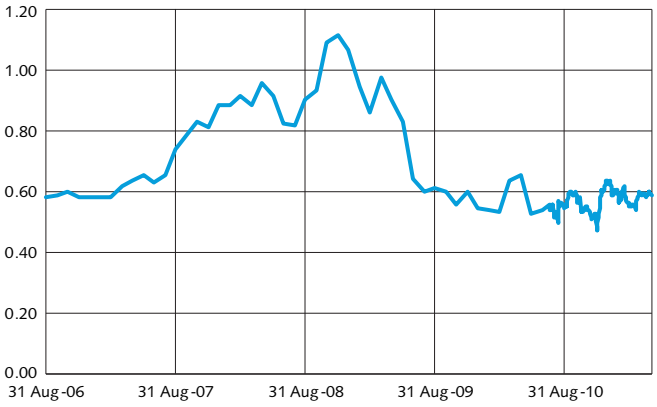
Beta is equal to the correlation of the asset with the market times the volatility of the asset divided by the volatility of the market.

$$\beta = \frac{\text{cov}(r_A, r_M)}{\text{var}(r_M)} = \rho_{A,M}\frac{\sigma_A}{\sigma_M} \quad \text{So, } \mu_A - r = \rho_{A,M}\sigma_A(\mu_M - r)/\sigma_M = \rho_{A,M}\sigma_A SR$$

Here SR is the Market Sharpe ratio, the market risk premium per standard deviation of market risk, and, thus, $(\mu_A - r)/\sigma_A = \rho_{A,M} SR$.

According to MKMV data, $\rho_{A,M}$ is usually around 0.5 to 0.7 (calculated bank by bank in the *MKMV* Credit Edge model) and the around 0.55 to 1.2 during the last few years.[29] The main driver of the market price of risk in this model is the global Sharpe ratio. The correlation does not change much over time, but the SR changed considerably, see Figure A2 below.

Figure A2. Global Sharpe ratio



A higher global Sharpe ratio is associated with higher average volatility for Swedish banks. There is systemic impact on volatility in addition to the idiosyncratic change in volatility described in Appendix 1. For the Swedish banks, average volatility is around 16 per cent

29 See MKMV (2003), Crouhy et al., Galai and Mark (2000).

(annualised) when the Sharpe ratio is 0.6, but increases to 23 per cent when the Sharpe ratio reaches 1.1. This systemic increase in volatility is included in the scenarios, empirically the change in Sharpe ratio times 0.09 gives the incremental change in volatility (measured as a fraction).[30]

30 Changes in risk appetite affect risk perceptions going forward affecting the dynamics of the market price of risk. The market price of risk, over a one-year horizon is $\lambda = \rho_{A,M} SR$ and it provides a way to translate between the actual default probability (EDF) and the risk-neutral default probability.

Appendix 3. Interaction and feedback between sovereign CCA balance sheet and the financial sector: potential destabilisation processes

The CCA framework can be used to calibrate sovereign balance sheets and be integrated with banking sector balance sheets in a simple but illustrative framework to show the interaction and potential destabilisation of values of spreads and risks in both the sovereign and banking sectors. In the absence of measureable equity and equity volatility, such as in the case of a developed country sovereign, including where there are assets and debt all in the same currency, the term structure of sovereign spreads can be used to estimate implied sovereign assets and asset volatility and calibrate market-implied sovereign risk adjusted balance sheets.

Sovereign spreads are related to the sovereign implicit put option, P_{Sov}, and sovereign default barrier, B_{Sov} (or threshold that debt restructuring is triggered) in the following way. Rearranging the formula for the sovereign implicit put option gives:

$$\frac{P_{Sov}}{B_{Sov}e^{-rT}} = N(-d_2) - \frac{A_{Sov}}{B_{sov}}\frac{1}{e^{-rT}}N(-d_1)$$

Inserting this equation into the equation for sovereign spreads and using (i) an estimate of the sovereign default barrier from debt data, and (ii) the full term structure of the sovereign CDS, (CDS for years 1, 3, 5, 7 and 10) one can estimate the implied sovereign assets, A_{Sov}, and implied sovereign asset volatility, σ_A that most closely matches the sovereign spread term structure. The sovereign asset value can be broken down into its key components: Reserves (R); net fiscal asset or present value of the primary fiscal surplus (PVPS); implicit and explicit contingent liability (αPut_{Bank}); and "Other" remainder items, i.e. $A_{Sov,t=0} = R + PVPS - \alpha Put_{Bank} + Other$. The value of the foreign currency reserves can be observed and the contingent liabilities can be estimated from the banking sector CCA models (i.e. systemic CCA). Subtracting these from the implied sovereign asset and subtracting an estimate of the present value of the expected primary surplus allows us to calculate the residual (Other). There are a number of government assets and various unrealised liabilities, pension and healthcare obligations, which are not known but are aggregated in "Other", which may include contingent financial support from other governments or multilaterals or other backstop assets (e.g. land or other public sector assets of value). We can use this valuation formula to evaluate the effects of changes in reserves, the primary fiscal balance, and the implicit banking sector guarantee on the sovereign asset value. This can be used with changes in the composition of short-term and long-term debt for stress tests to evaluate changes in sovereign credit spreads and other values and risk indicators.

The spreads for the banks can be seen as a function of the implicit put option, P_{Bank} (derived from equity information) times the fraction of risk retained by the banks (as

described in the systemic CCA section above) plus a premium (δ) if high sovereign spreads spill over to increase bank spreads.

$$s_{Bank} = -\frac{1}{T}\ln(1-\frac{(1-\alpha)P_{Bank}}{B_{Bank}e^{-rT}})+\delta$$

This simple model shows the ways in which sovereign and bank spreads can interact and potentially lead to a destabilisation process. If sovereign spreads increase, this can lead to an increase in bank spreads for several reasons: (i) the credibility of sovereign guarantees decreases (alpha goes down); (ii) the implicit bank put option could increase as the value of the bank's holdings of government debt decrease; (iii) the bank default barrier may increase due to higher borrowing costs as the premium (δ) increases (and if banks can't roll over debt). Prospects of a much more fragile banking system can feed back on sovereign spreads via several possible channels, e.g. large and increasing bank guarantee/bailout costs that may overwhelm the budget, reduced ability of sovereigns to borrow from banks and potential crowding-out effects.

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