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A systemic risk indicator for the Swedish banking system

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In this Economic Commentary, we present a systemic risk indicator for the Swedish banking system. The indicator illustrates the probability of the four major Swedish banks becoming distressed at the same time. It shows that the systemic risk in the banking sector is currently somewhat increased. This is probably a reflection of the unease that has existed for some time in the financial markets as a consequence of the strained public finances in many places in the world. Even if the indicator at present shows a higher score than in 2006–2007 its value is still lower than was the case at the most acute stage of the 2008–2009 financial crisis.

Following and analysing systemic risk in the financial system is a central component of the Riksbank's activities. In this Economic Commentary we present an estimate of the systemic risk based on indicator that can identify different risks, such as liquidy and solvency risks, in the Swedish banking system. The indicator shows that the risk in the banking system increased substantially in 2007 and 2008 in connection with the latest financial crisis. The indicator subsequently fell back somewhat at the beginning of 2010. In the second half of 2010, however, it started to rise again as a consequence of the crisis in public finances and the unease caused by this crisis in the financial markets.

Systemic risk in the banking system is an important element in assessing financial stability

One of the functions of the Riksbank is to promote a safe and efficient payment system. This means that the Riksbank must act to ensure that the financial system maintains its basic functions, such as mediation of payments and converting savings into funding. In addition, the Riksbank is to act to ensure that the financial system is resilient to disruptions threatening its functions. This is because a situation in which the financial system cannot carry out its basic functions can entail serious consequences on development in large parts of the real economy.

Some of the risks in the financial system arise as a natural consequence of banks fulfilling their basic functions. Banks' funding, for example savings and borrowing, is often short-term by their nature. At the same time their lending is often long-term. The imbalance between savers' short-term commitments to the banks and the banks' long-term commitments to borrowers mean that savers must have confidence in the banks' ability to fulfil their commitments to their savers. Otherwise stability in the financial system is upset.[2] If a bank has problems in obtaining funding it may be forced to suspend payments. If the bank is large, or closely linked to other banks, the problems may assume such proportions that they give rise to considerable social cost. To prevent this type of systemic risk arising it is important to continually follow and analyse the risks in the banking system. In other words it is important to follow and analyse systemic risk in the banking system.[3] In this Commentary we estimate a systemic risk indicator that illustrates the probability of banks in the Swedish banking system being affected by problems that are so great that they entail social costs.

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2. The problem of imbalance in maturities between banks' liabilities and assets applies to other types of funding as well as savings.

3. There are several other parts of the financial system that are important from a systemic risk perspective. For example there are systemically important markets and instruments. See for example Forss Sandahl et al. (2011) for a description of a stress index for financial markets.

Systemic risk in the banking sector cannot be described using one single measure

To make an assessment of systemic risk in the banking sector various types of tool, measurement and indicator can be used. One tool used today by the Riksbank is stress tests. Stress tests are carried out on the banks' capital ratios and on their liquidity buffers. By carrying out stress tests on the banks' capital ratios it is possible to investigate the extent to which there is a risk of the capital requirements specified in rules and regulations not being met in periods when the economy is weak. In order to identify the link between economic development and banks' loan losses, historical correlations between different macroeconomic variables and loan losses are often used. By starting from an unfavourable macroeconomic scenario, the banks' resilience to loan losses can be investigated. In this way, the stress tests give a picture of how sensitive the banking system is to adverse economic disruptions.

However, stress tests of banks' capital only provide a partial picture of the systemic risks that exist in the banking sector. One reason for this is that the stress tests, as we mentioned above, often rely on historical correlations between macroeconomic development and loan losses. To the extent this correlation varies over time, there is a risk that stress tests will not provide a correct picture of systemic risks that apply at the time when the tests are carried out. In addition, it is not certain that a systemic crisis in the banking sector would necessarily arise as a consequence of the banks incurring loan losses on their lending. A systemic crisis can also arise as a consequence of a reduction in the banks' funding possibilities without this being directly related to loan losses.

Under certain circumstances, different agents in the economy, such as households and financial institutions, may prefer to keep their assets in forms other than bank savings. In such situations the banks' possibilities of funding their operations decrease. If the lack of funding becomes sufficiently acute a systemic crisis could break out without there being any problems with loan losses on the banks' lending. Thus it is important to stress test not only the banks' capital levels but also their liquidity position. This can be done in various ways but the main principle is to compare different types of funding and lending to see how great the risk is of imbalances arising between long-term and short-term items on the banks' balance sheets.[4]

Just as in stress testing the banks' capital situation, the liquidity stress tests are based on experience of how great a risk various types of funding pose to the banks' liquidity situation. To the extent there is only limited historical experience of the relevant situation at a certain time, there is a risk that the liquidity stress tests will not fully identify the systemic risk that exists.

A general drawback to both capital and liquidity stress tests is that there is a risk of missing important systemic aspects through focusing on individual institutions rather than the entire system. Interactions and correlations between individual institutions may imply that the total risk in a system of institutions may be greater than the risk obtained by simply adding the individual institutions' risks.

Thus it is important to supplement the results obtained from stress tests with systemic risk measurements and systemic risk indicators that identify systemic aspects while providing a forward-looking picture of different types of risk. In this Commentary we therefore present a systemic risk indicator that indicates how great the probability is of banks in the Swedish banking system getting into difficulties, regardless of whether these difficulties concern solvency, liquidity or other types of problem.

The systemic risk indicator is a broad measure of systemic risk

The indicator of systemic risk we are looking at in this Commentary consists of a measurement of the probability that all the banks studied will become distressed. The type of distress may, however, vary. One example is that a bank can no longer pay back the full value of its outstanding debt since it has too little capital. The systemic risk indicator should under such circumstances identify aspects that lie close to the stress tests

4. See Sveriges Riksbank (2010) for a more detailed description of the Riksbank's liquidity stress test.

of the banks' capital situation and give an idea of the risk of a systemic crisis breaking out as a consequence of the banks having solvency problems. But a bank becoming distressed can also mean that the bank gets into a situation that prevents it from conducting its operations on the same terms as before. For example, impaired liquidity may force the bank to pay more for its funding than before. This in turn means, at least in the short term, a worsened profit situation for the bank. If by distress one is also referring to this type of situation, the indicator will be a broader measurement of systemic risk than is the case if the calculations are only based on probabilities of default. Consequently, the risks identified by the indicator will entirely depend on the type of information on which the calculation of the systemic risk indicator is based. The systemic risk indicator presented in this commentary is based on a measurement of distress that can identify both solvency risks and liquidity risks in the banking sector.

The systemic risk indicator is calculated from individual probabilities of distress

The data on which the current systemic risk indicator is based consists of information on the level and volatility of the market value of the assets of the banks studied and the level and structure of the liabilities of the banks studied. This information is weighted into a probabality of individual banks becoming distressed. The weighting is done, as a first step, by producing an approximate market value for the assets of the banks studied and a volatility for this value.[5] The idea is then to compare the value of the assets with a threshold consisting of a certain percentage of the liabilities of the respective banks.[6] If the value of a bank's assets falls under this threshold the bank is distressed. By measuring the distance between the asset value and the threshold a probability of distress can be obtained.[7]

The method we use to obtain probabilities of distress for individual banks means that all factors affecting the level and volatility of the market value of the banks' assets and the level and structure of the banks' liabilities will be reflected in the individual banks' probability of distress. This means in turn that the individual banks' probabilities of distress can provide a picture of both banks' solvency position and their liquidity situation. By amalgamating the individual banks' probabilities of distress it is then possible to construct a systemic risk indicator that identifies these factors.

To be able to calculate a systemic risk indicator that identifies the risk in the banking system as a whole it is not sufficient to study the individual banks' probabilities of distress. Instead a joint probability distribution for the entire banking system is required. This joint probability is necessary to capture information on how the interactions and correlations between banks contribute to risk in the entire system. If the covariation is not taken into account there is a risk that the systemic aspect of the risk indicator will be lost. The reason for this is that many of the systemic risks in the banking sector probably arise as a consequence of several banks, under certain conditions, being affected in a similar way by adverse disruptions. Hence covariation is probably an important part of all systemic risk indicators. It is therefore important to bring to together the individual banks' probabilities of distress so that a systemic risk indicator can be constructed.

There are several different ways of calculating a joint probability of distress on the basis of information about the individual banks. In this Commentary we use the CIMDO approach.[8] Using this approach we can derive the probability of all banks becoming distressed at the same time from the individual banks' probability of distress. The methodology is described in detail in Segoviano and Goodhart (2009).[9] One of the advantages of using the CIMDO methodology, according to Segoviano and Good-

5. The calculations approximate the asset value to the sum of the market value of the banks' outstanding shares and the banks' liabilities (see Byström, 2006). The banks' liabilities and the volatility of the assets' market value are obtained from the Creditedge database which is provided by Moody's KMV while the market value of the banks' outstanding shares is obtained from Bloomberg. The banks' liabilities and volatility of the asset value are interpolated from monthly to daily frequency. To eliminate the jumps in these series that exist in connection with the reporting dates the series are HP-filtered.

6. The critical limit consists of the respective bank's current liabilities and half of the bank's long-term liabilities.

7. This probability can be calculated by making a distribution assumption for the distance to the critical limit.

8. See Segoviano and Goodhart (2009) and Segoviano (2006).

9. See also Appendix 1 and Appendix 2 for a more detailed description of the methodology.

hart, is that certain types of dependence between banks can be taken into account in a way that is not necessarily captured by other methods.[10]

The systemic risk indicator is the probability of all banks becoming distressed. Chart 1 shows the estimated systemic risk indicator for the period February 2006–October 2011. Four banks are included in the calculations. These are Nordea, Handelsbanken, SEB and Swedbank.

Development of the systemic risk indicator between 2006 and 2011

Outbreak of the financial crisis

Based on from the method described above the estimation of the systemic risk indicator gives rise to the time series presented in Chart 1. The Chart shows that the indicator has a low value from February 2006 until the end of spring 2008. For the following period, from spring 2008 and approximately one year onwards there is a substantial increase in the value of the indicator. During this period several events occur that could lie behind an elevated systemic risk in the Swedish banking sector. One important event is that liquidity in the international banking system is very hard hit by the uncertainty applying to international banks' exposures to assets that are difficult to value and assets that lost a lot in value from autumn 2007 onwards.[11] The shortage of liquidity makes it both more difficult and more expensive to borrow for households and companies around the world. In addition, the shortage of liquidity in the banking system leads to a substantial fall in expectations regarding future real economic development. This is because the real economy is entirely dependent on a functioning financial system for trade credits, loans for investment etc. The fact that it becomes more difficult and more expensive to obtain credit while expectations of future economic development fall severely contributes to a sudden halt to international demand. This has major consequences on export-dependent countries. For example, the Baltic economies are severely affected. For the Swedish banks with exposures in the Baltic countries this meant that credit quality in parts of the banks' portfolios was considerably impaired and fears arose that Swedish banks' exposures in these countries could lead to severe loan losses. The fact that the Swedish banks ended up in a situation in which liquidity and loan losses were a problem meant that their future outlook, in terms of probabilities of distress, became much worse in the course of 2009. This development is captured by an increase in the systemic risk indicator.

An active economic policy mitigates the effects of the crisis

The situation in the financial markets in 2008–2009 brings about strong monetary and fiscal policy responses worldwide. Central banks implement measures to help increase liquidity in the financial system. At the same time, governments contribute support to the financial sector by such measures as guaranteeing the banks' borrowing. But the banks themselves also act to improve their financial position. For example, some of the major Swedish banks issue shares to strengthen their capital situation.

However, economic policy not only needs to support the financial markets. The weak trend in the real economy also requires vigorous stimulation to avoid a very long and very deep recession. Expansionary fiscal policy that was intended to support the real economy was implemented in many parts of the world. The powerful stimulation contributed to turning the fall in global GDP at the end of 2008 and beginning of 2009 to an upturn. The brighter situation in both financial markets and the real economy by and large is reflected in the development of the systemic risk indicator from the end of 2009 up to and including the third quarter of 2010. During this period the systemic risk indicator fell back. However, it does not fall to the levels seen before the outbreak of the crisis.

10. References to essays on other systemic indicators can be found for example in Acharya et al. (2010) and Gray and Jobst (2011).
11. Among these assets are various types of securitisation of credit.

Hopes of a sustainable recovery are dashed

From the end of 2009 and for a large part of 2010, hopes were entertained that the economic stimulus measures taken were so powerful that economic growth would continue even after the stimulus effects had subsided. For many countries economic growth, in the absence of further fiscal policy stimulation, was an important condition for solving the problems of high central government debt and large budget deficits that have been made worse as a consequence of the measures implemented during the financial crisis. From the end of 2010 onwards, however, it becomes obvious that a number of countries are not be able to meet their public finance commitments without international help. Besides Greece, both Ireland and Portugal needed support packages in order to fulfil their commitments. Uncertainty concerning the extent of the public finance problems meant that the risk in the financial system increased again.

In addition, in late summer 2011 there are signals that economic activity in some parts of the world are not living up to the hopes that exist. Fears of a new wave of international economic slowdowns and further uncertainty concerning management of public finance problems, mainly in Greece, Ireland, Italy, Portugal, Spain and the USA mean that the financial markets are again hit. Large falls in the stock market together with the fact that the markets for covered and unsecured bank bonds are functioning increasingly badly again increase the risk in the banking system.

The increase in the systemic risk indicator in 2011 can be explained by several factors. One of these factors is probably a spillover to Swedish banks of a general international unrest about the solvency and liquidity situation of foreign banks. This results in an increase in the estimated systemic risk in the Swedish banking sector.

When comparing the development of the systemic risk indicator over time it is, however, important to note that the indicator's value of course to a great extent depends on how the individual probabilities of distress develop. There may be reason to believe that some of the individual banks' probabilities of distress do not give a correct picture of how problematic the situation was in 2008 and 2009. This in turn may mean that the indicator does not give a correct picture of how current systemic risk relates to the systemic risk that existed in 2008 and 2009. But despite this, the systemic risk indicator shows that the recent central government debt problems have increased systemic risk in the Swedish banking sector.

How long the systemic risk indicator will stay at an elevated level depends in all probability on how well the public finance problems are handled and whether uncertainty as to capital requirements for some international banks remains. Apart from the international economy, ability to take political action plays an important role in this context.

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Appendix 1. Calculation of individual banks' probability of distress

The systemic risk indicator that we present in this Commentary consists of the probability of all banks becoming distressed at the same time. To be able to calculate this probability it is necessary to know the joint probability distribution of the banks becoming distressed. The joint distribution is derived using the CIMDO methodology that is partly based on individual banks' probabilities of distress. A detailed description is given in this appendix of how the individual banks' probabilities of distress are calculated. The calculation of the joint distribution is then described in Appendix 2.

As mentioned in the Commentary, the individual banks' probabilities of distress are calculated with the help of the level and volatility of individual banks' asset value and the level and structure of individual banks' liabilities. More specifically, first an approximate market value for each bank's assets is calculated. This is done by adding bank i's debt (D^i) to the market value of bank i's outstanding equity (V_E^i).[12] If the market value of the bank's assets (V_A^i) falls below a critical threshold (T^i), consisting of the bank's current liabilities and half of the bank's long-term liabilities, it is assumed the bank will become distressed. By measuring how the market value of assets relates to the critical threshold and relating this to volatility, more specifically the standard deviation, in the change in the bank's asset value (σ^i) it is possible to calculate a distance-to-distress measure (DD^i) as in (1) below.

$$DD^i = \frac{\ln V_A^i - \ln T^i}{\sigma^i} \qquad (1)$$

The expression in (1) shows that DD^i measures how close the asset value is to the critical threshold when, besides the difference between asset value and critical threshold, the degree of historical variation in asset value is also taken into consideration. In that way DD^i illustrates how much, in relation to the historical change, the value of a bank's assets can fall in a given period of time without the bank becoming distressed.[13]

When the distance-to-distress is calculated for each of the different banks, the probability of each individual bank becoming distressed can be calculated.[14] This can be done by assuming that the probability of distress, PoD^i, at a certain DD^i value derives from a certain distribution. In this Commentary the probability of distress is calculated as

$$PoD^i = 1 - F_{t(4)}(DD^i) \qquad (2)$$

where $F_{t(4)}(\cdot)$ is a cumulative t-distribution with four degrees of freedom. Starting with the calculated probabilities of distress, the CIMDO methodology can now be used to derive the systemic risk indicator.

12. An alternative here could be to calculate the market value of the banks' assets using the Merton model (see Merton, 1974, Crossbie and Bohn, 2001, or Byström, 2006). It can be noted that the results obtained by using the option price setting equations in these essays are similar to the results obtained by calculating the assets' market value as the sum of debt and market value of outstanding equity.

13. In this Commentary the annual volatility is used in the calculations. This means that DD^i illustrates how much the value of a bank's assets can decrease in the next year without the bank becoming distressed.

14. It is possible to calculate the probability of all banks becoming distressed, and thus obtain the systemic risk indicator, by making an assumption for the probability distribution that describes how probable it is that all banks become distressed at given distance-to-distress values. The systemic risk indicator can thus be obtained directly, through a distribution assumption, instead of calculating the systemic risk indicator using the CIMDO methodology based on individual banks' distress probabilities. Such an assumption is based on the joint distress probability following a four-variate t-distribution with four degrees of freedom and a correlation matrix given by the correlation between the banks' distance-to-distress in the sample available. When making such an assumption a probability is derived for all banks becoming distressed at the same time which is similar to the estimated systemic risk indicator presented in Chart 1.

Appendix 2. Calculation of the systemic risk indicator using the individual probabilities of distress

It is possible to derive the systemic risk indicator based on the individual banks' probabilities of distress using the CIMDO methodology. This is done by first obtaining a joint distribution for the banks' probabilities of distress and then calculating how probable it is that all the observed banks will become distressed at the same time.

Derivation of the joint distribution for the banks' probabilities of distress must proceed from a tentative distribution. This tentative distribution can take various forms but should be an acceptable estimate of the actual joint probability distribution. Since the tentative distribution can be chosen arbitrarily it is not certain that it will initially result in the probability of the individual banks becoming distressed being the same as the probabilities calculated for the individual banks. In other words it is not certain that the marginal probabilities of the tentative distribution are the same as the PoD^i. But by changing the tentative distribution to give the same marginal probabilities as the individual banks' probabilities of distress PoD^i it is possible to obtain a final joint distribution. From this joint distribution it is then possible to calculate the probability of all banks becoming distressed at the same time. It is this probability that constitutes the systemic risk indicator presented in Chart 1.

A case in which only two banks are studied can be used to illustrate how the CIMDO methodology works. Assume that the probability of distress for these banks is governed by their respective distance-to-distress and that you want to obtain a joint probability of distress distribution for these two banks, $f(DD^1, DD^2)$, with the help of a tentative distribution, $g(DD^1, DD^2)$. The CIMDO methodology, based on the minimum cross entropy approach, involves choosing $f(DD^1, DD^2)$ so that the value of the expression in (3) is minimised.

$$\int\int f(DD^1, DD^2) \ln\left(\frac{f(DD^1, DD^2)}{g(DD^1, DD^2)}\right) dDD^1\, dDD^2 \qquad (3)$$

Minimising the value of the expression in (3) involves choosing a joint probability distribution so that the deviation between the final joint distribution and the tentative distribution is as small as possible. The minimisation is done using the constraints that the individual banks' probabilities of distress, PoD^1 and PoD^2, are to be found as marginal distributions in the final joint distribution. In addition the total probability mass for the final joint distribution is to be one. The constraints are set out below in (4)–(5) and (6).

$$\int\int f(DD^1, DD^2)\, \chi^1\, dDD^1\, dDD^2 = PoD^1 \qquad (4)$$

$$\int\int f(DD^1, DD^2)\, \chi^2\, dDD^2\, dDD^1 = PoD^2 \qquad (5)$$

$$\int\int f(DD^1, DD^2)\, dDD^1\, dDD^2 = 1 \qquad (6)$$

In (4)–(5) χ^1 and χ^2 are indicator functions that assume the value of one if a bank is in distress and otherwise the value is zero. When the minimisation problem is solved, according to Segoviano (2006) and Segoviano and Goodhart (2009) a final joint distribution is obtained in the form of (7) below.

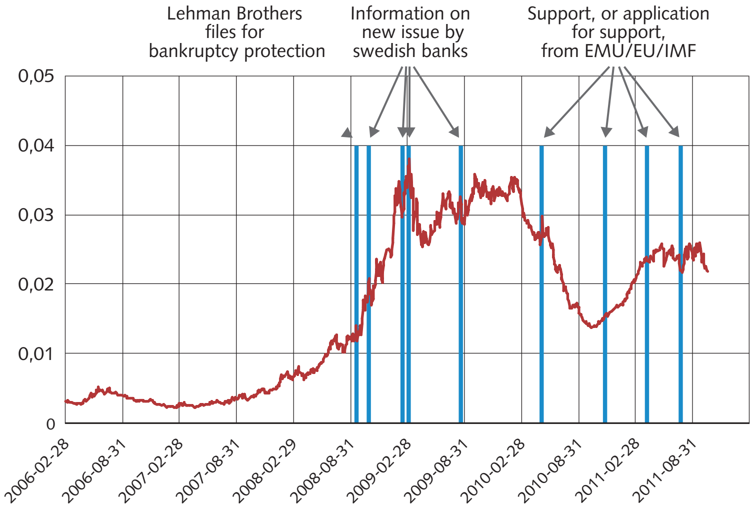
$$f^*(DD^1, DD^2) = g(DD^1, DD^2)e^{-1-\lambda_1\chi^1-\lambda_2\chi^2-\mu} \qquad (7)$$

In the expression above λ_1, λ_2 and μ denote multipliers that are associated with the restrictions in (4)–(6). By finding multipliers such that the constraints are met a final joint distribution can be produced.

The final joint distribution for the four major Swedish banks studied in this Commentary is calculated on the same principle as in the case with two banks. It is this final joint distribution that forms the basis of the systemic risk indicator in Chart 1.

Chart

Chart 1. Systemic risk indicator, February 2006 – October 2011. Probability, percent



Note: Vertical lines in the chart indicate the following important dates. 15/9 2008: Lehman Brothers files for bankruptcy. 27/10 2008 and 17/8 2009: information on new issue of shares by Swedbank. 10/2 2009 and 4/3 2009: information on new issue of shares by Nordea and SEB. 4/5 2010 and 21/7 2011: Greece receives rescue package. 22/11 2010 and 6/4 2011: Ireland and Portugal apply for rescue package. The systemic risk indicator constitutes the probability of all four major banks becoming distressed at the same time. This probability is denoted JPoD in Segoviano and Goodhart (2009).

Sources: Bloomberg, Moody's KMV and the Riksbank