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  Danmarks Nationalbank,
  Communications,
  Havnegade 5,
  DK-1093 Copenhagen K.
Telephone +45 33 63 70 00 (direct) or +45 33 63 63 63.
Inquiries: Monday-Friday 9.00 a.m.-4 p.m.
E-mail: kommunikation@nationalbanken.dk

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Peter Askjær Drejer, Statistics, Marianne Clausager Koch, Morten Hedegaard Rasmussen, Morten Spange and Søren Vester Sørensen, Economics

Changes in monetary-policy interest rates have a potential impact on households and firms via two channels, i.e. the interest-rate channel and the credit channel. We find that the pass-through from monetary-policy interest rates to bank retail rates is high, but there are indications that it has diminished in connection with the financial crisis. According to the credit channel, a change in monetary-policy interest rates may also influence the total supply of loans. The analysis does not demonstrate that this channel plays an important role in Denmark. The sensitivity of the Danish economy to fluctuations in interest rates has increased considerably since the mid-1990s. This can be attributed mainly to higher indebtedness and more widespread use of adjustable-rate loans for housing finance. If monetary policy is "appropriate" relative to the business cycle, high interest-rate sensitivity could be an advantage. But if changes in monetary-policy interest rates are independent of the business cycle and are prompted by e.g. the need to address speculative pressure on the krone, the effect may be procyclical.

Anders Jørgensen, Market Operations, Paul Lassenius Kramp, Carina Moselund Jensen and Lars Risbjerg, Economics

The money market, including the market for interbank loans, played a central role during the financial crisis. In the autumn of 2008, the money markets froze and the Danish krone came under pressure as international investors withdrew from minor currencies. This article explores why the Danish money and foreign-exchange markets were hit during the crisis, the impacts and Danmarks Nationalbank's measures in this respect. The analyses presented relate to 1) the banks' exposure to the money market and the spillover effect from foreign markets to the Danish market; 2) the monetary-policy instruments and the functioning of the money market; 3) the spread between uncollateralised and collateralised money-market interest rates, broken down by liquidity and credit factors; 4) the Danish foreign-exchange market; and 5) the significance of Danmarks Nationalbank's provision of euro and dollars to the banks.

The Effects of Monetary Policy in Denmark[1]

By
  Peter Askjær Drejer, Statistics
  Marianne Clausager Koch, Economics
  Morten Hedegaard Rasmussen, Economics
  Morten Spange, Economics
  Søren Vester Sørensen, Economics

1. INTRODUCTION AND SUMMARY

What are the effects of a change in monetary-policy interest rates? That is the overriding question that we seek to answer in this article. Monetary-policy interest rates are the rates of interest applied to accounts between Danmarks Nationalbank and the banks, i.e. the current-account rate, the rate of interest on certificates of deposit and the lending rate. An adjustment of monetary-policy interest rates will initially affect Danish banks' costs of obtaining liquidity. This impacts on the short-term money-market interest rates.

Households and non-financial corporations do not participate in the money market. Since the banks use the money market as a source of funding, an adjustment of monetary-policy interest rates can be expected to influence the retail rates that the banks offer to households and firms. Moreover, short-term mortgage yields will be affected. If an adjustment of monetary-policy interest rates is perceived as permanent, it will also affect longer-term market rates. This plays a role e.g. for home buyers opting for long-term mortgage bonds as a source of financing.

Both households and firms use the banks extensively. How much and how quickly the banks adjust their interest rates following an adjustment of monetary-policy interest rates therefore determine the impact of monetary policy on the real economy. Based on data for the 29 largest banks, we find that the interest-rate pass-through has generally been high in Denmark, and that it takes effect relatively quickly after adjustment of the monetary-policy interest rates.

Nevertheless, there are signs that the extent and speed of the pass-through have declined since the financial crisis in 2008. On the deposit

side, a possible reason is that, in the wake of the crisis, the banks have competed for deposits and therefore hesitated to lower the deposit rates in step with the decrease of monetary-policy interest rates. On the basis of bank-specific data, we analyse whether different characteristics at bank level result in different responses to interest-rate changes. However, it is difficult to trace a general tendency for the responses of banks with certain characteristics to diverge from the average.

The impact on market interest rates is the classic channel for transmission of monetary policy to the real economy.[1] It has been incorporated into the vast majority of macroeconomic models. In many models it is in fact the only transmission channel for monetary policy. All the same, it has been discussed on an ongoing basis among central banks and in the academic literature whether frictions in the financial markets cause an interest-rate adjustment to impact not only on market rates, but also on the total supply of loans. In that case, a credit channel for the transmission of monetary policy applies. During the financial crisis, there was a strong focus on firms' access to credit from the banks. Consequently, the credit channel has attracted considerable attention recently.

The credit channel can be divided into a bank lending channel and a balance-sheet channel. The bank lending channel relates to the banks' ability to lend. Higher interest rates lead to increasing losses and provisions on loans and reduce the value of the banks' asset portfolios. This undermines the banks' capital base and may force them to reduce their lending to ensure continued compliance with capital adequacy requirements. This negative supply effect on the lending side reinforces the contractive effect of an interest-rate increase.

The other part of the credit channel, the balance-sheet channel, relates to the firms' balance sheets. The drop in asset prices as a result of a tightening of monetary policy reduces the firms' ability to pledge collateral for loans, which increases the banks' lending risk. Since banks have only limited information about estimated failure rates for the individual firms, a higher overall risk in the economy will generally cause the banks to tighten their credit policies. This increases the risk that profitable investments cannot be realised due to insufficient financing.

Consequently, the credit channel, if effective, will amplify the economic effects of an adjustment of monetary-policy interest rates. A closer empirical analysis of the credit channel is therefore interesting – to gain better insight into the cyclical fluctuations of the economy, among other reasons.

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[1] In an economy with a floating exchange-rate, an interest-rate adjustment will also impact on the exchange rate. This channel is not considered here.

In order to find evidence of the existence of a bank lending channel, we examine the possible link between a bank's ability to lend, based on relevant key ratios, and its actual lending growth. In general, this link is difficult to establish for Danish banks, but there is a tendency for lending growth to be slightly stronger for banks with high excess liquidity coverage after the financial crisis than for less liquid banks. In an international context, the results are also inconclusive, and the conclusions of empirical analyses concerning the existence and importance of a bank lending channel vary considerably. Compared with the results of this article, the international studies provide more indications of the existence of this channel, however.

This article contains no separate econometric analysis of the balance-sheet channel for Danish firms. Studies of a number of euro area member states, the USA and the UK have previously found indications of a balance-sheet channel, but the results are inconclusive and cannot be applied directly to Denmark. More descriptive analyses indicate that tighter financial conditions have a stronger impact on small firms than on large ones. Since banks often have less information about their smaller customers, they will tend to tighten the credit policy for these customers if the economic outlook deteriorates. This can be taken to indicate that the balance-sheet channel plays a certain role for small firms. But in overall terms, we cannot conclude that the credit channel plays a significant role in monetary-policy transmission in Denmark.

Although this article does not find evidence of a credit channel, there is nevertheless a procyclical effect from the financial sector. On the basis of a data series beginning in 1983, we find that the banks' interest-rate margins widen in periods of economic downturn and narrow in periods of boom, to a large extent reflecting the risk of loan losses. Despite the absence of an actual credit channel, the financial sector thus contributes to amplifying cyclical fluctuations. But this is an inevitable phenomenon in a market economy, and the overall effect is potentially mitigated by the widespread use of mortgage financing.

It is generally concluded throughout the article that monetary policy is primarily transmitted through interest rates. Consequently, we look into the effects of an interest-rate adjustment on households and firms. There are three classic effects of interest-rate adjustments, i.e. the direct effect on income, the effect on private-sector wealth and the effect on the incentive to save. We focus on the income channel, i.e. the channel that has potentially been affected the most as a result of changed patterns of household financing. A description of the wealth channel and the effect on the savings incentive requires more structured modelling

of the economy, including the behaviour of households and firms, which is outside the scope of this article.

We find that an interest-rate change has a marked impact on household disposable income. The last decade has seen a considerable increase in interest-rate sensitivity as a result of the widespread use of adjustable-rate mortgages and higher indebtedness. Firms, too, use variable-rate loans extensively, which means that the Danish economy is characterised by a high degree of interest-rate sensitivity. All things being equal, the higher interest-rate sensitivity has reinforced the consequences of interest-rate changes for the real economy.

A frequent issue in the public debate has been that variable-rate loans and higher indebtedness in general have made the households more vulnerable to interest-rate fluctuations. This may be detrimental to both macroeconomic and financial stability. But if the course of monetary-policy interest rates is appropriate in relation to cyclical developments, higher interest-rate sensitivity also has a number of advantages, since it amplifies the role of interest rates in macroeconomic stabilisation. We therefore conclude by discussing the macroeconomic consequences of the changed pattern of financing.

The article is structured as follows: Section 2 analyses the pass-through from monetary-policy interest rates to bank retail rates. Section 3 examines the existence of a bank lending channel, while section 4 discusses the balance-sheet channel. The interaction between interest rates and economic developments is discussed in more general terms in section 5, while section 6 contains an analysis of the significance of an interest-rate adjustment to households and firms. Section 7 concludes.

2. INTEREST-RATE PASS-THROUGH

Danmarks Nationalbank occasionally adjusts the level of monetary-policy interest rates vis-à-vis the group of banks acting as monetary-policy counterparties. This is an element of the fixed-exchange-rate policy to keep the krone stable against the euro. The adjustments impact on bank retail rates in relation to households and firms. This is because monetary-policy interest rates function as alternatives to the interest rates on loans and placements in the money market, whereby monetary-policy interest rates play a crucial role for money-market interest rates. Consequently, monetary-policy interest rates determine the price of the banks' liquidity and therefore their financing costs in Danish kroner.[1] In this
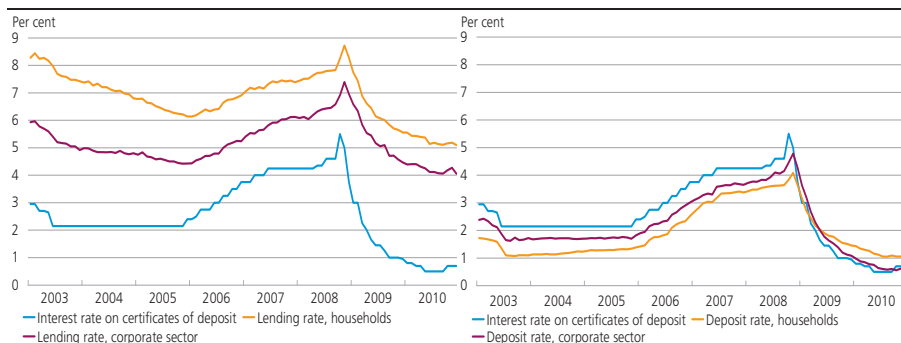
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[1] The relation between monetary-policy interest rates and money-market rates is described in more detail in Danmarks Nationalbank (2009), Chapter 4.

DANMARKS NATIONALBANK'S INTEREST RATE ON CERTIFICATES OF
DEPOSIT AND BANKS' DEPOSIT AND LENDING RATES AT SECTOR LEVEL   Chart 2.1

Note: Month-end.
Source: Danmarks Nationalbank.

section we focus on the link between monetary-policy interest rates and retail rates. This interest-rate channel is the primary channel for transmission of monetary policy to the real economy.

In a previous study of interest-rate pass-through in Denmark, Carlsen and Fæste (2007) find that the pass-through from monetary-policy interest rates to retail rates was generally high in the period 1983-2006. We update their results for the period 2007-10. The monetary-policy interest rates have been significantly reduced after the financial crisis in the autumn of 2008, cf. Chart 2.1, while the fall in retail rates has been less pronounced. Moreover, there are indications that the link between monetary-policy interest rates and money-market interest rates has weakened during the financial crisis, cf. The money and foreign-exchange markets during the crisis on p. 69 of this Monetary Review. This prompts us to examine whether the financial crisis in the autumn of 2008 has changed the pass-through to retail rates.

Unlike previous studies of the banking sector as a whole, this article also includes data for the individual banks. This provides for an analysis of how various characteristics, including the banks' financial position, affect the pass-through. Moreover, the larger number of observations provides for estimation for shorter periods. However, we also estimate at sector level, where the banks' interest rates are weighted together according to size. The analysis provides insight into how the pass-through works in relation to the overall economy and total interest payments. The data set is described in more detail in Box 2.1.

We construct and estimate a model for the pass-through from monetary-policy interest rates to retail rates, as described in more detail in Box 2.2. The model enables us to analyse the extent and speed of pass-through from adjustments of monetary-policy interest rates to re-

DATA DESCRIPTION	Box 2.1

The analysis of interest-rate pass-through and the existence of a bank lending channel in Denmark involves a panel data set covering the period from July 2000 to December 2010, comprising 29 of the largest Danish banks. Since for some of the banks there is not a full sample of observations, the data set is unbalanced[1]. The total number of observations is 3,114. Data for individual interest rates are only available from 2003, which limits the number of observations for the analysis of the interest-rate pass-through to 2,403.

The data set is constructed by linking Danmarks Nationalbank's statistics for monetary financial institutions, MFIs, with key financial indicators. The MFI statistics comprise monthly observations of bank-specific data from the largest banks operating in Denmark. These include lending volumes and interest rates broken down by deposits and lending for households and the corporate sector. The frequency of the indicators varies between 3, 6 and 12 months and depends partly on the nature of the financial ratio and the size of the individual bank. The MFI statistics are coupled with the most recently available financial indicator for the individual bank.

Some banks only have modest business in both lending to and deposits from households or the corporate sector, which may lead to high volatility in the series. Consequently, we apply various sub-populations in the individual analyses. A few of the banks in the data set were taken over by the Financial Stability Company. They are included in the usual manner until the takeover, after which they are excluded, as the object of the Financial Stability Company is to wind up banking activities, whereby it does not reflect ordinary banking operations. Moreover, we make a general correction for outliers. Extreme values may occur as reporting errors or in situations where two banks merge, or a bank takes over another bank.

Corrections for interest rates are carried out by excluding observations with a monthly interest-rate change of more than 1.5 percentage points, and for lending volumes by excluding the 2 per cent of growth rates that are lowest and highest, respectively. The lending volumes are subsequently seasonally adjusted.

[1] I July 2000, 23 banks are included and in December 2010, 24 banks are included. 19 of the banks are included in both July 2000 and December 2010. However, not all banks provide observations for all variables examined. The number of banks may therefore be lower in some of the regressions.

tail rates. The model is estimated on monthly observations for 2003-10. The assumption is that adjustments of retail rates are determined only by adjustments of monetary-policy interest rates.

This means that other factors with a potential impact on bank retail rates, e.g. the degree of competition between banks and the risk assessments of counterparties, have been excluded. In order to mitigate the effect of this, we have excluded the periods without variation in the explanatory variables from the regression. For example, the model includes no observations for 2004 since monetary-policy interest rates remained unchanged throughout that year. Furthermore, the period September-December 2008 has been excluded since the considerable adjustments of retail interest rates in this period, triggered by the financial crisis, reflected adjustments of monetary-policy interest rates only to a limited extent.

MODEL FOR INTEREST-RATE PASS-THROUGH	Box 2.2

To assess changes in pass-through before and after the financial crisis, the degree of pass-through is estimated separately for the period from January 2003 up to and including August 2008 and for the period from January 2009 to December 2010. Our estimates are based on monthly data. In the period up to the crisis, adjustments of the interest rate on certificates of deposit occurred in 14 months, while adjustments occurred in 12 months after the crisis. The estimation of the interest-rate pass-through is based on a model, specifying changes in retail interest rates as a function of adjustment of the monetary-policy interest rate in the current and the previous periods. The separation into the two periods surrounding the financial crisis is implemented in the model by introducing period-specific dummy variables. More specifically, the following relation is estimated:[1]

$$\Delta r_{i,t} = \mu_i + D_{1,t} \sum_{m=0}^{M} \beta_{1,m} \Delta pp_{t-m} + D_{2,t} \sum_{m=0}^{M} \beta_{2,m} \Delta pp_{t-m} + D_{1,t} + D_{2,t} + \varepsilon_t$$

$\Delta r_{i,t}$ indicates the change in retail interest rates in period t for bank i, Δpp_t is the change in the monetary-policy interest rate in period t, and μ_i is an bank-specific constant[2] $D_{1,t}$ has a value of 1 if the observation lies before the autumn of 2008, and a value of 0, if it lies after this time. The opposite applies to $D_{2,t}$. Pass-through is estimated for the overall deposit and lending rates for households and the corporate sector, respectively. The model includes the four most recent observations of the monetary-policy interest rate (M=3). For panel data, the model is estimated by least squares dummy variables, LSDV, with bank-specific fixed effects, while ordinary least squares, OLS, are applied to estimations at sector level.

The model shown is specified for panel data. For estimations at sector level, a corresponding specification is applied, only without the bank-specific constant.

Interest-rate pass-through in relation to households

The estimations for households indicate a generally high overall pass-through from monetary-policy interest rates to retail rates until the autumn of 2008. The sum of the β coefficients is 0.90 for loans and 0.98 for deposits. Consequently, 90 and 98 per cent, respectively, of the adjustments of monetary-policy interest rates had been passed through to bank retail rates after three months, cf. Chart 2.2.[3] This is consistent with the previous estimations for the period 2003-06, cf. Carlsen and Fæste (2007).

[1] Several international studies of interest-rate pass-through apply an error-correction model, which decomposes the adjustment into a short-term adjustment and an adjustment relative to a long-term equilibrium interest-rate margin, see e.g. de Bondt (2002). However, attempts to fit an error-correction model to Danish data have not been successful. The reasons are believed to be the relatively short period for which data is available and the major shifts in the equilibrium interest-rate margin during the estimated period.

[2] Danmarks Nationalbank's interest rate on certificates of deposit is applied as the monetary-policy interest rate. Until 8 June 2009, it was identical to Danmarks Nationalbank's lending rate. Subsequently, the interest rate on certificates of deposit has been considered the key interest rate for Danish money-market interest rates, as the monetary counterparties have had a positive net position vis-à-vis Danmarks Nationalbank during the same period.

[3] All estimation results at sector level are shown in Table A1 in the Appendix.

PASS-THROUGH TO RETAIL INTEREST RATES (SECTOR LEVEL)   Chart 2.2

Per cent

- Change in interest rate on certificates of deposit two and three months earlier
- Change in interest rate on certificates of deposit one month earlier
- Change in interest rate on certificates of deposit in the same month
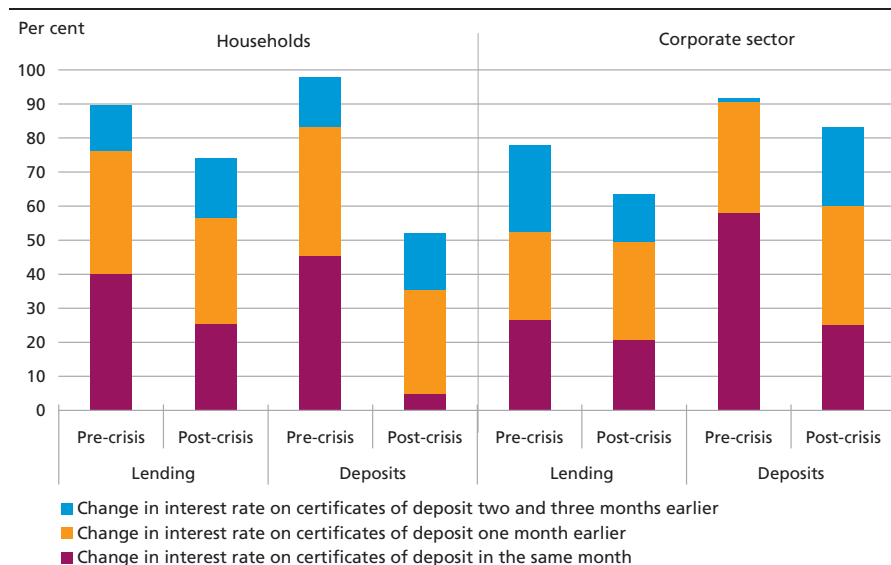
After the crisis, the pass-through to loans, and particularly to deposits, seems to have declined, and there are tentative signs of a lower overall pass-through. The results at sector level are consistent with the results achieved by means of panel data. While the decrease in the pass-through is not significant in the estimation at sector level, it is clearly significant in the estimations on panel data, cf. Table 2.1. At the same time, tests on panel data show that the overall pass-through is less than 100 per cent in all cases. All in all, the results show that the pass-through, as regards both deposits from and lending to households, has declined in extent and speed as from 2009.

Interest-rate pass-through in relation to firms
For firms, the overall pass-through after three months in the period up to the financial crisis was 78 per cent for loans and 92 per cent for deposits, cf. Chart 2.2. As with lending to households, there is a tendency for the pass-through to have declined in extent and speed after the crisis. This applies to both deposits and loans. Again, the results are confirmed by estimations on panel data, which show a significantly lower sum of β coefficients after the crisis than before. In all cases, the overall pass-through after four months is less than 100 per cent, cf. Chart 2.2.

The banks' deposit and lending rates are calculated as an average of all underlying transactions. Some products, such as mortgage loans and many business loans, are contractually linked to a monetary-policy inter-

PASS-THROUGH TO RETAIL INTEREST RATES (PANEL DATA)					Table 2.1
		Households		Corporate sector	
Period	Variable	Lending	Deposits	Lending	Deposits
2003:1-2008:8	ΔPP_t	0.37	0.37	0.39	0.51
		(0.05)	(0.03)	(0.06)	(0.06)
	ΔPP_{t-1}	0.41	0.41	0.29	0.35
		(0.04)	(0.03)	(0.04)	(0.02)
	ΔPP_{t-2}	0.07	0.07	0.06	0.06
		(0.03)	(0.01)	(0.03)	(0.02)
	ΔPP_{t-3}	0.03	0.00	0.11	-0.03
		(0.06)	(0.02)	(0.04)	(0.03)
	Constant	-0.03	0.00	0.00	0.01
		(0.00)	(0.00)	(0.00)	(0.00)
2009:1 - 2010:12	ΔPP_t	0.07	-0.06	0.13	0.13
		(0.05)	(0.05)	(0.09)	(0.05)
	ΔPP_{t-1}	0.32	0.34	0.25	0.32
		(0.04)	(0.03)	(0.06)	(0.03)
	ΔPP_{t-2}	0.05	0.11	0.08	0.16
		(0.03)	(0.02)	(0.06)	(0.03)
	ΔPP_{t-3}	0.16	0.10	0.15	0.09
		(0.03)	(0.02)	(0.04)	(0.03)
	Constant	-0.01	-0.02	-0.02	-0.02
		(0.01)	(0.01)	(0.01)	(0.01)
Total pass-through 2003:1 – 2008:8		0.87	0.85	0.86	0.88
Difference from full pass-through (Wald test)		0.13**	0.15***	0.14***	0.12***
Total pass-through 2009:1 – 2010:12		0.61	0.49	0.61	0.71
Difference from full pass-through (Wald test)		0.39***	0.51***	0.39***	0.29***
Difference in pass-through between the two periods (Wald test)		-0.26***	-0.36***	-0.24***	-0.17***

Note: Standard deviations are stated in brackets. White-heterogeneity-consistent standard deviations are reported. In cases where the parameter difference is tested to be significant, the estimation is repeated for the group separately, and standard deviations from this regression are stated. In these cases, the test of whether beta coefficients add up to 1 is also carried out within the separate regressions.
"*", "**"and"***" indicate significance at the 10, 5 and 1 per cent levels, respectively. Significance is not indicated for the individual coefficients.
Source: Danmarks Nationalbank.

est rate or a market reference rate. Consequently, the extent and speed of the pass-through depend not only on the banks' active decisions on interest-rate adjustments in relation to their customers but also on the volume and type of transactions with contractual interest-rate adjustments.

The share of loans linked to a reference interest rate has increased over the last decade. This has contributed to the quick and high pass-through observed before the financial crisis. Although no statistics have

been collected as to the exact volume of this loan type, there are no signs of a reduction since 2009.

Several international studies show that the banks adjust their lending rates more quickly when monetary-policy interest rates are raised than when they are lowered, see e.g. Borio and Fritz (1995) and Thomson (2006). A possible explanation is that periods when monetary-policy interest rates are reduced often coincide with a cyclical downturn, see e.g. Dueker (2000). The lower pass-through can therefore be attributed to the banks' greater restraint in lowering interest rates due to the larger debtor risk. This may explain the decline in the pass-through to Danish banks' lending rates after the financial crisis.[1]

A potential explanation for the lower pass-through on the deposit side is the intensified competition for deposits, fuelled by some banks' liquidity problems in connection with the financial crisis. The banks that experienced problems may have tried to raise liquidity by maintaining high deposit rates despite the declining monetary-policy interest rates. In the estimations, this will appear as a decrease in the coefficients that measure the pass-through to deposit rates.

An alternative explanation of the lower pass-through could be that Danmarks Nationalbank's interest-rate adjustments mirrored the ECB's adjustments of its official interest rates to a lower degree, which may have made it more difficult for the banks to assess the duration of the adjustments. This hypothesis will be elaborated later. Moreover, the low level of monetary-policy interest rates in 2010 may have contributed to reducing the pass-through to deposit rates. In the period 2003-08, corporate deposit rates were, on average, 0.5 percentage point lower than the rate of interest on certificates of deposit, while the corresponding figure for household deposit rates was 1.0 percentage point. The rate of interest on certificates of deposit was below 1 per cent throughout 2010. Consequently, the banks were unable to lower their deposit rates to match fully the reduction of the rate of interest on certificates of deposit since interest rates cannot be negative.

Balance-sheet structure and interest-rate pass-through
In studies of German and Italian banks, respectively, Weth (2002) and Gambacorta (2004) find that the balance-sheet structures of the individual banks play a role in the interest-rate pass-through. The pass-through from market interest rates to retail rates is lower for banks that are less dependent on market funding. This can be explained by the banks' wish

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[1] Since our observations cover one period of rising interest rates and one period of falling interest rates, almost coinciding with the respective test periods, we have not attempted to model this effect.

to shield their customers from temporary interest-rate fluctuations. Moreover, the banks' individual balance-sheet structures have possibly impacted on the pass-through from monetary-policy interest rates to retail rates since the financial crisis, given that some banks had liquidity problems during the crisis. As a result of the crisis, some banks experienced a liquidity shortage, which may have affected the interest-rate pass-through in that these banks raised their deposit rates to attract deposits. In a situation with falling monetary-policy interest rates, this reduces the pass-through on the deposit side. Similarly, banks under pressure may have attempted to increase earnings by delaying the transmission of interest-rate decreases to their borrowers.

We analyse whether the pass-through varies across banks, applying three key indicators that measure their access to funding, i.e. deposits as a ratio of lending, liquidity and the size of the balance sheet. For all three indicators, a high value indicates better access to liquidity. Deposits as a share of lending is an indicator of the stability of the current sources of funding since deposits are generally assumed to be a stable source. Moreover, large banks are generally assumed to have wider access to liquidity in the international financial markets because they typically have an international credit rating, among other reasons. The correlation between pass-through and balance-sheet characteristics is examined by dividing the banks into two groups for each characteristic in the analysis. One group consists of the strongest half, while the other consists of the weakest half. The estimation includes a dummy variable indicating whether an explanatory variable belongs to the group with low ratio values or the group with high ratio values.

The degree of pass-through is highly similar across the different groups, cf. Charts 2.3 and 2.4.[1] We can only identify one significant difference in the coefficients for households, i.e. for deposits, where the pass-through is higher for large banks than for smaller banks. This difference supports the hypothesis that banks with poorer access to liquidity have had to operate with higher interest rates than their competitors in order to attract depositors, which has impeded the pass-through of the declining monetary-policy interest rates. However, it may also reflect that large banks are generally the first to adjust interest rates, while the smaller banks wait and see what the large banks do. There are no significant differences as regards lending to firms. The very consistent pass-through for the various groups indicates a uniform interest-rate

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[1] In these estimations, the banks are included at the same weight irrespective of size. Hence, no comparison can be made with the pass-through at sector and institution level in the previous section, where the pass-through to retail rates is weighted by the volume of lending. The estimation results are presented in Table A2 in the Appendix.

PASS-THROUGH TO LENDING RATE BY BANK CHARACTERISTICS   Chart 2.3
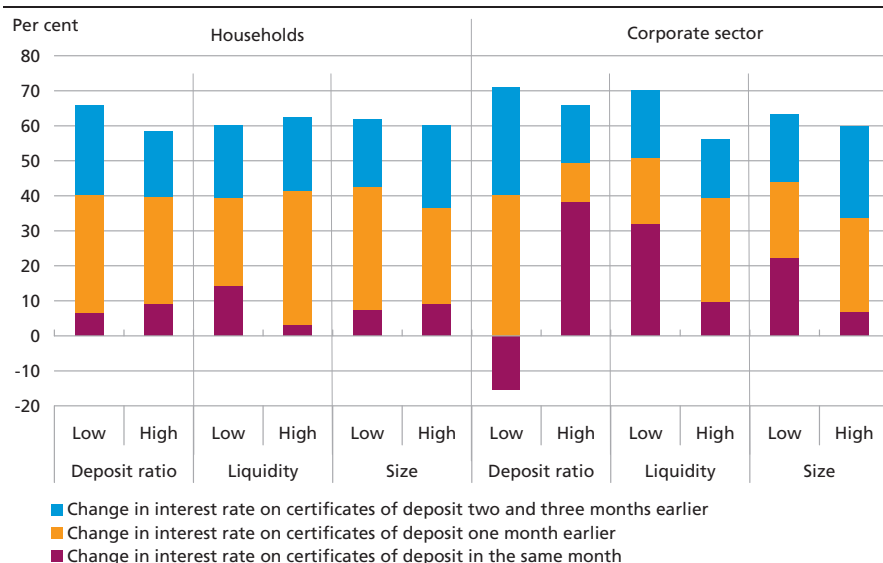
Note: Estimation period: January 2009-December 2010.
Source: Danmarks Nationalbank and Danish Financial Supervisory Authority.

pass-through across the banks in the period after the crisis. Consequent-ly, there does not seem to be any marked explanatory effect from the individual banks' financial positions.

PASS-THROUGH TO DEPOSIT RATE BY BANK CHARACTERISTICS   Chart 2.4
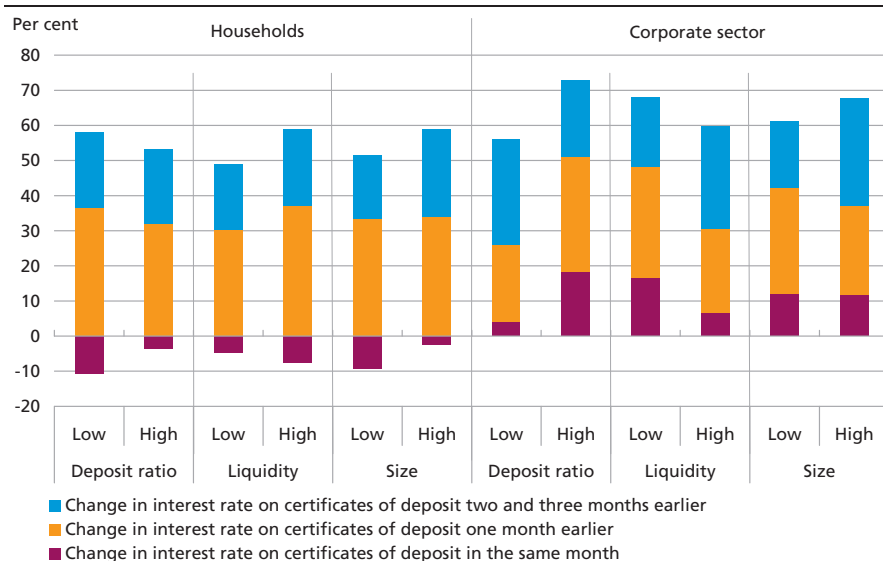

Note: Estimation period: January 2009 – December 2010.
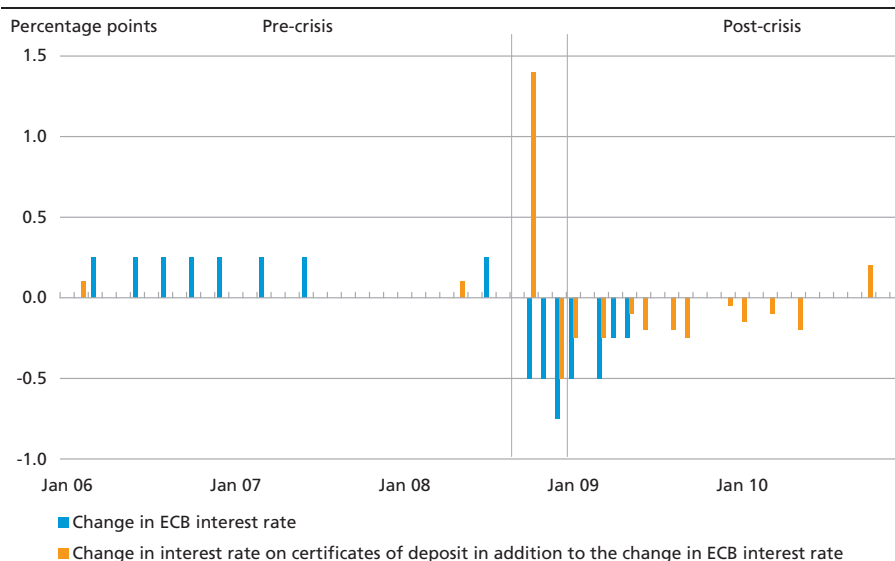Source: Danmarks Nationalbank and Danish Financial Supervisory Authority.

Changed background to adjustments of monetary-policy interest rates

As a result of Denmark's fixed-exchange-rate policy vis-à-vis the euro, the level of monetary-policy interest rates in Denmark over time mirrors that of the euro area. Consequently, the ECB's interest-rate adjustments are normally matched by Danmarks Nationalbank. But from time to time Danmarks Nationalbank also adjusts its interest rates unilaterally in order to stabilise the krone. Chart 2.5 shows changes in the rate of interest on certificates of deposit, broken down by the ECB's interest-rate adjustments and Denmark's unilateral adjustments.

The ECB's and Danmarks Nationalbank's adjustments of monetary-policy interest rates virtually coincided from January 2003 to the summer of 2008, during which period Danmarks Nationalbank adjusted interest rates unilaterally on two occasions only. Since 2009, on the other hand, there have been 13 unilateral Danish interest-rate adjustments, while the ECB has made only 4 interest-rate adjustments, cf. Chart 2.5. Denmark's unilateral interest-rate adjustments should be viewed against the backdrop of the ECB's implementation of non-standard measures in the money market, such as supplying ample liquidity, during this period. These measures caused money-market interest rates to decline, while the ECB's official interest rates remained unchanged, cf. Chart 2.6. The lower money-market interest rates in the euro area contributed to the reduction of the Danish monetary-policy interest rates.

DECOMPOSITION OF CHANGE IN INTEREST RATE ON CERTIFICATES OF DEPOSIT   Chart 2.5

Note: The ECB's minimum bid rate is used as a measure of the monetary-policy interest rate in the euro area until 14 October 2008 when the fixed rate in the Eurosystem's main refinancing operations is applied.
Source: ECB and Danmarks Nationalbank.

MONETARY-POLICY INTEREST RATES IN DENMARK AND THE EURO AREA   Chart 2.6

Per cent

Danmarks Nationalbank's interest rate on certificates of deposit
ECB's official interest rate
Uncollateralised 3-month money-market interest rate in the euro area (Euribor)
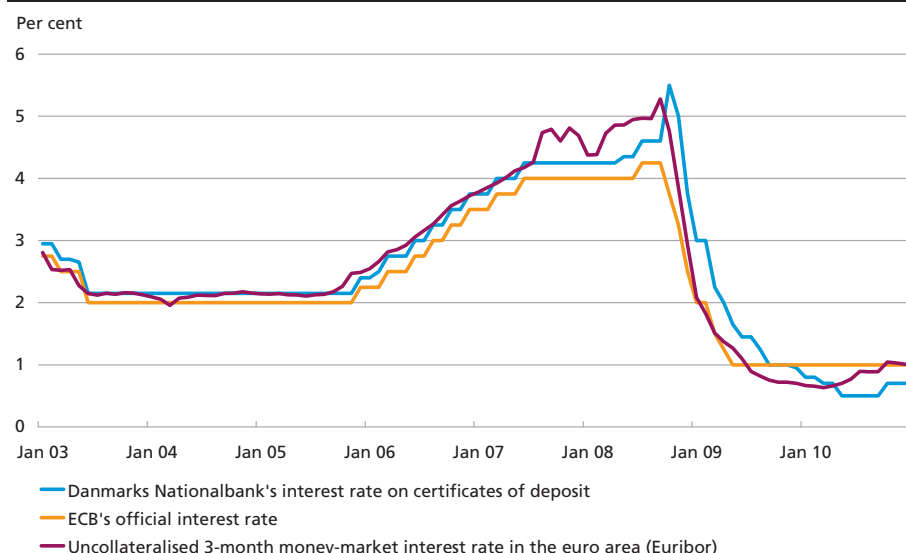
Note: Month-end. The ECB's minimum bid rate is used as the monetary-policy interest rate in the euro area until 14
         October 2008 when the fixed rate in the Eurosystem's main refinancing operations is applied.
Source: ECB and Danmarks Nationalbank.

Consequently, one possible explanation of the lower pass-through as from 2009 is that the banks have found it more difficult to assess the duration of the monetary-policy adjustments relative to a situation where Danmarks Nationalbank mirrors the ECB. If the banks perceive unilateral Danish interest-rate adjustments as temporary, they are less likely to pass on the adjustments to the retail rates.

Conclusion on interest-rate pass-through
We have found that the pass-through from monetary-policy interest rates to retail rates is high. However, there are indications that the pass-through has diminished in extent and speed after the financial crisis. On the lending side, this is consistent with the results of previous studies, i.e. that the pass-through to lending rates is typically lower in periods of falling monetary-policy interest rates. On the deposit side, the lower pass-through probably indicates that the banks wish to maintain high deposit rates in order to attract liquidity in the wake of the financial crisis.

   The slightly slower pass-through should be viewed in the light of the large number of unilateral Danish interest-rate adjustments since the crisis. In a period of extraordinary liquidity conditions in the euro area money market, the banks may have found it more difficult to assess whether adjustments of monetary-policy interest rates are of a more

permanent nature. Moreover, the extraordinary conditions in the money market have dampened the pass-through from monetary-policy interest rates to money-market interest rates. This may have weakened the pass-through to retail interest rates, since the banks' funding costs are determined by the market rates. Whether the fall in the interest-rate pass-through can be expected to last depends on the underlying causes. There are indications that the reduced pass-through can, to some extent, be attributed to specific crisis-related factors, which cannot be expected to play a permanent role.

3. THE BANK LENDING CHANNEL

In section 2, we demonstrated close links between monetary-policy interest rates and the banks' retail rates. Another precondition of an efficient monetary-policy transmission mechanism is that the banks are willing and able to lend. Otherwise, a monetary-policy expansion, for instance, will have only a limited effect on households and firms, since some of them will be unable to obtain loans and thus to exploit the lower interest rates.

The bank lending channel means that banks with solvency and liquidity problems in periods of tight financial conditions may have to tighten their credit policies. In practice, they may operate with a higher lending rate than they would otherwise have done. This results in a lower supply of loans for a given interest rate. Alternatively, the banks may reduce the volume of loans by rejecting loans they would otherwise have granted. Both of these factors will improve the bank's balance sheet. One reason for the balance-sheet problems may be that a tighter money market entails higher interest rates, leading to losses on fixed-income assets. Moreover, the capital base can be weakened by rising loan losses in an economic downturn, cf. Peek and Rosengren (1995) and Walsh (2010).

In the first instance, it is not likely that all banks will simultaneously suffer capital losses of a magnitude that would force them all to tighten their credit policies. For the bank lending channel to have any real economic importance, the customers who are exposed to tighter credit policies must not have access to funding on the original terms from another bank or mortgage bank. If this is the case, it may be due to asymmetrical information, cf. Stiglitz and Weiss (1981) and Holmström and Tirole (1997). Other banks do not know why the credit policy in relation to a customer is tightened. All they know is that it could possibly be because the customer's own bank finds that lending to this specific customer is associated with great risk. Consequently, according to this theory, other

LENDING BY BANKS AND MORTGAGE BANKS   Chart 3.1
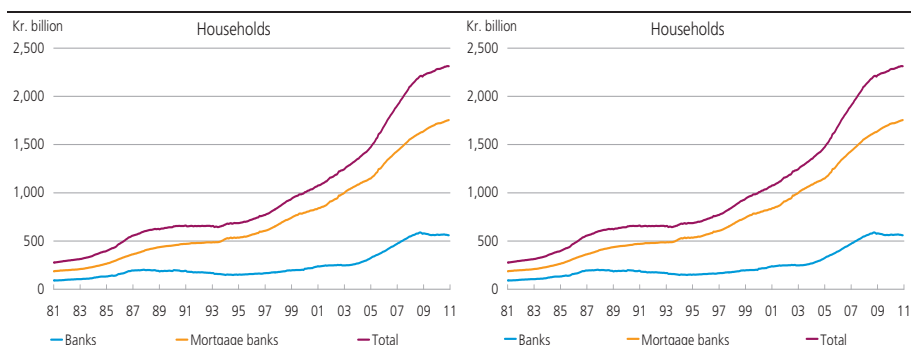
Note: Seasonally adjusted data. Outstanding loans to Danish households and the corporate sector from banks and mortgage banks located in Denmark. Households include sole proprietors and unincorporated partnerships, including agriculture. The corporate sector covers non-financial corporations.
Source: Danmarks Nationalbank.

banks will be less willing to lend to a customer of a bank that is forced to reduce its lending.

In Denmark, mortgage loans are a much-used alternative to bank loans. The access to mortgage financing may reduce the potential for a bank lending channel. Even if all Danish banks reduce their supply of loans after a common shock, such as contraction of monetary policy, higher capital adequacy requirements or greater uncertainty in the money market, this does not necessarily have a real economic effect, provided that the borrowers have access to more borrowing from mortgage banks. In the early 1990s, problems in the banking sector prompted the banks to reduce their lending, whereas the mortgage banks increased their lending to households. During the latest financial crisis, the mortgage banks increased their lending to both households and firms, while the banks' lending to households remained unchanged and their lending to firms declined. Total lending has therefore to some extent been shielded from the drop in bank lending, cf. Chart 3.1.[1]

Differences between Danish banks
In the Danish banking sector, the banks' balance sheets differed con- siderably at the end of 2006, cf. table 3.1. The capital adequacy of some banks was close to the statutory minimum, while it markedly exceeded the minimum for other banks. The same applied to excess liquidity cov- erage. Deposits as a ratio of lending also showed substantial variations. Since some banks had posted considerable customer funding gaps, they

[1]   A bank's ability and willingness to lend must be expected to be independent of whether the counterparty is resident in Denmark or abroad. Consequently, we have applied data for the change in the volume of lending by resident banks to all counterparties. Most banks by far have only very limited lending to non-resident counterparties, and regressions on data for lending by resident banks to residents have only a negligible effect on the analysis results.

KEY INDICATORS FOR BANKS IN THE ANALYSIS (END-2006)   Table 3.1

Bank characteristics	Ave.	Median	Minimum	Maximum	Standard deviation	No. of banks
Solvency ratio	11.9	11.6	9.8	16.2	1.7	18
Tier 1 ratio	9.9	9.5	7.3	16.8	2.5	18
Deposits as a ratio of lending, per cent	83.9	77.3	50.0	158.3	26.0	20
Total assets, kr. billion	121.6	30.3	8.4	1,270.0	273.0	23
Loan impairment ratio	1.1	1.2	0.2	2.2	0.6	
Excess liquidity coverage relative to the statutory minimum requirement, per cent	84.9	70.7	19.4	202.0	53.2	18

Note: The average is unweighted, which means that all banks are included with the same weight regardless of size.
Source: Danish Financial Supervisory Authority and Danmarks Nationalbank.

were dependent on market funding, while banks that had recorded customer funding surpluses were less affected by the market conditions.

As a result of these differences, the individual banks' ability to lend is affected to a varying degree by a change in monetary policy. The transmission of monetary policy can thus depend on the banks' balance sheets. The variations between the banks provide for analysis of whether the supply of loans varies across banks with different values for a number of bank-specific characteristics. We examine the role of excess liquidity coverage, deposits as a share of lending, size, and Tier 1 ratio, solvency ratio and loan impairment ratio. Any differences in lending growth may reflect that at times some banks struggle with balance-sheet problems of a magnitude that forces them to reduce the supply of loans. This would be an indication of a bank lending channel.

Initial analysis of a bank lending channel in Denmark
In our analysis of whether a bank lending channel exists in Denmark, we have used the data set described in Box 2.1. The banks are divided into two groups – i.e. the strongest and weakest half – for each of the bank characteristics under review. For each bank, the lending growth year-on-year is calculated, and the median for each group represents the lending growth for the group, cf. Charts 3.2 and 3.3. The loan supply of a bank can be expected to depend on how close a given bank-specific characteristic is to constituting a binding constraint. A bank is unlikely to reduce its lending even though it has e.g. lower capital adequacy than most other banks, provided that it is sufficiently far from the statutory minimum and the market does not assesses that a potential problem exists. This has prompted us to take an extra close look at the period from

MEDIAN FOR LENDING GROWTH BY TIER 1 RATIO AND LOAN
IMPAIRMENT RATIO
Chart 3.2
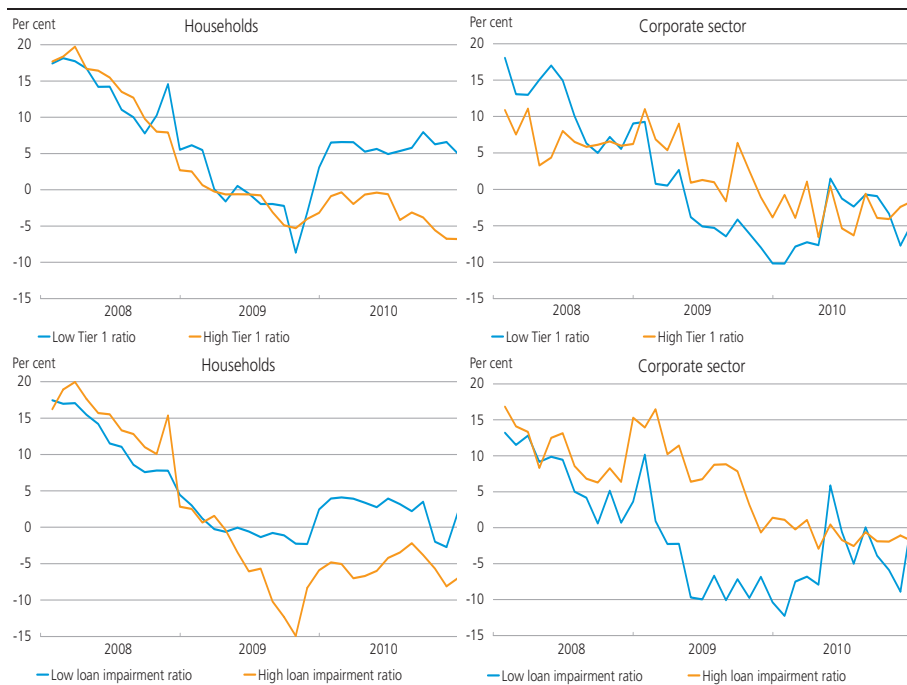
Note: The banks are categorised on the basis of their financial ratios at end-2006.
Source: Danish Financial Supervisory Authority and Danmarks Nationalbank.

January 2008 to date, given that some banks have had particular focus on their balance sheets in this period[1].

Since the onset of the financial crisis, the banks have had the option of concluding agreements that improve their capital adequacy. But as these agreements may involve substantial costs, the banks will potentially try to reduce their supply of loans despite a high solvency ratio[2]. This is taken into account by grouping the banks on the basis of their key ratios at end-2006, cf. Charts 3.2 and 3.3.

Initially, we expect lending growth to be lower for a bank with low capital adequacy than for a bank with high capital adequacy. This applies especially if the Tier 1 ratio or solvency ratio is close to the statutory minimum since this implies a direct restriction of the bank's scope for expanding its lending in the absence of further capital injections.

[1] For the period 2001-07 no clear correlation is evidenced between bank characteristics and lending.
[2] One example is that Bank Rescue Package 2 provided a facility for the banks to receive capital injections from the government in the form of Additional Tier 1 capital, which improved their capital adequacy. The Additional Tier 1 capital was raised at a rate of interest reflecting the government's risk on lending to the individual banks, i.e. approximately 9-12 per cent. Consequently, the banks have an incentive to improve their capital adequacy over time to such an extent that they will be able to redeem the Additional Tier 1 capital borrowed from the government. One way to improve the capital adequacy is to reduce lending.

MEDIAN FOR LENDING GROWTH BY EXCESS LIQUIDITY COVERAGE AND SIZE   Chart 3.3
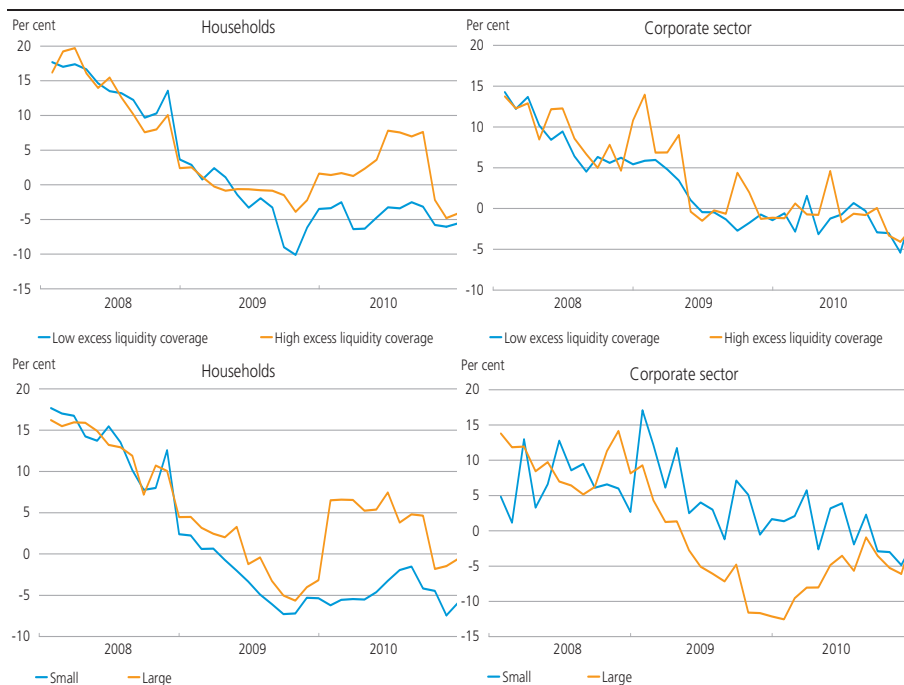
Note: The size of a bank is based on its total assets. Excess liquidity coverage is excess liquidity beyond the statutory
        minimum requirement (the 10 per cent requirement under section 152 of the Danish Financial Business Act) as a
        percentage of the statutory requirement. The banks are categorised on the basis of their financial ratios at end-
        2006.
Source: Danish Financial Supervisory Authority and Danmarks Nationalbank.

The money market as such may also exert a disciplinary effect if other
market players assess a bank to be less stable if its capital adequacy is
low. As a result, the bank's costs of funding in the money market in-
crease, forcing it to reduce the supply of loans at a given interest rate
offered to its own customers. Another possible outcome is that the
bank is barred from raising funds in the money market, forcing it to
reduce its lending. Annual growth in lending to the corporate sector
seems to be slightly supportive of this hypothesis, cf. Chart 3.2, top. On
the other hand, banks with a low Tier 1 ratio posted the strongest
growth in lending to households in 2010, which is contrary to expec-
tations.

   Loan impairment charges erode the banks' equity, to the detriment of
capital adequacy. Moreover, large loan impairment charges reflect high
risk. Consequently, the bank may find it more difficult and more expen-
sive to raise external financing for lending purposes. A bank that has
posted large loan impairment charges can therefore be expected to

tighten its credit policy.[1] This is consistent with the result that the annual growth in lending to households as from 2009 is lowest for banks with high loan impairment ratios. However, the opposite applies to lending to the corporate sector, cf. Chart 3.2, bottom. It is inconclusive how loan impairment charges influence lending growth, which may be attributable to the banks' different risk profiles. Some of them may be willing to lend to more risky projects, setting interest rates that can cover the expected losses. Consequently, in an economic downturn, lending growth will be higher for these banks than for banks with less risk appetite, and at the same time, their loan impairment charges will be larger.

In a tighter money market, it will be more costly and more difficult for the banks to raise liquidity. Banks that already hold a large share of liquid assets will be less affected since they are not dependent on the money market for liquidity in the first instance. Instead, they can use their reserves at Danmarks Nationalbank or realise liquid securities. Less liquid banks do not have this option, so they may have to reduce their debt commitments. Consequently, they have a smaller volume of liabilities for lending purposes. This fuels the hypothesis that the lower the degree of liquidity of a bank, the lower its lending growth, cf. Kashyap and Stein (2000) and Ehrmann et al. (2003), reviewing the USA and the euro area, respectively. This is consistent with data for Denmark, where the annual growth in lending to households tends to be lowest for the group of banks with low excess liquidity coverage, cf. Chart 3.3, top[2]. This applies as from the autumn of 2008, when the money market froze and access to liquidity became difficult. However, this trend is less pronounced for firms.

US studies of the bank lending channel find that lending by large banks is affected less than lending by small banks when money-market conditions change, cf. Kashyap and Stein (1995 and 2000) and Kishan and Opelia (2000)[3]. In Denmark during the financial crisis, it was observed that small and medium-sized banks had to pay higher interest rates than large banks for funding in the money market, cf. Ejerskov (2009) and the article on p. 69 in this Monetary Review. The large banks

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[1] The MFI statistics include loans subject to impairment charges until they have in all certainty lost their value. In the MFI statistics, loan impairment charges mean that these loans are no longer recognised as loans, whereby they also contribute to the decline in the bank's total lending.

[2] This is not the case for the deposit ratio (deposits as a ratio of lending), as there does not seem to be any appreciable difference between the group of banks with a high deposit ratio and the group with a low deposit ratio. It could otherwise be expected that the larger the customer funding gap, the greater the dependence of a bank on money-market funding. Hence, the bank should restrain further lending in periods when the money market is tight and money-market funding of further lending becomes more expensive.

[3] In general, this situation does not seem to apply to the euro area member states, cf. Angeloni (2003).

would thus appear to be less exposed to changes in the money market. The explanation could be that, given their size, they are in a better position to negotiate in the money market and are better able to obtain external financing to strengthen their capital base. However, this analysis does not unequivocally support a positive correlation between size and lending growth, cf. Chart 3.3, bottom. Growth in lending to households is highest for the group of large banks, whereas growth in lending to the corporate sector is highest for the small banks.

Econometric analysis of the bank lending channel
Charts 3.2 and 3.3 indicate that there is no clear correlation between a bank's balance sheet and its ability to lend. We now expand the analysis, examining whether bank characteristics have any influence on a bank's lending growth in the event of an adjustment of monetary-policy interest rates. Hence, we examine whether the banks' balance sheets play a role in the transmission of monetary policy.

   In studies of the bank lending channel it is difficult to identify what is attributable to a lower supply of loans and what is attributable to lower demand for loans in the event of changes in overall lending. We use the same panel data set as above to solve this problem. The bank characteristics are assumed to have a direct effect on the supply of loans, while the demand for loans is independent of the balance sheet of the individual bank. Instead, demand is assumed to be dependent only on macroeconomic conditions, in this analysis growth in the gross domestic product, GDP.

   If a bank lending channel exists, we would expect diverging lending growth across banks with different characteristics when conditions in the money market change. Hence, loan supply can be isolated from loan demand in total lending, cf. Kashyap and Stein (1995).

   We estimate a model that is described in more detail in Box 3.1. The demand for loans can be expected to rise if economic activity increases. Hence, we expect the coefficient before $\Delta \log GDP_{i,t-m}$ to be positive. Conversely, a tighter money market, modelled by a rise in $\Delta Cibor3m$, must be expected to reduce total lending. The coefficient for Cibor3m should therefore have a negative sign. The interaction term $Bchar_{i,t} \Delta Cibor3m_{t-m}$ shows how the individual bank characteristic influences the supply of loans if conditions in the money market change. A robust bank can be expected to be less affected by such a change. The coefficient before the interaction term, λ, must therefore be expected to be positive when the interaction term includes size, excess liquidity coverage, deposits as a ratio of lending, Tier 1 ratio and solvency ratio, respectively. When the loan impairment ratio is included, λ must be

LENDING GROWTH MODEL	Box 3.1

The test for the existence of a bank lending channel in Denmark is based on each bank's lending ratio and financial ratios. This is the most frequently used approach in the literature, cf. Kashyap and Stein (1995) and Worms (2001). The underlying estimation equation is

A0
$$\Delta \log \text{Loans}_{i,t} = \alpha_i + \sum_{m=1}^{M} \beta_m \Delta \log \text{Loans}_{i,t-m} + \sum_{m=1}^{M} \gamma_m \Delta \text{Cibor3m}_{t-m} +$$
$$\sum_{m=1}^{M} \phi_m \Delta \log \text{GDP}_{t-m} + \sum_{m=1}^{M} \rho_m \text{Bchar}_{i,t} + \sum_{m=1}^{M} \lambda_m \text{Bchar}_{i,t} \Delta \text{Cibor3m}_{t-m} + \varepsilon_{i,t}$$

where i indicates bank, t indicates the period of time to which the observation belongs, Δ is the difference operator, i.e. the change in the given variable from period $t-1$ to period t, and logLoans$_i$ is the logarithm of the volume of the seasonally adjusted lending in real terms from bank i. Lending is broken down by loans to households and to the corporate sector, respectively, which are modelled separately. α_i is a bank-specific constant. Δ Cibor3m is the change in the uncollateralised 3-month interbank rate in the Danish money market at month-end. It functions as an indicator of whether money-market conditions have been tightened. Δ *logGDP* is the quarterly change in the logarithm of real, seasonally adjusted GDP. As the analysis is carried out on monthly data, while GDP is only published quarterly, the variable will assume the same value for three consecutive months. $\varepsilon_{i,t}$ is an error term. *Bchar*$_{i,t}$ is a bank-specific variable for bank i in period t and covers size, excess liquidity coverage, deposit ratio, solvency ratio, Tier 1 ratio and loan impairment ratio in the analysis. The bank-specific variables are transformed to remove trends.[1] As variable, the size of a bank is defined by how much its total assets deviate from the average of the banks in the period under review, cf. equation (A1).

A1
$$Bchar_{i,t} = \log Size_{i,t} - \frac{1}{N} \sum_i \log Size_{i,t}$$

The other bank-specific variables are transformed according to the deviation from the overall average across banks and time, i.e.,

A2
$$Bchar_{i,t} = Z_{i,t} - \frac{1}{T} \sum_t \left(\frac{1}{N} \sum_i Z_{i,t} \right)$$

where $Z_{i,t}$ is excess liquidity coverage, deposits as a share of lending, Tier 1, solvency and loan impairment ratios. The transformation in equation A2 allows the given variable to vary over time, while the average for all observations is zero.

The explanatory variables are lagged for at least one period to avoid endogeneity. The number of lags in the model is determined by testing down until the explanatory variables are significant. Unlike in the analysis of the interest-rate pass-through, the regressions are performed by dynamic equations for lending growth, which has prompted us to apply 1-step Generalised Method of Moments, GMM, cf. Arellano and Bond (1991). The endogenous variable lagged and the exogenous right-side variables are used as instruments.

[1] For a detailed explanation of the transformation of variables, see Worms (2001), p. 18.

GROWTH IN LENDING TO HOUSEHOLDS BY BANK
CHARACTERISTICS   Table 3.2

Variable	Lag	Solvency	Tier 1	Liquidity	Deposit ratio	Size	Loan impairment charges
$Bchar_{t-1}$ x $\Delta Cibor$	1	-0.0024	0.0004	-0.0001*	-0.0024	-0.0076**	-0.0018
		(0.0016)	(0.0013)	(0.0000)	(0.0180)	(0.0033)	(0.0036)
	2	-0.0003	-0.0002	-0.0001-	0.02139	0.0043*	0.0032
		(0.0010)	(0.0009)	(0.0001)	(0.0190)	(0.0023)	(0.0025)
	3	0.0009	0.0018**	-0.0001**	0.0134	-0.0001	-0.0011
		(0.0008)	(0.0009)	(0.0000)	(0.0107)	(0.0016)	(0.0032)
Δ Cibor	1	0.0121**	0.0106	0.0079	0.0067	0.0056	0.0087
		(0.0063)	(0.0065)0)	(0.0061)	(0.0057)	(0.0053)	(0.0059)
	2	-0.0044	-0.0043	-0.0031	-0.0064	-0.0075	-0.0041
		(0.0053)	(0.0050)	(0.0041)	(0.0049)	(0.0052)	(0.0042)
	3	-0.0084**	-0.0086***	-0.0066**	-0.0095***	-0.0102***	-0.0074***
		(0.0034)	(0.0033)	(0.0032)	(0.0025)	(0.0028)	(0.0026)
Δ logGDP	3	-0.0006	-0.0006	-0.0007	-0.0007	-0.0008	-0.0004
		(0.0007)	(0.0007)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
Bchar	1	0.0002	0.0012	-0.0000	0.0020	-0.0116	-0.0005
		(0.0009)	(0.0011)	(0.0000)	(0.0064)	(0.0153)	(0.0006)
Δ logLoans	1	-0.3745**	-0.3695**	-0.3624**	-0.2425	-0.1830	-0.3332***
		(0.1699)	(0.1688)	(0.1605)	(0.1836)	(0.1847)	(0.1080)
	2	-0.2076*	-0.2030*	-0.2008*	-0.1272	-0.0846	-0.1960***
		(0.1175)	(0.1169)	(0.1080)	(0.1207)	(0.1217)	(0.0789)
	3	0.0039	0.0071	0.0036	0.0386	0.0628	-0.0053
		(0.0547)	(0.0545)	(0.0548)	(0.0686)	(0.0718)	(0.05179)
No. of obs.		1937	1937	2003	2410	2410	2020
1st period		2001:8	2001:8	2001:1	2001:1	2001:1	2001:1
Banks		23	23	24	28	28	23

Note: The table reads vertically and shows the coefficient estimates by estimation of the model described in equation
         A0. The independent variable is lending growth in period t in all regressions, while the bank-specific
         characteristic, Bchar, is different in each of the estimations. Standard deviations are stated in brackets. White-
         heterogeneity-consistent standard deviations and covariances. ***Significant at 1 per cent level, ** significant at
         5 per cent level, * significant at 10 per cent level.
Source: Danish Financial Supervisory Authority and Danmarks Nationalbank.

expected to be negative. The estimation results are shown in Tables 3.2
and 3.3.

Results

We are unable to demonstrate the existence of a bank lending channel
in Denmark on the basis of the regressions of A0. This applies to lending
to firms and households alike, cf. Tables 3.2 and 3.3. The coefficients for
the interaction term $Bchar_{i,t}\Delta Cibor$ are generally insignificant. This indi-
cates that although a bank is weak in terms of a bank-specific variable,

GROWTH IN LENDING TO THE CORPORATE SECTOR BY BANK
CHARACTERISTICS

Table 3.3

Variable	Lag	Solvency	Tier 1	Liquidity	Deposit ratio	Size	Loan impairment charges
Bchar$_{t-1}$ x ΔCibor	1	-0.0004	-0.0004	0.0001	0.0363	-0.0006	-0.0028
		(0.0021)	(0.0017)	(0.0001)	(0.0221)	(0.0039)	(0.0032)
	2	-0.0002	0.0010	0.0002	0.0324	-0.0009	-0.0018
		(0.0021)	(0.0019)	(0.0002)	(0.0287)	(0.0050)	(0.0034)
	3	-0.0021**	-0.0001	0.0002	0.0144	-0.0079***	0.0075**
		(0.0011)	(0.0017)	(0.0002)	(0.0327)	(0.0022)	(0.0034)
Δ Cibor	1	0.0103	0.0097	0.0098	0.0022	-0.0030	0.0062
		(0.0120)	(0.0119)	(0.0094)	(0.0080)	(0.0069)	(0.0076)
	2	0.0255**	0.0253*	0.0280**	0.0215**	0.0170**	0.0239***
		(0.0124)	(0.0123)	(0.0110)	(0.0089)	(0.0074)	(0.0092)
	3	0.0173	0.0162	0.0155	0.0100	0.0077	0.0086
		(0.0215)	(0.0212)	(0.0126)	(0.0103)	(0.0072)	(0.0108)
Δ logGDP	3	-0.0019	-0.0019	-0.0017	-0.0000	-0.0000	-0.0012
		(0.0019)	(0.0020)	(0.0012)	(0.0011)	(0.0011)	(0.0014)
Bchar	1	0.0044**	0.0052	0.0000	0.0741***	-0.0540	0.0029
		(0.0022)	(0.0025)	(0.0000)	(0.0278)	(0.0420)	(0.0045)
Δ logLoans	1	-0.6495	-0.6448	-0.4620*	-0.2438	-0.2364	-0.4245
		(0.5907)	(0.5992)	(0.2640)	(0.2069)	(0.2131)	(0.2662)
	2	-0.3515	-0.3480	-0.2246	-0.1044	-0.0981	-0.1914
		(0.3325)	(0.3376)	(0.1425)	(0.1353)	(0.1330)	(0.1401)
	3	-0.0634	-0.0621	-0.0128	0.0102	0.0146	-0.0019
		(0.1588)	(0.1614)	(0.0747)	(0.0744)	(0.0721)	(0.0707)
No.of obs.		1988	1988	2041	2586	2628	2057
1st period		2001:8	2001:8	2001:1	2001:1	2001:1	2001:1
Banks		24	24	25	29	30	24

Note: See note in Table 3.2.
Source: Danish Financial Supervisory Authority and Danmarks Nationalbank.

its lending is no more vulnerable to changes in money-market conditions than lending by a strong bank.

A possible reason why the bank-specific variables have no measurable influence on lending growth is that the Danish banks are generally so robust that they do not have to reduce the supply of loans even if the money market tightens. Indeed, the data indicates that only very few banks have been close to or have been in conflict with the statutory minimum requirements for capital and liquidity. Technically, another factor influencing the regressions is the very low number of observations showing that the bank-specific variables constitute a binding constraint on a bank's lending. Consequently, it is difficult to obtain statistically significant results of the influence of bank characteristics on lending growth.

The banks probably have different preferences as regards operating with key ratios that are stronger or weaker than the corresponding ratios for other banks. This may contribute to blurring the bank characteristics in the estimations. For example, even a bank with a relatively high solvency ratio will not increase lending if its solvency ratio is close to or below the bank's own target, cf. Berrospide and Edge (2010). Moreover, the statutory minimum solvency requirement is determined individually, which is not taken into account in the estimations either.

The model assumes the same growth in the demand for loans across banks. The implied assumption is that the composition of customer types and their demand for loans is also the same across the banks. Recent international studies using data at firm and bank level can take into account the demand for loans from the individual bank, cf. e.g. Jiménez et al. (2010) and Albertazzi and Marchetti (2010). These studies have found more pronounced effects of bank characteristics on a bank's lending, compared with the studies assuming one level of demand for all banks. We have not been able to perform a similar analysis of Danish conditions due to a lack of data. Consequently, there is a risk that our analysis underestimates the effect of a bank lending channel in Denmark. Finally, it should be borne in mind that the analysis is based on a modest number of banks compared with the international studies, which makes it more difficult to draw firm conclusions.

Robustness

Some aspects of the results are contrary to what could be expected. This prompts us to consider whether the model is well specified. To address this, we perform a number of robustness checks. According to the regressions, an increase in GDP does not lead to higher lending, as could otherwise have been expected. However, the results remain the same whether we apply gross value added or GDP growth less public-sector expenditure or the output gap, measured as the gap between GDP and an HP-filtered trend, as an indicator of the demand for loans. The same applies if inflation, measured in terms of the consumer price index, is included together with a measure of output.

A tighter money market should dampen banks' lending, but this effect is not visible in the results. For both firms and households, the effect of a change in 3-month Cibor is most often insignificant. This could imply that 3-month Cibor is not the right indicator of money-market conditions in Denmark. However, the results are robust in terms of the variables used to model these conditions. Besides the change in 3-month Cibor, we have also attempted to model changes in money-market con-

ditions using 1-month and 6-month Cibor, 1-month, 3-month and 6-month Euribor and the rate of interest on German 3-month T-bills.

We have analysed a number of other specifications of the model that do not change the qualitative conclusions either. Instead of monthly observations of lending growth and the change in money-market interest rates, the regressions have also been performed on quarterly data. This removes some noise, but does not alter the conclusions.

We have also attempted to adjust for outliers in several ways, but we have not been able to demonstrate that individual bank characteristics influence lending growth. The estimations are based on data from 2001 to 2010. The qualitative results remain unchanged if other regression periods are applied, e.g. before and after the financial crisis, or if the starting point of the regression is moved forward to the summer of 2007 when the money-market turmoil set in.[1]

International perspective on the bank lending channel
The analysis could not provide evidence of the existence of a bank lending channel in Denmark. The results of international studies are also inconclusive, and the conclusions of empirical analyses concerning the existence and role of a bank lending channel differ considerably.

For the euro area, Ehrmann et al. (2003) find that bank lending declines significantly in the wake of a tightening of monetary policy, both at the aggregated level and in the individual member states. This applies particularly to banks with relatively low excess liquidity coverage, which may indicate a supply effect. Ehrmann et al. (2003) point out that national structural differences across the euro area should also be borne in mind. For example, the role of bank loans in firms' financing, the size of the banks and the degree of government influence, which vary across member states, may affect the individual bank's response to a change in monetary policy.

Variations in national structures may also partly explain the Danish results. On the basis of an extensive cross-section data set at bank level, Kashyap and Stein (2000) find evidence of a bank lending channel in the USA, just as Huang (2003) points to the existence of a bank lending channel in the UK. However, in an analysis of 16 OECD countries,

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[1] As a robustness check, we have also used the Least Squares Dummies Variables method, LSDV, in our regression. LSDV results in a small bias because the first lagged term of the left-hand-side variable is not independent of the error term. As opposed to GMM, the LSDV method does not make adjustment for this by means of instruments. Hence, the LSDV estimates can be applied as a robustness check of whether the instruments used in Tables 3.2 and 3.3 are critical to the estimates. We find that the qualitative conclusions remain true even if we apply the LSDV method instead of the GMM method.

INDICATORS FOR CAPITAL ADEQUACY IN SELECTED COUNTRIES   Chart 3.4

Per cent and percentage points

Solvency ratio   Tier 1 ratio   Change in solvency ratio 2007-09
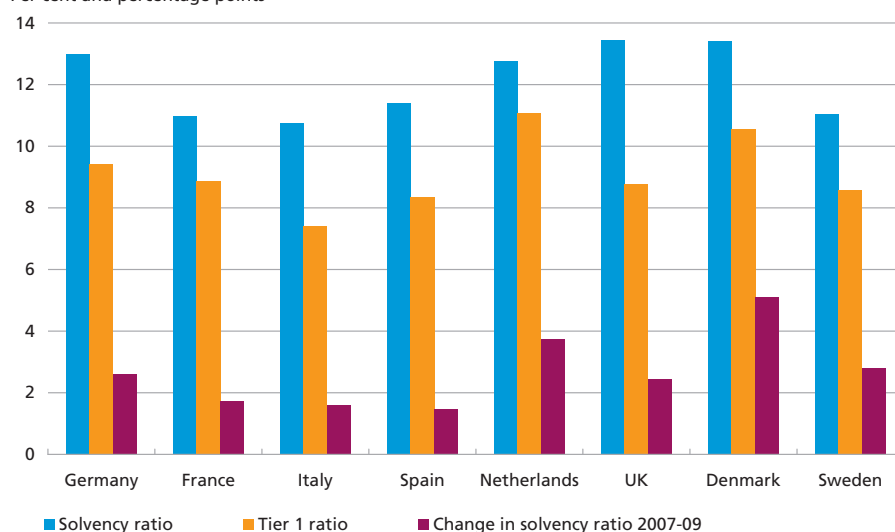
Note: Data is average for 2007-09.
Source: Statistics on Consolidated Banking Data (CBD) 2007, 2008, 2009. European Central Bank.

including Denmark, Brissimis and Delis (2009) find indications of a bank lending channel in only two countries, i.e. Japan and Greece.

As described previously, the level of a bank's capital adequacy must be important to the bank lending channel. Consequently, it is also relevant to examine the solvency of Danish banks in an international perspective, and it is relatively high, cf. Chart 3.4. This applies both over a number of years and in the most recent data, showing that Danish banks have considerably increased their solvency in recent years. This may contribute to reducing the effects of a change in monetary policy on the loan supply[1].

Moreover, Cetorelli and Goldberg (2009) point out that the import-ance of the bank lending channel is reduced by the more global oper-ations of the banks, which have closer operational links with their for-eign branches. Access to capital and liquidity via more countries makes the banks less exposed to changes in national monetary policy, which would suggest a lower effect of the bank lending channel. As regards Denmark, several of the largest banks have, together with their foreign branches, formed an internal capital market, and their internationally oriented business models may contribute to mitigating the effect of a

[1] Part of the increase in the solvency ratio of Danish banks is attributable to injections of government Additional Tier 1 capital. As discussed previously, this type of capital is relatively expensive, giving the banks an incentive to repay the injections. This may influence their decisions on further lending despite their current high degree of capitalisation.

bank lending channel in Denmark. But an internationally oriented business model would not have given the relevant banks better access to liquidity during the money-market crisis in the autumn of 2008, as the money markets of all countries froze at the same time.

Conclusion on the bank lending channel

We have not found indications of a link between a bank's lending growth and indicators of its ability to lend in the event of a change in monetary policy. Hence, it is not possible to demonstrate the existence of a bank lending channel in Denmark. In the analysis, we have used a data set at bank level, coupling key ratios with the respective banks' lending to households and firms. We find that neither size, nor deposit, solvency, Tier 1 or loan impairment ratios have impacted on a bank's ability to lend in the period 2001-10. But after the financial crisis, there has been a slight tendency for the most liquid banks to post higher lending growth than less liquid banks.

The analysis also suggests that the banks did not restrict their lending during the financial crisis. A possible reason could be that the banks' capital requirements only in a few cases constituted a binding restraint on their lending. Hence, the access to Additional Tier 1 capital under Bank Rescue Package 2 may have helped to prevent a bank lending channel. Moreover, on the basis of the analysis, it cannot be ruled out that the banks, independently of their positions prior to the crisis, may have tightened lending more than immediately warranted by the cyclical position.

4. THE BALANCE-SHEET CHANNEL

In this section, we look into the balance-sheet channel, i.e. the part of the credit channel that relates to the balance sheets of the borrowers. This channel is based on the assumption that a tightening of monetary policy will erode the value of the firms' assets. This applies to both tangible assets, e.g. machinery and buildings, and financial assets. Hence, the firms' pledging of collateral for loans is restricted. Moreover, an interest-rate hike should be expected to lead to lower demand, which will reduce the firms' future earnings.

In other words, the theory implies that a tightening of monetary policy increases the banks' risk of loan losses. This highlights the need for firms to be able to pledge collateral for the loans granted, as asymmetry in the information between banks and firms should be expected. Typically, a firm will have a better indication of its estimated failure rate than the banks, but since firms wish to achieve the most favourable borrow-

ing terms, they have an incentive to tone down the risk of loss on a given project. Consequently, the banks cannot base their lending decisions solely on the information they receive from the firms. As a result of the asymmetry, the banks will demand an interest premium on loans, i.e. the external financing premium, cf. Bernanke et al. (1999).

A bank's knowledge of a firm's finances will typically be determined by the size of the bank's exposure with the firm. While the banks often spend considerable resources on close monitoring of their large customers' finances, their knowledge of their smaller customers tends to be more limited. Hence, a loan to a small customer can be regarded as riskier than a loan to a large customer. The difference in risk is amplified by the general overrepresentation of small firms in the bankruptcy statistics.

In order to factor in a higher risk of loan losses resulting from a tightening of monetary policy, the banks may raise their lending rates by more than warranted by an increase in monetary-policy interest rates. This causes the external financing premium to go up, making it more attractive for firms to finance new investments using internal funds rather than raising loans. Besides a higher external financing premium, another consequence of a balance-sheet channel could be that tighter credit ratings in some periods limit the firms' access to external financing even though they are willing to pay the current interest rate. This also increases the importance of internal financing. As a result, some fully profitable investments cannot be realised unless the firms have enough internal funds to finance them. This is detrimental to growth and employment.

Identification of a balance-sheet channel

The balance-sheet channel may imply that firms for which a credit rating is difficult to perform are particularly dependent on internal financing, cf. Gilchrist and Zakrajsek (1995). Alternatively, the balance-sheet channel may imply that the correlation between cash flow and investments is most pronounced in periods of tight monetary conditions, as the cash flow constitutes a measure of the firm's ability to finance investments by means of internal funds, cf. Oliner and Rudebusch (1996).

In a world without financial friction, investments would depend exclusively on expected yield relative to capital costs. This measure is often called Tobin's Q, cf. Tobin (1969). If Tobin's Q is greater than 1, it is, in theory, profitable for the firm to expand its capital stock, and net investment becomes positive. It is possible to calculate Tobin's Q for listed firms since a listed firm's market value is known via its share price, reflecting the expected potential yield.

In Denmark, listed firms make up only a small share of the total number of firms. So for most firms it is not possible to calculate a reliable measure of Tobin's Q. If unlisted firms are to be included, the growth in turnover in recent years can be used instead of Tobin's Q as the underlying explanatory variable for the volume of investment. In order to clarify whether a balance-sheet channel exists, the firm's cash flow is included in the analyses as an additional explanatory variable.

The balance-sheet channel in the USA and the EU

Analyses of the balance-sheet channel are usually based on panel data sets with information from the financial statements of a number of firms over a number of years, cf. Box 4.1. Since it is beyond the scope of this article to construct such a data set for Danish firms, there is no separate econometric analysis of the balance-sheet channel based on Danish data. Instead, we summarise the most important results from studies of the balance-sheet channel for a number of European countries and the USA. Our review is supplemented with a discussion of the extent to which these results can be applied to a Danish context.

A research project coordinated by the ECB comprised studies of the balance-sheet channel for Germany, France, Italy and Spain as well as a number of smaller euro area member states. Table 4.1 shows the long-term effect of cash flow on investment as a share of the existing capital stock in the four largest euro area member states. For the member states overall, there is a significant relation between corporate cash flows and investment. This is not surprising, since cash flow may be a good indicator of a firm's future turnover and thus its expected future earnings.

The fundamental hypothesis in Chatelain et al. (2001) is that the balance-sheet channel impacts on small firms in particular. Hence, the Table also shows the difference between the cash flow's estimated long-term effect on investment for small and large firms. A difference is observed only for Italy. However, this may reflect that the size of a firm is not the right indicator of the factors behind a balance-sheet channel. This has prompted analysis of alternative firm groupings in more detailed studies for the individual euro area member states.

As regards Germany, von Kalckreuth (2001) finds that firms with poor credit ratings are more exposed to credit constraints. As regards France, the cash-flow dependence is greater for firms in the capital goods industry, firms with poor credit ratings and firms that are strongly dependent on trade credits, cf. Chatelain and Tiomo (2001). For Italy, the dependence on current financial conditions is strongest for firms with a relatively large share of intangible assets, besides for small firms, cf. Gaiotti and Generale (2001). This may reflect that banks find it parti-

ECONOMETRIC ANALYSIS OF THE BALANCE-SHEET CHANNEL   Box 4.1

Analyses of the balance-sheet channel are usually based on a panel data set with information from the financial statements of a number of firms over a number of years. Based on data, a variation of the following equation is typically estimated, cf. for example Chatelain et al. (2001):

$$I_{i,t}/K_{i,t-1} = \alpha_i + \delta_t + \sum_{m=1}^{M}\left(\beta_m I_{i,t-m}/K_{i,t-m-1}\right) + \sum_{m=0}^{M}\left(\gamma_m \Delta \log S_{i,t-m}\right) +$$

$$\sum_{m=0}^{M}\left(\phi_m \Delta \log BP_{i,t-m}\right) + \sum_{m=0}^{M}\left(\lambda_m PS_{i,t-m}/K_{i,t-m-1}\right) + \varepsilon_{i,t}$$

I is the firm's investments intended to be explained. *S* is sales, *BP* is the capital's user cost, and *PS* is cash flow. Investments and cash flow are calculated relative to the value of the firm's capital stock, K. α_i is a firm-specific constant, δ_t is a period dummy, and ε_t is a stochastic error term. *t* is an index indicating the period of time, and *i* is an index indicating the firm. Δ is the difference operator, which indicates a change in the subsequent variable from period *t-1* to period *t*, and log is designates the natural logarithm.

On the basis of the coefficient to the firms' cash flows, λ, there are two approaches to testing whether monetary policy operates through a balance-sheet channel. One is to divide the firms in the data set into groups based on their expected credit conditions. If, for example, mainly small firms are expected to be hit by credit restrictions, the firms can be divided into groups by size. If the coefficient to the cash flow is largest for small firms, this will indicate a credit channel. The method was applied in connection with a major research project on the monetary-policy transmission mechanism in the euro area, coordinated by the ECB. The results of the project are summarised in Angeloni et al. (2003).

An alternative approach is to identify periods during which monetary policy is tight, and periods during which it is more accommodative. If the link between cash flow and investments is stronger in periods with tight monetary policy, this is also an indication of the existence of a credit channel. This method is applied by Oliner and Rudebusch (1996) for the USA and by Angelopoulou and Gibson (2007) for the UK.

cularly difficult to rate these firms. The analyses, all in Angeloni et al. (2003), do not present a clear conclusion as to whether a balance-sheet channel exists in the euro area.

LONG-TERM EFFECT OF CASH FLOW ON INVESTMENT AS A SHARE OF
THE CAPITAL STOCK   Table 4.1

	Germany	France	Italy	Spain
Cash flow/value of capital stock	0.092 (0.038)*	0.221 (0.030)**	0.196 (0.027)**	0.116 (0.021)**
Difference between large and small firms	-0.050 (0.050)	-0.035 (0.031)	0.144 (0.045)**	0.030 (0.033)

Note: * and ** indicate significance at 5 per cent and 1 per cent levels, respectively.
Source: Chatelain et al. (2001).

Oliner and Rudebusch (1996) investigate the possible existence of a balance-sheet channel in the USA, while Angelopoulou og Gibson (2007) seek to do the same for the UK. The previously mentioned studies for the euro area compare the dependence of investments on cash flow for different groups of firms. Instead, Oliner and Rudebusch and Angelopoulou and Gibson examine whether the monetary-policy stance has an impact on the link between investment and cash flow. For both the USA and the UK, there are indications that small firms are more dependent on internal financing when monetary policy is tightened. There are no visible indications of a balance-sheet channel for large firms, however.

The relatively weak indications of a credit channel may reflect either that it plays only a limited role or that the statistical methods used in the analyses are insufficient for identifying this channel. All of the studies mentioned in the section on the bank lending channel are based on bank-specific data, while the studies of the balance-sheet channel are based on firm-specific data. A more recent study for Spain by Jiménez et al. (2010) is based on data for individual loan applications matched with key indicators for the banks and firms involved. This study finds that the balance sheets of both banks and firms influence the supply of credit. To our knowledge, this is the only study of the credit channel that is based on individual loan applications.

The balance-sheet channel in Denmark
The monetary transmission mechanism depends on a number of country-specific factors. For example, it plays a role how firms finance their activities. Consequently, the results of the studies mentioned previously cannot be applied directly to Denmark. Below we will take a closer look at a number of indicators that can give us an impression of whether a balance-sheet channel exists in Denmark.

The hypothesis that the balance-sheet channel primarily plays a role for small firms is corroborated by quite a few empirical studies. The corporate structure in Denmark and other countries is predominantly made up of small and medium-sized firms with less than 250 employees. In Denmark, these firms accounted for approximately 68 per cent of total value added in the non-financial sector in 2006. Most of them are very small, with 1-9 employees. In Denmark, they account for just under 87 per cent of the total number of firms, cf. Table 4.2. This is a relatively low percentage in an international context. However, the percentage of very small firms is lower in Germany and the USA. Overall, in terms of firm size Denmark's corporate structure is comparable with that of other countries. Consequently, firm size does not suggest that the strength of

SMALL AND MEDIUM-SIZED ENTERPRISES IN THE NON-FINANCIAL SECTOR, 2006   Table 4.2

Per cent of total number of firms	Micro (1-9 employees)	Small (10-49 employees)	Medium-sized (50-249 employees)	Small and medium-sized enterprises, SMEs (1-249 employees)	Large (more than 250 employees)
Denmark	86.8	11.0	1.9	99.7	0.3
Sweden	94.2	4.8	0.8	99.8	0.2
UK	87.5	10.5	1.7	99.6	0.4
Germany	83.1	14.1	2.3	99.5	0.5
France	92.3	6.5	1.0	99.8	0.2
Italy	94.6	4.8	0.5	99.9	0.1
Spain	92.2	6.8	0.8	99.9	0.1
EU27	91.8	6.9	1.1	99.8	0.2
USA	78.8	-	-	-	-

Note: The non-financial sector comprises industry, building and construction as well as non-financial services. For the USA, the "Micro" group includes firms with 0-9 employees. Comparable categorisations for the other firm sizes are not available. The data for the Netherlands is from 2005, while data for the USA is from 2007.
Source: Eurostat, European Business Economy Overview 2009 and U.S. Census Bureau.
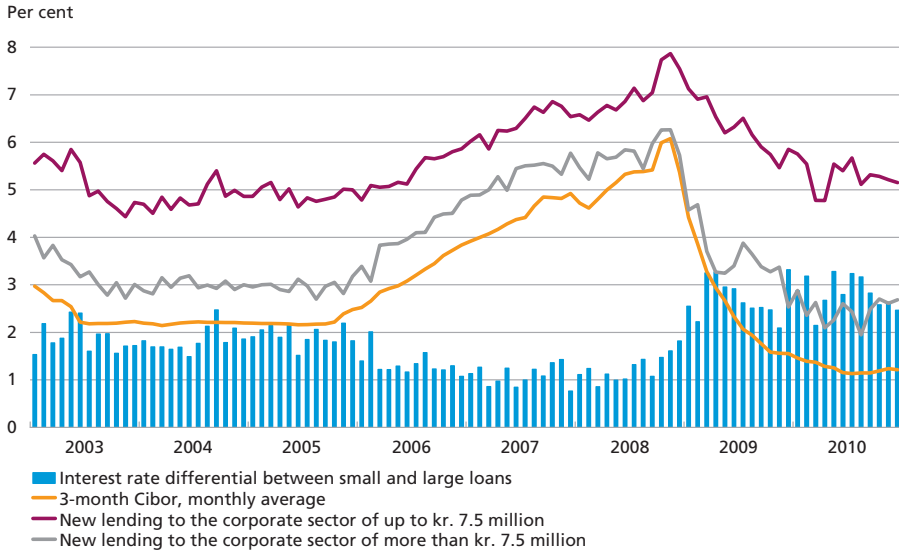
the balance-sheet channel in Denmark differs relative to the rest of Europe.

In order to examine whether credit conditions show different patterns for large and small firms in Denmark over the business cycle, it is useful to examine developments in interest-rate spreads between large and small corporate loans. It is assumed that there is typically a link between a firm's size and the size of the loans it raises. Data for lending rates broken down by loan size is only available from 2003, so the analysis is based on the experience gained during the most recent business cycle. In the years up to the peak of the financial crisis in 2008, the interest-rate differential between small and large bank loans to firms was approximately 1 percentage point, cf. Chart 4.1. This was almost half the level seen in the preceding period. The very low interest margin is probably attributable to the search for yield in the period up to the crisis, which resulted in interest rates not always reflecting the real risk on the loan. In connection with the crisis, the differential widened substantially to around 3 percentage points, which is the highest level since the start of the series in 2003.

Moreover, the interest margin on loans to sole proprietors and unincorporated partnerships has increased relatively markedly in connection with the crisis, cf. Chart 4.2. But the widening of the margin primarily reflects the return to a more normal situation after a period of extraordinarily favourable financing conditions. Large firms have better access to funding via the capital markets, and the interest rate on the banks'

INTEREST RATES ON SMALL AND LARGE NEW LOANS TO
THE CORPORATE SECTOR   Chart 4.1

Per cent

- ■ Interest rate differential between small and large loans
- — 3-month Cibor, monthly average
- — New lending to the corporate sector of up to kr. 7.5 million
- — New lending to the corporate sector of more than kr. 7.5 million

Source: Danmarks Nationalbank.

large loans to the corporate sector typically mirrors the money-market
rates more closely than interest rates on other loan types. In addition,
large firms are possibly able to pledge more collateral than small firms.

INTEREST-RATE MARGIN FOR HOUSEHOLDS AND
THE CORPORATE SECTOR   Chart 4.2

Percentage points

- — Households   — Corporate sector   — Sole proprietors and unincorporated partnerships
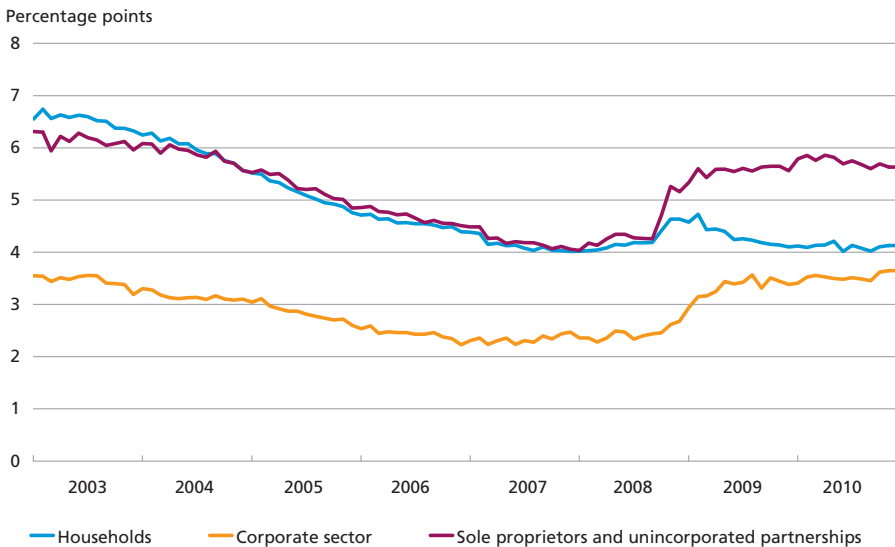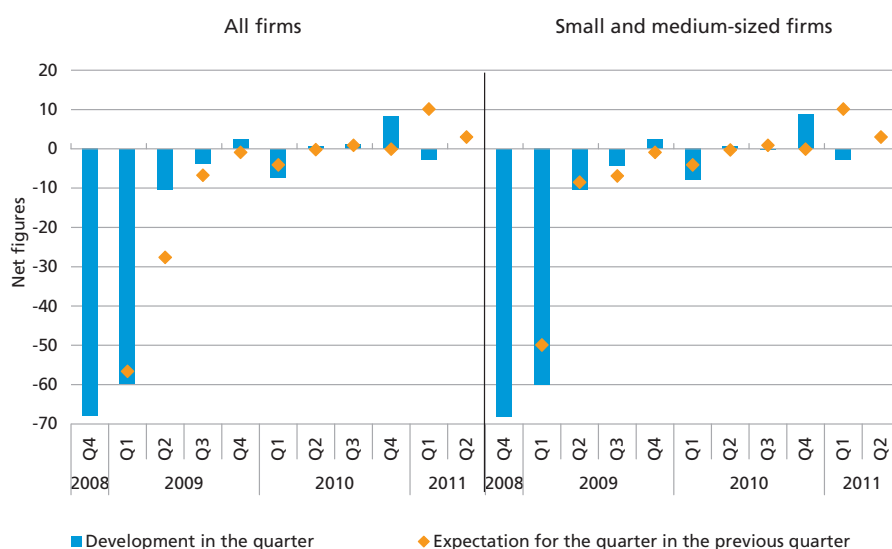
Note: Households include sole proprietors and unincorporated partnerships. The interest margin indicates the
        difference between the average deposit and lending rates. .
Source: Danmarks Nationalbank.

CHANGE IN CREDIT STANDARDS   Chart 4.3

Note: Each quarter, credit managers of the largest Danish banks and mortgage banks answer questions about changes in their credit policies. There are five possible answers, each with a value: -100 (tightened/declined considerably), -50 (tightened/declined slightly), 0 (unchanged), +50 (eased/increased slightly), +100 (eased/increased considerably). The answers are co-weighted to a net figure according to the banks' share of total lending. A negative (positive) figure shows that credit policy has been tightened (eased), implying that it has become more difficult (easier) to obtain a loan. The net figure is the banks' assessment of changes on a quarterly basis. Therefore, the results do not show developments in absolute levels. When the net figure for expectations for the following quarter is 0, the banks do not expect further changes in the following quarter, while a negative (positive) figure means that they expect to tighten (ease) their policy in the following quarter.
Source: Danmarks Nationalbank.

In Danmarks Nationalbank's bank lending survey, the banks are asked whether they have changed their credit standards. In response to the crisis, they tightened their credit standards considerably in relation to the corporate sector in the last part of 2008, cf. Chart 4.3. This is a natural consequence of a rising risk of loan losses during a cyclical downturn. Moreover, the banks' credit policies were generally lenient in the years up to the outbreak of the financial crisis. The Chart shows no indications of the tightening being targeted at small and medium-sized enterprises in particular.

   Naturally, the consequences of a tightening of the banks' credit standards depend on the extent to which the firms depend on bank funding. On the basis of firms' transactions in Denmark, the euro area and the USA, it is evident that internal financing is by far the most important funding channel for firms in all three economies, cf. Chart 4.4. In Denmark, internal financing accounted for 55 per cent in the period 2004-09, a slightly higher percentage than in the euro area and a considerably higher percentage than in the USA.

BREAKDOWN OF ACCUMULATED FUNDING, 2004-09   Chart 4.4

Per cent
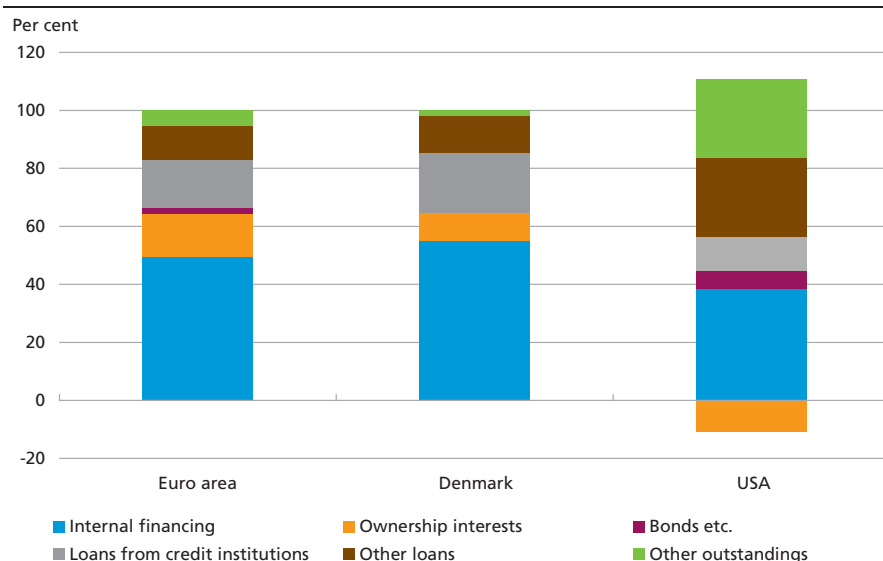
Note: Non-financial corporations. Accumulated funding is calculated as the sum of the net increase in individual
        sources of funding relative to GDP in the individual years in the 2004-09 period. The cross-border comparison is
        partly based on estimates due to methodological differences in statements of financial accounts, cf. ECB (2009a).
        Internal financing is calculated as the sum of gross savings and ingoing capital transfers. As the gross surplus does
        not take into account investment income, depreciation and corporate tax, gross savings etc. do not provide a
        complete description of the firms' internal financing. *Other loans* comprise, among other things, loans from
        other firms, and *Other outstandings* comprise trade credits and tax payable. The negative contribution from
        funding of ownership interests for the USA is attributable to repurchase of shares as well as mergers and
        acquisitions.
Source: ECB, Eurostat, Statistics Denmark, Danmarks Nationalbank, Federal Reserve and Bureau of Economic Analysis.

According to Petersen and Risbjerg (2009), the proliferation of commercial funds in Denmark may contribute to the higher degree of internal financing among Danish firms, because these funds are usually more patient owners. The share of bank loans as a source of funding is almost the same in Denmark and the euro area. In the euro area, however, there is a high degree of heterogeneity in the firms' financial structures, just as the availability of external funds and industrial structures differ across euro area member states.

Danish banks' sources of external financing are primarily bank loans and other loans, including from other firms, while issuance of shares and bonds accounts for only around 10 per cent. The latter source of funding is used slightly less than in the euro area, while issuance of corporate bonds and other credit-market instruments is significantly more prevalent in the USA.

Consequently, compared with the USA, European banks play a larger role in the funding of non-financial corporations. This could indicate a more pronounced balance-sheet channel in the euro area and Denmark.

Conversely, the tighter financial conditions behind the balance-sheet channel may, to some extent, undermine the conditions for other types of external financing. Given the smaller overall role of external financing in Denmark than in the USA, it is not clear where the balance-sheet channel is most important.

Conclusion on the balance-sheet channel

In this section, we have examined the role of the balance-sheet channel in the transmission of monetary policy. As we have demonstrated, there are indications that the balance-sheet channel may, in some countries, impact on certain groups of firms. For Denmark, experience from the period after the financial crisis indicates that the balance-sheet channel may have played a certain role for small firms, which have found it more difficult to obtain external financing compared with larger firms. For large firms, the balance-sheet channel does not seem to play any important role. Their interest margins have been less affected, and they also have easier access to alternative sources of funding. Consequently, the balance-sheet channel hardly plays any important role in Denmark at the macrolevel.

5. INTEREST-RATE MARGINS AND THE BUSINESS CYCLE

In the preceding sections we have analysed whether monetary policy is also transmitted to the real economy through a credit channel – in addition to the traditional interest-rate channel. In this section, we will examine, in more general terms, how bank retail rates and mortgage yields depend on the cyclical position of the economy. This analysis can shed light on the role of the financial system in cyclical developments in Denmark. The theoretical literature has identified several channels through which frictions in the financial system may amplify the cyclical fluctuations in the economy. A key channel is that the margin between the banks' deposit and lending rates typically widens in a downturn and narrows in a boom. This tends to strengthen the fluctuations, cf. Bernanke et al. (1999).

Denmark's monetary policy is aimed at maintaining a fixed exchange rate of the krone against the euro. This means that the monetary-policy interest rates do not directly reflect Danish cyclical developments. In the euro area, the primary objective of monetary policy is to maintain price stability. Broadly speaking, price stability is ensured by managing demand via the monetary-policy interest rates to avoid major fluctuations in economic activity and hence in inflation. Consequently, a link between cyclical developments and monetary-policy interest rates is to be expected in the euro area.

Cyclicality of bank retail rates

In general, there is a high degree of covariation in cyclical fluctuations between Denmark and the euro area, cf. Dam (2008), reflecting Denmark's close integration with the euro area in both real and financial terms. This integration must be expected to be reinforced further, so the cyclical pattern of Denmark will still mirror that of the euro area fairly closely. Consequently, Denmark's monetary-policy interest rates will, to a certain degree, be in sync with the business cycle although this is not an objective for monetary policy.

Welfare will benefit if monetary policy is able to dampen cyclical fluctuations by stimulating the economy through low interest rates in economic downturns and by dampening growth via higher interest rates during boom periods. But the stabilising effect of monetary-policy interest rates may, to a certain extent, be counteracted by frictions in the financial system. In a downturn, the risk of loan losses will be greater than in a normal cyclical situation. Hence, in a downturn the banks can be expected to raise their lending rates relative to the rate of interest at which they finance themselves, i.e. monetary-policy interest rates, short-term money-market rates and the banks' own deposit rates. This results in a widening of the spread between the banks' deposit and lending rates, reinforcing the economic downturn.

Dueker and Thornton (1997) argue that the banks have an incentive to reduce their market share during a downturn, amplifying the fluctuations in the interest margin. This can be attributed to an adverse selection problem. A bank expanding its customer base during a downturn will run a great risk of capturing customers who have been denied credit by other banks. Consequently, the banks may use their knowledge of the credit risk for existing customers to raise interest rates on loans to these customers beyond what is warranted by the risk of loss, without the customers turning to other banks, cf. Aliaga-Diaz and Olivero (2010).

The interest-rate margins of Danish banks have declined since the mid-1990s, cf. Chart 5.1, especially in relation to households, while no clear trend can be detected in the interest margin relating to the corporate sector. One of the factors behind the decline for households is the more widespread use of relatively low-yield loans based on real property as collateral. Although it is difficult to discern any clear relation between interest-rate margins and cyclical developments from the Chart, a few episodes stand out. For example, the interest margin narrowed substantially in 1997 and 1998 when the Danish economy was in a pronounced expansion. Conversely, the interest-rate margin widened considerably in response to the strongly deteriorating outlook as a result of the financial crisis in 2008-09.

INTEREST-RATE MARGIN FOR BANKS   Chart 5.1

Percentage points
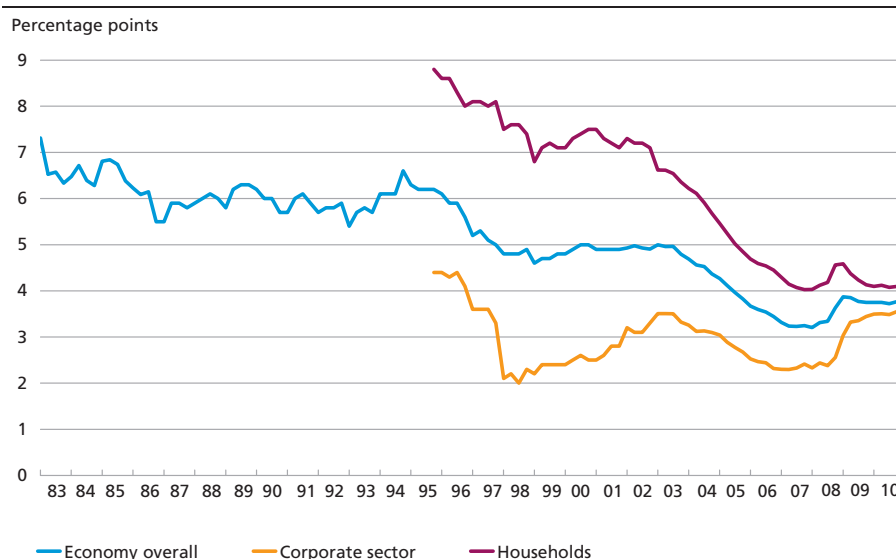
Note: Quarterly data. Interest-rate margins are calculated on the basis of the banks' average deposit and lending rates,
        which are weighted averages of interest on outstanding amounts with general government, non-financial
        corporations and households. The MFI sector and other financial corporations are thus not included. Adjustments
        for data breaks are made retrospectively.
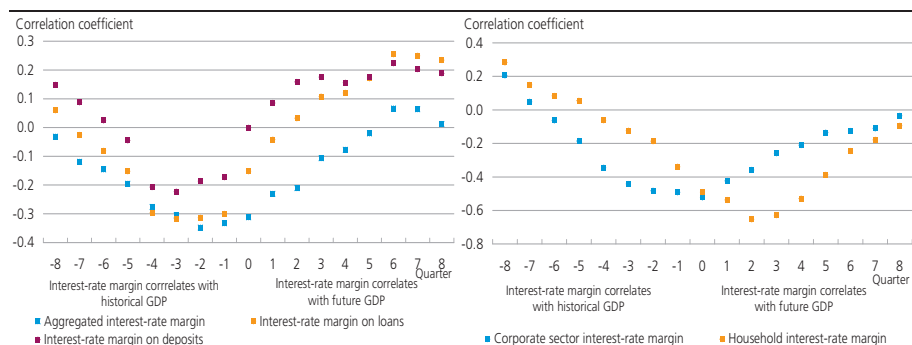Source: Danmarks Nationalbank.

With a view to analysis of the cyclicality of the interest-rate margin, it is useful to examine the dynamic correlations between the cyclical component of the interest-rate margin and the cyclical component of GDP, cf. Chart 5.2, left. The negative contemporaneous correlation coefficient indicates that the margin is countercyclical. This correlation is statistically significant, meaning that the interest-rate margin tends to be relatively low during a boom. But the analysis is too simple to determine the underlying cause of this countercyclicality of the margin, which amplifies business cycle fluctuations.

If banks are forward looking, they will begin to adjust the interest margin ahead of the economic reversal. This will be reflected in a strong correlation between the margin and future GDP growth. However, we find the strongest empirical correlation between the interest-rate margin and GDP lagged 0-2 quarters. This indicates that the banks are more likely to be lagging slightly behind the macroeconomic development when adjusting their deposit and lending rates.[1] Since 1995, the banks have tended to be more forward-looking when adjusting interest rates

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[1]   Nevertheless, Abildgren (2010) finds, on the basis of quarterly data for 1948-2010, that the banks do
      to some extent take the expected future cyclical developments into account when adjusting their
      interest margin.

CORRELATION BETWEEN OUTPUT GAP AND INTEREST-RATE MARGINS IN
PREVIOUS, CURRENT AND SUBSEQUENT QUARTERS   Chart 5.2

Note: The calculation is for the cyclical component of the time series, defined as the deviation from an HP-filtered
       trend. The left-hand chart is based on data for 1983-2010. The right-hand chart is based on data for 1995–2010.
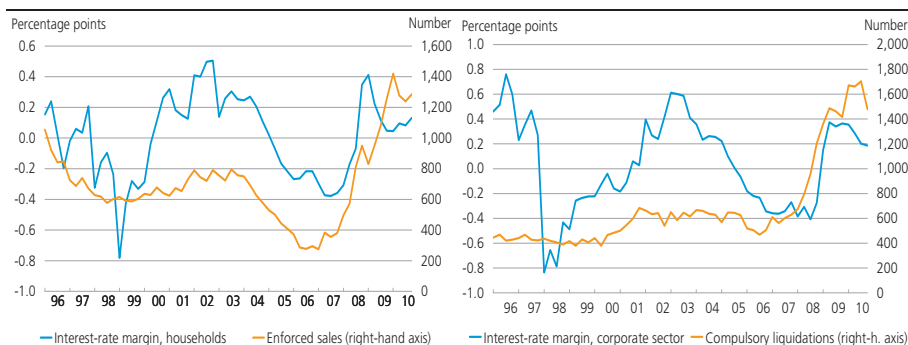Source: Danmarks Nationalbank and Statistics Denmark.

on loans to households, compared with adjusting interest rates on loans
to the corporate sector, cf. 5.2, right.

The banks can widen their interest-rate margin by lowering deposit
rates, raising lending rates or both. For analysis purposes, we break
down the interest-rate margin into the margin between the banks' lend-
ing rate and Danmarks Nationalbank's rate of interest on certificates of
deposit (the lending-rate margin) and the margin between Danmarks
Nationalbank's rate of interest on certificates of deposit and the banks'
deposit rate (the deposit-rate margin). GDP is a little more closely cor-
related with the interest-rate margin for lending than with that for
deposits, cf. Chart 5.2, left. A possible explanation is that the banks re-
gard deposits as an alternative to funding in the money market. This
warrants a close correlation between the banks' deposit rates and the
monetary-policy interest rates. If that is the case, the interest-rate
margin will have to be adapted primarily by adjusting lending rates.

The development in the interest-rate margin reflects the variation in
the risk of loan losses, among other factors. Consequently, it may be
relevant to compare developments in the interest-rate margin with
indicators that capture the risk of loan losses to a higher degree than
overall GDP growth. For households, a positive correlation between the
interest-rate margin and the number of enforced sales can be found, cf.
Chart 5.3, left. For the corporate sector, the most recent widening of the
interest-rate margin coincided with the strong rise in the number of
compulsory liquidations resulting from the economic crisis, cf. Chart 5.3,
right. The widening of the interest-rate margin in 2002-06 does not
appear to be related to major losses on compulsory liquidations to the
same extent.

INTEREST-MARGIN, HOUSEHOLDS AND CORPORATE SECTOR   Chart 5.3

Note: The interest-rate margin is the cyclical component, defined as the deviation from an HP-filtered trend.
Source: Danmarks Nationalbank and Statistics Denmark.

The interest-rate margin is only one of several sources of income for the banks, which typically offer their customers a wide range of financial products. This makes it more cumbersome to change banks, and customer loyalty increases. It is not unusual that interest income accounts for no more than half of a bank's total income on a firm. But the cyclicality of fee income is difficult to determine.
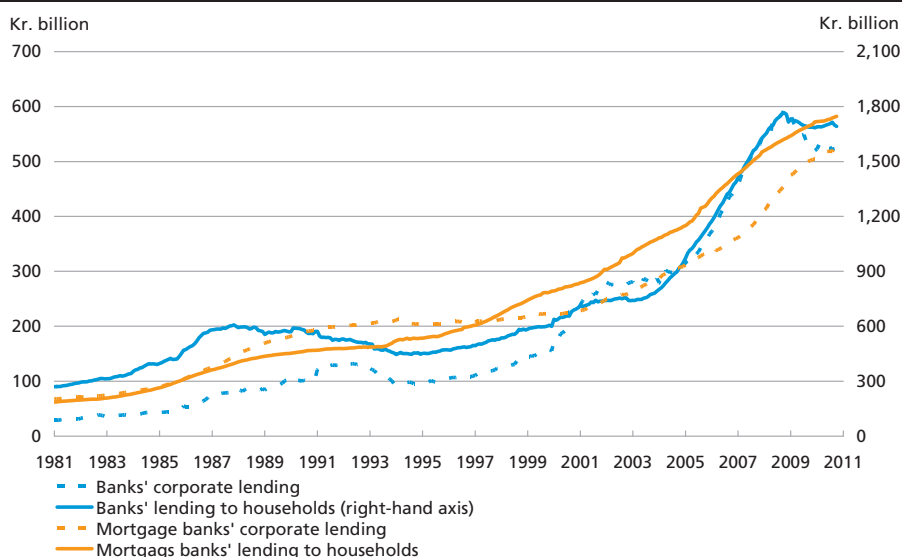
Cyclicality of mortgage yields
In addition to bank loans, both households and firms often raise mortgage loans based on real property as collateral, cf. Chart 5.4. This means that the procyclical effect of variations in banks' interest-rate margin can be somewhat dampened if mortgage yields are less cyclical than retail rates. We will examine whether this is the case.

As regards bank loans, the interest-rate margin can be seen as a reflection of how frictions in the financial sector accentuate the cyclical fluctuations in the economy. A corresponding measure for mortgage loans is not available. We compare the yield on mortgage bonds with the yield on government bonds, which thus approximate a risk-free claim, in order to achieve a measure of the cyclical, risk-related element of mortgage yields. This comparison is by no means straightforward, since differences in credit risk constitute only one of several determinants of the yield spread. Moreover, the mortgage bond yield must be expected to deviate from the government bond yield, given the differences in payment profiles, investor interests and conversion risk, cf. Larsen (1993).

The payment profiles of government and mortgage bonds typically differ. Government bonds are issued as bullet loans, while mortgage bonds are primarily annuity loans. Consequently, the duration of a 30-year mortgage bond, disregarding the convertibility, is only around two

LENDING TO HOUSEHOLDS AND THE CORPORATE SECTOR   Chart 5.4

Kr. billion   Kr. billion

[Chart showing lending to households and corporate sector from 1981 to 2011. Left axis: Kr. billion 0 to 700. Right axis: Kr. billion 0 to 2,100. Legend:]

- - - Banks' corporate lending
——— Banks' lending to households (right-hand axis)
- - - Mortgage banks' corporate lending
——— Mortgags banks' lending to households

Note: Seasonally adjusted data. Outstanding loans to Danish households and the corporate sector from banks and
        mortgage banks located in Denmark. Households comprise sole proprietors and unincorporated partnerships,
        including agriculture. The corporate sector covers non-financial corporations.
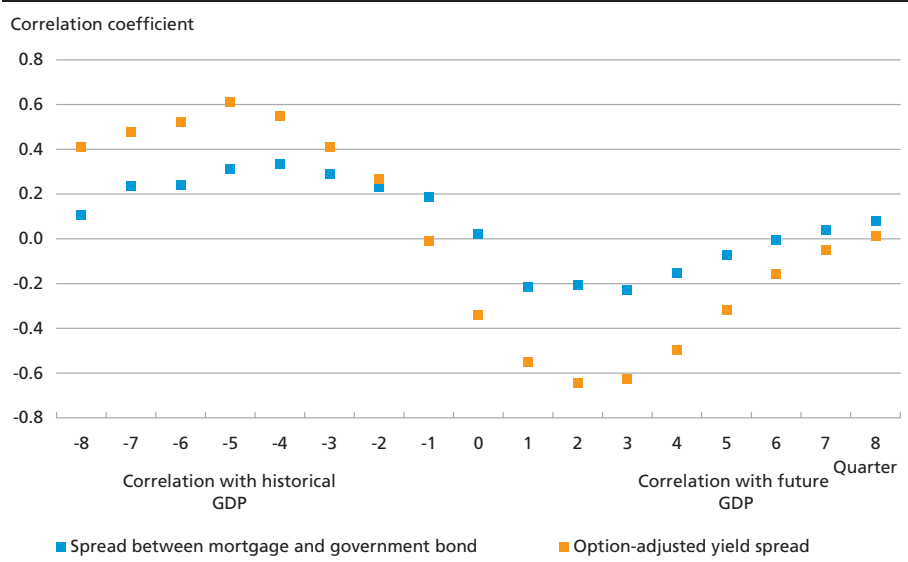Source: Danmarks Nationalbank.

years longer than the duration of a 10-year government bond.[1] The
difference in payment profiles may result in diverging yield levels, par-
ticularly when the yield curve is steep. Furthermore, fixed-rate mortgage
bonds are callable as opposed to government bonds. Since conversions
take place in periods of falling yields, this is not an attractive situation
for the investors, who will demand a yield premium for holding mort-
gage bonds rather than government bonds, cf. Lybek (1992).

The probability of a mortgage bond reaching a price of 100, at which
level redemption becomes attractive to the borrower, depends on the
current yield level. In order to take this into account, we also look at the
option-adjusted spread, OAS, which is adjusted for the issuer of a mort-
gage bond exercising the option to redeem at par despite a further price
rise. Historically, the yield spread between mortgage bonds and govern-
ment bonds has tended to be lowest at the beginning of a boom, cf.
Chart 5.5, only to widen again at a later stage of the boom. Hence, this
development deviates from the pattern of the banks' interest margin,
which bottoms out a few quarters after the cyclical turning point. To

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[1] Duration means a weighted average of the due dates for payments related to a bond. For a bond
     with short duration, the payments will fall due over a short time horizon, while the opposite is the
     case for a bond with long duration.

CORRELATION BETWEEN BOND YIELD SPREADS AND OUTPUT GAP IN
PREVIOUS, CURRENT AND SUBSEQUENT QUARTERS
Chart 5.5

Correlation coefficient

Correlation with historical
GDP

Correlation with future
GDP

Quarter

■ Spread between mortgage and government bond   ■ Option-adjusted yield spread

Note: The calculation is for the cyclical component in the times series, defined as the deviation from an HP-filtered
         trend.
Source: Statistics Denmark, Danmarks Nationalbank and Nordea Analytics.

some extent, the correlations are driven by developments during the most
recent crisis when the spread widened a few quarters ahead of the
strong fall in the output gap.

MORTGAGE BANKS' CONTRIBUTION RATES
Chart 5.6

Percentage points

━━ Households   ━━ Corporate sector
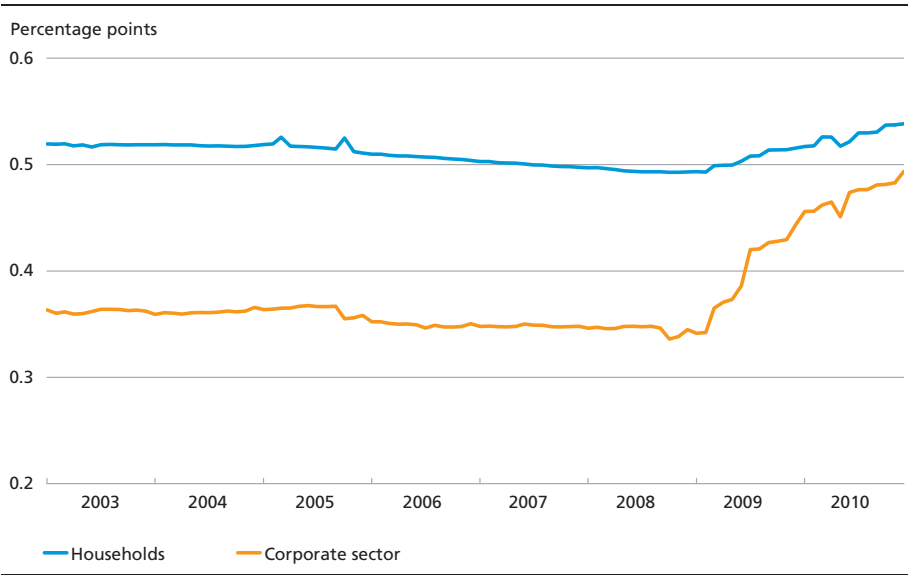
Note: Outstanding amounts.
Source: Danmarks Nationalbank.

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In addition to the yield reflecting the market value of the mortgage bonds, the borrower must also pay contributions to the mortgage bank. This contribution is to cover the administration costs of the mortgage bank and its expected loan losses. The risk of losses on mortgage lending is low in any case, because these loans are based on real property as collateral and subject to a statutory limit on the loan-to-value ratio. Indeed, the rates have been very stable in recent years, cf. Chart 5.6.

Conclusion on the cyclicality of interest rates
This section looks into the cyclicality of selected interest rates of importance to households and firms. We find that the bank's interest-rate margin is cyclical, since it widens during a downturn and narrows when the economy is doing better. This amplifies business cycle fluctuations. Moreover, the yield spread between mortgage and government bonds tends to narrow at the beginning of a boom, only to widen at a later stage.

6. INTEREST-RATE SENSITIVITY OF INCOMES

Monetary policy works primarily via the pass-through to market interest rates and bank retail rates, and through interest rates on financial claims. Below we examine how households and firms are affected by an increase in monetary-policy interest rates. Three classic channels are typically mentioned, i.e. the direct income effect, the wealth channel and the effect on the incentive to save. The income effect applies when an interest-rate adjustment influences interest flows in the economy and consequently the income and expenses of households and firms. An interest-rate adjustment also affects the value of both real and financial assets, resulting in a wealth effect. Moreover, an interest-rate increase makes it more attractive to save than to consume.

We focus on the income effect. Since this is the channel most strongly affected by the financing patterns of households and firms, it has also seen the strongest development in connection with the more wide-spread use of adjustable-rate loans. Both the wealth channel and the effect of an interest-rate adjustment via the incentive to save require a more structural modelling of the behaviour of households and firms. It is beyond the scope of this article to estimate relations for consumer behaviour.

Access to adjustable-rate mortgages with more amortisation alternatives plays an important role in household disposable income and corporate profits. First we examine the development in the use of these instruments, then we look at the financial transactions of firms and
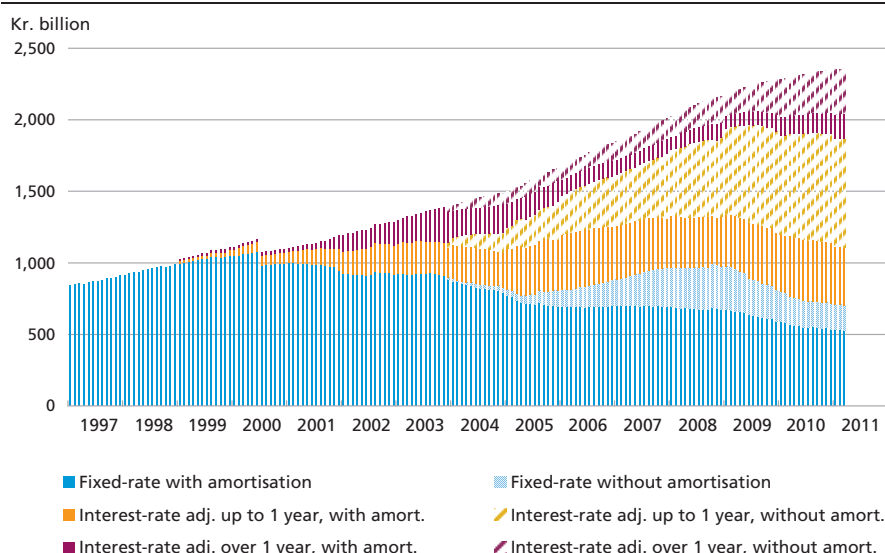
households, including whether their interest-rate sensitivity has in-
creased over time. We proceed by applying an international perspective
to the characteristics of the Danish mortgage market, and we conclude
by looking into the relationship between the financial structures and the
transmission of monetary policy.

Adjustable-rate loans and deferred amortisation
The last decades have seen a deregulation of the financial markets, with
substantial consequences for Danish households and firms. In the mid-
1990s, it became possible to issue adjustable-rate mortgages, and the
option of deferred amortisation was introduced in 2003. Loans with
adjustable rates and deferred amortisation are now widely used, ac-
counting for an increasing share of the mortgage banks' total lending.
The share of adjustable-rate loans has grown from being negligible in
2000 to constituting around 70 per cent of total outstanding mortgage
loans in March 2011, cf. Chart 6.1. Adjustable-rate mortgages with
floating rate or initial fixed rate period of up to 1 year (including 1 year)
account for 70 per cent of these loans. Likewise, in March 2011 more
than half of lending by mortgage banks constituted deferred-amortisa-
tion loans.

TOTAL MORTGAGE BANK LENDING BY LOAN TYPE   Chart 6.1

Kr. billion

■ Fixed-rate with amortisation	▨ Fixed-rate without amortisation
■ Interest-rate adj. up to 1 year, with amort.	◪ Interest-rate adj. up to 1 year, without amort.
■ Interest-rate adj. over 1 year, with amort.	◪ Interest-rate adj. over 1 year, without amort.

Note: 'Interest-rate adjustment up to 1 year' covers adjustable-rate mortgage loans with floating rates or initial rate
       fixation period of up to 1 year (1 year included). 'Interest-rate adjustment over 1 year' covers adjustable-rate
       mortgage loans with initial rate fixation period of over 1 year. 'Fixed rate' denotes mortgage loans with fixed
       rate to maturity. The series are shown with and without amortisation in the chart.
Source: Danmarks Nationalbank.

Other things being equal, a lower interest rate entails lower monthly payments on a loan. Add to this the effect of suspending instalments for a period. Lower monthly payments mean that existing homeowners have more money to spend. Moreover, lower monthly payments may have opened the market for owner-occupied housing for people whose income or wealth would not otherwise have been sufficient to buy a home. This has resulted in higher house prices, cf. Dam et al. (2011).

The more widespread use of adjustable-rate mortgages should be viewed against the backdrop of recent years' widening of the spread between short-term and long-term interest rates. In the period 2000-10, short-term mortgage bond yields were, on average, more than 2.3 percentage points lower than long-term yields. There is a clear tendency for adjustable-rate mortgages as a share of total new lending to increase when the spread between short-term and long-term mortgage yields widens, and vice versa, cf. Chart 6.2. Mortgages for owner-occupied housing, etc.[1] show a closer correlation between the short-term/long-term spread and the share of adjustable-rate loans compared with loans for other purposes; for the latter the share of adjustable-rate loans is typically more stable. This has prompted households in particular to let shifts in the yield structure influence their choice of mortgage type. Firms mainly use adjustable-rate mortgages. In the next two subsections we examine the financial transactions of households and firms, illustrating that their interest-rate sensitivity has increased over time.
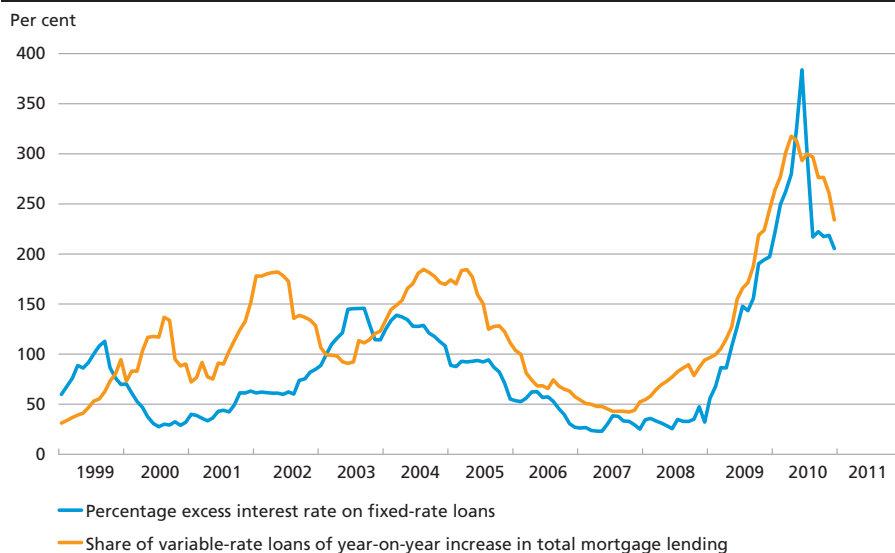
Household indebtedness and wealth

Danish households have a high degree of indebtedness, but their holdings of financial assets are even larger, resulting in positive net financial wealth corresponding to 92 per cent of GDP. Holdings of both assets and liabilities have increased substantially in recent years, cf. Table 6.1. Pension savings account for approximately half of the assets, while more liquid funds such as cash and bank deposits as well as shares and investment fund shares account for 22 and 24 per cent, respectively. In addition, the households have considerable values in their homes, cars, etc. In the 4th quarter of 2010, housing wealth amounted to kr. 2,865 billion or just over 164 per cent of GDP. Households' debt consists predominantly of loans, two thirds of which are collateralised in real property. Since the introduction of adjustable-rate loans, their share of the households' mortgage loans has increased, to around two thirds of total mortgage lending in 2010.

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[1] Owner-occupied housing, etc. consists of owner-occupied homes, summer cottages and farms.

CHOICE OF ADJUSTABLE-RATE MORTGAGE AND EXCESS INTEREST RATE ON A FIXED-RATE MORTGAGE LOAN

Chart 6.2

Per cent

— Percentage excess interest rate on fixed-rate loans

— Share of variable-rate loans of year-on-year increase in total mortgage lending

Note: The percentage excess interest rate on a fixed-rate mortgage loan is the excess interest rate as a percentage when choosing a fixed-rate mortgage loan based on the average long- and short-term bond yields as stated by the Danish Association of Mortgage Banks. The share of variable-rate loans of the year-on-year increase in total mortgage lending will exceed 100 per cent when the increase in variable-rate mortgage loans exceeds the increase in total mortgage lending.

Source: Danmarks Nationalbank and Association of Danish Mortgage Banks.

HOUSEHOLDS' FINANCIAL ACCOUNTS AND HOUSING WEALTH

Table 6.1

Kr. billion	2000	2005	2010
Financial assets			
Cash, bank deposits and credits etc.	568	785	950
Bonds etc.	191	173	153
Shares and investment fund shares	528	1,121	1,215
Pension savings etc.	1,116	1,617	2,117
Total financial assets	2,403	3,696	4,435
Financial assets as a percentage of GDP	185.7	239.2	254.1
Financial liabilities			
Mortgage loans[1]	830	1,281	1,753
Bank loans[1]	252	428	603
Total financial liabilities	1,232	1,891	2,663
Financial liabilities as a percentage of GDP	95.2	122.4	152.5
Financial net worth	1,170	1,805	1,772
Financial net worth as a percentage of GDP	90.4	116.8	101.5
Housing wealth[2]	1,591	2,722	2,850
Housing wealth as a percentage of GDP	123.0	176.1	164.1

Changes in the interest-rate sensitivity of households

Changes in interest-rate sensitivity influence the transmission of monetary policy. As a result of falling interest rates and rising house prices, borrowing by households has grown considerably. Due to the low level of interest rates and the widespread use of deferred amortisation, the share of interest and instalments relative to total household disposable income has not increased despite more extensive borrowing, cf. Chart 6.3. However, rising interest rates may have a rapid impact on the disposable amount, given the widespread use of variable-rate loans.

As a result of shifting funding patterns, households have become markedly more sensitive to adjustments of short-term interest rates, cf. Chart 6.4[1]. The calculation is based solely on the items on the households' financial balance sheet for which interest payments will be affected, within a short time horizon, by changes in short-term interest rates (i.e. bank deposits and loans, short-term bonds and adjustable-rate mortgages with floating rate or initial rate fixation period of up to 1 year). A rise by 1 percentage point in short-term interest rates causes household disposable income to fall by approximately 0.7 per cent in 2010. Previously, this effect was relatively limited.[2] It follows that the income effect on private consumption of changes in short-term interest rates has increased, and the households have become more sensitive to interest-rate changes. This change is very much attributable to the growing popularity of adjustable-rate loans, cf. Chart 6.4.
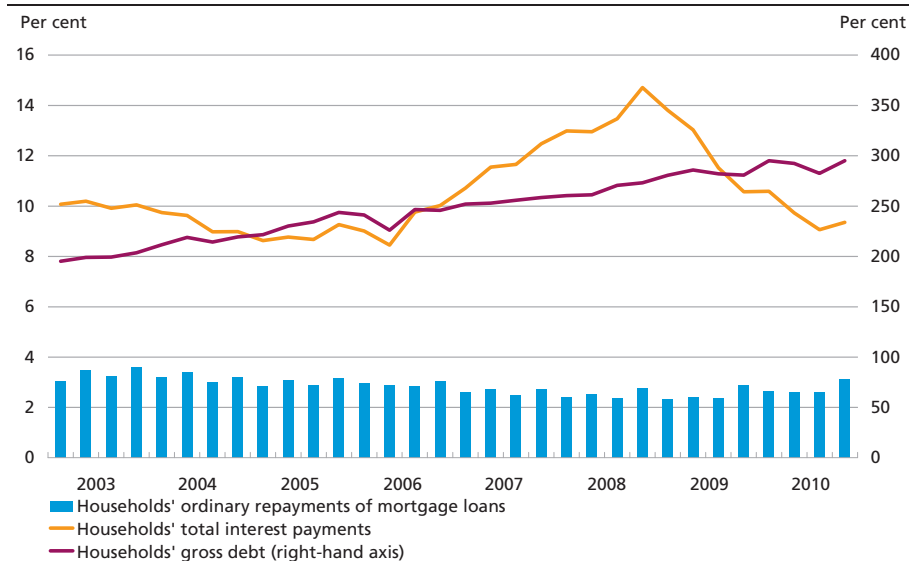
This calculation is partial since it does not take into account that a large proportion of mortgage bonds is owned indirectly by the households via their pension savings. However, this applies mainly to long-term bonds, while short-term bonds are predominantly owned by banks. The calculation also excludes other effects of an interest-rate increase on household disposable income resulting from the pass-through to the economy (e.g. via employment), or via changes in the households' transactions. In addition, the reasons for the interest-rate increase are excluded. Moreover, the calculation does not take into account the effects

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[1] The calculation example is based on an estimate of household financial assets and liabilities with floating rate or initial rate fixation period of up to 1 year. For example, in 2010 the households' adjustable-rate loans with floating rate or initial rate fixation period of up to 1 year amounted to kr. 1,460 billion (i.e. adjustable-rate mortgages with floating rate or initial rate fixation period of up to 1 year (based on estimates) for kr. 857 billion and bank loans amounting to kr. 603 billion). Bank deposits and holdings of short-term bonds totalling kr. 624 billion are offset against this amount. This results in net household liabilities with floating rate or initial rate fixation period of up to 1 year amounting to kr. 836 billion. If these liabilities are assumed to follow short-term interest rates, a rise in the short-term interest rate by 1 percentage point will lead to increased expenditure of kr. 5.7 billion after tax at a tax rate of 32 per cent. This corresponds to 0.7 per cent of total household disposable income.

[2] It is difficult to determine a comparable direct effect on households from changes in long-term interest rates. Long-term interest rates have no immediate direct effect on households' interest expenditure on loans, since interest payments on fixed-rate loans are fixed. On the other hand, there may be effects from conversion gains.

HOUSEHOLDS' INTEREST PAYMENTS AND INSTALMENTS AS A PERCENTAGE OF DISPOSABLE INCOME

Chart 6.3

Per cent   Per cent

Households' ordinary repayments of mortgage loans
Households' total interest payments
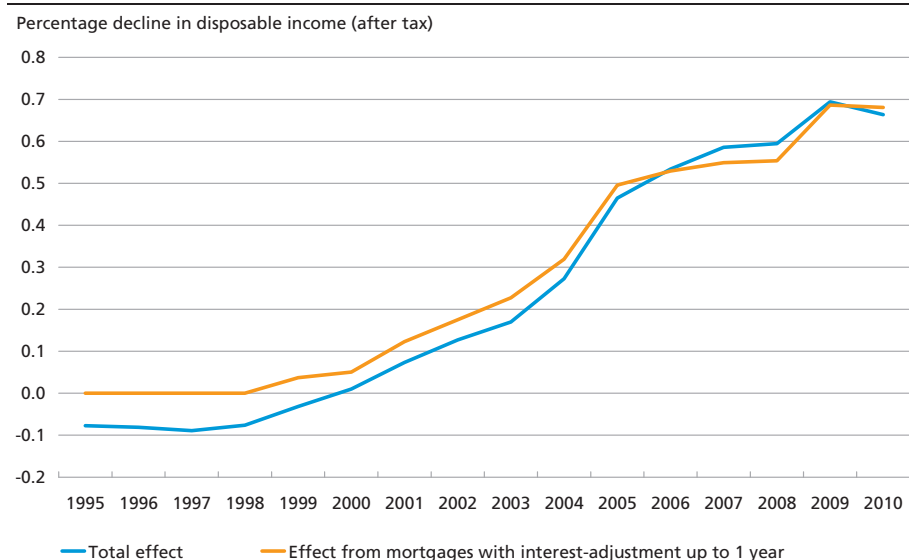Households' gross debt (right-hand axis)

Note: The statement of disposable income excludes pension contributions, as they are not immediately available for payment of interest costs. The figures for the household sector include agriculture. Excluding agriculture does not change the figure markedly.
Source: Danmarks Nationalbank.

HOUSEHOLDS' INTEREST-RATE EXPOSURE OVER TIME

Chart 6.4

Percentage decline in disposable income (after tax)

Total effect   Effect from mortgages with interest-adjustment up to 1 year

Note: The chart shows the effect on households' disposable income after tax (in per cent) of a 1 percentage point increase in short-term interest rates. In some cases, the underlying data for the calculation are partly based on estimates. 'Mortgages with interest-rate adjustment up to 1 year' covers adjustable-rate mortgages with floating rates or initial rate fixation period of up to one year (1 year included).
Source: Danmarks Nationalbank and own calculations.

of interest-rate adjustments on other financial items, such as adjustable-rate mortgages with initial rate fixation period of over 1 year.

Besides the direct effect on disposable income, interest-rate changes also affect the households' incentives to increase their savings and postpone consumption. Consequently, the effect of an interest-rate increase via the interest-rate channel clearly points to lower consumption[1]. The effect on disposable income and consumption varies across households, depending on whether the household has net interest income or expenditure. Households with net interest income normally have ample liquidity and good access to borrow, making them less sensitive to changes in disposable income compared with households with net interest expenditure. Consequently, the effect of interest-rate adjustments on consumption is probably more pronounced for households with net interest expenditure.

Changes in short-term interest rates influence house prices and thus housing wealth, which constitutes a large share of household assets. Wealth is an important explanatory variable in private consumption via the wealth channel, cf. Danmarks Nationalbank (2003). An increase in short-term interest rates by 1 percentage point entails, other things being equal, a drop of approximately 1 per cent in house prices after one year, cf. the model described in Dam et al. (2011). The maximum effect occurs after seven years, when prices have declined by 6.4 per cent according to the model.[2] Moreover, changes in short-term interest rates impact on wealth via long-term interest rates and share prices, but this impact is difficult to quantify.

Hence, there are several indications that the interest-rate sensitivity of Danish households has increased over the last decade. The widespread use of adjustable-rate loans and deferred amortisation plays a key role, and – given the higher indebtedness – an increase in monetary-policy interest rates will have a stronger impact on households than in previous interest-rate cycles.

The financial transactions of firms

Interest-rate adjustments affect firms' profits and balance sheets as well as their incentive to invest. The strength of the effect depends on the composition of the firms' financial assets and liabilities. In this section,

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[1] The effect via pension wealth is disregarded here. A higher interest rate entails a higher yield on pension wealth, which will, in the longer term, flow back to the households in the form of higher pension disbursements. But this depends on short-term interest rates only to a limited extent, since pension companies invest primarily in long-term bonds and shares.

[2] In the long term, house prices will be approximately unchanged, because the supply will adapt to the changed demand.

FIRMS' FINANCIAL ASSETS AND LIABILITIES			Table 6.2
Kr. billion	2000	2005	2010
Assets			
Cash, bank deposits and credits etc.	497	792	1,173
Bonds etc.	132	162	124
Shares and investment fund shares	1,102	2,197	2,544
Total financial assets	1,730	3,151	3,841
Financial assets as a percentage of GDP	133.7	203.9	220.0
Liabilities			
Loans etc.	1,098	1,345	1,933
Of which bank loans	186	457	606
Of which mortgage loans	226	334	532
Issued bonds etc.	73	143	142
Issued shares and other equity	1,703	3,218	3,620
Total liabilities	2,874	4,706	5,695
Financial net worth as a percentage of GDP ...	222.1	304.5	326.2
Financial net worth	-1,144	-1,555	-1,854
Financial net worth as a percentage of GDP ...	-88.4	-100.6	-106.2

Note: The figures in the table apply to non-financial corporations.
Source: Danmarks Nationalbank.

we look into the financial balance sheets and transactions of Danish firms and how they are affected by an interest-rate adjustment.

The firms' liabilities exceed their financial assets. This results in negative net financial wealth. Approximately 97 per cent of the liabilities is equity securities and loans, etc. On the assets side, shares, investment fund shares and more liquid funds account for the greater part of the financial assets.

The firms' loans accounted for 111 per cent of GDP in 2010, against 85 per cent in 2000. Outstanding bank loans constitute more than half of the firms' loans from banks and mortgage banks, cf. Table 6.2. This percentage is considerably higher than that for households. One of the reasons is that the value of the firms' buildings sets a limit on their borrowing from mortgage banks. Moreover, the interest-rate spread between mortgage loans and bank loans is narrower for firms than for households. As opposed to households, firms tend to opt for adjustable-rate loans irrespective of the size of the spread between long-term and short-term interest rates.

Changes in the interest-rate sensitivity of firms
It can be difficult to determine the firms' sensitivity to changes in interest rates for various maturities solely on the basis of the composition of the firms' loans. The reason is that firms may use different financial in-

FIRMS' INTEREST-RATE SENSITIVITY OVER TIME   Chart 6.5

Decline in post-tax profits as a percentage of gross value added

— Total effect   — Effect from mortgages with interest-rate adjustment up to 1 year
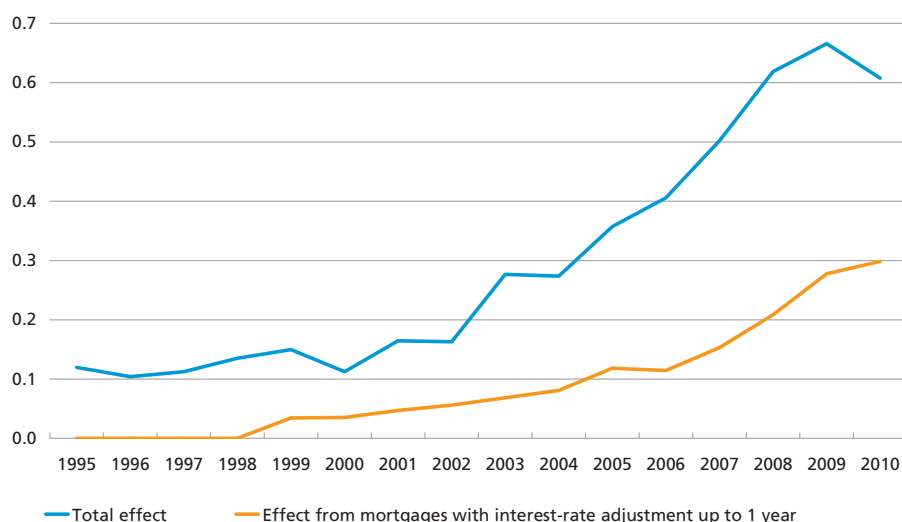
Note: Effect on firms' post-tax profits as a percentage of gross value added as a consequence of a 1 percentage point
        increase in short-term interest rates. Some underlying data for the calculation are partly based on estimates.
        'Mortgages with interest-rate adjustment up to 1 year' covers adjustable-rate mortgages with floating rates or
        initial rate fixation period of up to one year (1 year included).
Source: Association of Danish Mortgage Banks, Statistics Denmark, Ministry of Finance and Danmarks Nationalbank.

struments to manage their interest-rate sensitivity, e.g. converting a fixed-rate loan to a variable-rate loan by means of an interest-rate swap.

Estimated on the basis of the items on the firms' financial balance sheets that are affected by changes in short-term interest rates, the sensitivity to changes in short-term interest rates can, other things being equal, be expected to have risen over time.

Chart 6.5 shows a calculation of how a change in short-term interest rates impacts on the firms' profits relative to gross value added. Like the corresponding calculation for households, this calculation is based on non-financial corporations' holdings of mortgage loans with floating rate or initial rate fixation period of up to 1 year, loans and deposits in banks and holdings of short-term bonds[1].

The calculation shows that the interest-rate sensitivity has increased for firms too. But this may be attributed to other factors, particularly increased bank loans, just as much as it is attributable to the more widespread use of mortgage loans with short initial fixed rate periods. Adjustable-rate loans as a share of new lending from mortgage banks to firms has been relatively stable in recent years.

[1]   A tax rate of 28 per cent is applied in the calculation for firms.

An international perspective

It is concluded that the interest-rate sensitivity of Danish households and firms has increased. The sensitivity is influenced by both the size of the debt and its funding, especially as regards housing finance. In this section we make a comparison with foreign households and firms, with a view to assessing the interest-rate sensitivity of the Danish economy.

Household indebtedness has risen strongly over a number of years in many countries. In Denmark, it grew by 66 per cent of GDP in the period 1995-2009, which is one of the highest percentages among the industrialised countries. Household indebtedness has increased from a high level, and total indebtedness of almost 1.6 times GDP in 2009 places Danish households among the most indebted in an international context, cf. Chart 6.6. In 2009, household indebtedness varied between around 60 and 160 per cent of GDP in the USA and selected European economies. All of the countries except Germany have seen an increase in debt as a ratio of GDP over the last decade, driven by such factors as rising house prices, favourable credit terms and new financial products that have widened access to the market for owner-occupied housing, cf. OECD (2006) and ECB (2009b).

HOUSEHOLDS' FINANCIAL LIABILITIES AND FINANCIAL NET WORTH (AFTER TAX), 2009   Chart 6.6
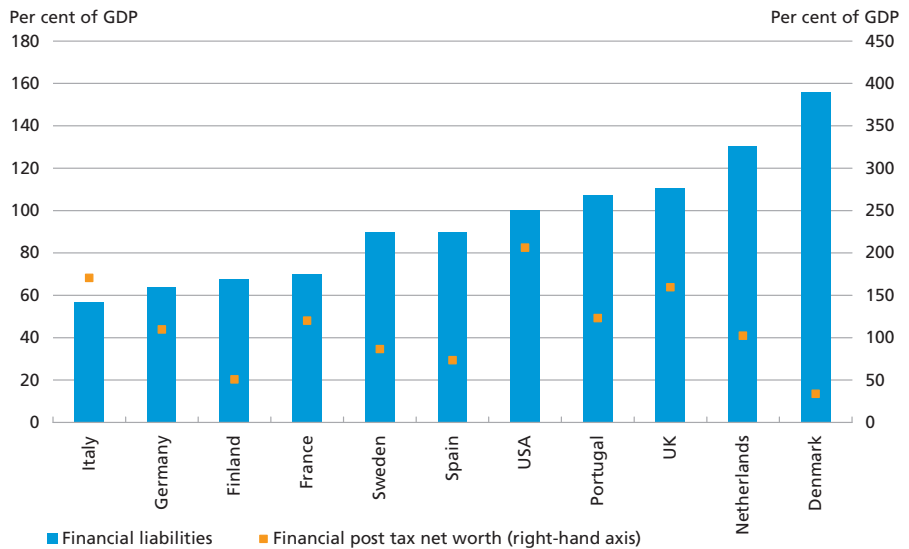
Note: The household sector, including self-employed persons such as farmers. Financial net worth is the households' total financial assets less financial liabilities. Financial assets include pension assets. To take tax withheld into account, pension assets are adjusted for tax by tax rates for pension income reported in the OECD's "Pensions at a Glance, 2011". For Denmark, Danmarks Nationalbank's quarterly financial accounts with correction in the pension part are applied. It is adjusted in such a way that SP (special pension funds), LD (employees' capital pension fund) and pension savings in private banks as well as ATP and life insurance and pension fund reserves form total pension assets. For other countries, financial accounts are applied without corrections.
Source: Eurostat, OECD, Statistics Denmark, Danmarks Nationalbank and own calculations.

In general, the households' financial assets exceed their debt. The most important items are cash and deposits, life insurance and pension savings and private holdings of shares and other equity. The distribution predominantly reflects the country-specific pension structures. This results in substantial divergence in the liquidity of household assets. In Denmark, almost 50 per cent of the financial assets is life insurance and pension savings (116 per cent of GDP). This percentage is substantially lower in the euro area and the USA, i.e. around 30 per cent of assets, while private holdings of shares and other equity are somewhat larger in the USA and the euro area. However, the value of life insurance and pension savings is influenced by the differences in taxation of pension income across the countries. If withheld tax in pension wealth is taken into account, the financial assets of Danish households are reduced by approximately 50 per cent of GDP, to 189 per cent of GDP. Among the countries reviewed, withheld tax in pension wealth plays the largest role in Denmark and the Netherlands. Whether or not withheld tax in pension wealth is taken into account, Denmark is among the countries in the analysis with the lowest household net financial wealth.

In addition to financial assets such as shares, cash and deposits and pension savings, households not only hold considerable wealth in owner-occupied housing, but also in land, summer cottages, boats and cars. In the absence of harmonised statistics for the households' total non-financial assets, it is difficult to make cross-country comparisons of household wealth. A comparison of the Nordic countries shows that the net wealth of Danish households, i.e. the sum of net financial wealth adjusted for withheld tax in pension wealth and housing wealth, is at the same level as net wealth in Sweden, but higher than net wealth in Finland and Norway, despite the high debt ratio of Danish households, cf. Danmarks Nationalbank (2011).

There are considerable cross-country variations in housing finance. This applies in terms of loan types, which come in many flavours as regards interest-rate variability, and in terms of maturity and typical loan-to-value ratio. Moreover, there are marked variations in statutory and regulatory frameworks, which are important to market flexibility. This applies to e.g. the access to early redemption of loans or to capitalisation via the housing market, including home equity withdrawal, cf. ECB (2008).

In Denmark, the most widespread loan products are fixed-rate loans with long maturities, typically 30 years, and flexible-rate loans with initial fixed rates of typically 1-5 years. The degree of interest-rate variability in loans for house purchase varies across countries. Variable-rate loans or loans with short initial rate fixation, i.e. up to and in-

MORTGAGE LENDING CHARACTERISTICS IN SELECTED COUNTRIES   Table 6.3

	Most widely used type of interest rate for mortgage loans	Share of new variable-rate loans, 2010[1]	Mortgage loans as a percentage of GDP, 2009	IMF Mortgage Market Index[2]
Denmark	Variable	70.4	103.8	0.82
Sweden	Variable	71.8	82.0	0.66
Finland	Variable	96.7	58.0	0.49
UK	Variable	52.1	87.6	0.58
Germany	Fixed	17.0	47.6	0.28
France	Fixed	11.4	38.0	0.23
Italy	Variable	66.5	21.7	0.26
Spain	Variable	86.2	64.6	0.40
Portugal	Variable	99.2	67.5	-
Netherlands	Fixed	20.4	105.6	0.71
USA[3]	Fixed	6.5	81.4	0.98

Source: European Mortgage Federation, Association of Danish Mortgage Banks, Bank of Finland, Banque de France, De Nederlandsche Bank, Federal Reserve Bank of New York and IMF (2008).

[1] Mortgage loan types with floating interest rates and an initial rate fixation period of up to and including 1 year as a share of total new mortgage lending. For Denmark, the figure covers adjustable-rate mortgages overall and thus also loans with initial rate fixation period of over 1 year. The average of available data for 2010, except for Italy and the USA, where data is for Q4 2009 and November 2010, respectively. For France only new lending to households, and for the USA, the share relative to active housing loans in data from the Federal Reserve Bank of New York.

[2] IMF (2008) index of mortgage-market flexibility. The index is based on six indicators: mortgage equity withdrawal, fee-free prepayment, typical loan-to-value ratio, average typical term, mortgage-backed security issues and covered bond issues. The index shows values in the 0-1 range, a high rating indicating great market flexibility measured by the indicators mentioned above.

[3] Based on prime loans, which are loans to creditworthy borrowers and housing loans via Government Sponsored Enterprises, GSE. Overall, they account for around 80 per cent of active mortgage loans. Among loans to non-creditworthy borrowers and persons with no credit history (subprime and Alternative A paper), the share of variable-rate loans is higher. These loan types accounted for approximately 7 per cent of active mortgage loans in November 2010. Federal Reserve Bank of New York's database comprises mortgage loans from 9 of the 10 largest mortgage lenders in the USA, corresponding to coverage of 50-70 per cent. Data comprises first-lien loans, meaning the primary mortgage secured on the home. In the case of default, first-lien loans take priority over any other housing loans.

cluding 1 year, are the most popular loan types in 11 out of 15 euro area member states, cf. ECB (2009b). In several countries the other loan types are also predominantly adjustable-rate loans, but with longer periods of fixed rates e.g. 5-10 years.

Table 6.3 shows characteristics of the markets for housing finance in selected countries. Denmark is at the high end as regards the use of variable-rate loans and loans with short initial rate fixation periods.[1] But it should be borne in mind that the remainder of housing loans in Denmark are mainly fixed-rate loans with long maturities, typically 30 years. In Finland and Portugal, mortgage lending consists predominantly of variable-rate loans, and these loan types are also popular in Spain and the UK. Loans with a fixed interest rate for the entire maturity are hardly used at all in the UK, cf. European Mortgage Federation (2006).

[1] For Denmark, the figure includes adjustable-rate loans in general, i.e. also loans with an initial fixed rate period of over 1 year although they are used to a relatively modest extent, cf. previously.

Germany, France and the USA stand out, in that house purchases are mainly financed by means of fixed-interest loans.

There are other points of variation across the markets for housing finance, including market flexibility. IMF (2008) constructs an overall index for the ability of the mortgage market to provide credit to borrowers based on institutional characteristics in the national markets. It is seen that the mortgage markets are most flexible and "complete" in Denmark and the USA, Sweden and the Netherlands, among other countries, while the markets in Germany, France and Italy are less flexible. According to IMF (2008), flexibility in the housing finance markets can contribute to explaining the substantial variation in housing debt across countries.

The interest-rate sensitivity of housing debt shows strong cross-country divergence. But generally housing debt has increased in recent years in many countries, and households have become more dependent on flexible-rate loan products. Sensitivity has therefore grown in relation to both interest-rate adjustments and shifts in house prices, cf. OECD (2006). The dependence on flexible-rate loans seen in the Danish market is not unusually high in an international context. But if the high debt ratio is taken into account, the overall picture that emerges is that the interest-rate sensitivity of Danish households is at the high end internationally.

The composition of the firms' liabilities is relatively similar across countries, given the differences in indebtedness, cf. Chart 6.7. The financial structure of Danish firms has many characteristics in common with that of firms in the euro area in particular. This applies to the composition of assets and liabilities as well as the degree to which e.g. investments are financed using external or internal sources, cf. section 4 and Petersen and Risbjerg (2009).

Correlation between financial structure and monetary-policy transmission

In recent years, increasing indebtedness across countries and uncertainty concerning the sustainability of price developments in the housing market have prompted several studies of the importance of developments in the financial structure to the monetary-policy transmission, see e.g. ECB (2009b), IMF (2008), Calza et al. (2010) and Rubio (2008).

In an extensive study of housing finance in the euro area, ECB (2009b) finds it difficult to draw any firm empirical conclusions on the impact of recent years' housing finance patterns on the transmission of monetary policy to the real economy. The reason is that there are opposite factors at play. The tendency towards more market-based mortgage systems,

FIRMS' LIABILITIES AS A PERCENTAGE OF GDP, 2009 Chart 6.7

Per cent of GDP
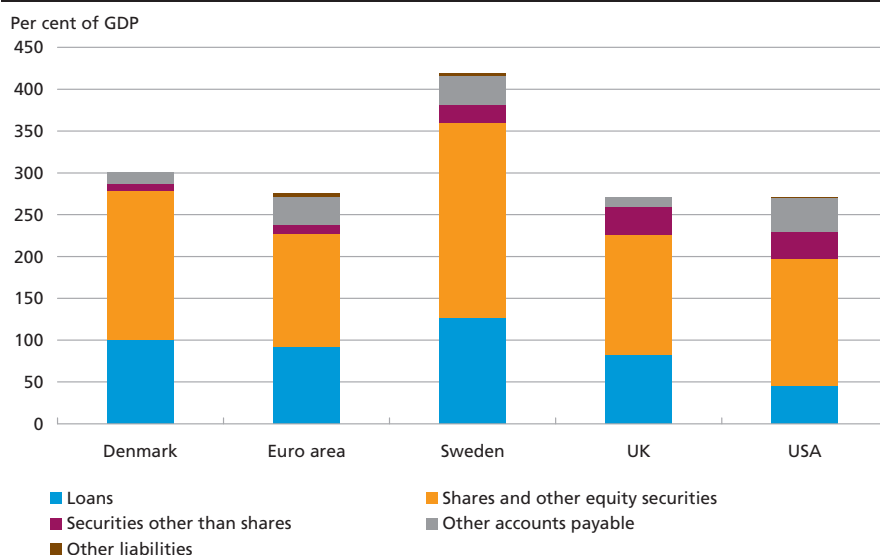
Note: Non-financial corporations. Other accounts payable include trade credits and tax payable. Other liabilities are any liabilities within the categories of insurance technical reserves and cash and deposits.
Source: Eurostat, OECD, Statistics Denmark and Danmarks Nationalbank.

higher indebtedness and more widespread use of variable-rate loans all point to strengthening of the transmission. On the other hand, fewer liquidity restraints on households via a larger supply of products, access to convert mortgage loans and more amortisation options may partially dampen the short-term effect of an interest-rate increase on the house-holds' disposable amount.

Several studies argue that monetary-policy transmission is stronger, the more widespread the use of flexible-rate loan types is. Rubio (2008) examines, within a new-Keynesian DSGE framework[1], how the shares of fixed-rate and variable-rate mortgages influence the pass-through of economic shocks. She constructs impulse-response reactions for three types of shocks (interest rate, inflation and technology) for two types of economies – one where the predominant loan type is variable-rate loans and one where it is fixed-rate loans. The results show that a change in interest rates has a stronger impact on borrowers in the first type of economy than in the second type, because borrowers with variable-rate loans reduce their consumption and demand for housing to a greater extent than borrowers with fixed-rate loans. The aggregated effects on the economy are also more pronounced for the economy dominated by

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[1] Dynamic Stochastic General Equilibrium Model, DSGE.

variable-rate loans. Likewise, the conclusion of Calza et al. (2010), in an empirical paper based on a DSGE model with two sectors for a number of countries, is that monetary-policy transmission is stronger (measured in terms of residential investment and house prices) in countries with a flexible framework for housing finance and variable-rate mortgage loans. Relative to consumption, this effect mainly depends on the dominance of variable-rate housing debt and on whether borrowers can release capital gains via transactions in the mortgage market. The impact on consumption of the access to release capital gains, including withdrawal of home equity, is supported by Iacoviello and Neri (2010), Mian and Sufi (2010) and Calza et al. (2010), among others.

An overall result of comparisons of euro area member states, cf. Peersman (2004), is that the interest-rate pass-through is lower in e.g. the Netherlands and Austria – which are characterised by housing loans with longer initial rate fixation periods – compared with member states where housing loans have shorter maturities, e.g. Spain. As regards the UK, Miles (2003) finds, via simulations using macroeconometric models, that the transmission is stronger in a system with variable-rate mortgage loans relative to a system with fixed-rate mortgage loans with access to refinancing. He finds that the transmission of monetary policy is 60-70 per cent stronger with the present UK mortgage system compared with alternative mortgage systems, e.g. a system with widespread use of freely callable fixed-income mortgage bonds.

Does high interest-rate sensitivity present a problem?
The Danish economy has become more sensitive to changes in short-term interest rates due to the restructuring of the mortgage system and increased borrowing. Moreover, the interest-rate sensitivity is probably also relatively high in an international perspective. Whether this is good or bad is hard to say.

Changes in monetary-policy interest rates are not necessarily strictly exogenous shocks, from which households and firms must be shielded. Monetary-policy interest rates follow the cyclical patterns to a large extent, although this is not an objective of monetary policy in Denmark. This is attributable to the generally relatively high correlation between cyclical fluctuations in Denmark and in the euro area, cf. Dam (2008). Consequently, monetary-policy interest rates in the euro area, which reflect the cyclical position there, are typically also "appropriate" from a Danish point of view. But the correlation is not perfect. For example, the boom in the middle of the last decade was notably stronger in Denmark than in the euro area. This may explain why the most recent downturn in Denmark has been relatively strong.

If monetary-policy interest rates in Denmark reflect the cyclical pattern, higher interest-rate sensitivity entails a monetary-policy gain via the effect on disposable income. In addition, house prices tend to fall in a downturn. If interest rates reflect the cyclical position of the economy, they may contribute to stabilising house prices in a downturn. Likewise, rising interest rates during a boom tend to dampen price increases. At the same time, low interest payments in periods of falling house prices will allow the households to increase their free savings in periods of falling home equity,[1] thereby reducing the risk of technical insolvency. Moreover, low interest rates tend to shield household disposable income, thereby stabilising demand.

On the other hand, convertible fixed-rate loans act as insurance for the home equity of households. The argument is that an interest-rate increase that puts downward pressure on house prices will also reduce bond prices and hence the cash value of homeowners' debt. But this line of reasoning is based on the assumption that interest-rate changes are not related to the real economy. If monetary policy is in tune with the business cycle, interest-rate increases will most often occur in periods of rising house prices and home equity. In that case, the drop in bond prices as a result of increasing interest rates will only contribute to strengthening the rise in home equity, while declining interest rates during a downturn will reinforce the fall in home equity. The conversion option limits the latter, however.

In terms of assessing the extent to which the widespread use of adjustable-rate loans is detrimental to macroeconomic stability, it is a key issue whether monetary-policy interest rates are generally "appropriate" in relation to the business cycle. If monetary policy is in sync with the business cycle, a high degree of pass-through to the real economy should be regarded as a benefit. But if changes in monetary-policy interest rates are independent of the business cycle and are prompted by e.g. the need to address speculative pressure on the krone, the effect may be procyclical.

Given the close international economic integration, we expect the correlation in cyclical patterns between Denmark and the euro area to remain high and that the ECB's monetary policy will therefore, to a reasonable degree, be consistent with cyclical developments in Denmark. On the other hand, it cannot be ruled out that there will be situations where unilateral Danish interest-rate increases are required due to pressure on the krone, as seen e.g. during the financial crisis. The

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[1] The fall in interest rates also reduces the households' incentive to save. Hence, it is not clear whether the net effect is an increase or a decrease in free savings.

more widespread use of variable-rate loans and the general growth in household gross debt have definitely increased the sensitivity of the households to unilateral Danish interest-rate increases.

Conclusion on the interest-rate channel

Adjustable-rate loans and deferred-amortisation loans have gained considerable ground over the last decade. There are many indications that this has contributed to increasing the interest-rate sensitivity of Danish households and firms. Other countries have also seen growth in household indebtedness and more variable-rate loans. But in an international context, the interest-rate sensitivity of Danish households is high due to the combination of high indebtedness and widespread use of variable-rate loans.

If the cyclical position of Denmark resembles that of the euro area, higher interest-rate sensitivity may be an advantage. But in so far as the interest-rate sensitivity of the Danish economy is higher than that of the euro area, fluctuations in monetary-policy interest rates could have a more pronounced effect on the cyclical patterns in Denmark compared with the euro area, even though the relatively high interest deductibility in Denmark compensates to some extent. If the business cycle in Denmark deviates from that of the euro area, or if interest rate changes are required to defend the krone, the higher interest-rate sensitivity also presents a clear challenge.

7. CONCLUSION

This article has shown how adjustments of Danmarks Nationalbank's monetary-policy interest rates are transmitted through the financial system. The primary channel is the banks' deposit and lending rates. We find that a close correlation exists between monetary-policy interest rates and bank retail rates. There are no indications of the credit channel playing an important role in the transmission of monetary policy in Denmark, but cyclical developments impact on key interest-rate spreads. This indicates that the financial sector contributes to reinforcing cyclical fluctuations in the economy despite the absence of a credit channel. However, the procyclical effect of the financial sector is inevitable in a market economy.

It is generally concluded throughout the article that monetary policy is primarily transmitted through the interest-rate channel. The importance of this channel to households and firms has grown over the last decade in step with the more widespread use of adjustable-rate mortgage loans and generally growing indebtedness. Consequently, there is reason to

believe that the effect of an interest-rate adjustment on the real economy has become more pronounced. Whether the higher interest-rate pass-through is generally beneficial to the economy depends on the "appropriateness" of the level of interest rates relative to the business cycle.

APPENDIX

Period		Households		Corporate sector	
		Lending	Deposits	Lending	Deposits
2003:1-2008:8	ΔPP_t	0.40	0.45	0.27	0.58
		(0.14)	(0.09)	(0.04)	(0.11)
	ΔPP_{t-1}	0.36	0.38	0.26	0.32
		(0.13)	(0.06)	(0.01)	(0.07)
	ΔPP_{t-2}	0.11	0.10	0.13	0.07
		(0.07)	(0.02)	(0.01)	(0.04)
	ΔPP_{t-3}	0.03	0.05	0.13	-0.06
		(0.15)	(0.01)	(0.05)	(0.10)
	Constant	-0.03	-0.01	0.00	0.00
		(0.00)	(0.01)	(0.02)	(0.01)
2009:1 2010:12	ΔPP_t	0.25	0.05	0.21	0.25
		(0.28)	(0.11)	(0.06)	(0.04)
	ΔPP_{t-1}	0.31	0.31	0.29	0.35
		(0.10)	(0.02)	(0.22)	(0.05)
	ΔPP_{t-2}	0.05	0.13	0.00	0.13
		(0.01)	(0.01)	(0.01)	(0.02)
	ΔPP_{t-3}	0.12	0.04	0.13	0.10
		(0.12)	(0.07)	(0.02)	(0.01)
	Constant	-0.01	-0.02	-0.02	-0.01
		(0.01)	(0.04)	(0.04)	(0.06)
Total pass-through in the period 2003:1 – 2008:8		0.90	0.98	0.78	0.92
Difference from full pass-through (Wald test)		0.10	0.02	0.22	0.08
Total pass-through in the period 2009:1 – 2010:12		0.74	0.52	0.63	0.83
Difference from full pass-through (Wald test)		0.26***	0.48***	0.37***	0.17***
Difference in pass-through between the two periods (Wald test)		-0.16	-0.46***	-0.14	-0.08

PASS-THROUGH TO RETAIL INTEREST RATES (SECTOR LEVEL) — Table A1

Note: See note for Table A2.
Source: Danmarks Nationalbank.

RESULTS FOR GROUPINGS BASED ON PANEL DATA

Table A2

Group	Households						Corporate sector					
	Lending			Deposits			Lending			Deposits		
	Deposit ratio	Liquidity	Total assets	Deposit ratio	Liquidity	Total assets	Deposit ratio	Liquidity	Total assets	Deposit ratio	Liquidity	Total assets
Total pass-through for weak banks	0.66	0.60	0.62	0.47	0.44	0.42	0.56	0.70	0.63	0.56	0.68	0.61
Difference from full pass-through, weak banks (Wald test)	0.34***	0.40***	0.38***	0.53***	0.56***	0.58***	0.44***	0.30***	0.37***	0.44***	0.32***	0.39***
Total pass-through for strong banks	0.58	0.63	0.60	0.50	0.51	0.57	0.66	0.56	0.60	0.73	0.60	0.68
Difference from full pass-through, strong banks (Wald test)	0.42***	0.37***	0.40***	0.50***	0.49***	0.43***	0.34***	0.44***	0.40***	0.27***	0.40***	0.32***
Difference in pass-through between groups of banks (Wald test)	-0.07	0.02	-0.01	0.02	0.07	0.14**	0.10	-0.14	-0.04	0.17	-0.08	0.06

Note: In cases where the parameter difference is found to be significant, the estimation is rerun for the group separately, and the standard deviations from this regression are stated. In these cases, the test of whether the beta coefficients add up to 1 is also carried out within the separate regressions.
"*", "**" and "***" indicate significance at the 10, 5 and 1 per cent levels, respectively.

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The Money and Foreign-Exchange Markets during the Crisis

Anders Jørgensen, Market Operations, Paul Lassenius Kramp, Carina Moselund Jensen and Lars Risbjerg, Economics[1]

1. INTRODUCTION AND SUMMARY

The money market, comprising the market for interbank loans and short-term securities, came under the spotlight at the onset of the financial turmoil in August 2007. The turmoil developed into a financial crisis after the suspension of payments by Lehman Brothers in September 2008. Central banks worldwide responded quickly and massively, launching a number of extraordinary measures to support the banks' liquidity and access to funding. In the course of March 2009 the negative sentiment in the financial markets changed. While the situation in the financial markets gradually improved, the negative consequences for the real economy were already evident. This article analyses the reasons why the Danish money and foreign-exchange markets were affected, the consequences and Danmarks Nationalbank's measures to address the crisis.

The crisis erupted from the market for mortgages to less creditworthy American homeowners, (the subprime market). Several US banks as well as banks in other countries had invested in assets exposed to the US housing market, which was suffering mounting losses. Moreover, the assets were often complex financial instruments with opaque exposure. In addition to making the banks uncertain about their counterparties' credit standings and their own liquidity situation, these conditions made them hesitant to grant credit in the money market.

The key to understanding the dissemination of the crisis is the banks' high degree of dependence on the international money and capital markets as sources of funding and the close integration of the markets. Several banks in a number of countries were thus, to a large and increasing extent, relying on short-term funding in foreign currency, especially dollars, via the international money markets. During the crisis in the autumn of 2008, there was a shortage of dollars when US banks

became reluctant in their lending to European banks, among others. They needed the dollar liquidity themselves and were concerned about the credit standings of the European banks.

The backdrop for the rapid dissemination of the crisis is that several large international banks that were key providers of credit across currencies were severely affected by the problems in the US housing market. As a result, they generally put a stop to their international money-market lending.

What was the situation in Denmark?

The Danish banks' direct credit exposure to the subprime market was limited, but, like the banks in some other countries, they were exposed to the development in the international money markets due to their high dependence on short-term funding in foreign currency, particularly dollars and euro, cf. section 2. As foreign banks generally ceased to grant interbank loans in the autumn of 2008, the banks to a large extent borrowed from central banks instead.

Like the large banks, small and medium-sized banks also had a customer funding gap in foreign currency and were dependent on the international money and capital markets. Their access to those markets was predominantly through the large banks only. This illustrates the general experience that the crisis spread from large international banks to large domestic banks and then to smaller banks.

An econometric analysis shows that the problems in the Danish money market primarily came from the US market. It indicates that the spillover effect from the US to the Danish money market took place mainly through the euro area money market. Because of Denmark's fixed-exchange-rate policy, the Danish money market is closely linked to that of the euro area.

The crisis has shown that it is important that banks to limit their dependence on individual markets where liquidity can disappear very rapidly. Against this background, Danmarks Nationalbank and the Danish Financial Supervisory Authority have intensified their monitoring of the banks' liquidity management.

What happened in the Danish money market in kroner?

The development in Danish banks' money-market loans in kroner and Danmarks Nationalbank's provision of liquidity are analysed in section 3. Danmarks Nationalbank's monetary-policy instruments give the banks a high degree of flexibility in terms of obtaining collateralised liquidity. The market operations provide access for all banks and mortgage banks to obtain the loans they demand at a fixed interest rate and against a

wide range of collateral. Thanks to the flexible structure of Danmarks Nationalbank's monetary-policy instruments, the Danish money market functioned comparatively well during the first part of the crisis. No extraordinary liquidity facilities were established, and the framework for Danmarks Nationalbank's liquidity management was not changed.

Extraordinary facilities were introduced at a later stage. The extent of loans from Danmarks Nationalbank in that connection was very limited, but the measures were important in order to ensure the banks' ability to meet the liquidity requirements under section 152 of the Financial Business Act.

Turnover in the money market fell during the crisis, however. It became concentrated at the very short end of the market and switched from uncollateralised to collateralised lending as growing credit and liquidity risks kept banks from granting long-term uncollateralised loans. The short-term interbank market was partly replaced by accounts with Danmarks Nationalbank, with banks increasing both their loans and deposits at Danmarks Nationalbank in the autumn of 2008. The gross accumulation peaked in December 2008 when the banks and mortgage banks' holdings of certificates of deposit exceeded their net position vis-à-vis Danmarks Nationalbank by just over kr. 280 billion. Kr. 170 billion of this was attributable to the fact that some banks placed certificates of deposit while others raised monetary-policy loans. Hence, the increased gross positions vis-à-vis Danmarks Nationalbank to a large extent reflected that banks with a liquidity surplus placed it at Danmarks Nationalbank rather than relending it. Consequently, banks with a funding requirement had to obtain monetary-policy loans rather than borrowing in the money market.

Based on data from Danmarks Nationalbank's payment system, Kronos, it is shown by section 3 that some of the small and medium-sized banks in particular were affected by the problems in the money market. Compared with large banks, at the end of 2008 they on average paid a premium of 0.25-0.5 percentage point for loans in the overnight money market, which is fundamental to the banks' ongoing liquidity management. In a few instances some banks paid a premium of 2-3 percentage points. The small banks had to increase the number of counterparties in order to ensure their liquidity, and they almost doubled the number of loans and counterparties in the overnight money market.

What does the spread between uncollateralised and collateralised interest rates indicate?

The modest and stable pre-crisis spread between uncollateralised and collateralised money-market interest rates – known as the money-mar-

ket spread – quickly became a key indicator of the funding problems in the money market, mirroring the crisis development in general. Using regression analysis, we investigate the factors behind the development in the Danish money-market spread in section 4.

Knowledge about the breakdown of the money-market spread into credit and liquidity factors is relevant for decisions on which measures should be taken in a crisis situation. If the primary reason for the widening of the spread is the deterioration of liquidity conditions, measures to improve the way the money market works or the liquidity situation of the banks may be useful. If the widening reflects higher credit risk, measures to support the banks' solvency may be more relevant.

In practice, the credit and liquidity factors of the money-market spread are closely linked and difficult to separate. With this in mind, the empirical analysis shows that during the first part of the crisis a very large proportion of the spread could be attributed to liquidity conditions, and that the liquidity conditions in the euro area had a significant impact on the Danish money-market spread.

However, in the course of 2009 the Danish spread, like that of the euro area, came to predominantly imply a credit premium, reflecting that the crisis evolved from a liquidity crisis into a credit crisis. The money-market spreads narrowed as liquidity returned to the markets in the wake of the massive interventions by central banks worldwide. But at the same time it also became clear that the banks' solvency was under pressure following major losses, and that policies aimed at improving the liquidity situation were insufficient.

On the face of it, the wide credit-related spread was remarkable in view of the fact that Bank Rescue Package 1 included a government guarantee for all depositors' and other unsecured creditors' claims in banks from October 2008 to September 2010. A key explanatory factor is that most banks determined their credit policies vis-à-vis other banks as if Bank Rescue Package 1 did not exist.

What happened in the foreign-exchange markets and to the Danish krone?

In the wake of Lehman's suspension of payments, investors withdraw from minor currencies, cf. section 5. This led to exchange-rate pressure, and minor currencies with floating exchange rates, e.g. Swedish kronor, depreciated. Furthermore, there were indications of some investors speculating in Danmarks Nationalbank not being able to maintain the fixed-exchange-rate policy. In addition to international investors withdrawing from minor currencies, the shortage of dollars and euro led to a

reduction of loans in foreign currency via FX swaps because it was intractable and expensive. The demand for foreign currency conse-quently increased, putting pressure on the Danish krone.

As a result of the Danish fixed-exchange-rate policy against the euro, Danmarks Nationalbank made intervention purchases for considerable amounts and raised its monetary-policy interest rates while other central banks generally lowered theirs. Danmarks Nationalbank's measures con-tributed to stabilising the krone. The issuance of 30-year government bonds, which were in high demand from the Danish pension sector, and Bank Rescue Package 1 also contributed to stabilising the situation.[1] During the crisis the krone remained stable at a level close to its central rate against the euro.

The transmission from monetary-policy interest rates to the krone rate weakened substantially during the crisis, making it impossible to substi-tute the outflow from the foreign-exchange reserve for government currency loans at the peak of the crisis. According to experience from the autumn of 2008, very large amounts may be required for inter-vention purposes if the krone is under pressure, and a large foreign-exchange reserve is therefore needed. Danmarks Nationalbank more than doubled the foreign-exchange reserve in relation to the situation before the autumn of 2008 when the pressure on the krone really set in. The crisis also showed that Danmarks Nationalbank may need to provide foreign exchange to the banks from the foreign-exchange reserve.

What did Danmarks Nationalbank do to ensure funding in foreign currency?

In the autumn of 2008, against the backdrop of the shortage of dollars and euro, Danmarks Nationalbank established swap lines with the Federal Reserve and the European Central Bank, ECB, in order to provide US dollar and euro liquidity to Danish banks. According to our regres-sion analyses in section 6, the announcement of the swap lines substan-tially improved the conditions for funding in foreign currency, reflecting that market participants were reassured by the support of the Federal Reserve and the ECB for dollar and euro financing. The results are in line with similar studies for other countries. Danmarks Nationalbank also provided dollar and euro FX swap loans from the foreign-exchange reserve in September and October 2008. The euro-denominated lending supported the conditions for funding in euro, while the result of FX swaps in dollars was less clear-cut.

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[1] The issuance of 30-year government bonds supported the demand for kroner to the extent that pension companies sold European bonds in order to buy Danish government securities.

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2. SPREADING OF THE FINANCIAL CRISIS TO DENMARK

Prior to the crisis, the Danish banks had limited exposure to the US market for subprime mortgages, so their subprime-related losses were limited.[1] However, like the banks in some other countries, they were exposed to the international money markets because of their great dependence on short-term financing in foreign currency, especially dollars and euro. It was prevalent for banks to finance themselves in one currency and then swap it to another currency. As a result, they were exposed to the swap markets. Because of the high degree of dependence on financing via the international money markets and the close integration of the money markets, the problems rapidly spread from the US money market to the money markets in the euro area and Denmark.

Below we discuss how, up to and during the crisis, the banks financed themselves in foreign currency, and how it became increasingly difficult for them to obtain dollars and euro. We show how this shortage of foreign currency created problems in the FX swap markets, making it difficult and expensive to obtain funding in US dollars, among other currencies, via FX swaps. We also investigate how the widening of the spread between uncollateralised and collateralised interest rates spread from the US and European money markets to the Danish money market.

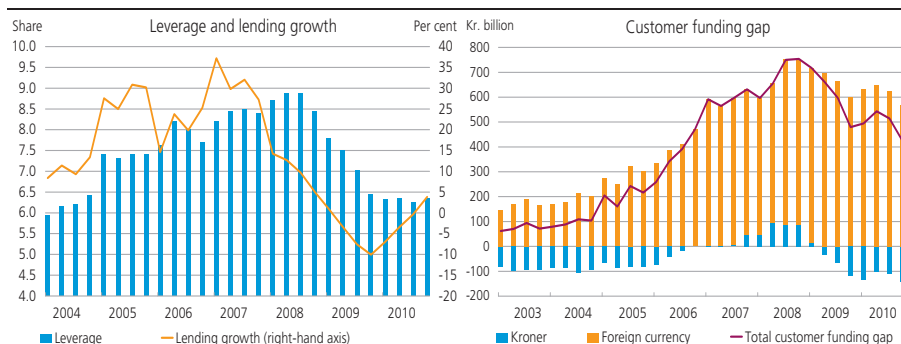### The Danish banks' customer funding gap

For Danish banks, as was the case for many European and US banks, the years preceding the financial crisis were characterised by high lending growth rates and increased leverage, cf. the left-hand side of Chart 2.1.

The banks' lending growth was much stronger than the growth in their non-MFI deposits[2], which are normally considered a stable source of funding. As a result, they had a considerable customer funding gap, cf. the right-hand side of Chart 2.1, which had to be financed in the money and capital markets.

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1 US as well as European banks had invested in and provided liquidity guarantees in dollars to structured investment vehicles (SIVs), which had invested in securities collateralised by subprime mortgages. It became difficult for the SIVs, which were typically funded by short-term loans, to continue financing themselves. As a result, the SIVs began to draw on the liquidity guarantees provided by US and European banks. Several large Danish banks also had liquidity commitments to SIVs and had, to a lesser extent, purchased capital certificates in SIVs. In the wake of the subprime crisis the Danish banks reduced their liquidity commitments and direct investments in SIVs, cf. Danmarks Nationalbank (2008b). The spread between uncollateralised and collateralised money-market interest rates widened significantly on 9 August 2007 after the announcement by the French bank, BNP Paribas, that it would stop paying instalments on its debt and calculating mark-to-market for three SIVs exposed to the subprime market. See Lund (2007), Krishnamurthy (2009) and Sarkar and Shrader (2010) for a background to the subprime crisis and the way it spread. See BIS (2009 and 2010) for a breakdown of the crisis into phases and an overview of central-bank measures.

2 MFIs stands for monetary financial institutions, primarily comprising banks and mortgage banks.

THE BANKS' LEVERAGE, LENDING GROWTH AND CUSTOMER FUNDING GAP   Chart 2.1

Note: The compilation comprises the Danish banks that were included in the Danish Financial Supervisory Authority's groups 1-4 in 2010 and their foreign branches and subsidiaries. The customer funding gap is calculated as the difference between lending to and deposits from non-MFIs. The leverage is calculated as the relationship between the banks' lending to non-MFIs and their equity capital in the form of capital and reserves. The lending growth is calculated as year-on-year growth rates. Last observation: 4th quarter of 2010.
Source: Danmarks Nationalbank.

The banks with customer funding gaps in foreign currency were dependent on financing in the international money and capital markets, either directly via currency loans or indirectly via FX swaps. The banks overall had large outstanding balances at central banks and other MFIs, typically short-term, in both euro and US dollars, cf. Chart 2.2. Due to the short-term financing, the banks were subject to considerable refinancing risks.

The large Danish banks accounted for the main part of the customer funding gap in foreign currency in the autumn of 2008, but small and medium-sized banks also had a considerable customer funding gap and therefore needed currency financing.[1] Not all banks had direct access to the international markets. The smaller banks mainly obtained their financing via the large Danish banks. For both the large and medium-sized banks the customer funding gap amounted to 13 per cent of total assets in the autumn of 2008, while the corresponding figure was 28 per cent for the small banks.

The banks' financing of the customer funding gap
The banks' financing in the money and capital markets can be divided into loans from central banks, loans from other MFIs and debt issuance, cf. the left-hand side of Chart 2.3.

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[1]   Large, medium-sized and small banks are defined according to the Danish Financial Supervisory Authority's groups for 2010. In the 3rd quarter of 2010 the large banks in group 1 accounted for around 86 per cent of the banks' total balance sheet, while the medium-sized banks in group 2 accounted for 8 per cent and the small banks in groups 3 and 4 accounted for 7 per cent.

THE BANKS' BALANCE SHEETS IN EURO AND DOLLARS   Chart 2.2
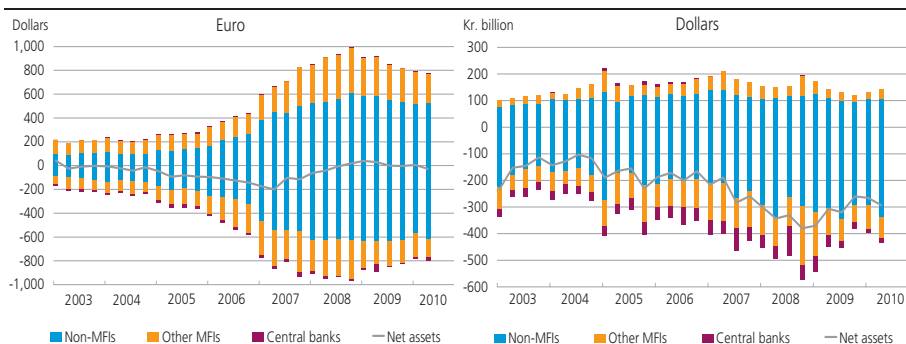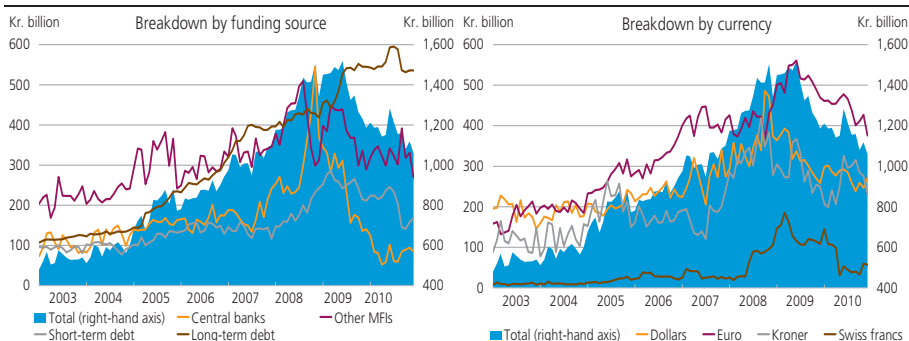

Note: The compilation comprises all Danish banks and their foreign branches and subsidiaries. Assets have a positive
         sign; liabilities have a negative sign. Last observation: 2nd quarter of 2010.
Source: Bank for International Settlements' international locational and consolidated banking statistics and own
         calculations.

Before the onset of the turmoil the widening customer funding gap was
mainly financed by deposits from other MFIs. These deposits declined
significantly from the autumn of 2008. To a large extent, non-residents
stopped granting loans to Danish banks following Lehman Brothers'
suspension of payments, cf. section 5. Furthermore, Roskilde Bank drew
negative attention to Denmark in the international financial markets in
August 2008 when it was taken over by Danmarks Nationalbank and
private banks in Denmark via the Danish Contingency Association. At
the same time, the banks responded by reducing the exchange of

THE BANKS' BORROWING IN THE MONEY AND CAPITAL MARKETS
BROKEN DOWN BY FUNDING SOURCE AND CURRENCY   Chart 2.3

Note: The compilation comprises Danish banks in the Danish Financial Supervisory Authority's groups 1 and 2, excluding
         their foreign branches and subsidiaries. Loans from MFIs constitute net borrowing from MFIs other than central
         banks and foreign branches and subsidiaries. Debt is debt securities issued. Short-term debt is issuance with an
         original maturity of up to and including 1 year, while long-term debt has a maturity of more than 1 year.
Source: Danmarks Nationalbank.

interbank liquidity.[1] Loans from central banks and short-term debt issuance became the predominant sources of funding when the crisis in the financial markets culminated in the autumn of 2008.

Bank Rescue Package 1, which was announced on 5 October 2008 and included a government guarantee for all depositors' and other unsecured creditors' claims in banks, contributed to supporting the Danish money market and the banks' access to financing. At the end of 2008 and the beginning of 2009, the deposits from non-resident MFIs gradually returned, and the banks increasingly issued debt securities with longer maturities.

Together with Danish kroner, US dollars accounted, to a high degree, for the increased financing in the money and capital markets up until October 2008, cf. the right-hand side of Chart 2.3. Financing in euro subsequently began to take over, reflecting the beginning return of deposits from non-resident MFIs and the gradual increase in the issuance of debt securities in euro.

The banks' dollar loans

Dollar funding was to a large extent obtained via short-term debt issuance. This business model made the banks vulnerable to the US money market when the debt was to be refinanced.

Short-term debt issuance in dollars in the Commercial Paper (CP) market played an important role. Here, conditions deteriorated strongly in the autumn of 2008, so it became difficult to obtain funding in this market. The Federal Reserve, the Fed, supported the market by establishing the Commercial Paper Funding Facility, CPFF, with the aim of reducing the banks' refinancing risks by purchasing 3-month CPs from financial institutions with a high credit rating. At the end of October 2008, the Fed purchased CPs issued by the largest Danish bank, Danske Bank, equivalent to 13 per cent of the total short-term debt issuance by Danish banks. The purchase totalled just over 5 billion dollars. The CPs matured in January 2009.[2]

The banks' access to dollar funding was also supported by Danmarks Nationalbank's swap line with the Fed, which was established in September 2008, cf. sections 5 and 6. The banks borrowed up to 15 billion dollars using this facility. In addition to dollars, the largest central-bank loans in foreign currency were in Swiss francs. During the crisis, a few major banks had direct access to borrowing both Swiss francs and dollars from the Swiss National Bank.

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[1] Cf. Danmarks Nationalbank (2008a).
[2] Cf. http://www.federalreserve.gov/newsevents/reform_cpff.htm.

Financing via FX swaps

Some Danish banks were dependent on short-term financing in foreign currency and exposed to the developments in the FX swap markets. Part of the banks' financing in dollars was thus used to finance their lending in other currencies, e.g. Swiss francs.[1] The exchange-rate risk was covered by swapping dollars to the foreign-exchange exposure of the lending. As the crisis made it more difficult to access the international money and foreign-exchange markets, the banks took the opportunity to finance their loans by borrowing from central banks instead.

The banks' increased exposure to funding in foreign money and capital markets in the period leading up to the crisis was an international trend. Prior to the crisis, the euro area banks had built up large foreign-exchange assets in dollars. The maturity of the funding was typically shorter than that of the assets and some of the funding was not directly in dollars. As a result, there was a pronounced currency and maturity mismatch between the banks' assets and liabilities. This increased the sensitivity to the US money market and the FX swap market where the banks needed to refinance lending on an ongoing basis, cf. Fender and McGuire (2010) and McGuire and von Peter (2009). At the end of 2008, the euro area banks' net assets in dollars amounted to around 400 billion dollars that needed to be hedged. This created an underlying demand for dollars in the FX swap market, cf. Allen and Moessner (2010a).

Dollar shortage

As the crisis evolved, it became more difficult to obtain dollars because the US banks became less willing to grant loans to e.g. European banks. Consequently, European banks increasingly had to raise dollars by borrowing in other currencies and swapping to dollars via the FX swap market rather than borrowing dollars directly. This pushed up the price of dollar funding via FX swaps considerably compared with direct dollar loans, thereby creating large deviations from the covered interest-rate parity, cf. Chart 2.4 and Box 2.1. Normally, the deviations would be eliminated by arbitrage, but to a large extent the European banks were unable to obtain direct financing in the US money market and thus to perform the arbitrage.

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[1] In the years leading up to the crisis, the banks built up large assets in Swiss francs, including lending to the agricultural sector. The assets were not financed by liabilities in Swiss francs but by liabilities in other currencies.

DEVIATION FROM THE COVERED INTEREST-RATE PARITY   Chart 2.4

Percentage points
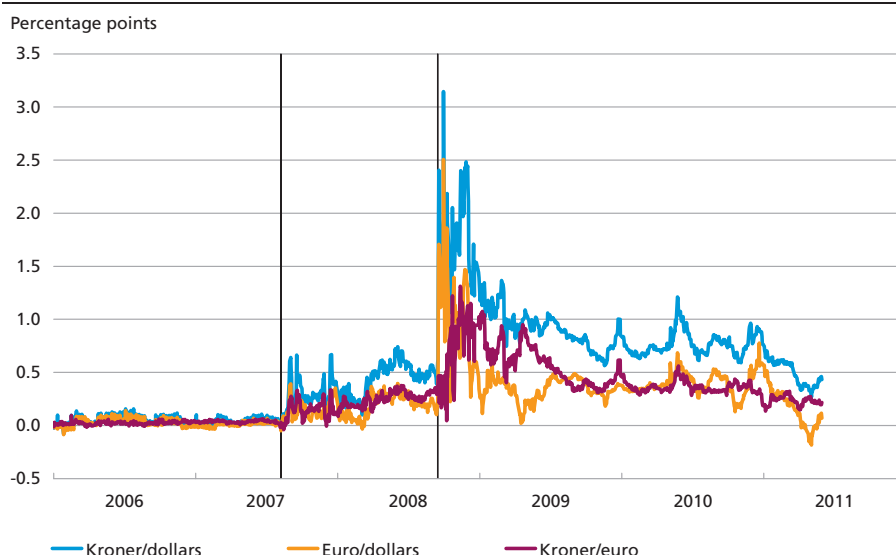
Note: The uncollateralised money-market interest rates, Cibor, Libor and Euribor for the Danish, US and euro area
        money market, respectively, are used to calculate the deviation from the covered interest-rate parity in
        accordance with equation (3) in Box 2.1. "Kroner/dollars" expresses the difference between the cost of loans in
        kroner combined with FX swaps and the cost of direct borrowing in dollars. The same applies to "Kroner/euro"
        and "Euro/dollars". The vertical lines are set at 9 August 2007 (the onset of the turmoil after the announcement
        by French bank BNP Paribas that it would stop paying instalments on its debt and calculating mark-to-market for
        three SIVs exposed to the subprime market) and 15 September 2008 (Lehman Brothers' suspension of payments).
        Last observation: 31 May 2011.
Source: Bloomberg.

The Fed and the ECB established swap lines with a number of central
banks to remedy the shortage of dollars and euro, initially in December
2007.[1]

The European banks were dependent on dollar financing and to some
extent directly exposed to the US subprime loans. The free movement of
capital and the close integration of the international money markets
resulted in a spilleover effect from the US money market to the inter-
national money markets as a result of arbitrage between the markets,
cf. Box 2.1. But during the crisis, the money-market spread varied con-
siderably across countries, cf. Chart 2.5. For instance, in the autumn of
2008 the US spread was somewhat wider than the spreads in Denmark
and the euro area. From the end of 2008 until the end of 2010, the
Danish spread was wider than that of the euro area. The spillover effects
among the money markets are described in more detail in Box 2.2.
Section 4 divides the effects into credit and liquidity factors.

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[1]   See Allen and Moessner (2010a) for an overview of the deviations from the covered interest-rate
      parity for a number of currencies and the central-bank measures to remedy the shortage of
      international liquidity.

FX SWAPS AND THE COVERED INTEREST-RATE PARITY	Box 2.1

An *FX swap* is an agreement comprising a simultaneous spot transaction and forward contract. In connection with the spot transaction an amount is exchanged between two currencies at the current spot rate; in connection with the forward contract the amount is exchanged back at an agreed future point in time and at an agreed exchange rate. FX swaps are concluded with standardised maturities from 1 day up to 12 months. They can be regarded as secured loans in one currency against collateral in another. When a bank supplies Danish kroner and receives currency in a spot transaction, this is the same as lending in kroner. Banks mainly use FX swaps as a money-market instrument to fund their activities across money markets in different currencies. It is possible to conclude the spot transaction with one counterparty and the forward contract with another. The financial aspects are the same, and this article does not distinguish between FX swaps and forward contracts.

The covered interest-rate parity indicates that the cost of borrowing directly in the domestic currency, e.g. Danish kroner, is equivalent to the cost of raising a loan in a foreign currency, e.g. dollars, while at the same time concluding an FX swap where the dollar exposure is hedged (converted into krone exposure). The interest-rate parity consequently entails that:

$$F/S \cdot (1 + r_{USD}) = 1 + r_{DKK}, \tag{1}$$

where F is the forward rate and S is the spot rate (kroner per dollar) and r_{USD} and r_{DKK} are the money-market interest rates in dollars and kroner, respectively. If the covered interest-rate parity does not apply, there will be a basis for arbitrage, since loans can be raised in one currency and invested and hedged in another currency at a higher interest rate. The relationship (1) can be approximated as follows:

$$(F-S)/S = r_{DKK} - r_{USD}. \tag{2}$$

The left-hand side of the equation is an expression of the cost in per cent of borrowing kroner against foreign currency, e.g. dollars, via an FX swap. The cost is an expression of the implied interest-rate spread between kroner and dollars in an FX swap. If the covered interest-rate parity remains unchanged, the implied interest-rate spread will be in accordance with the actual spread between the Danish and the US money-market interest rates (the right-hand side of the equation).

If the covered interest-rate parity remains unchanged for both collateralised and uncollateralised interest rates, this would entail that the spread between uncollateralised and collateralised interest rates across money markets would be the same. This can be seen by the fact that (2) would apply to both collateralised and un-collateralised interest rates.

In practice, deviations from the covered interest-rate parity may be observed, and the spread between collateralised and uncollateralised interest rates will not be the same across money markets due to e.g. transaction costs and differences in credit risk and liquidity conditions between the markets. During the crisis, large and sustained deviations from the covered interest-rate parity occurred, making it cheaper to borrow dollars directly in the US money market rather than borrowing in e.g. euro,

CONTINUED	Box 2.1

pounds sterling, Swedish kronor or Danish kroner and converting the loan into a dollar loan via an FX swap. Hence, the following applied:
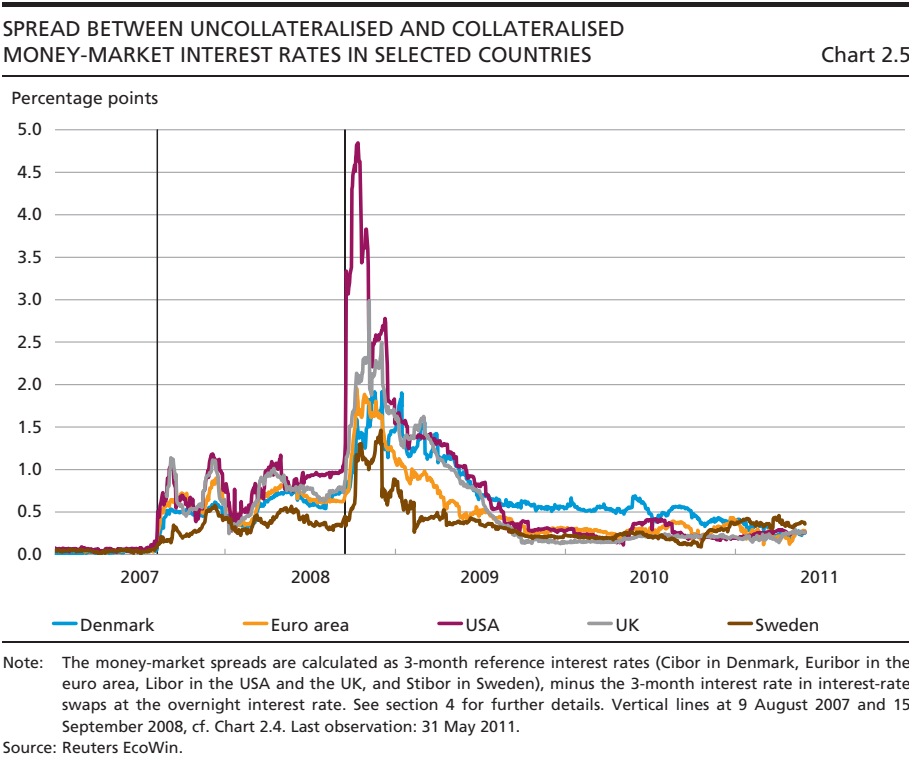
$$(1/F)/(1/S) \, (1 + r_{DKK}) > (1 + r_{USD}), \tag{3}$$

where 1/S and 1/F are spot and forward rates expressed as dollars per krone.

Similarly, it was cheaper to borrow directly in euro rather than raising a loan in pounds sterling, Swedish kronor or Danish kroner and converting it into a euro loan via an FX swap.

During the crisis, however, European banks found it difficult to borrow dollars directly in the money market, and they had to resort to the FX swap market in order to raise dollars. As a result of the increase in demand, the related costs rose compared to direct borrowing. This can be illustrated by the example of FX swaps between kroner and dollars where dollar funding meant spot purchases of dollars (against kroner) and forward sales of dollars (against kroner). This drove down the forward rate (F) of dollars compared to the spot rate (S), making it more expensive to borrow dollars via FX swaps against kroner than to borrow directly in dollars, cf. (3) above.

Cross-currency swaps, exchanging principals and interest in two currencies, can be used in the same way as FX swaps.

SPREAD BETWEEN UNCOLLATERALISED AND COLLATERALISED MONEY-MARKET INTEREST RATES IN SELECTED COUNTRIES	Chart 2.5

Note: The money-market spreads are calculated as 3-month reference interest rates (Cibor in Denmark, Euribor in the euro area, Libor in the USA and the UK, and Stibor in Sweden), minus the 3-month interest rate in interest-rate swaps at the overnight interest rate. See section 4 for further details. Vertical lines at 9 August 2007 and 15 September 2008, cf. Chart 2.4. Last observation: 31 May 2011.
Source: Reuters EcoWin.

| SPREADING OF THE CRISIS TO THE DANISH MONEY MARKET	Box 2.2

The development in the money markets in the USA and the euro area affected the Danish money market. In order to assess how the shocks spread from the USA and the euro area to Denmark, we set up a VAR model with three endogenous variables, i.e. the 3-month money-market spread in the three countries.[1] Similar analyses have been conducted for other countries.[2]

The VAR analysis shows that in the period leading up to the crisis the European spread had only a limited impact on the Danish money-market spread, while the US spread was of no consequence, cf. Chart 2.6 and Table 2.1.[3] The weak spillover effect from abroad on the Danish money market is attributable to the fact that no substantial shocks to the foreign money markets occurred during that period.

This changed in the period from the onset of the crisis up to Lehman, and both the European and the US money-market spreads became more important for the Danish money market. The increased spillover effect from the USA to Denmark is in line with other similar analyses concerning the euro area, Japan and Sweden.

BREAKDOWN OF VARIANCE IN THE DANISH MONEY-MARKET SPREAD	Chart 2.6
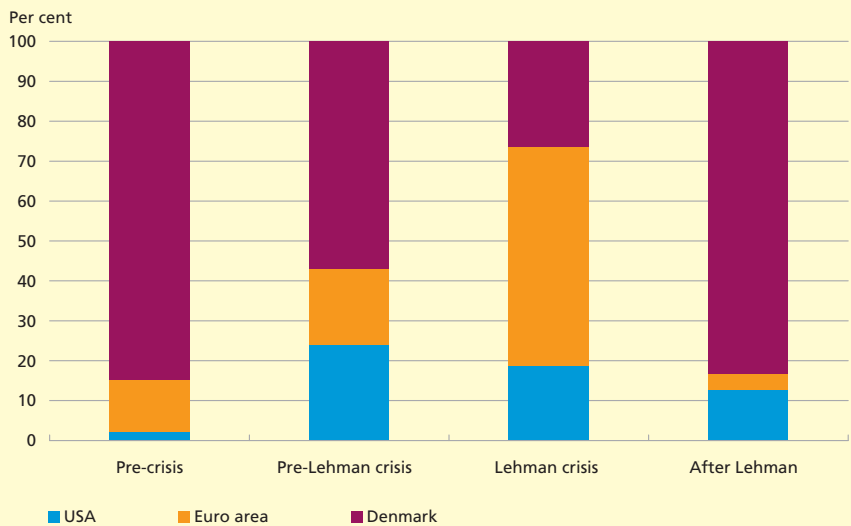
Note: Based on a VAR model with the 3-month money-market spreads of the USA, the euro area and Denmark as well as VIX. The variance is calculated over a horizon of 21 days. Pre-crisis: 2 January 2006 to 7 August 2007. Pre-Lehman crisis: 8 August 2007 to 12 September 2008. Lehman crisis: 15 September 2008 to 31 December 2008. After Lehman: 2 January 2009 to 30 June 2009.
Source: Own calculations and Reuters EcoWin.

INTERNATIONAL IMPACT ON THE DANISH MONEY-MARKET SPREAD		Table 2.1

	No Granger causality from the USA to Denmark	No Granger causality from the euro area to Denmark
Before the crisis	Not rejected	Rejected**
The pre-Lehman crisis	Rejected*	Rejected***
The Lehman crisis	Rejected*	Rejected**
After Lehman	Rejected**	Not rejected

Note: * 10 per cent significance level, ** 5 per cent significance level and *** 1 per cent significance level. For a breakdown into periods, see Chart 2.6.
Source: Own calculations based on data from Reuters EcoWin.

CONTINUED	Box 2.2

The money-market spreads widened substantially in the USA in connection with Lehman Brothers' suspension of payments, due to special conditions in the dollar market among other factors. The spreads in the euro area and Denmark widened somewhat less. While the importance of the euro area spread for the Danish spread increased substantially, the direct spillover effect from the USA declined, showing that the spillover effect from the US to the Danish money market was effected mainly through the euro area money market.

After Lehman, in early 2009, the money-market spreads narrowed, e.g. as a result of a number of extraordinary measures introduced by central banks worldwide, cf. section 3. According to the VAR model, the international development had only a relatively limited effect on the Danish money-market spread during that period. This should be viewed in relation to the sluggish response of Cibor, cf. Andersen and Arp (2010), which caused isolated fluctuations in the Danish money-market spread. Furthermore, Cibor declined more slowly than the corresponding uncollateralised money-market interest rates in the USA and the euro area, causing a different development in the Danish spread than in the euro area. It is clear, however, that the narrowing of the money-market spreads in the USA and euro area was the main driver behind the narrowing of the Danish spread.

[1] The analysis uses day-to-day data. The number of lags was selected using sequential modified LR test statistics. LR typically results in relatively many lags, thereby reducing any autocorrelation problems. The results do not change if the number of lags is determined by Akaike or Schwarz information criteria. Dummies are included to correct e.g. large fluctuations in the money-market spread due to a difference in the information content between collateralised and uncollateralised interest rates, because they are calculated at different times across countries. Furthermore, the US VIX is included as an exogenous variable (tests confirm that VIX can be regarded as exogenous). VIX can be seen as a measure of the underlying market risk that may affect risk aversion. Including VIX practically eliminates autocorrelation, heteroskedasticity and too much bias (part of the normal distribution assumption). The results are robust to the exclusion of VIX.
[2] See e.g. ECB (2008) and Imakubo, Kimura, Nagano (2008) and Soultanaeva and Strömquist (2009).
[3] Impact is defined here as Granger causality, i.e. whether historical observations of a variable may contribute to forecasting another variable. More specifically, an F test is calculated as to whether lagged values of a variable, X, generally contribute to explaining another variable, Y, compared to a situation where Y can only be explained by its own lagged values. If the F test can be rejected, i.e. if R2 improves when including lagged values of X, X is said to Granger-cause Y.

Conclusion

Prior to the crisis, Danish banks had accumulated substantial customer funding gaps, especially in foreign currency. The gaps were to a large extent financed in the international money and foreign-exchange markets through loans from MFIs and short-term debt securities. When the crisis in the US and European money markets caused foreign banks to reduce their international money-market lending, Danish banks found it difficult to refinance their short-term currency debt. As a result, the Danish banks increased their central-bank loans in foreign currency considerably in the autumn of 2008. A number of small and medium-sized Danish banks relied on having access to financing through the large banks. This illustrates the general experience that the crisis spread from large international banks to large domestic banks and then to smaller banks. The Danish banks had substantial short-

term debt in dollars, rendering them highly sensitive to conditions in the money and swap markets for dollars. According to an econometric analysis, the transmission was from the US money market to the money markets worldwide. The analysis also indicates that the transmission from the US to the Danish money market was effected mainly through the euro area. Because of the fixed-exchange-rate policy, conditions in the Danish money market are closely linked to those in the euro area.

The crisis has shown that it is important for banks to limit their dependency on individual markets where liquidity can disappear all of a sudden.[1] Accordingly, Danmarks Nationalbank and the Danish Financial Supervisory Authority have intensified their monitoring of the banks' liquidity situation, including by requesting banks to provide monthly liquidity forecasts and stress tests.

3. MONETARY-POLICY INSTRUMENTS AND THE MONEY MARKET

The Danish money market functioned relatively well during the first part of the crisis. The structure of Danmarks Nationalbank's monetary-policy instruments made it easy for the banks to obtain the liquidity they demanded against collateral. No extraordinary liquidity facilities were needed, and the framework of Danmarks Nationalbank's liquidity management was not changed. As the crisis escalated, the interbank exchange of liquidity in the money market declined, and Danmarks Nationalbank introduced extraordinary liquidity facilities.

The efficiency of the monetary-policy instruments can generally be assessed by the extent of the pass-through from monetary-policy interest rates to money-market interest rates and the exchange rate, and the extent to which it is ensured that the banking sector gets the liquidity it needs and that interbank transactions in the money market are supported. The transmission of monetary-policy interest rates is discussed below, including on the basis of data from Danmarks Nationalbank's payment system, Kronos, for the individual banks' loans in the overnight money market. The provision of liquidity is illustrated by the way the banks have used the monetary-policy instruments and extraordinary facilities and there is made a comparisons with the measures introduced by other central banks. The functioning of the money market and the interbank exchange of liquidity are also analysed on the basis of data from Kronos.
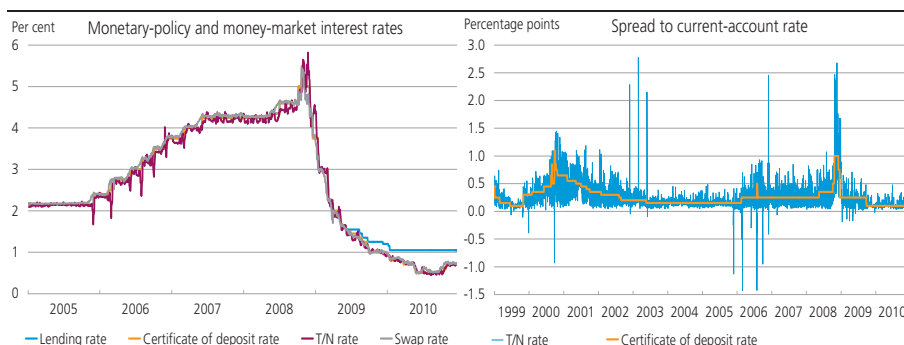
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[1] Danmarks Nationalbank (2010).

DEVELOPMENT IN MONETARY-POLICY INTEREST RATES AND
MONEY-MARKET INTEREST RATES

Chart 3.1

Note: Left-hand side: The T/N interest rate is a 5-day moving average. Right-hand side: Due to the use of 14-day maturities on monetary-policy loans and certificates of deposit, interest-rate speculation in connection with the monetary-policy interest-rate adjustments around 2002-03 and 2005-07 resulted in large technical fluctuations in the overnight rate. As a consequence, Danmarks Nationalbank changed its maturities to 7 days with effect from 2 May 2007. Until 8 June 2009, the lending rate equalled the rate of interest on certificates of deposit. The net position was subsequently positive. Last observation: 30 December 2010.
Source: Reuters EcoWin and Danmarks Nationalbank.

Transmission of monetary-policy interest rates to the money market

A well-functioning money market is important to ensure a clear pass-through from Danmarks Nationalbank's monetary-policy interest rates to the short-term interest rates in the money market and to the rest of the financial system. The formation of interest rates in the money market is the basis for the deposit and lending rates that banks offer their customers and for variable-rate mortgage loans.

The levels of the overnight interest rate in the money market and the 1-month swap rate[1] have kept close to Danmarks Nationalbank's monetary-policy interest rates, cf. the left-hand side of Chart 3.1. Danmarks Nationalbank's monetary-policy instruments are described in Box 3.1. The fluctuations in the overnight rate normally increase in step with the spread between Danmarks Nationalbank's rate of interest on certificates of deposit and the current-account rate, which was wide in the autumn of 2008. As might be expected, this led to substantial technical volatility in the T/N rate, cf. the right-hand side of Chart 3.1.[2]

On 8 June 2009, Danmarks Nationalbank introduced a margin between the lending rate and the rate of interest on certificates of deposit. The aim was to give the banks and mortgage banks a greater in-

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[1] The swap rate is the fixed interest rate in an interest-rate swap with the overnight rate (the T/N rate), cf. Danmarks Nationalbank (2009a), Box 4.2 for further details.

[2] The cause of the technical volatility is that while the overnight rate will normally be close to the current-account rate on days when Danmarks Nationalbank does not conduct open market operations, counterparties with a liquidity surplus require a comparatively high overnight rate to lend it rather than placing it in certificates of deposit on days when Danmarks Nationalbank conducts open market operations. Market participants understand the technical volatility of the overnight rate, and the fluctuations do not normally have a effect on the longer-term money-market interest rates, cf. Andersen (2004).

DANMARKS NATIONALBANK'S MONETARY-POLICY INSTRUMENTS[1]	Box 3.1

In practice, Danmarks Nationalbank conducts monetary policy via its monetary-policy instruments, i.e. the facilities used by Danmarks Nationalbank to manage and remunerate accounts (lending and deposits) with banks and mortgage banks (the monetary-policy counterparties). The instruments are used to set the monetary-policy interest rates in view of the fixed-exchange-rate policy and to manage the counterparties' accounts with Danmarks Nationalbank in terms of volume to ensure that there is always adequate liquidity within the banking system as a whole. The counterparties exchange liquidity in the money market, which includes the market for interbank loan agreements of up to 1 year. The monetary-policy counterparties have access to two facilities at Danmarks Nationalbank:

- Open market operations where, on the last banking day of each week, the counterparties can borrow funds for 7 days against securities as collateral or deposit funds for 7 days by purchasing certificates of deposit.
- Current accounts where the counterparties can place liquidity on demand. The balance of a current account cannot be negative at the close of the day.

In the weekly open market operations, the monetary-policy counterparties normally manage their accounts with Danmarks Nationalbank so as to ensure that their total deposits in current accounts meet the banking sector's expected liquidity requirement in the subsequent week. If necessary, Danmarks Nationalbank conducts extraordinary open market operations, in which it sells or buys certificates of deposit to offset liquidity fluctuations.

An overall limit has been set for the monetary-policy counterparties' total current-account deposits with Danmarks Nationalbank at the close of the day. The purpose of these limits is to prevent the build-up of large current-account deposits that may be used without notice for speculation in interest-rate and exchange-rate changes if the krone is under pressure. The counterparties may use the certificates of deposit to raise liquidity in connection with Danmarks Nationalbank's extraordinary open market operations.

[1] For a more detailed description, see Danmarks Nationalbank (2009a).

centive to even out mutual liquidity differences via the money market rather than using Danmarks Nationalbank's facilities. In general terms, the T/N rate has subsequently matched Danmarks Nationalbank's current-account rate and rate of interest on certificates of deposit. This is also to be expected when the banks' net position vis-à-vis Danmarks Nationalbank is positive, as has been the case since the introduction of the interest margin.

The development in the short-term money-market interest rates during the crisis indicates that there were no general problems with the transmission of the monetary-policy interest rates or with ensuring that there was sufficient liquidity in the banking sector.

However, there are indications that the small and medium-sized banks' exchange of liquidity in the money market was impeded in some

SPREAD BETWEEN AND DEVIATION ACROSS THE BANKS' DEPOSIT RATES
IN THE OVERNIGHT MARKET   Chart 3.2
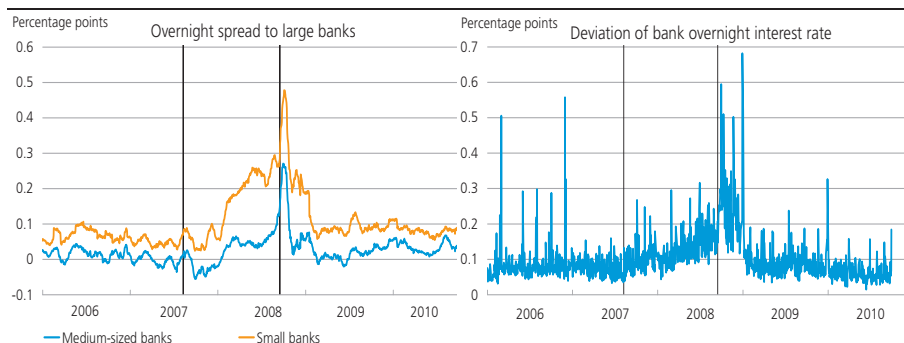
Note: The vertical lines are set at 9 August 2007 and 15 September 2008. The interest rates are the banks' interest rates
        on deposits from Danish banks and foreign T/N providers. Data from Kronos. Last observation: 30 September
        2010. Left-hand side: Large, medium-sized and small banks refer to the Danish Financial Supervisory Authority's
        groups 1, 2 and 3. 21-day moving average. Right-hand side: The strong fluctuations in 2006 reflect the 14-day
        maturities on monetary-policy loans and certificates of deposit. This resulted in large technical fluctuations in the
        overnight rate in connection with monetary-policy interest-rate adjustments.
Source: Danmarks Nationalbank.

periods. The small banks paid a premium on uncollateralised overnight
loans, which rose in the course of the crisis, cf. the left-hand side of
Chart 3.2.[1] The spread between the overnight interest rates for the
individual banks also widened considerably, cf. the right-hand side of
Chart 3.2. The small banks were affected when a number of medium-
sized banks reduced their usual lending because they themselves ex-
perienced funding problems. Compared with the large banks, at the end
of 2008 the small banks on average paid an excess interest rate of 0.25-
0.5 percentage point for loans in the overnight money market. In a few
instances, some of the small banks paid an excess interest rate of 2-3
percentage points compared with the large banks. The results from the
uncollateralised overnight market are in accordance with studies of the
interest rates on the banks' total MFI loans. Ejerskov (2009) finds that
compared with the large banks, the medium-sized banks paid an aver-
age premium of almost 1 percentage point on their total loans from
other MFIs in the autumn of 2008. A number of the medium-sized banks
with considerable funding needs in the money market paid up to 3-4
percentage points more for their loans from MFIs than the average large
bank.

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[1]   Based on data from Danmarks Nationalbank's payment system, Kronos. The payments in Danish
      kroner between the monetary-policy counterparties are effected via Kronos and settled via accounts
      with Danmarks Nationalbank. Interbank trading in uncollateralised overnight loans between
      counterparties can therefore be identified using an algorithm that searches all individual payments
      in Kronos. See Abildgren and Arnt (2004) for a more detailed description of the method to retrieve
      data on overnight loans from Kronos. Banks under the Financial Stability Company are excluded from
      the data from the day they join the Financial Stability Company.

Danmarks Nationalbank's provision of liquidity

In principle, Danmarks Nationalbank only provides liquidity to the monetary-policy counterparties once a week in connection with the regular open market operations on the last banking day of the week. In the course of the week the counterparties have to exchange liquidity themselves via the money market, unless Danmarks Nationalbank conducts extraordinary open market operations.

Danmarks Nationalbank uses an "open window" in its weekly open market operations, leaving banks and mortgage banks free to determine the volume of monetary-policy loans and certificates of deposit at the rates of interest fixed by Danmarks Nationalbank, cf. Box 3.1.

Given the open window in Danmarks Nationalbank's provision of liquidity, the use of the instruments reflects the counterparties' demand. In the years up to the eruption of the crisis, the banks and mortgage banks had built up considerable holdings of both monetary-policy loans and certificates of deposit, exceeding what could be attributed to the development in the net position, cf. the left-hand side of Chart 3.3. This gross accumulation reflects increased contingency liquidity, primarily in the form of certificates of deposit, which can be used to obtain liquidity through Danmarks Nationalbank's open market operations. The gross positions increased considerably from the summer of 2007 to the end of 2008. At the beginning of December 2008, the gross positions exceeded kr. 280 billion. They were subsequently reduced due to the support of interbank loans under Bank Rescue Package 1, which included a government guarantee for all deposits and other unsecured claims in the banks.

Because of the interest margin between Danmarks Nationalbank's lending rate and the rate of interest on certificates of deposit intro-

MONETARY-POLICY COUNTERPARTIES' LOANS AND DEPOSITS AT
DANMARKS NATIONALBANK   Chart 3.3
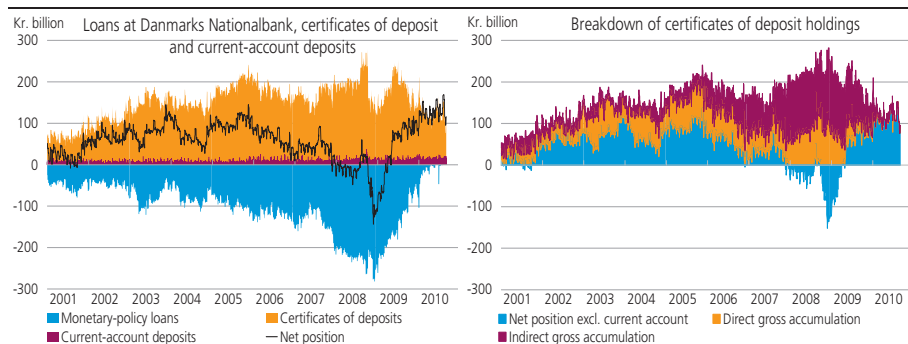
Note: Holdings of loans in foreign currency are not included in the net position. Last observation: 1 September 2010.
Source: Danmarks Nationalbank.

duced in June 2009, the gross positions have all but disappeared, so the net position corresponds to almost the entire position in current-account deposits and certificates of deposit.

The net position less current-account deposits can be seen as the banks' and mortgage banks' underlying demand for certificates of deposit. The remaining demand, i.e. the counterparties' gross accumulation, can be broken down into a direct accumulation with each counterparty financing its certificates of deposit by raising monetary-policy loans, and an indirect build-up where the counterparties' holdings of certificates of deposit correspond to other counterparties' monetary-policy loans[1], cf. the right-hand side of Chart 3.3, which shows an aggregation of this breakdown across all banks.

The direct gross accumulation amounted to around kr. 50 billion at the beginning of the crisis in August 2007. Up until the autumn of 2008, the banks increased their use of the direct channel to build up contingency liquidity. The build-up peaked at almost kr. 140 billion in early October 2008. At kr. 170 billion in early December 2008, the indirect gross accumulation was also substantial. Hence, the functioning of the money market left something to be desired, since most counterparties with a liquidity surplus preferred to place it at Danmarks Nationalbank rather than relending it. Consequently, counterparties with a funding requirement had to raise monetary-policy loans rather than borrow in the money market.

In connection with the crisis in the autumn of 2008, the counterparties also expanded their contingency liquidity by increasing their current-account deposits. This applied to the small and medium-sized banks in particular, cf. the right-hand side of Chart 3.4. On days characterised by considerable uncertainty in the market, the counterparties' total current-account liquidity was typically close to the overall current-account limit of around kr. 25 billion. At the peak of the crisis, the current-account limit was temporarily suspended on a few days at the end of September 2008. Danmarks Nationalbank was more frequently in the market unannounced to absorb liquidity by selling certificates of deposit. However, there were still only few days on which the balance was either close to or exceeded the current-account limit of just over kr. 25 billion.

All banks and mortgage banks have access to the monetary-policy instruments, enabling them to obtain liquidity in connection with open

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[1] In practice, the direct gross accumulation is found by identifying counterparties that have both certificates of deposit and monetary-policy loans. It consists of the holdings of certificates of deposit which can be offset by monetary-policy loans raised by the individual bank. The indirect gross accumulation consists of the holdings of certificates of deposit less the net position and the direct gross accumulation.

COUNTERPARTIES WITH MONETARY-POLICY LOANS AND CERTIFICATES OF
DEPOSIT, AND CURRENT-ACCOUNT DEPOSITS BROKEN DOWN BY BANKS   Chart 3.4
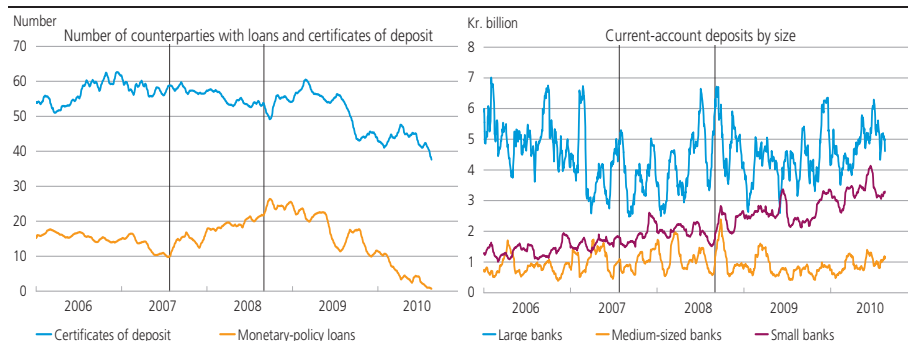
Note: The vertical lines are set at 9 August 2007 and 15 September 2008. 21-day moving averages. Right-hand side: The
        breakdown by large, medium-sized and small banks refers to the Danish Financial Supervisory Authority's groups
        1, 2 and 3. Last observation: 1 September 2010.
Source: Danmarks Nationalbank.

market operations, e.g. if this is difficult in the money market. The
number of counterparties raising monetary-policy loans doubled from
August 2007 to the autumn of 2008, cf. the left-hand side of Chart 3.4.
Small and medium-sized banks in particular accounted for the increase.
The number declined following the introduction of the interest margin
between monetary-policy loans and certificates of deposit.

Extraordinary measures introduced by Danmarks Nationalbank[1]
The open window in Danmarks Nationalbank's open market operations,
to which all banks and mortgage banks have access, and the wide range
of collateral of approximately kr. 3,000 billion, cf. Poffet (2010), have
generally been sufficient to ensure that the banks were able to obtain
the necessary liquidity at Danmarks Nationalbank. However, Danmarks
Nationalbank established temporary facilities to support the liquidity of
the small banks in particular, but they were only used to raise loans from
Danmarks Nationalbank to a limited extent. This can primarily be attri-
buted to the government guarantee under Bank Rescue Package 1, ef-
fective from October 2008. It provided all depositors and unsecured
creditors guarantee for their claims in the banks, thereby supporting the
interbank exchange of liquidity. These facilities improved confidence
among the banks about the availability of liquidity and helped small
banks to meet the Danish Financial Supervisory Authority's liquidity re-
quirement, cf. section 152 of the Danish Financial Business Act.
   In May 2008, Danmarks Nationalbank gave access to borrowing
against a new type of bond, loan bills, in order to boost the exchange of

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[1]   The measures introduced by Danmarks Nationalbank to ensure that the banks had sufficient dollar
      and euro liquidity are also described in section 6.

liquidity in the money market. Loan bills could be issued by a bank in Denmark and sold to another bank, which could pledge them as collateral to Danmarks Nationalbank, thereby raising liquidity. A total of 49 banks issued loan bills. The outstanding amount increased considerably in the autumn of 2008, reaching around kr. 30 billion. In the 1st half of 2009, the outstanding amount was gradually reduced. The loan bills issued were only to a limited extent pledged as collateral for credit from Danmarks Nationalbank. In October and November 2008, when the facility was utilised most, 4-5 banks pledged loan bills totalling up to kr. 1.5 billion. The banks that purchased the loan bills issued could include them in their liquidity, cf. section 152 of the Danish Financial Business Act. The loan bill facility was discontinued as from 17 July 2009, but the loan bills were included in the temporary collateral base until 26 February 2011, cf. below.

In September 2008, Danmarks Nationalbank introduced a new temporary credit facility. Banks and mortgage banks were given access to borrow an amount (credit facility) depending on their excess capital adequacy. Like the loan bills, the credit facility could be included in the banks' liquidity according to the Danish Financial Business Act. The purpose was to prevent liquidity problems for solvent banks as a result of shortages of assets eligible as collateral for loans from Danmarks Nationalbank. The lending rate was higher than the rate of interest for Danmarks Nationalbank's open market operations. The overall credit facility peaked at kr. 13.7 billion in April 2009. Of the 38 banks with a credit line only two banks were granted loans. The loans amounted to kr. 10-25 million. The facility was discontinued on 26 February 2011.

In connection with the introduction of loans against excess capital adequacy, the collateral basis for the usual borrowing by banks and mortgage banks from Danmarks Nationalbank was temporarily expanded to include quoted shares, investment fund shares and junior covered bonds. The collateral basis was subsequently expanded to include government-guaranteed bank bonds and junior covered bonds with individual government guarantees. Around 20 banks, primarily small ones, used the temporary collateral basis. A number of the temporary expansions of the collateral basis expired on 26 February 2011.

Measures introduced by other central banks

In view of the financial turmoil and the subsequent financial crisis, several central banks introduced a number of extraordinary measures to ensure confidence among the banks about the availability of the liquidity they needed. The measures varied from country to country depending on the countries' monetary-policy instruments. In addition to sup-

porting the availability of liquidity, the measures also aimed to improve the general funding opportunities for the banking sector as well as selected markets outside the banking sector. The latter were supported by central-bank lending and purchases of securities.

The measures comprised adjustment of existing instruments, including more frequent open market operations, larger loans, a larger supply of long-term loans, reduction of the interest rate for standing lending facilities compared to the interest rate for open market operations and expansion of the collateral base and the number of counterparties with access to central-bank instruments.[1] In October 2008, the ECB changed its liquidity allotment procedure in connection with the weekly refinancing operations by introducing full allotment of all bids at a fixed interest rate. The ECB used to determine the supply of credit at an interest rate set by tender.

The Financial Stability Forum[2], which includes the ministries of finance, central banks and financial supervisory authorities of major countries, among others, has analysed the factors and underlying weaknesses of the financial system that led to the onset of the financial turmoil in the summer of 2007.[3] Central banks are encouraged to ensure that their oprational frameworks are sufficiently flexible to handle extraordinary situations.

Even before the crisis, Danmarks Nationalbank's instruments had some of the above qualities that made it possible to manage the extraordinary liquidity situation.[4] The open window, the broad access to the instruments and the depth of collateral supported the banks' access to the liquidity they needed.

The functioning of the Danish money market
A well-functioning money market is characterised by the counterparties exchanging liquidity on market terms. Danmarks Nationalbank is the central bank in a market economy, and a market solution normally supports efficient liquidity management among its participants and efficient pricing with market interest rates reflecting market assessments of costs and risks and not only the terms of the monetary-policy instruments.

Monetary-policy counterparties use the overnight money market in their ongoing liquidity management. Total daily turnover of overnight lending fell from around kr. 50 billion at the end of July 2007, before

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[1] For an overview of the various measures, see Danmarks Nationalbank (2009a), Kjærgaard and Risbjerg (2008), Borio and Nelson (2008), Committee on the Global Financial System (2008), BIS (2009) and ECB (2009a and b).
[2] The Financial Stability Forum was replaced by the Financial Stability Board in 2009.
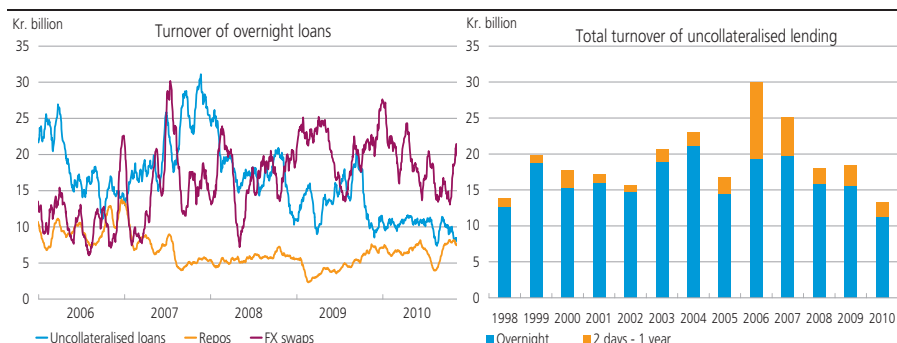[3] Cf. Financial Stability Forum (2008a), succeeded by Financial Stability Forum (2008b).
[4] Danmarks Nationalbank no longer provided lending or purchased securities. See Dam and Risbjerg (2009) for a discussion of this.

TREND IN MONEY-MARKET TURNOVER   Chart 3.5

Note: Turnover is based on reports from T/N providers. Left-hand side: 21-day moving averages. Uncollateralised loans
        are deposits. Last observation: 18 November 2010. Right-hand side: Average daily turnover in April of each year.
        Turnover of total lending in 2008 and 2009 is based on reports from a cross-section of T/N providers.
Source: Danmarks Nationalbank.

the onset of the crisis, to less than kr. 40 billion at the end of the 1st quarter of 2009. Turnover of uncollateralised lending showed the largest decline, cf. the left-hand side of Chart 3.5. This reflects the increased uncertainty about credit and liquidity conditions during the crisis. Following the introduction of the interest margin between Danmarks Nationalbank's lending rate and the rate of interest on certificates of deposit in June 2009, there was a tendency towards increasing turnover in the private market for lending against securities as collateral, i.e. the repo market.[1]

The money-market study of April 2010 – comprising the entire money market and not just the overnight market – shows lower turnover for all maturities compared with the situation in the period before the onset of the crisis in August 2007, and indicates that collateralised products accounted for a larger share of turnover than before, cf. Jørgensen and Risbjerg (2010). The study documents that the decline in turnover for uncollateralised loans was especially pronounced for longer maturities, for which the market almost disappeared, cf. the right-hand side of Chart 3.5. Turnover in the overnight market may be supported by the shift from long-term to short-term uncollateralised loans. This may be the reason for the increase in turnover in the market for uncollateralised overnight loans at the onset of the turmoil in the summer of 2007.

The small banks increased the number of uncollateralised overnight loans during the crisis, cf. the right-hand side of Chart 3.6. The number of loans and counterparties almost doubled in connection with the onset of the turmoil in the summer of 2007. Higher interest rates as well as increased current-account deposits for small banks are indications

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[1]   See Danmarks Nationalbank (2009a), Box 4.2, for a more detailed description of the repo market.

AMOUNT AND NUMBER OF UNCOLLATERALISED OVERNIGHT LOANS TO
SMALL, MEDIUM-SIZED AND LARGE BANKS   Chart 3.6
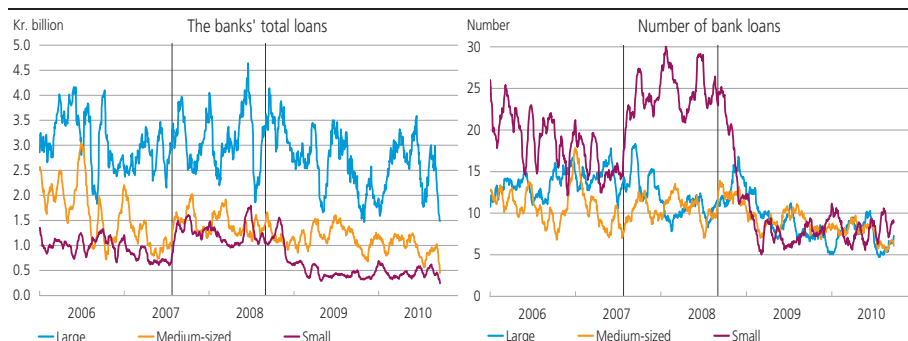
Note: The vertical lines are set at 9 August 2007 and 15 September 2008. 21-day moving averages. Large, medium-sized
         and small banks refer to the Danish Financial Supervisory Authority's groups 1, 2 and 3. Data from Kronos. Last
         observation: 30 September 2010.
Source: Danmarks Nationalbank.

that during certain periods they found it difficult to obtain liquidity in
the money market. Hence, the use of more counterparties may indicate
a reduction in the lenders' credit lines for the small banks so more banks
were needed to obtain the desired funding.

The small banks were affected when the medium-sized banks reduced
their lending because they themselves experienced funding problems.
This picture is supported by the fact that the small banks increased the
number of loans from the large banks in order to ensure their funding,
cf. the right-hand side of Chart 3.7.

The small banks also increased the volume of their overnight loans
from the large banks, cf. the left-hand side of Chart 3.7, cf. the left-hand
side of Chart 3.6.

AMOUNT AND NUMBER OF UNCOLLATERALISED OVERNIGHT LOANS
FROM SMALL, MEDIUM-SIZED AND LARGE BANKS TO SMALL BANKS   Chart 3.7
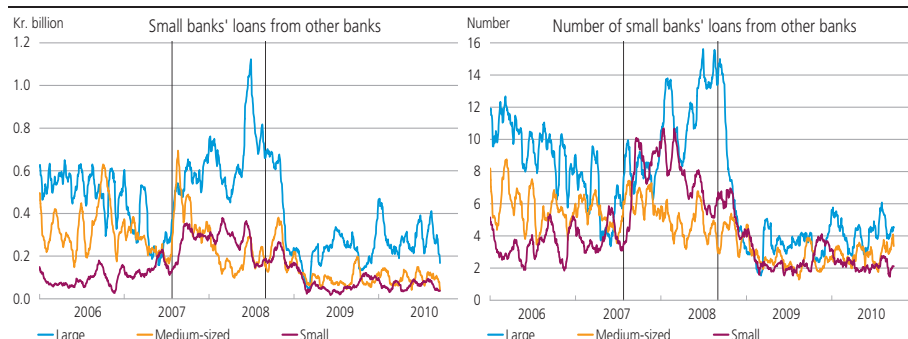
Note: The vertical lines are set at 9 August 2007 and 15 September 2008. 21-day moving averages. Large, medium-sized
         and small banks refer to the Danish Financial Supervisory Authority's groups 1, 2 and 3. Data from Kronos. Last
         observation: 30 September 2010.
Source: Danmarks Nationalbank.

Conclusion

The development in short-term interest rates indicates that during the crisis there were generally no problems with the transmission from the monetary-policy interest rates to the money market or with ensuring sufficient krone liquidity in the banking sector.

Turnover in the money market declined, however. It became concentrated at the very short end of the market and switched from uncollateralised to collateralised lending when growing credit and liquidity risks kept banks from granting long-term uncollateralised loans. The banks increased their loans and deposits at Danmarks Nationalbank at the end of 2008, whereby the short-term interbank market was partly replaced by accounts with Danmarks Nationalbank. In gross terms, the loans and deposits peaked in December 2008 when the banks and mortgage banks' holdings of certificates of deposit exceeded their net position vis-à-vis Danmarks Nationalbank by just over kr. 280 billion.

There are also indications that some small and medium-sized banks' exchange of liquidity in the money market was impeded during certain periods. The analysis in this article shows that the excess interest rate they paid on uncollateralised loans rose substantially. Compared with the large banks, at the end of 2008 the small banks on average paid an exceaa interest rate of 0.25-0.5 percentage point for loans in the overnight money market, which is fundamental to the banks' ongoing liquidity management. In a few instances some of the small banks paid a premium of 2-3 percentage points. The small banks were affected when the medium-sized banks put a stop to their usual lending when they themselves experienced funding problems. The spread in the individual banks' overnight interest rates widened considerably. The small banks' problems obtaining liquidity in the money market during the crisis was also reflected in the fact that they almost doubled the number of counterparties for uncollateralised overnight loans. They had to depend on more sources to ensure their funding. The small and medium-sized banks also increased their loans from Danmarks Nationalbank.

The structure of Danmarks Nationalbank's monetary-policy instruments proved to be resilient to the crisis, and they were not adjusted during the crisis. The open window in Danmarks Nationalbank's open market operations, the broad access to the instruments and the wide range of collateral supported the banks' access to the liquidity they needed. The extent of loans in connection with Danmarks Nationalbank's extraordinary measures was very limited, but the measures were important in order to underpin the banks' ability to meet the liquidity requirements in accordance with section 152 of the Danish Financial Business Act.

4. THE SPREAD BETWEEN COLLATERALISED AND UNCOLLATERALISED INTEREST RATES

A widened spread between uncollateralised and collateralised money-market interest rates may be a sign of a poorly functioning money market. If measures are to be taken to solve problems in the money market, it is necessary to identify the underlying reasons for the widened money-market spread. The spread can be broken down into a credit risk premium and a liquidity risk premium[1], cf. Box 4.1.

If the spread widens due to increasing liquidity risk, measures that improve the functioning of the money market or the banks' liquidity situation may be useful. But if the widening primarily reflects a higher level of credit risk, measures to support the banks' solvency may be more relevant. In addition to knowing the extent of credit or liquidity risk, it is important to know whether the pressures are caused by domestic problems or spillover effects from abroad.

In the wake of the crisis and the turmoil in the international money markets there was increased focus on breaking down the money-market spread.[2] As the credit and liquidity risk premiums cannot be observed directly, such a breakdown is subject to uncertainty. The relevant literature proposes several approaches to and many different measures of the credit and liquidity risk premiums. The results depend on the measures used.

In the following, the Danish money-market spread is first broken down by means of a simple but frequently used method. Thereafter, the credit and liquidity risk premiums as well as any spillover effects from the euro area and the USA are estimated using a number of different measures.

A simple breakdown of the money-market spread

The Danish money-market spread is calculated as the difference between the uncollateralised interest rate and the swap rate, cf. Box 4.2. The money-market spread is commonly broken down by estimating the credit risk premium based on the price of credit default swaps, CDS. The liquidity risk premium is then defined as the difference between the money-market spread and the estimated credit risk premium.[3]

A CDS is a contract that insures the buyer against losses on a bond if the bond issuer fails or defaults on its obligations. The price of a CDS –

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[1] It is in fact an illiquidity risk premium, since the premium is reduced with increasing liquidity.
[2] Typically, the authorities will very quickly be able to identify the underlying reasons for the widened money-market spread, e.g. through direct contact with the market participants.
[3] See Kjærgaard and Skjærbæk (2008) for a similar breakdown of the money-market spread in Denmark.

CREDIT AND LIQUIDITY RISK PREMIUMS	Box 4.1

Credit risk premium

The credit risk premium is a payment to a lender for assuming the risk that the borrower will default on its payment obligations. The premium rises when the probability that the borrower is unable to repay the loan increases. A higher credit premium may cause the creditworthy banks to reduce their borrowing or withdraw from the market for uncollateralised loans, after which it will increasingly be risky borrowers that raise loans in the market (adverse selection). This mechanism will result in a further reduction of average credit standing in the money market, cf. e.g. Heider, Hoerova and Holthausen (2009).

Liquidity risk premium

There are two types of liquidity: market liquidity and funding liquidity.

Market liquidity

Market liquidity concerns the liquidity of financial assets. A high level of market liquidity reflects the possibility of trading large amounts quickly without any particular price effect. By contrast, a low level of market liquidity means that trading affects prices. Hence, market liquidity risk can be defined as the risk of incurring costs as a result of poor liquidity when trading is needed. In general, price-quoting systems will support market liquidity. Throughout the trading day, the participants in the price quoting system are obliged to quote bid and ask prices at an agreed maximum amount and spread on their own account. The participants in the price quoting system are exposed to market and liquidity risk because they have holdings of securities, and they are compensated for this via the spread between bid and ask prices. Increased market volatility will consequently tend to reduce market liquidity, cf. Brunnermeier and Pedersen (2009).

Funding liquidity

Funding liquidity is the possibility of obtaining liquidity when needed. Funding liquidity risk is the risk of being unable to obtain sufficient liquidity when needed, or of a sharp rise in the costs involved. A bank may obtain liquidity via both assets and liabilities. On the assets side, it may e.g. draw on deposits with other banks, or it may sell securities. On the liabilities side, it may raise uncollateralised loans or loans with assets as collateral, e.g. repo loans. Loans raised at short notice are typically short-term loans, i.e. money-market loans. Hence, well-functioning money markets are essential to ensure the banks' access to funding liquidity.

Linkage between market liquidity and funding liquidity

Market liquidity and funding liquidity are closely linked. A decrease in the market liquidity of the assets owned by a bank normally leads to a decrease in the collateral value of the assets. One reason is that a haircut on repos normally increases with the degree of illiquidity. If the collateral value of the assets falls, access to funding liquidity will be reduced. This causality may also go from funding liquidity to market liquidity. If funding liquidity deteriorates for participants in price-quoting systems and other central players in the financial markets, their capacity to support market liquidity will also deteriorate. This may give rise to negative liquidity spirals in times of

CONTINUED	Box 4.1

crisis when negative shocks to funding liquidity, e.g. by losses related to problems in the subprime market, reduce market liquidity, which in turn means lower funding liquidity, and so forth.

During a crisis, market liquidity may also deteriorate due to heightened uncertainty and market volatility, and to banks tightening their risk management and reducing their positions. This may lead to a reduction of funding liquidity, which in turn causes a deterioration of market liquidity, and so forth, cf. Brunnermeier and Pedersen (2009), Pedersen (2008) and Brunnermeier (2009).

Linkage between credit and liquidity risk premiums

Credit and liquidity risk premiums are also interdependent. If a borrower is hit by a large unexpected liquidity shock, a low level of funding liquidity will increase the risk of the borrower being unable to repay the loan. For the lender, a defaulted loan is a liquidity shock, because the funds of the outstanding payment must be obtained in some other way.

known as the CDS spread – is the annual payment per krone for this insurance. The spread reflects the premium an investor requires to hold a specific bond compared with a risk-free bond. Hence, the CDS spread may be seen as a proxy for the credit risk premium.[1] A simple method to determine that premium is to equate it with the 1-year CDS spread and compare it with the 1-year money-market spread defined as the difference between Cibor and the swap rate.[2]

Obviously, credit risk premiums can only be calculated on the basis of CDS spreads for those banks for which such spreads are available. For a number of important participants in the uncollateralised Danish money market, no CDS prices are available, so the calculated CDS spread is not necessarily fully representative of the participants in the Danish money market.

At the onset of the crisis in the summer of 2007, the credit risk premium derived from the 1-year CDS spread rose only slowly, cf. Chart 4.1. It gradually gained momentum in late 2007 and early 2008. On the other hand, the substantial widening of the money-market spread from mid-2008 – and particularly in connection with Lehman Brothers' suspension of payments in September 2008 – seems to be generally linked to a higher liquidity risk premium. In the course of 2009 the spread came to

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[1] Alternatively, the probability that the bond issuer will fail can be derived from the CDS spread. The credit risk premium can then be determined on the basis of the estimated failure rate and the repayment rate, cf. Manning (2004). In practice, the difference between the CDS spread and the calculated credit risk premium – given risk-neutral investors – is quite small, however.

[2] The CDS market is most liquid for maturities of 5 years. As the credit risk premium increases with the maturity, the 5-year CDS spread cannot be used directly to determine the credit risk premium of e.g. the 1-year money-market spread.

CALCULATION OF THE MONEY-MARKET SPREAD	Box 4.2

In analyses of the money-market spread, the uncollateralised interest rate is typically determined by a reference rate based on rates fixed by a number of banks, e.g. Cibor in Denmark. There are two overall reasons for this. Firstly, data on actually traded uncollateralised lending is typically not available, except for the very short-term money market. Secondly, since a number of financial contracts are linked to the reference rate, this is of great importance to the economy as a whole. However, the use of reference rates is not unproblematic, as the actual turnover on which they are based is sometimes very limited, and they typically react more sluggishly to changed conditions than actually traded interest rates.

For the collateralised interest rate, the swap rate in swaps exchanging the overnight rate for a fixed interest rate, called the swap rate, is typically used. On expiry, the difference between the swap rate and the average overnight rates realised over the term of a swap is exchanged. Hence, the swap rate reflects the expectations of the overnight rate, i.e. the swap rate can be interpreted as the expected interest cost of regularly renewing an uncollateralised overnight loan over the term of the swap. This strategy entails an interest-rate risk in relation to e.g. a 3-month loan, as the future overnight rates are not known. The swap rate can also be seen as an expression of a strategy of overnight borrowing pooled with an interest-rate swap where the overnight rate is received and the swap rate is paid, cf. Gorton and Metrick (2009), thereby hedging the interest-rate risk. In practice, there will be a difference between a bank's overnight lending rate and the overnight reference rate in an interest-rate swap. From the lender's point of view, the swap rate consequently reflects ongoing overnight lending with limited credit and liquidity risk.

The spread between the uncollateralised money-market interest rate and the swap rate can be broken down into credit and liquidity risk premiums. The credit risk premium can be attributed to the fact that a credit event is more likely to occur during a period of e.g. 3 months than overnight. The liquidity risk premium reflects that in the case of 3-month loans the lender will not have access to the liquidity lent for 3 months, whereas in the case of overnight loans the lender has ongoing access to the liquidity and may decide whether to provide lending.

predominantly imply a credit risk premium, reflecting that the crisis developed from a liquidity crisis into a credit crisis.[1]

The use of CDS spreads as a measure of the credit risk premium is not unproblematic. Dick-Nielsen, Feldhütter and Lando (2009) argue that a liquidity risk premium is included in the CDS spread.[2] This is reflected by the CDS spread often being wider than the bond spread to the risk-free interest rate. Hence, the assumption that the entire CDS spread is an expression of credit risk may lead to a tendency to overestimate the impact of the credit risk premium.

[1] See e.g. Holthausen and Pill (2009) and Soultanaeva and Strömqvist (2009) for similar results for the euro area and Sweden, respectively. In the US market, several studies indicate that the crisis was already a credit crisis when Lehman Brothers suspended payments in September 2008, cf. Sarkar (2009) and Taylor and Williams (2009).

[2] See Jensen (2008) for a discussion of factors influencing the CDS spread.

MONEY-MARKET SPREAD AND CDS SPREAD   Chart 4.1

Basis points
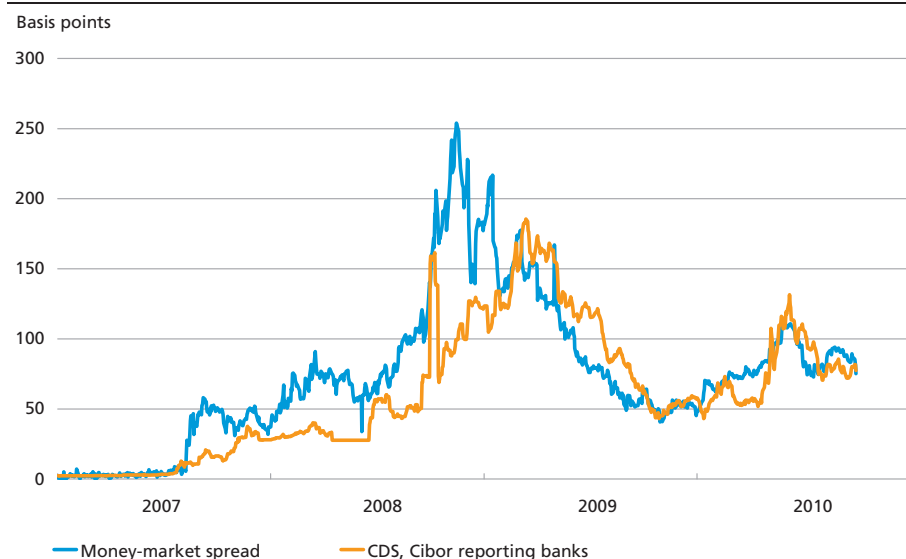
Note: The Chart shows the 1-year CDS spread and the 1-year money-market spread. The 1-year CDS market is not
        particularly liquid. Hence, there are periods during which the CDS spreads are unchanged. Last observation: 30
        September 2010.
Source: Reuters EcoWin and Bloomberg.

Estimation of the credit and liquidity risk premiums

The simple breakdown above defines the liquidity risk premium as a residual. However, in the literature there are suggested many different measures of the liquidity risk premium in order to allow the credit and liquidity risk premiums to be estimated separately. In the following, we construct a number of measures of the credit and liquidity risk premiums, which are subsequently used to break down the Danish money-market spread into three factors, i.e. a credit risk premium, a liquidity risk premium and spillover effects from abroad.

A measure of the credit risk premium in Denmark

As described in Box 4.1 above, the credit risk premium is a payment to a lender for assuming the risk of the borrower defaulting on its payment obligations. The adoption of Bank Rescue Package 1 in October 2008 included a government guarantee for all depositors' and other unsecured creditors' claims in banks. However, the banks mainly determined their credit policies vis-à-vis other banks as if Bank Rescue Package 1 did not exist. Furthermore, some market participants may have been uncertain about how quickly they would be able to receive government funds if a counterparty failed. If the government was only able to honour claims with a certain lag, the failure of a counterparty might lead to losses due to a shortage of liquidity. Consequently, Bank Rescue Package 1 did not

eliminate all credit risk, although it is expected to have reduced the credit risk premium.

The literature suggests a number of different credit risk measures. We have constructed three different types of credit measures for Denmark, the first being the CDS spreads, a widely used measure of credit risk, cf. above. The CDS market is most liquid for maturities of 5 years. We use the annual CDS spread for 5-year CDS contracts as a measure of the credit risk premium.

The second measure is daily standard deviations as regards uncollateralised money-market interest rates, cf. Sarkar and Shrader (2010). A large difference between the highest and lowest interest rates may imply that some banks find it difficult to obtain loans due to credit risk. We have constructed four such credit measures, i.e. the standard deviation of the reports for Cibor, O/N and T/N and of paid short-term money-market interest rates determined on the basis of Kronos data for uncollateralised overnight loans, cf. section 3.[1]

The third and last measure of the credit risk premium is a ranking measure based on Kronos data.[2] The banks are ranked according to the interest they pay on uncollateralised overnight loans. The ranking measure is subsequently calculated as the daily spread between the average interest paid by the seven banks which have, in relative terms, paid the lowest interest rates, and the seven banks which have, in relative terms, paid the highest.[3]

There is substantial correlation between the different measures. The credit measures based on the standard deviation of the short-term money-market interest rates and the ranking measure match each other closely, cf. Chart 4.2. The ranking measure and the standard deviation based on data from Kronos are the measures that seem to respond most to the adoption of Bank Rescue Package 1.

A measure of the liquidity risk premium in Denmark
Funding liquidity is normally measured on the banks' balance sheets and is consequently available only at a less than daily frequency. For this reason, measures of funding liquidity are not included, but, as described in Box 4.1 above, there is substantial correlation between market and

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[1] O/N and T/N rates are trade-weighted averages. Cibor and Kronos rates are non-weighted averages.
[2] Based on Schwartz (2010).
[3] The measure has been constructed using a panel estimation. The interest rate on individual money-market loans is estimated using constants for each bank and each day. The constant for each bank is an expression of the relative interest rate the bank pays compared with the other banks, and it can consequently be used as a ranking measure. Only banks that are active for at least 10 per cent of the days are included. In addition, the banks with the highest and lowest constant, respectively, are removed. Seven banks have been selected for each of the two groups as this was the lowest number that would ensure a ranking measure for which only few observations were missing.

CREDIT MEASURES   Chart 4.2
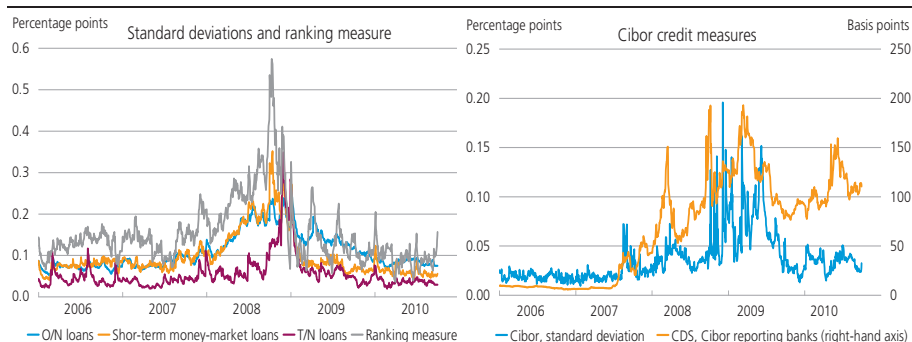
Note: Left-hand side: Data has been smoothed using simple exponential smoothing. Besides, four outliers in 2006 have
         been removed. Last observation: 30 September 2010.
Source: Own calculations based on data from Reuters EcoWin, Bloomberg, Nordea Analytics and Kronos.

funding liquidity.[1] Hence, the development in market liquidity can be used as a measure of funding liquidity.

As with the credit risk premiums, a number of different measures of market liquidity based on daily observations are mentioned in the literature. We have constructed four measures. The first measure is the yield spread between bonds issued by Ørestadsselskabet (Ørestad Development Corporation) and the government, respectively, maturing in 2015.[2] As the credit risk is identical for the two bonds, the yield spread equals the liquidity risk premium.[3]

The second measure is an Amihud index measuring the percentage price change for a given trade volume. We have constructed a weighted Amihud measure based on Amihud indices for Danish government and mortgage bonds, cf. Buchholst, Gyntelberg and Sangill (2010). Each index was given a weight corresponding to the share of the bond type in question of the total nominal outstanding volume.

The third measure is a Bollen Whaley index, cf. Schwartz (2010).[4] The index is calculated as the relationship between the bid and ask spread for 2-year government bonds and the volume that can be traded at the given bid and ask prices.[5] The development in the index is primarily determined by the price-quoting systems applying at a given time. Price-

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[1] However, we have tested two measures of funding liquidity, i.e. the banks' current-account deposits with Danmarks Nationalbank and their holdings of certificates of deposit. None of the measures are significant.

[2] As Ørestad Development Corporation is a general partnership owned by the Danish government and the City of Copenhagen, the government can be made liable for any losses of the company. Hence, its issuance is fully government-guaranteed, cf. Danmarks Nationalbank (2003), p. 103. We have also tested A/S Storebælt (the Great Belt Bridge) which resulted in almost identical estimations, albeit with slightly lower explanatory power.

[3] The maturity reduction will reduce the spread on an ongoing basis, but the impact is assessed to be minimal.

[4] Here, the index is calculated as an illiquidity index, i.e. the reciprocal of the Bollen Whaley index.

[5] The calculations are based on MTS data, see e.g. Danmarks Nationalbank (2009b), pp. 64 ff.

quoting systems are agreements between the price quoters and Government Debt Management under which the price quoters are obliged to quote bid and ask prices within fixed spreads and for fixed amounts. If the conditions of the agreement are changed, the index may show discrete leaps.

The fourth and last measure is the implied option volatility in the US equity market, the VIX index.[1] In many studies, this index is seen as an expression of the general market risk, cf. McAndrews, Sarkar and Wang (2008) and Sarkar and Shrader (2010). Increased market volatility may reduce market liquidity, and Brunnermeier and Pedersen (2009) see VIX as an underlying liquidity factor.

There is considerable overlap between the four measures and particularly between VIX and Amihud, cf. the right-hand side of Chart 4.3. On the other hand, the spread between government-guaranteed bonds and government bonds as well as the Bollen Whaley index show somewhat different development patterns.

International impact
According to the covered interest-rate parity, the interest rate on assets that are identical apart from the currency in which they are issued should be the same when the currency risk is hedged. If the covered interest-rate parity remains unchanged, the money-market spread will be almost the same across countries, cf. Box 2.1, and the spillover effect from abroad may be substantial.

The covered interest-rate parity is not always met, however, and in several instances deviations have been observed for prolonged periods in connection with turmoil in the financial markets. The deviations may be attributable to a number of factors, including large transaction costs or considerable credit and liquidity risk in individual markets.

Empirical studies indicate that large deviations from the covered interest-rate parity for a prolonged period and thus differences in the money-market spreads across countries are mainly attributable to major credit risk variations across markets, cf. Alper and Ardic (2010). If banks borrowing in a market are generally less creditworthy than banks in other markets, higher interest rates will reflect compensation for increased risk rather than an unrealised excess return. For banks with excess liquidity, however, lending in a market with limited liquidity will be an attractive option if it provides a higher return and the credit risk is the same.

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[1] VIX is a measure of the implied expected volatility derived from market-based option prices. Higher option prices signal higher expected volatility, since higher volatility increases the probability of the option getting "in-the-money".

LIQUIDITY MEASURES
Chart 4.3
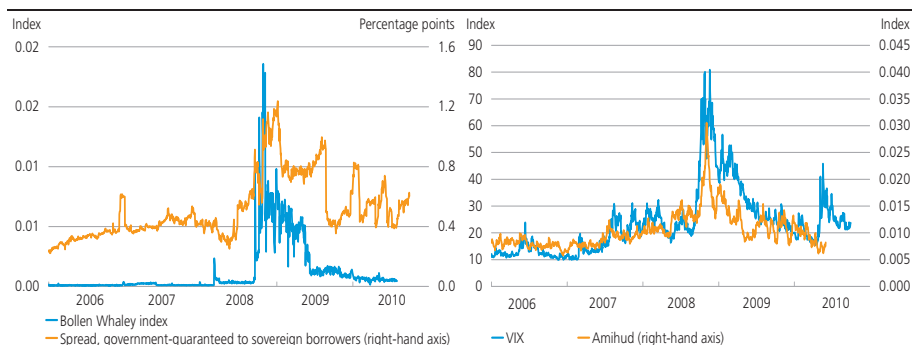
Note: The Amihud index has been smoothed using simple exponential smoothing, the smoothing parameter being estimated by minimising sums of the squared forecast errors. Last observation: Bollen Whaley index: 2 August 2010, Spread: 20 September 2010, VIX: 30 September 2010, Amihud: 2 June 2010.
Source: Own calculations based on data from Reuters EcoWin, Bloomberg, Nordea Analytics and Kronos.

First, the money-market spread in the euro area is used as a measure of international contagion. Measures of the international credit and liquidity risk premiums in both the euro area and the USA are subsequently applied to make it possible to identify the channels through which international contagion was particularly pronounced.

As a measure of the credit risk premium in the euro area, an average of the 5-year CDS spreads for selected Euribor reporting banks is used, cf. Eisenschmidt and Tapking (2009). For the USA, the 5-year CDS spreads for selected systemically important US banks are used, cf. Coffey, Hrung and Sarkar (2009). There is a high level of covariance between the three CDS indices.[1]

The yield spread between bonds maturing in July 2015 and issued by the German Kreditanstalt für Wiederaufbau and the German government, respectively, is used as a measure of the liquidity risk premium in the euro area. For the USA, the difference between 2-year benchmark bonds issued by Fannie Mae and the US government is used.

Estimations
We estimate the Danish money-market spread on the basis of the Danish and international credit and liquidity measures on a daily basis. The model is a simple OLS model based directly on the levels so that it can be used to break down the money-market spread. We use Newey-West standard deviations adjusting for autocorrelation and heteroskedasticity in the error terms. The following equation is estimated:

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[1] While the correlation between the CDS spreads for Cibor and Euribor reporting banks is 0.98, the correlation between the CDS spreads for Cibor reporting banks and US banks is 0.88.

$$Spread_t^{DK} = \alpha + \beta_1 Liquid_t^{DK} + \beta_2 Credit_t^{DK} + \beta_3 Liquid_t^{EUR}$$
$$+ \beta_4 Credit_t^{EUR} + \beta_5 Liquid_t^{USA} + \beta_6 Credit_t^{USA} + \varepsilon_t$$

where $Spread^{DK}$ is the money-market spread in Denmark, and $Liquid$ and $Credit$ are measures of the liquidity and credit risk premium, respectively, in Denmark, the euro area and the USA. α is a constant.

All the credit and liquidity measures used are significant and have the expected sign in estimations where they are included as the only credit or liquidity measure. The estimations are not shown.

For market liquidity, the best individual measure is the yield spread between government bonds and government-guaranteed bonds. Combining the three Danish liquidity measures, i.e. all the liquidity measures except VIX, using a principal component analysis, results in a liquidity measure that improves the explanatory power.[1] Consequently, we choose this index in the estimations.[2]

The highest explanatory power among the measures of the credit risk premium is obtained using the CDS spread. Combining several credit measures in a principal component analysis does not result in an index with higher explanatory power than the CDS spread alone. However, we choose to include the ranking measure which is considered to be the purest credit measure we have.

Model 1 estimates the Danish money-market spread solely using Danish measures. The spillover effect from abroad is included in model 2 via the money-market spread in the euro area. Model 3 models the international contagion using the measures of international credit and liquidity risk premiums. Given the reservations related to using the CDS spreads as a measure of the credit risk premium, we supplement the estimations with a model 4, in which the credit risk premium in Denmark is based only on the ranking measure, and the credit measures for the euro area and the USA are omitted on the grounds that spillover effects across markets are mainly caused by differences in liquidity premiums.

In general, high explanatory powers are obtained, and significant variables have the expected signs, cf. Table 4.1. There is considerable

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[1] In a principal component analysis, PCA, a purely mathematical partition is performed to break down the data into a number of uncorrelated components called principal components. The first component explains as much of the data variation as possible, and the subsequent components each explains as much as possible of the remaining data variation. If the data mainly follows a uniform pattern, the first component will be able to explain most of the data variance, and that component may therefore summarise the data without losing important information. See e.g. Campbell, Lo and MacKinlay (1997) for a review of PCA.

[2] We have also constructed a liquidity measure based on a PCA of all four liquidity measures, i.e. including VIX. This measure increases the explanatory power marginally, but to get a measure of liquidity in Denmark we choose to use the measure without VIX.

REGRESSION RESULTS FOR THE DANISH MONEY-MARKET SPREAD				Table 4.1
Right-hand-side variables	Model 1	Model 2	Model 3	Model 4
Credit premium, DK (CDS spread)	0.41*** (0.04)	0.35*** (0.02)	0.33** (0.16)	---
Credit premium, DK (ranking measure)	67.74*** (20.76)	---[1]	---[2]	39.84* (22.66)
International contagion (spread, EUR)	---	51.38*** (3.17)	---	---
Credit premium, EUR	---	---	-0.04 (0.14)	---
Credit premium, USA	---	---	0.10 (0.09)	---
Liquidity premium, DK	13.87*** (1.66)	6.64*** (0.83)	9.26*** (2.12)	6.09*** (2.05)
Liquidity premium, EUR	---	---	0.29* (0.17)	1.34*** (0.12)
Liquidity premium, USA	---	---	0.18*** (0.06)	0.15*** (0.05)
Constant	9.77** (4.32)	3.16 (2.55)	2.73 (4.51)	-4.26 (5.40)
R^2	0.89	0.94	0.90	0.87

Note: * 10 per cent significance level, ** 5 per cent significance level and *** 1 per cent significance level. The figures in parentheses indicate Newey-West standard deviations adjusting for autocorrelation and heteroskedasticity. Estimation period: daily observations from 4 January 2006 to 1 June 2010.
Source: Own calculations based on data from Reuters EcoWin, Bloomberg and Nordea Analytics.
[1]   The sign of the ranking measure becomes negative and is consequently omitted. This may create a bias towards overestimating the credit risk premium.
[2]   If the ranking measure is included, none of the credit risk premium measures become significant as a result of multicollinearity.

autocorrelation and heteroskedasticity in the error terms, which is why Newey-West standard deviations are shown.

Model 1 estimates the money-market spread solely using Danish measures of the credit and liquidity risk premiums, i.e. the weighted measure of liquidity and the Danish CDS spread and the credit ranking measure. The measures of both premiums are highly significant. The weight of the ranking measure is small, so the credit risk premium is driven mainly by the development in the CDS spread. The constant is significantly positive, indicating that the Danish credit and liquidity measures cannot fully explain the development in the Danish money-market spread.

Breaking down the money-market spread on the basis of model 1 gives a picture similar to the simple breakdown based on the CDS spread alone, cf. Chart 4.1. The estimation implies a significant positive constant, indicating that the estimated level of the pre-crisis money-market spread is too high. Accordingly, the model fails to adequately capture the great leap in the level in early August 2007. While the credit risk

FACTORS OF THE DANISH MONEY-MARKET SPREAD, MODEL 1   Chart 4.4

Basis points
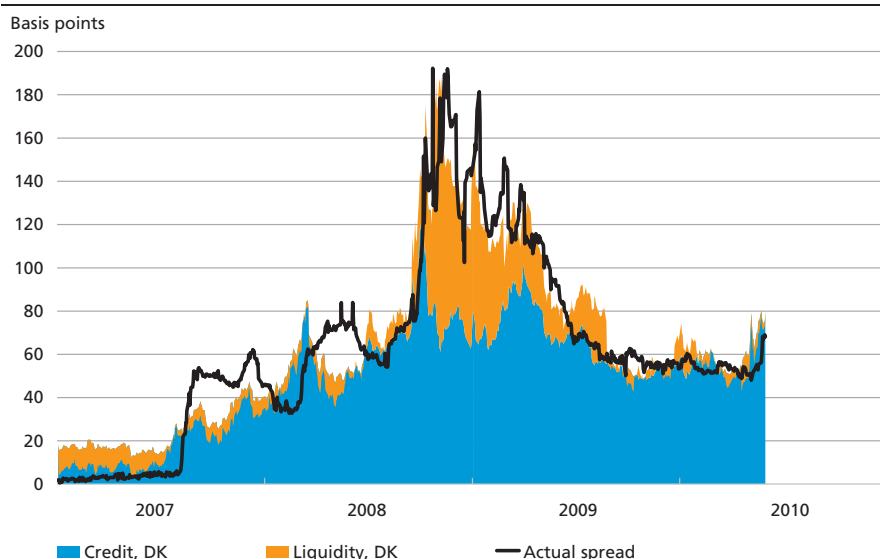
Note: Based on model 1 in Table 4.1. The breakdown does not add up to the actual spread as the estimation includes
         unexplained residuals. The constant is broken down into credit and liquidity risk premiums, leaving the relative
         weight between the two unchanged. Last observation: 1 June 2010.
Source: Own calculations based on data from Reuters EcoWin, Bloomberg and Nordea Analytics.

increases at the beginning of the crisis, this is not enough to fully ex-
plain the widening of the money-market spread, cf. Chart 4.4. In the
period after the failure of Lehman Brothers, the development was pri-
marily driven by higher liquidity risk. This changed in the course of 2009,
however, in that credit risk became the main driver.

The model is improved by including the money-market spread in the
euro area as an overall measure of international credit and liquidity risk
premiums. The constant is no longer significant, and the explanatory
power increases.

When the money-market spread is broken down using model 2, the
leap in the money-market spread in August 2007 is captured fairly well,
cf. Chart 4.5. Hence, at the beginning of the crisis, the Danish money-
market spread was driven primarily by external factors represented by
the money-market spread of the euro area, which, according to the ECB,
was mainly driven by liquidity risk premiums during that period, cf.
Holthausen and Pill (2010). From mid-2009, the spillover effect declined,
and subsequently the spread was mainly driven by the Danish credit risk
premium.

In model 3 the money-market spread of the euro area is replaced by
measures of international credit and liquidity risk premiums. According
to this model, international liquidity risk premiums in particular drove
up the Danish money-market spread at the beginning of the crisis, cf.

FACTORS OF THE DANISH MONEY-MARKET SPREAD, MODEL 2 | Chart 4.5

Basis points
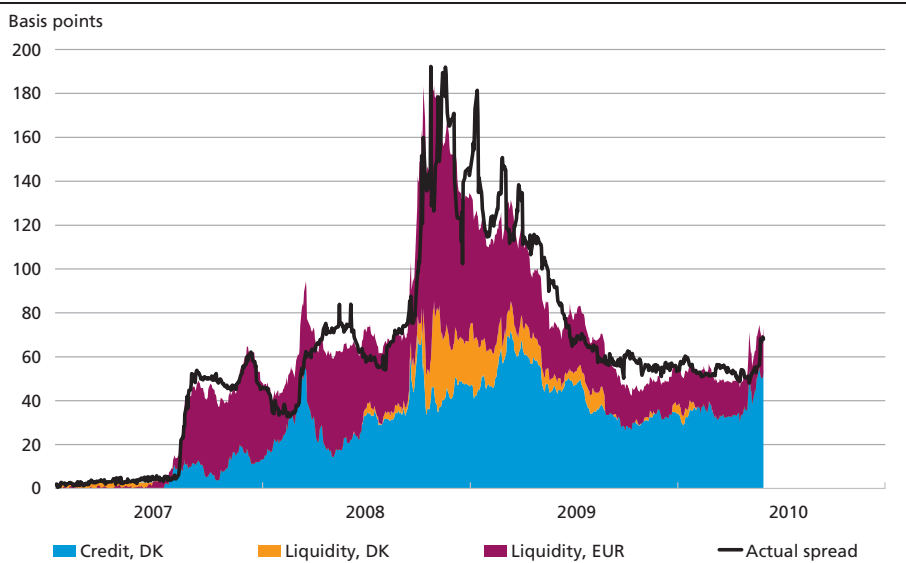
Note: Based on model 2 in Table 4.1. The breakdown does not add up to the actual spread as the estimation includes unexplained residuals. Last observation: 1 June 2010.
Source: Own calculations based on data from Reuters EcoWin, Bloomberg and Nordea Analytics.

Chart 4.6. This is in line with other empirical studies indicating that differences in credit risk among the money markets during periods of financial turmoil will typically be reflected in deviations from the covered

FACTORS OF THE DANISH MONEY-MARKET SPREAD, MODEL 3 | Chart 4.6

Basis points

Note: Based on model 3 in Table 4.1. The breakdown does not add up to the actual spread as the estimation includes unexplained residuals. Last observation: 1 June 2010.
Source: Own calculations based on data from Reuters EcoWin, Bloomberg and Nordea Analytics.
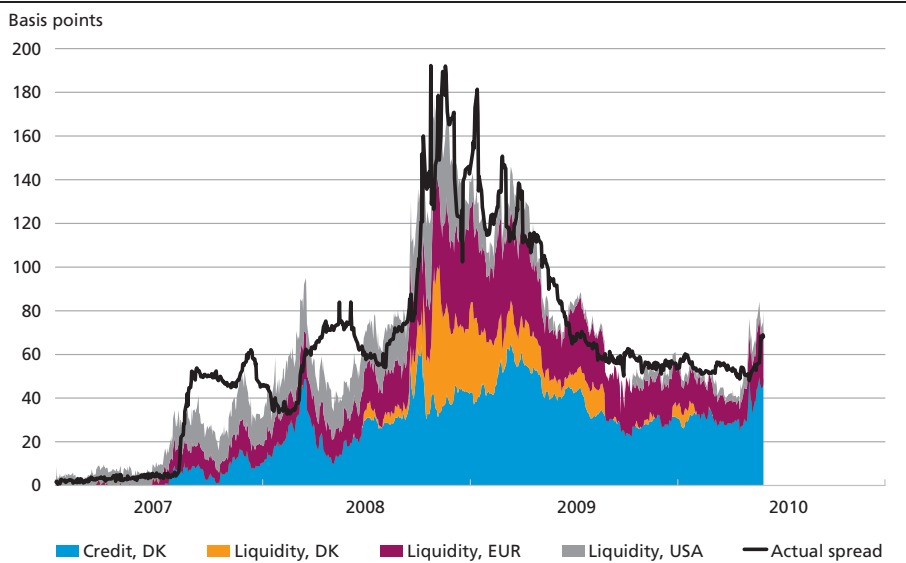
FACTORS OF THE DANISH MONEY-MARKET SPREAD, MODEL 4   Chart 4.7
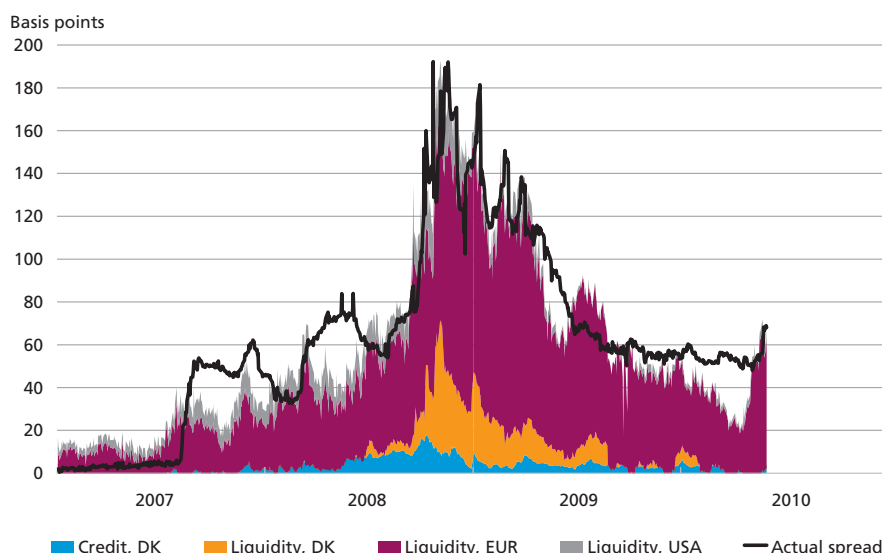
Basis points

Note: Based on model 4 in Table 4.1. The breakdown does not add up to the actual spread as the estimation includes
        unexplained residuals. Last observation: 1 June 2010.
Source: Own calculations based on data from Reuters EcoWin, Bloomberg and Nordea Analytics.

interest-rate parity rather than a spillover effect on the money-market spreads. At the beginning of the crisis, our measures of international credit and liquidity risk premiums cannot fully explain the development in the Danish money-market spread, however. After Lehman Brothers' suspension of payments, the Danish liquidity risk premium came to play a certain role. As liquidity returned to the money markets in the course of 2009, greater weight was attached to Danish credit risk premiums in model 3, though not as much as in model 1, cf. Chart 4.4 above.

In order to assess the importance of the CDS spreads in the estimation, all CDS spreads are omitted in model 4. The credit risk premium in Denmark is measured using the ranking measure, but alternative measures of the credit risk premiums in the euro area and the USA are not included on the grounds that international contagion takes place mainly via liquidity risk premiums.[1] This produces a markedly different result with the credit risk premium having little impact on the Danish money-market spread and the development being driven predominantly by the liquidity risk premium in the euro area, cf. Chart 4.7. Even though we have omitted the measures of the credit risk premiums in both the euro area and the USA, the explanatory power of the model declines very little.

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[1] If the CDS spread for the euro area is included, models 3 and 4 become practically identical. The reason is the very considerable overlap between the CDS spreads for Denmark and the euro area.

Model 4 is inconsistent with other data, however. Hence, the decreasing turnover in the uncollateralised money market, cf. section 3, indicates a substantial credit risk premium.

Robustness

If the period is shortened to the beginning of 2009, the estimated money-market spreads in 2009 and 2010 are generally lower than the observed spreads. This is particularly true in model 2, where the international contagion is described by means of the money-market spread in the euro area, but also to a lesser degree in models 3 and 4.

Estimation of a long-term model, in which the lagged value of the Danish money-market spread is included on the right-hand side of the equation, generally implies that the importance of the Danish credit risk premium increases without substantially changing the results.

It should be noted that after the adoption of Bank Rescue Package 1, the estimated credit risk premiums generally did not fall. This is consistent with other data, e.g. the falling turnover in the uncollateralised money market since the beginning of the crisis. The high estimated credit risk premiums after Bank Rescue Package 1 presumably reflect the fact that many banks determined their credit policies as if Bank Rescue Package 1 had not been adopted.

A comparison of the four models shows the importance of the measures selected for the credit and liquidity risk premiums to the breakdown of the money-market spread. This also illustrates why there is no broad consensus among economists as to whether the money-market spreads were driven by credit or liquidity risk during the crisis, cf. Holthausen and Pill (2010).

At least two factors make it difficult to break down the money-market spread. Firstly, there are considerable data problems, and no single measure of the credit and liquidity risk premiums seems to be clearly better than others. The CDS spread is among the most frequently used measures of the credit risk premium, but it also has its shortcomings. Our analysis shows that including CDS spreads typically increases the importance of the credit risk premium. It is not currently possible to determine whether this is due to the fact that liquidity risk premiums are included in the CDS spreads.

Secondly, the credit and liquidity risk premiums are not independent of each other, so higher liquidity risk premiums may be the underlying reason for the increasing credit risk premiums and vice versa. Other studies have also failed to find a solution to this problem.

Conclusion

The analyses indicate that the crisis in Denmark up to 2009 was primarily a liquidity crisis driven by the development in liquidity conditions in the euro area. At the beginning of the crisis, there was only a limited need for policy measures aiming to reduce the Danish liquidity and credit risk premiums, one underlying factor being the flexible structure of Danmarks Nationalbank's monetary-policy instruments. However, after the failure of Lehman Brothers, the liquidity situation, nationally and especially internationally, deteriorated substantially. This called for a number of policy measures, including swap lines with the Fed and the ECB and Bank Rescue Package 1, with a view to facilitating the banks' access to international liquidity and supporting their exchange of liquidity.

In the course of 2009, the crisis evolved from a liquidity crisis into a credit crisis. The exceptionally wide money-market spreads were reduced as liquidity returned to the markets in the wake of massive interventions by central banks worldwide. But at the same time it also became clear that the banks' solvency was under pressure following major losses, and that policies aiming to improve the liquidity situation were insufficient.

5. THE DANISH KRONE AND THE FOREIGN-EXCHANGE MARKET DURING THE CRISIS

In the wake of Lehman's suspension of payments, investors opted out of minor currencies. This led to exchange-rate pressure, and minor currencies with floating exchange rates, e.g. Swedish kronor, depreciated. As a result of the Danish fixed-exchange-rate policy against the euro, Danmarks Nationalbank made intervention purchases for considerable amounts and raised its monetary-policy interest rates while other central banks generally lowered theirs. But Danmarks Nationalbank's measures contributed to stabilising the krone at a level close to its central rate against the euro. The central government's issuance of 30-year government bonds, which were in high demand from the Danish pension sector, and Bank Rescue Package 1 also contributed to stabilising the situation. The krone was stable during the crisis.

Since borrowing in foreign currency via FX swaps was reduced because market conditions made it cumbersome and expensive, demand for foreign currency increased in relation to kroner, putting pressure on the krone.

The transmission from monetary-policy interest rates to the krone rate was weakened substantially during the crisis. According to experience from the autumn of 2008, very large amounts may be needed for intervention purposes if the krone is under pressure, so a substantial foreign-

exchange reserve is necessary. Danmarks Nationalbank more than doubled the foreign-exchange reserve in relation to the situation before the autumn of 2008 when the pressure on the krone really set in.

This section elaborates on the foreign-exchange market, the situation of pressure on the krone and Danmarks Nationalbank's response.

The foreign-exchange market and the pressure on the krone during the crisis[1]

Denmark conducts a fixed-exchange-rate policy against the euro, so monetary and foreign-exchange policies are aimed at keeping the krone stable against the euro.[2] The krone was stable during the crisis without showing remarkably large fluctuations, cf. Chart 5.1.

The stable development in the krone rate is attributable to extraordinary factors in the foreign-exchange market and large capital flows which were addressed by the introduction of a number of measures.

The culmination of the crisis in the autumn of 2008 resulted in plummeting turnover in the foreign-exchange markets. While the drop was pronounced for the dollar, and the dollar swap market was periodically closed, turnover of kroner and euro also fell considerably.[3] The effect on the foreign-exchange markets can be illustrated by the development in the value of transactions settled via CLS (Continuous Linked Settlements)[4]. Here, the average value of daily foreign-exchange transactions involving kroner fell by 9 per cent from September to October 2008, while the value of transactions involving dollars and euro fell by 14 and 5 per cent, respectively, cf. Chart 5.2.

The lower turnover during the crisis was driven especially by a drop in the turnover of FX swaps, which account for most of the turnover in the foreign-exchange market.[5]

The pressure on the krone in the autumn of 2008 reflected a general tendency among international investors to withdraw from minor currencies. Non-resident banks reduced their deposits with Danish banks considerably, and non-residents also withdrew from Danish securities, cf.

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[1] See also Bernstein (2010) for a description of the situation in relation to the krone during the crisis.
[2] The formal framework for Denmark's fixed-exchange-rate policy is the European Exchange Rate Mechanism, ERMII.
[3] See Straarup (2010) for a description of the crisis from the perspective of Danske Bank.
[4] The system is used primarily by banks and investment associations to settle various types of foreign-exchange transactions, including spot transactions, forward contracts and FX swaps. The system limits the counterparty risk on settlement, as the two legs of the foreign-exchange transaction are settled at the same time. The enhanced security generally makes it more attractive for banks and investment associations to make transactions in the foreign-exchange market.
[5] See Sinding-Olsen (2010) for a description of the development in turnover in the Danish foreign-exchange market based on a survey of the foreign-exchange market coordinated by the Bank for International Settlements (BIS). This survey is conducted every three years, most recently in April 2010. No official statistics are available of turnover broken down by instruments showing the development during the crisis in the autumn.

THE KRONE RATE AGAINST THE EURO AND THE VOLATILITY OF THE KRONE

Chart 5.1

Kroner per euro

Per cent

| Market rate | Central rate | Band limits (+/- 2,25 per cent) | Volatility (right-hand axis) |
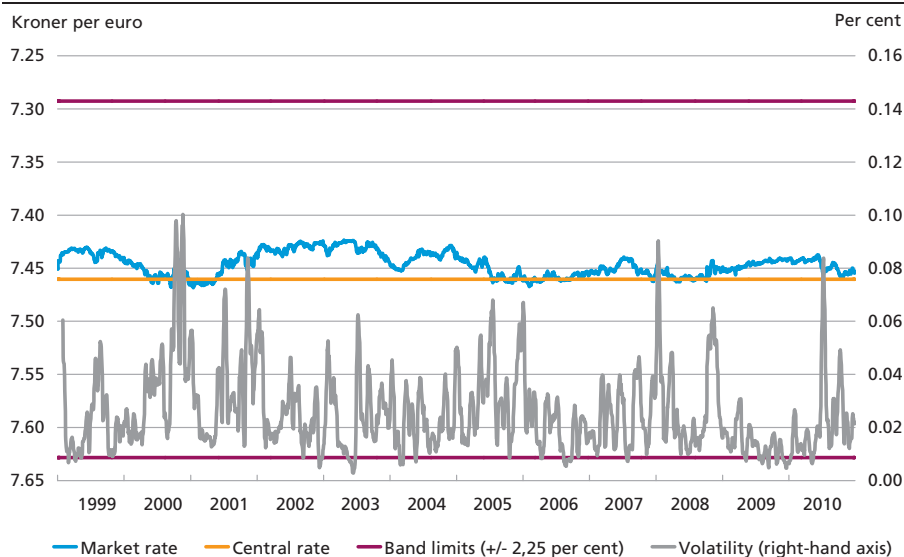
Note: Central rate and band limits in ERM2. Inverted scale on the left-hand axis. The volatility is a 21-day moving standard deviation in per cent. Last observation: 30 December 2010.
Source: Danmarks Nationalbank.

GROSS VALUE OF FOREIGN-EXCHANGE TRANSACTIONS IN DOLLARS AND KRONER IN CLS

Chart 5.2

Billion dollars

Kr. billion

| Dollars | Kroner (right-hand axis) |
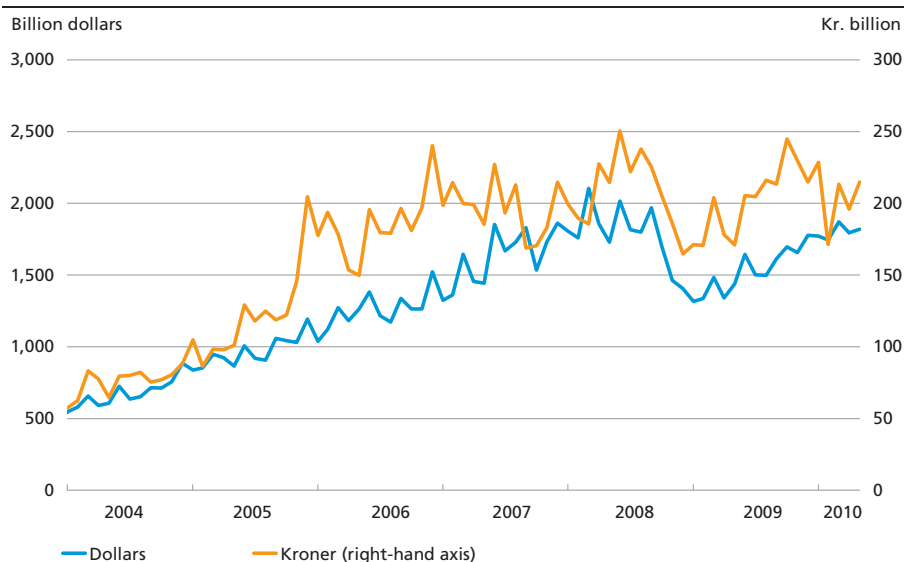
Note: Monthly averages of daily transactions. In the calculation of the gross value of transactions, FX swaps count double, as each leg of a transaction involves separate payment instructions in the currency concerned. Last observation: May 2010.
Source: CLS Bank International.

NON-RESIDENTS' DEPOSITS WITH DANISH BANKS AND ACCUMULATED
PORTFOLIO INVESTMENTS   Chart 5.3

Kr. billion   Kr. billion

[Chart showing two lines: "Deposits with banks" (blue) on left-hand axis (Kr. billion, scale 100-900) and "Accumulated portfolio investments (right-hand axis)" (orange) on right-hand axis (Kr. billion, scale -100 to 600), spanning years 2006 to 2010]

— Deposits with banks   — Accumulated portfolio investments (right-hand axis)

Note: Danish banks are defined as the Danish Financial Supervisory Authority's groups 1-4, excluding the branches of
        non-resident banks. Bank deposits exclude deposits of non-resident units and central banks. The portfolio
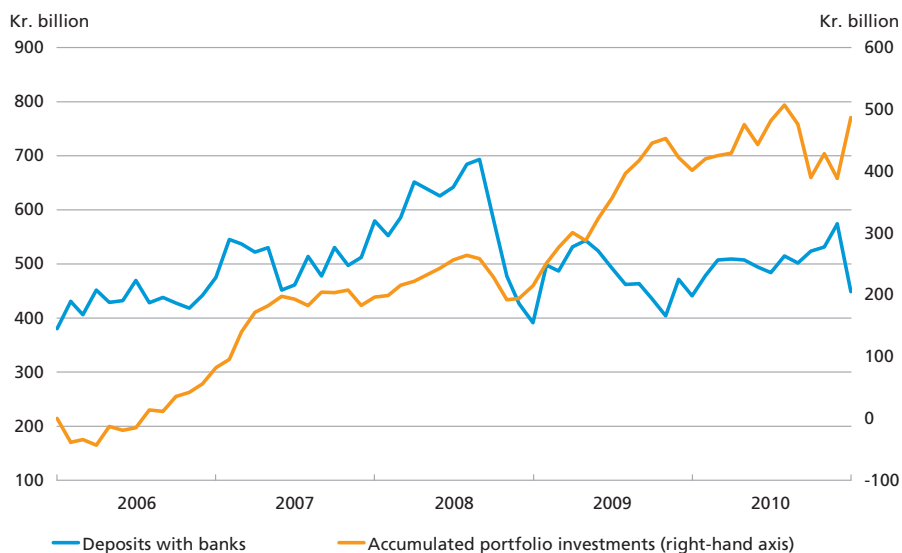   investments have been accumulated since early 2006. Last observation: December 2010.
Source: Danmarks Nationalbank.

Chart 5.3. During the last four months of 2008, non-resident banks
reduced their deposits with the banks by kr. 302 billion. Foreign-ex-
change deposits accounted for around 80 per cent of non-residents'
reduction of bank deposits.

Furthermore, there were indications of some investors speculating in
Danmarks Nationalbank not being able to maintain the fixed-exchange-
rate policy, cf. Bernstein (2010).

The money-market spread, measured by the spread between Dan-
marks Nationalbank's lending rate and the ECB's marginal rate of inter-
est in its weekly refinancing operations, was generally very low from the
onset of the turmoil in the summer of 2007 until the krone came under
pressure in September and October 2008, and for a period it was nega-
tive, cf. Chart 5.4. The narrow interest-rate spread could be attributable
to euro area banks requesting far more liquidity than what was offered
in connection with the ECB's weekly refinancing operations. This caused
the ECB's marginal rate to rise to a high level.[1] Due to the shortage of
euro liquidity and the narrowing of the monetary-policy interest-rate

[1]   Before 8 October 2008, the ECB allotted liquidity at the weekly tenders at a variable interest rate and
      subsequently at a fixed interest rate. The change was announced on 8 October, taking effect from
      the refinancing operation settled on 15 October 2008.

MONEY-MARKET INTEREST-RATE SPREAD AND 3-MONTH INTEREST-RATE
SPREAD BETWEEN DENMARK AND THE EURO AREA   Chart 5.4

Percentage points

Note: The money-market spread is the spread between Danmarks Nationalbank's lending rate and the ECB's marginal
        rate of interest on its main refinancing operations. In October 2008, the ECB, which had previously allotted a
        given amount of liquidity at a variable interest rate, introduced full allotment at a fixed interest rate. The interest-
        rate spread for uncollateralised lending is the spread between 3-month Cibor and Euribor. For interest-rate swaps
        it is the difference between the fixed 3-month interest rate in a swap (at the overnight interest rate) in Denmark
        and the euro area. The implied interest-rate spread from FX swaps is given by (F-S)/S, where F is the forward rate
        between kroner and euro (kroner per euro), and S is the spot rate, cf. Box 2.1.
Source: Reuters EcoWin and Danmarks Nationalbank.

spread, Danmarks Nationalbank had to unilaterally raise its monetary-
policy interest rates already in May 2008.

The shortage of euro and dollars in Denmark was exacerbated by non-
resident investors withdrawing their foreign-exchange investments. This
led to increased demand for euro and dollar funding via FX swaps and
contributed to further dislocations in the FX swap market. See Box 2.1
for a description of the underlying mechanism.

The same applies to non-resident investors in Danish securities who
had financed their investments in kroner via FX swaps (loans in kroner
against foreign exchange as collateral). When the investors withdrew,
demand for kroner via FX swaps was reduced.

The dislocation in the FX swap market in itself made it expensive and
difficult to hedge funding of assets in e.g. dollars and euro via FX swaps.
Due to the difficulties in obtaining foreign currency funding, some bor-
rowers repaid their short-term loans in foreign currency rather than
extending them as they matured.[1] This contributed to the pressure on

[1]   Banks are obliged by law to predominantly hedge their currency risk. The banks' customers financed
      e.g. dollar-denominated assets by loans in kroner rather than dollars, thereby failing to match the
      foreign-exchange exposure of the assets with that of the liabilities.

MONEY-MARKET INTEREST-RATE SPREAD BETWEEN DENMARK AND
THE EURO AREA AND DANMARKS NATIONALBANK'S INTERVENTION
PURCHASES OF FOREIGN EXCHANGE   Chart 5.5
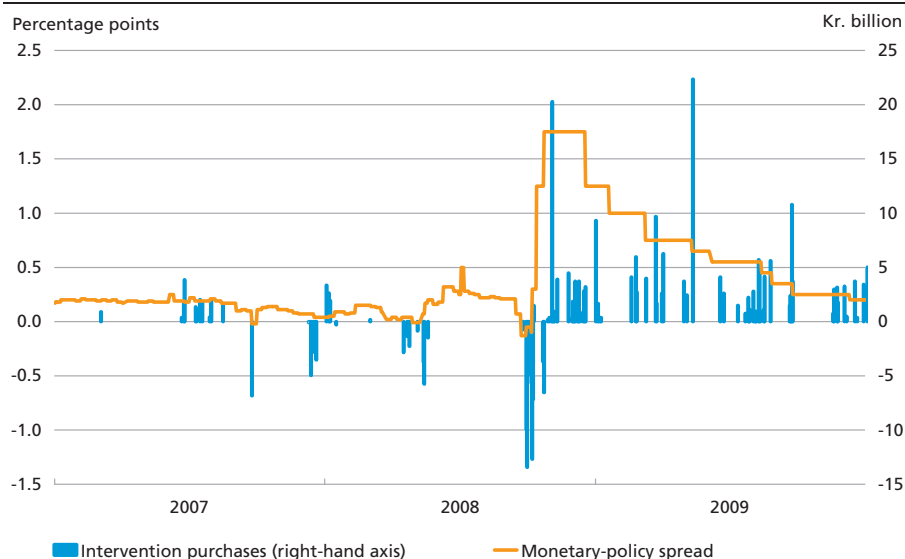
Note: Daily interventions. The money-market spread is the spread between Danmarks Nationalbank's lending rate and the
         ECB's marginal rate of interest on its main refinancing operations. In October 2008, the ECB, which had previously
         allotted a given amount of liquidity at a variable interest rate, introduced full allotment at a fixed interest rate. Last
         observation: 30 December 2009.
Source: Danmarks Nationalbank.

the krone, because demand for foreign currency increased in step with
the repayment of the currency loans.[1]

Danmarks Nationalbank's response

To stabilise the krone, Danmarks Nationalbank intervened in the
foreign-exchange market, buying kroner against foreign exchange for a
considerable amount from late September to early October 2008, cf.
Chart 5.5. However, this proved insufficient to withstand the pressure on
the krone, and in accordance with the fixed-exchange-rate policy Dan-
marks Nationalbank unilaterally raised its monetary-policy interest rates
to widen the monetary-policy interest-rate spread. As from 8 October
2008, the lending rate and the rate of interest on certificates of deposit
were raised by 0.4 percentage point, and the discount rate and the
current-account rate were raised by 0.25 percentage point. Danmarks
Nationalbank subsequently continued to intervene in the foreign-
exchange market. On 8 October around midday, the ECB announced a
reduction of the interest rate by 0.5 per cent on the basis of the

[1] Similar trends were seen in a number of countries, cf. Allen and Moessner (2010a). It is normally
     possible to hedge funding of long-term foreign-currency assets by means of short-term FX swaps that
     are subject to regular renewal, cf. Danmarks Nationalbank (2004), pp. 51-53.

intensified financial crisis,[1] causing the spread to widen further when Danmarks Nationalbank maintained its monetary-policy interest rates.

Despite the widening of the interest-rate spread, the pressure on the krone continued due to the outflow of foreign exchange. At the end of October, Danmarks Nationalbank therefore intervened in the foreign-exchange market again. Its interventions in October totalled around kr. 64 billion net. On 24 October, Danmarks Nationalbank raised the lending rate and the rate of interest on certificates of deposit by a further 0.5 percentage point, widening the spread to the ECB's interest rate to 1,75 percentage points.

The issuance of 30-year government bonds for a total of kr. 90 billion in November and December 2008 also had substantial foreign-exchange effect. In the pension sector there was strong demand for long-term Danish government bonds to hedge long-term liabilities in kroner. The sale supported the demand for kroner to the extent the pension sector sold European bonds to buy Danish government securities.[2] Finally, the introduction of Bank Rescue Package 1 in early October 2008 also had a highly stabilising effect on the situation.

During the crisis in the autumn of 2008, the monetary-policy interest-rate spread to the euro area widened by 1.40 percentage points, and Danmarks Nationalbank sold currency for kr. 64 billion. This illustrates that the transmission from monetary-policy interest rates to the exchange rate weakens during currency crises.

From the end of October the krone appreciated again, and Danmarks Nationalbank was able to repurchase foreign exchange over the next months. For this reason, it was possible to gradually lower the monetary-policy interest rates, thereby narrowing the spread to the ECB's interest rate. Subsequently, the foreign-exchange reserve was gradually built up through government borrowing and especially via intervention purchases of foreign exchange, cf. Chart 5.6. At the peak of the crisis, it was impossible to substitute the outflow from the foreign-exchange reserve by short-term government CP loans, which had been possible during previous crises. Furthermore, it took some time before the government was able to raise long-term government loans in foreign currency at acceptable prices.

Danmarks Nationalbank's foreign-exchange reserve is part of its contingency resources for intervention in the foreign-exchange market. In view of its size it also has a signalling function which may contribute to dampening any speculation against the krone. According to experi-
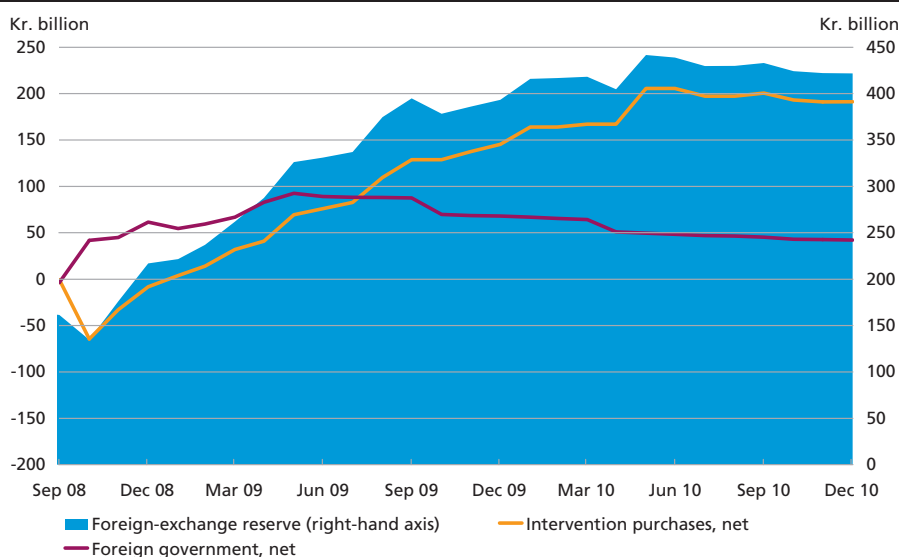
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[1] This was a coordinated reduction of interest rates by a number of central banks.
[2] See Danmarks Nationalbank (2009b).

FOREIGN-EXCHANGE RESERVE AND ACCUMULATED INTERVENTION
PURCHASES OF FOREIGN EXCHANGE AND FOREIGN GOVERNMENT
BORROWING SINCE SEPTEMBER 2008   Chart 5.6

Note: Last observation: December 2010.
Source: Danmarks Nationalbank.

ence from the autumn of 2008, very large amounts may be required for
intervention purposes if the krone is under pressure. Hence, a substan-
tial foreign-exchange reserve is necessary, and Danmarks Nationalbank
has increased it considerably.

A special issue was that the extensive government guarantee under
Bank Rescue Package 1 might potentially make great demands on Dan-
marks Nationalbank's foreign-exchange reserve, given the banking sec-
tor's large foreign liabilities.

The banks' dependence on funding in dollars and euro and the
shortage thereof during the crisis also show that there may be a need to
be able to offer loans in foreign currency. Accordingly, Danmarks Natio-
nalbank supported the banks' funding in euro and dollars by providing
loans in foreign currency from the foreign-exchange reserve. See section
6 for further details.

The financial crisis has shown that an international shortage of foreign
currency may suddenly occur. The dollar shortage was addressed by
massive supplies of dollars from the Fed via swap facilities with other
central banks. The Fed's rapid response in this connection was essential
to their efficiency, cf. Allen and Moessner (2010a). Apparently, this has
already prompted several countries which experienced serious currency-

specific liquidity shortages during the crisis to accumulate foreign-exchange reserves as a means of insurance, cf. Allen and Moessner (2010b).

Conclusion

The extraordinary conditions in the foreign-exchange market during the crisis were addressed by a number of policy measures, which kept the krone stable during the crisis. In addition to Danmarks Nationalbank's interventions and interest-rate increases, government borrowing contributed to stabilising the foreign-exchange reserve and supported the capital inflow to Denmark, even though at the peak of the crisis it was difficult to substitute the outflow of foreign exchange for government borrowing. The pressure on the krone reflected a general tendency among international investors to withdraw from minor currencies. The crisis revealed that a larger foreign-exchange reserve is required than warranted by previous experience, and Danmarks Nationalbank has more than doubled its foreign-exchange reserve in relation to the situation before the onset of the crisis in the autumn of 2008.

6. DANMARKS NATIONALBANK'S PROVISION OF EURO AND DOLLARS

Against the backdrop of the need for currency funding and insufficient access to dollars and euro, Danmarks Nationalbank, in the autumn of 2008, established swap lines with the Fed and the ECB in order to be able to supply dollar and euro funding to Danish banks. In September and October 2008, Danmarks Nationalbank also provided dollar and euro loans out of its foreign-exchange reserve.

There was a global shortage of dollars, and the Fed established dollar swap lines with a number of central banks, initially in December 2007. The ECB established euro swap lines with a number of central banks. Swap lines were also established by other central banks, e.g. the Swiss National Bank and the Bank of Japan.[1]

In the following, we describe the establishment of Danmarks Nationalbank's swap lines with the Fed and the ECB and the associated allotment of euro and dollar liquidity. We then assess the efficiency of the provision of foreign exchange in an econometric analysis. We also investigate whether liquidity measures introduced by the Fed and the ECB, which were not targeted directly at Denmark, have had a measureable effect on the dollar and euro liquidity for Danish banks.

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[1] See Allen and Moessner (2010a).

Establishment of Danmarks Nationalbank's euro and dollar loans
Danmarks Nationalbank provided euro and dollar loans to facilitate access to euro and dollar liquidity for Danish banks.[1]

Initially, Danmarks Nationalbank supplied euro and dollars from the foreign-exchange reserve in the form of FX swaps with the banks. In mid-September 2008, Danmarks Nationalbank intervened in the FX swap market, offering dollars against kroner for a total of kr. 2.6 billion with a maturity of 4 days. Likewise, in early October 2008, Danmarks Nationalbank intervened in the euro market by offering euro for a total of kr. 16.8 billion with maturities of 1 week and 1 month. Danmarks Nationalbank had not previously intervened in the FX swap market in recent times.

Danmarks Nationalbank's temporary swap line with the Fed was established on 24 September 2008. It was expanded from 5 to 15 billion dollars on 29 September 2008. The swap line was extended twice and expired on 1 February 2010. During the swap line, the Fed lent dollars to Danmarks Nationalbank, which offered dollar loans to the banks via auction. 18 auctions were held, the last one in September 2009. The need for this facility was emphasised by the fact that in the first auctions demand was considerably higher than the volume allotted, and that the participants also included large banks. The swap line of 15 billion dollars was fully exercised at the end of 2008, cf. Chart 6.1. Demand fell as the dollar funding problems declined, and the widening of the spread between the interest rate in the auctions and the market rate. While the bid volume exceeded the volume allotted in all auctions in 2008, the bid volume was lower than the volume allotted in the auctions held in 2009.

On 27 October 2008, Danmarks Nationalbank and the ECB established an equivalent swap line for 12 billion euro. Nine auctions were held, most recently on 21 August 2009. The largest outstanding volume amounted to kr. 5.9 billion. The bid volume was lower than the volume allotted in all the auctions. This probably reflects that several banks have access to the ECB's monetary-policy facilities via units in the euro area. The facility increased the availability of euro funding, however, especially for banks without access to euro via the ECB's monetary-policy facilities.

The currency loans in dollars and euro under the swap lines with the Fed and the ECB were provided via auctions in which all Danmarks Nationalbank's monetary-policy counterparties were allowed to participate. Participants could each submit a maximum of three bids stating amounts and bid rates. The bid rate had to be higher than or equal to

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[1] See Danmarks Nationalbank (2009c).

OUTSTANDING LOANS IN CONNECTION WITH DANMARKS NATIONALBANK'S
EURO AND DOLLAR AUCTIONS   Chart 6.1
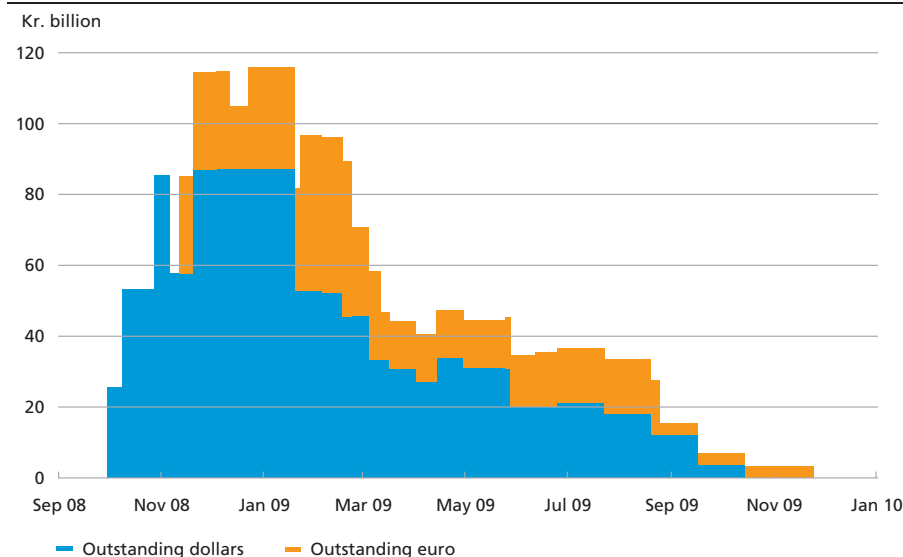
Source: Danmarks Nationalbank.

the minimum bid rate fixed by the ECB and the Fed. The highest bid rates were accepted first followed by bid rates in descending order until the full amount in euro or dollars had been allotted. All participants paid the marginal rate, which is the lowest among the accepted bid rates. This auction method has the advantage that all participants pay the same rate of interest, which protects banks with less market know-how.

The banks provided collateral for the currency loans using the same collateral base as for Danmarks Nationalbank's normal monetary-policy lending denominated in kroner. The ECB and the Fed lent euro and dollars to Danmarks Nationalbank against kroner (FX swaps). The amount in euro or dollars that Danmarks Nationalbank lent to its counterparties, it received from the ECB and the Fed, respectively, in return for a corresponding amount in kroner. When the loan matured, Danmarks Nationalbank forwarded the reverse transaction, including interest payments, to the ECB and the Fed.

The swap lines with the ECB and the Fed did not affect the foreign-exchange reserve, and Danmarks Nationalbank had no income from the swap agreements. Euro and dollar lending via the swap lines increased Danmarks Nationalbank's balance sheet.[1]

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[1] See Dam and Risbjerg (2009) for a description of the effect of the swap operations on Danmarks Nationalbank's balance sheet.

While the minimum rate of interest in connection with Danmarks Nationalbank's euro auctions was on average 75 basis points higher than the market rate of interest-rate swaps with corresponding maturities, the corresponding figure for the dollar auctions was 84 basis points on average.

Empirical analysis of Danmarks Nationalbank's euro and dollar facilities

Below we analyse the extent to which Danmarks Nationalbank's interventions in the FX swap market and the euro and dollar auctions alleviated the dislocations in the FX swap market for euro and dollars against kroner. During the crisis, it was considerably more expensive to fund dollars by combining loans in kroner with FX swaps between kroner and dollars rather than raising loans directly in the money market for dollars. In other words, there was a clear deviation from the covered interest-rate parity between kroner and dollars, cf. Chart 6.2. Similarly, there were deviations from the covered interest-rate parity between kroner and euro. See Box 2.1 for a description of the covered interest-rate parity.

We analyse the importance of the measures by investigating whether the deviations from the covered interest-rate parity between kroner and, respectively, euro and dollars were reduced by Danmarks Nationalbank's provision of foreign exchange. As seen from Chart 6.2, the deviation during the crisis in the autumn of 2008 is smaller when calculated for uncollateralised rather than collateralised interest rates. The reason is that the difference between uncollateralised and collateralised interest rates is larger in the US money market than in the Danish money market, cf. section 4.

DEVIATION FROM THE COVERED INTEREST-RATE PARITY BETWEEN
KRONER AND, RESPECTIVELY, DOLLARS AND EURO   Chart 6.2
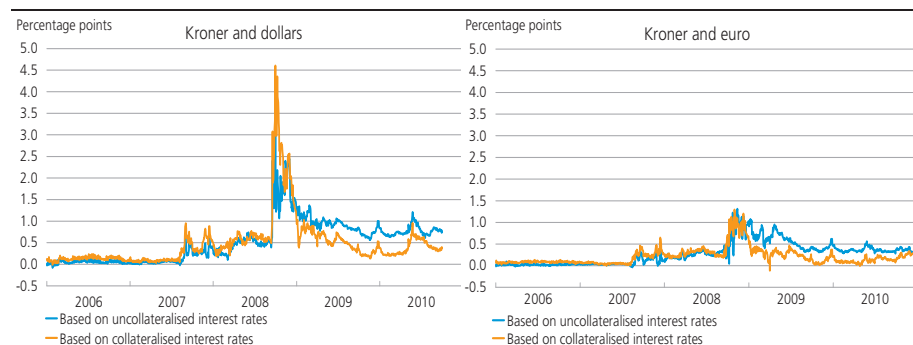
Note: Deviation for a maturity of 3 months. Uncollateralised interest rates refer to the uncollateralised money-market interest rates in kroner, euro and dollars (Cibor, Euribor and Libor). Collateralised interest rates are the 3-month interest rate in interest-rate swaps at the overnight rate in the respective markets. Last observation: 30 December 2010.
Source: Reuters EcoWin and Bloomberg.

OLS ESTIMATION	Box 6.1

We use an OLS model on daily data to estimate the efficiency of Danmarks National-bank's supply of euro and dollars. The model estimates the interest-rate parity deviation based on policy variables and control variables for liquidity, credit and market risk. The estimation is made on the basis of (daily) changes in the interest-rate parity deviation variable and the control variables.[1]

The estimated variable can be summarised as the following estimation equation:

$$\Delta irpdev_t = \beta_0 + \beta_1 \Delta irpdev_{t-1} + \beta_2 \Delta creditDK_t + \beta_3 \Delta creditABR_t$$
$$+ \beta_4 \Delta liquidDK_t + \beta_5 \Delta liquidABR_t + \beta_6 \Delta marketvol_t + \beta_7 D_t + \varepsilon_t, \qquad (1)$$

$irpdev_t$ is the dependent variable, i.e. the deviation from the covered interest-rate parity, which is also included as an explanatory variable with a 1-day lag to capture any autocorrelation effects. The equation then includes variables for credit and liquidity risk in the Danish market (*credit*DK and *liquid*DK) and abroad (*credit*ABR and *liquid*ABR, where ABR stands for the US market and the euro area market, respectively). The general market risk is indicated as *marketvol.* The explanatory variable D_t contains the variables for policy measures. Newey-West standard deviations are used to allow for autocorrelation and heteroskedasticity.

[1] Making this type of change estimations is standard procedure. See McAndrews, Sarkar and Wang (2008) for a discussion of estimating the effect of policy measures using data in differences and levels, respectively.

Empirical model

Using regression analysis, we assess the effect on the deviation from the covered interest-rate parity of Danmarks Nationalbank's FX swap inter-ventions as well as its euro and dollar auctions, cf. Box 6.1. The depend-ent variable is deviations from the covered interest-rate parity based on uncollateralised interest rates with a maturity of 3 months, which we seek to explain by variables for policy measures and a number of addi-tional explanatory variables for credit, liquidity and market risk to check for other conditions that may have affected the deviation. This method relies on similar analyses performed by Coffey, Hrung and Sarkar (2009) and Hui, Genberg and Chung (2009).[1]

The variables for credit risk are the CDS spreads for the banks, cf. section 4. All other things being equal, higher credit risk for the banks in the Danish money market will make it more difficult to obtain (uncolla-teralised) funding directly in the money market for dollars. This leads to increased demand for dollars via FX swaps and points to a larger devia-tion from the covered interest-rate parity. Increased credit risk for US banks has the opposite effect, since, all other things being equal, it in-

[1] Baba and Shim (2010) perform EGARCH analyses in order to examine the efficiency of policy measures on interest-rate parity deviations for Korea. Baba and Packer (2009) perform a similar analysis of the euro area, Switzerland and the UK.

creases their demand for kroner via FX swaps. On the other hand, the global shortage of dollars may also make it necessary for US banks, which are subject to a higher credit risk, to obtain dollars via FX swaps, and this points to an increased interest-rate parity deviation. Accordingly, the expected sign of the CDS spread for the US banks is inconclusive.

As a measure of liquidity risk, the spread between uncollateralised and collateralised money-market interest rates (the money-market spread) is included as an explanatory variable. This spread contains both a credit risk premium and a liquidity risk premium, but development in the spread is driven mainly by liquidity conditions, cf. section 4.[1]

A wider money-market spread in Denmark indicates tighter liquidity conditions in kroner for Danish banks. All other things being equal, this will increase the cost of borrowing in kroner combined with an FX swap to dollars (or euro), and this means a larger deviation from the covered interest-rate parity. Similarly, tighter liquidity conditions in e.g. the dollar money market will increase the costs of borrowing directly in dollars and reduce the deviation from the covered interest-rate parity.

Finally, a variable for general market risk is included. The model for dollars uses the VIX index, cf. section 4. The model for the euro area uses VSTOXX, which similarly indicates the implied volatility of options based on the Euro STOXX 50 stock index.

The policy measures include Danmarks Nationalbank's euro and dollar loans via FX swap interventions and the euro and dollar auctions in connection with the swap lines with the ECB and the Fed, cf. Table 6.1. Dummy-variables are included for dates on which the swap facilities are announced or extended. The amount for volumes sold on the auction day is included as a variable to determine the effect of holding the auctions. A priori the policy measures must be expected to contribute to reducing the interest-rate parity deviations.

We also investigate whether other measures introduced by the Fed and the ECB to improve the liquidity situation in dollars and euro have alleviated the shortage of dollars and euro in Denmark.

On 12 December 2007, the Fed announced its establishment of dollar swap lines with a number of central banks, including the ECB, cf. Fleming and Klagge (2010). The limit of the swap line with the ECB was subject to ongoing upward adjustment. The effect of policy measures on the deviation from the covered interest-rate parity between euro and dollars

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[1] Coffey, Hrung and Sarkar (2009) do not include funding liquidity variables in their estimations of the effect of policy measures, as the measures are aimed at reducing liquidity risk. The money-market spread is included in a number of other studies of the effect of policy measures, however, cf. e.g. Baba and Packer (2009), Baba and Shim (2010), Hui, Genberg and Chung (2009), Griffoli and Ranaldo (2010).

POLICY MEASURES   Table 6.1

Euro	Date	Notes
FX swap intervention (volume)	**2008**: 2/10, 10/10	Danmarks Nationalbank supplies euro amounting to a total of kr. 16.8 billion via the FX swap market at maturities of 5 days and 1 month
Establishment of swap line (dummy) .	**2008**: 27/10	Danmarks Nationalbank opens a swap line with the ECB
Auctions (volume) ...	**2008**: 10/11, 12/12, 19/12 **2009**: 21/1, 19/2, 10/3, 19,5 10/6, 21/8	Danmarks Nationalbank conducts a total of 9 auctions lending euro via its swap line with the ECB
ECB, full allotment (dummy)	**2008**: 8/10	The ECB announces its introduction of full allotment and fixed interest rates in connection with its weekly refinancing operation
ECB, increase of LTRO	**2008**: 15/10	The ECB announces an increase in its long-term refinancing operations with full allotment at fixed interest rates
ECB, 1-year LTRO	**2009**: 7/5	The ECB announces 1-year refinancing operations

Dollars	Date	Notes
FX swap intervention (volume)	**2008**: 18/9	Danmarks Nationalbank supplies dollars amounting to a total of kr. 2.6 billion via the FX swap market at maturities of 5 days
Establishment of swap line (dummy) .	**2008**: 24/9	Danmarks Nationalbank opens a swap line with the Fed for an original amount of 5 billion dollars
Increase of swap line (dummy)	**2008**: 29/9	The swap line between Danmarks Natio-nalbank and the Fed is increased to 15 billion dollars
Extension of swap line (dummy)	**2009**: 3/2, 26/6	Danmarks Nationalbank extends the swap line with the Fed
Auctions (volume) ...	**2008**: 26/9, 7/10, 24/10, 18/11, 2/12 **2009**: 16/1, 3/2, 12/2, 3/3, 13/3, 31/3, 7/4, 28/4, 26/5, 23/6, 21/7,18/8, 15/9	Danmarks Nationalbank conducts a total of 18 auctions lending dollars via its swap line with the Fed
The Fed's swap facility with the ECB (dummy)	**2007**: 12/12 **2008**: 11/3, 2/5, 30/7, 18/9, 26/9, 29/9, 13/8 **2009**: 6/4	On 12 December 2007, the Fed estab-lished a swap line with the ECB which has been increased on an ongoing basis

Source: Danmarks Nationalbank, ECB, Fed.

has been investigated in a number of studies, which generally find that the deviation was significantly reduced by the measures.[1] The Fed's fast

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[1] Coffey, Hrung and og Sarkar (2009), Hui, Genberg and Chung (2009) and Griffoli and Ranaldo (2010).

establishment of swap lines was essential to the efficiency of their impact on the market, cf. Allen and Moessner (2010a). In connection with the agreed swap line, the ECB offered dollars via auctions to which their monetary-policy counterparties had access, including a number of Danish banks with units in the euro area. In addition, the improved conditions in the FX swap market between euro and dollars may have a second order effect on the FX swap market between kroner and dollars. As a result of the fixed-exchange-rate policy vis-à-vis the euro, FX swaps between euro and dollars may be widely used instead of FX swaps between kroner and dollars.

The ECB launched a number of measures to support the liquidity conditions in the euro area, cf. ECB (2009a and b). In early October 2008, the ECB announced that until further notice its weekly refinancing operations would be performed with full allotment of liquidity at a fixed interest rate. In mid-October 2008, the ECB announced an expansion of its longer-term refinancing operations. In May 2009, the ECB announced the introduction of refinancing operations for 1-year loans, completing three in the course of 2009. We finally investigate whether excess liquidity in the Eurosystem has affected liquidity conditions in Denmark.[1]

The estimation for the euro and dollar model is based on a data period from early August 2007 to early October 2009. This period covers the entire crisis and includes all Danmarks Nationalbank's euro and dollar operations. The last dollar auction was held in September 2009.

The effect of liquidity, credit and market risk
It appears from the estimated models for euro and dollars, respectively, cf. Tables 6.2 and 6.3, that a widening of the Danish money-market spread (*liquidDK*) significantly increases the interest-rate parity deviations in all the estimated models. This is in line with the assumption that higher liquidity risk for Danish banks contributes to dislocations in the FX swap market. As expected, the money-market spread in euro (*liquidEUR*) is also significant with a negative sign. The money-market spread for dollars (*liquidUS*) is not significant.

The coefficients for credit risk, *credit*, are neither significant in the euro nor the dollar model. The CDS spreads in Denmark and the euro area are highly correlated, and there are elements of both credit and liquidity risk in CDS spreads as well as in the money-market spreads, which may contribute to blurring the estimation results for the credit variable.

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[1] Excess liquidity is given as the banks' current-account deposits in the Eurosystem and lending in connection with the ECB's fine-tuning operations less its reserve requirements and the banks' use of the marginal credit facility.

ESTIMATION RESULTS FOR EURO			Table 6.2
Variable	Model 1	Model 2	Model 3
Constant	0.06	0.27	0.24
	(0.24)	(0.27)	(0.26)
$irpdev_{t-1}$	-0.23***	-0.28***	-0.29***
	(0.09)	(0.05)	(0.06)
$\Delta creditDK_t$	-0.21	-0.21	-0.17
	(0.20)	(0.19)	(0.19)
$\Delta creditEUR_t$	0.12	0.09	0.07
	(0.17)	(0.16)	(0.15)
$\Delta liquidDK_t$	0.83***	0.87***	0.87***
	(0.10)	(0.09)	(0.10)
$\Delta liquidEUR_t$	-0.56***	-0.54***	-0.55***
	(0.13)	(0.12)	(0.14)
$\Delta marketvol_t$	-0.23	-0.11	-0.13
	(0.16)	(0.15)	(0.16)
FX swap interventions(m)		-9.76**	-9.36*
		(4.45)	(4.73)
Establishment of swap line(d)		-42.41***	-42.64***
		(4.81)	(5.05)
Auctions(m)		-3.21***	-3.22***
		(0.81)	(0.81)
ECB, full allotment(d)			2.77
			(6.55)
ECB, increase of LTRO (d)			11.38***
			(2.14)
ECB, 1-year LTRO			4.76***
			(1.45)
ECB, excess liquidity			-0.00
			(0.01)
Adjusted R[1]	0.48	0.53	0.53
Log-Likelihood	-1,774.16	-1,747.09	1,745.21

Note: (d) = dummy variable, (m) = volume variable.
[1] Significance tests are based on Newey-West's heteroskedasticity-robust standard error. ***, **, * means that the estimates are significant at the 1, 5 and 10 per cent level, respectively. Estimation period: 9 August 2007 - 1 October 2009.

The coefficients for general market risk (volatility index) are not significant in any of the models.

The effect of provision of euro
Danmarks Nationalbank's provision of euro to Danish counterparties via FX swaps reduced the interest-rate parity deviation. The estimation shows that FX swap interventions reduced the deviation by approximately 9 basis points per 1 billion euro.

Besides, the announcement of Danmarks Nationalbank's swap line with the ECB for 12 billion euro in itself significantly reduced the interest-rate parity deviation by approximately 43 basis points. The fact

ESTIMATION RESULTS FOR DOLLARS			Table 6.3
Variable	Model 1	Model 2	Model 3
Constant	0.07	0.27	0.22
	(0.43)	(0.45)	(0.47)
$\Delta irpdev_{t-1}$	-0.03	-0.07	-0.07
	(0.07)	(0.10)	(0.10)
$\Delta creditDK_t$	0.45	0.47	0.49
	(0.46)	(0.46)	(0.48)
$\Delta creditUS_t$	0.01	0.02	0.01
	(0.12)	(0.13)	(0.13)
$\Delta liquidDK_t$	0.66***	0.63***	0.63***
	0.18)	(0.15)	(0.15)
$\Delta liquidUS_t$	0.29	0.38	0.38
	(0.27)	(0.30)	(0.30)
$\Delta marketvol_t$	-0.58	-0.60	-0.58
	(0.38)	(0.39)	(0.37)
FX swap interventions(m)	---	103.57***	94.43***
		(22.82)	(28.00)
Establishment of swap line(d)	---	-46.04***	-46.01***
		(11.37)	(11.41)
Increase of swap line(d)	---	-5.28	-10.38
		(10.06)	(13.95)
Extension of swap line(d)	---	0.90	1.15
		(2.47)	(2.64)
Auctions(m)	---	-1.48**	-1.55**
		(0.61)	(0.63)
The Fed's swap line with the ECB(d)	---	---	4.50
			(6.47)
Adjusted R[1]	0.15	0.20	0.21
Log-Likelihood	-2,134.53	-2,118.68	-2,118.28

Note: (d) = dummy variable, (m) = volume variable.
[1]   Significance tests are based on Newey-West's heteroskedasticity-robust standard error. ***, **, * means that the estimates
     are significant at the 1, 5 and 10 per cent level, respectively. Estimation period: 9 August 2007 - 1 October 2009.

that the ECB backed the efforts to solve the Danish banks' euro funding problems had strong signalling value. The allotted volumes on individual auction days also had a significant impact on the deviation with an average of just over 3 basis points for each 1 billion euro allotted via the auctions or a total of 19 basis points for the total allotment of 5.9 billion euro. Although the total swap line was not fully exercised, the euro provision contributed to alleviating the dislocations in the FX swap market. This gave the Danish banks confidence that they would have access to the euro liquidity they needed.

The ECB's announcement of full allotment of euro at a fixed interest rate in its weekly refinancing operations had no significantly reducing

effect on the interest-rate parity deviation. This may reflect the appreciation of the krone when, on the same day, the ECB lowered its interest rate by 0.50 percentage point, while Danmarks Nationalbank kept its interest rate unchanged, cf. section 5. The result was a widening of the spread between kroner and euro and a strengthening of the krone. This may have contributed to blurring the effect of the ECB's announcement.

The ECB's announcement in October 2008 of the expansion of its longer-term refinancing operations and in May 2009 of its establishment of the 1-year credit facility did not reduce the interest-rate parity deviation between kroner and euro, possibly because the market participants did not yet know the implications for the liquidity situation. Nor did the ECB's auctions in connection with the new longer-term refinancing operations significantly reduce the interest-rate parity deviation. It should be noted, however, that in large part the impact of e.g. the 1-year euro-providing lending facility gradually affected the money market up to the auctions, so the overnight dummy variable for individual auctions only shows the isolated auction effect. Likewise, the excess liquidity in the euro area did not have a significant effect on the interest-rate parity deviation.

The effect of dollar supplies
The estimation shows a substantial and statistically significant widening of the interest-rate parity deviation on the day Danmarks Nationalbank supplied dollars from the foreign-exchange reserve via the FX swap market. The period immediately after the failure of Lehman Brothers, during which the intervention took place, was characterised by highly volatile markets. This may have contributed to blurring the effect of the interventions on market prices. Besides, the supply of dollars via the FX swap market was modest compared with the amount of Danmarks Nationalbank's operations in the euro swap market. The market for FX swaps between kroner and dollars is almost twice the size of the FX swap market between kroner and euro. If the market participants believed there was less support for the dollar operations out of the foreign-exchange reserve than for euro, this may also explain the less pronounced effect of the dollar operations compared to the euro operations.

The establishment of Danmarks Nationalbank's swap line with the Fed significantly reduced the deviation from the covered interest-rate parity between kroner and dollars by 46 basis points, thereby helping to normalise the dislocations in the FX swap market. While the expansion of the swap line from 5 to 15 billion dollars reduced the interest-rate parity deviation, the effect was not statistically significant.

The allotted volumes on individual auction days also reduced the inter-est-rate parity deviation. Overall, the dollar auctions held all contributed to reducing the deviation by 1.5 basis points per 1 billion dollars allotted or by a total of 23 basis points for the total allotment of 15 billion dollars.

The estimations did not show a significant effect of the Fed's swap lines with the ECB. However, the general improvement of the funding conditions in dollars undoubtedly contributed to supporting the condi-tions of dollar funding in Denmark.

Robustness of the results

We have made a number of additional estimations to check the robust-ness of the results:

- Estimations have been made where the covered interest-rate parity is based on collateralised interest rates (swap rates) rather than uncollat-eralised interest rates.
- The spread between uncollateralised and collateralised interest rates has been replaced by the interest-rate spread between government-guaranteed and government issuance as an expression of the liquidity risk, cf. section 4.
- The estimations above use CDS spreads for selected Cibor reporting banks and selected European and US banks, cf. section 4. Estimations have also been made using the CDS spread for the largest banks in the Danish money market, i.e. Danske Bank and Nordea, and the index for CDS spreads in the euro area (iTraxx) and in the USA (CDX).
- The estimations above use exchange rates from the broker firm of Tullet Prebon sourced from Bloomberg. Estimations have also been made on the basis of data from Reuters where the exchange rates are determined on the basis of various reporting banks (Reuters' compo-site rates).
- The level of deviation from the covered interest-rate parity has been included as an additional explanatory variable to allow for level de-pendence in the deviation. This is also the case in e.g. Baba and Shim (2010). The deviation from the covered interest-rate parity between dollars and euro and the spread between bid and ask prices in FX swaps has also been added as an explanatory variable.
- Finally, estimations have been made with the estimation period begin-ning on 15 September 2008, the date of Lehman Brothers' suspension of payments, instead of 9 August 2007.

The announcement of the swap lines with the Fed and the ECB also significantly reduces the deviation from the covered interest-rate parity

in the alternative specifications. While in a few instances the effect of holding the auctions in connection with the swap lines and Danmarks Nationalbank's own supply of euro becomes insignificant, it has the expected sign in all instances.

Conclusion

The econometric analyses in this section show that the announcement of the swap lines led to a marked improvement of the funding conditions, expressed as a reduction of the deviation from the covered interest-rate parity. This reflects that market participants were reassured by the support of the Fed and the ECB to safeguard dollar and euro funding. The announcement of the swap line with the Fed led to a significant reduction of the deviation from the covered interest-rate parity between kroner and dollars of 46 basis points. On average, the dollar auctions in connection with the swap line with the Fed reduced the deviation by 1.5 basis points per billion dollars sold at the auctions, or by 23 basis points for the total allotment of 15 billion dollars. Similarly, the announcement of the swap line with the ECB led to a statistically significant reduction of the deviation from the covered interest-rate parity between kroner and euro of 43 basis points. The actual euro auctions reduced the deviation by an average 3 basis points per 1 billion euro or by a total of 19 basis points for the total allotment of 5.9 billion euro. The results are in line with similar surveys for other countries.

Danmarks Nationalbank also provided dollar and euro swap loans out of the foreign-exchange reserve. FX swaps in euro in early October 2008 led to a statistically significant reduction, by 9 basis points, of the deviation from the covered interest-rate parity while the result for FX swaps in dollars in mid-September was less clear-cut. One explanation may be that the market participants believed there was more support for the euro operations from the foreign-exchange reserve. In addition, the euro operations amount was considerably larger than the dollar amount.

We do not find that the estimations show a significant effect of the Fed's swap lines with the ECB. However, the general improvement of the funding conditions in dollars through the measures introduced by the Fed has undoubtedly also supported the conditions of dollar funding in Denmark. Similarly, it is difficult to identify, by means of the estimations, a measurable improvement of the euro funding situation in Denmark by the ECB's liquidity measures in the euro area.

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