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Interest Rate Pass-through During the Global Financial Crisis: The Case of Sweden

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By Niels-Jakob Harbo Hansen and Peter Welz

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ABSTRACT/RÉSUMÉ

Interest rate pass-through during the global financial crisis: the case of Sweden

A stable relationship between monetary policy rates and bank lending and deposit rates faced by consumers and companies is essential for the effective transmission of monetary policy decisions. This paper studies how changes in the policy rate set by the Swedish central bank, the Riksbank, have been transmitted to money market rates and, in turn, to retail rates before and during the financial turmoil that erupted in summer 2007. Historically, the Riksbank has been successful in effectively controlling money market rates, but during the financial turmoil the transmission of impulses from the policy rate to money market rates appears to have been weakened by elevated and volatile risk premia, although these increased less in Sweden than in the euro area, United Kingdom and United States. The pass-through from money market rates to retail rates is found to have been complete, but sluggish, before the turmoil. Pass-through was also faster into short-term loan rates for non-financial companies than for households. During the turmoil the pass-through from money market to lending rates has been preserved at short maturities, but not at longer maturities. Lack of access to long-term funding has likely played a role.

JEL codes: E43; E52.
Keywords: Monetary transmission; interest rate pass-through; Sweden; financial crisis.

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Le canal de transmission des taux d'intérêt pendant la crise financière mondiale : le cas de la Suède

L'existence d'une relation stable entre les taux d'intérêt fixés par les autorités monétaires et les taux que les banques offrent aux ménages et aux entreprises est essentielle pour la transmission des décisions de politique monétaire. Cet article étudie comment les changements de taux d'intérêt de la banque centrale de Suède, la Riksbank, se répercutent sur les taux du marché monétaire, puis sur les taux proposés par les institutions financières à leurs clients, avant et pendant la crise financière démarrant en 2007. Le contrôle de la Riksbank sur les taux du marché monétaire, fort au court des dernières années, apparaît affaibli par l'importance et la volatilité des primes de risque depuis l'été 2007, même si ces dernières ont moins augmenté en Suède que dans d'autres pays de l'OCDE. La transmission des variations des taux du marché monétaire aux taux offerts par les institutions financières semble avoir été complète avant la crise, bien que lente. Elle était aussi plus rapide pour les prêts de court terme aux entreprises non-financières que pour les prêts aux ménages. Pendant la crise, le canal de transmission des taux du marché monétaire aux taux offerts par les institutions financières a été préservé pour les courtes maturités, mais affaibli pour les longues maturités. Le manque d'accès à des financements de long terme a pu jouer un rôle.

Classification JEL: E43; E52.
Mots-clefs: canaux de transmission de la politique monétaire ; transmission des taux d'intérêt ; Suède ; crise financière.

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TABLE OF CONTENTS

INTEREST RATE PASS-THROUGH DURING THE GLOBAL FINANCIAL CRISIS: THE CASE OF SWEDEN 5

Introduction and key findings 5
The pass-through from policy rates to money market rates 6
The pass-through from money market to retail rates 13

BIBLIOGRAPHY 21

ANNEX A1. NON-CONVENTIONAL MEASURES TAKEN BY THE RIKSBANK 24

Provision of longer-term liquidity 24
Relaxation of collateral eligibility requirements 24
Expansion of the list of counterparties to central bank operations 24
Liquidity provisions in foreign currency 25
Supporting specific institutions 25
Other measures 25

ANNEX A2. DATA DESCRIPTION AND TESTS 27

Retail and money market rates for various interest rate fixation periods, non-financial companies 29
Retail and money market rates for various interest rate fixation periods, households 30

ANNEX A3. MODEL SPECIFICATIONS AND EMPIRICAL STRATEGY 34

Autoregressive distributed lag models 34
Error correction models 34
Robustness checks 35

Tables

Table 1. Money market volatility 9
Table 2. Non-conventional measures taken as of June 2010 12
Table 3. Estimated pass-through from money market to retail rates prior to July 2007 16
Table 4 Studies of the pass-through from money market to retail rates during the crisis 20
Table A.1. Money market and retail rates 28
Table A.2. Contemporaneous correlation of retail and money market rates, levels 31
Table A.3. Determination of integration order for selected interest rate series 31
Table A.4. Tests for co-integration 32
Table A.5. Tests for co-integration 34
Table A.6. ECM estimates and tests 37
Table A.7. ARDL estimates and tests 38

Figures

Figure 1. Money market interest rates 8
Figure 2. Money market spreads....8
Figure 3. Risk premia measured by basis spreads across countries....9
Figure 4. International CDS spreads....9
Figure 5. Central banks' balance sheet 12
Figure 6. Basis spread and announcements by the Riksbank....13
Figure 7. Changes in money market and short-term retail lending and deposit rates 14
Figure 8. Changes in money market rates and long-term retail lending rates....14
Figure 9. Households' new mortgage loans broken down by interest rate fixation period....15
Figure 10. Spreads between money market rates and mortgages rates to households, short-term lending17
Figure 11. Spreads between money market rates and mortgages rates to households, long-term lending 17
Figure 13. Money market spreads....18
Figure 14. Estimated long-run pass-through to non-financial companies mortgage rates....18
Figure 15. Predicted and actual interest rate for households, three-month fixation....19
Figure 16. Predicted and actual interest rate for households, five-year fixation....19
Figure 17. MFIs lending to companies and households across countries 20
Figure 18. MFIs lending to companies and households in Sweden....20
Figure A.1. Fixation period less than 3 months 29
Figure A.2. Fixation period between 3 and 12 months....29
Figure A.3. Fixation period between 1 and 5 years 29
Figure A.4. Deposit rate....29
Figure A.5. Fixation period less than 3 months 30
Figure A.6. Fixation period between 3 and 12 months....30
Figure A.7. Fixation period between 1 and 5 years 30
Figure A.8. Deposit rate....30
Figure A.9. Fixation period of 3 months....30
Figure A.10. Fixation period of 5 years....30

INTEREST RATE PASS-THROUGH DURING THE GLOBAL FINANCIAL CRISIS: THE CASE OF SWEDEN

By Niels-Jakob Harbo Hansen and Peter Welz[1,2]

Introduction and key findings

The interest rate channel constitutes a key part of monetary policy transmission, especially in countries like Sweden, where banks play a major role in financing. Reductions in policy rates normally translate into broadly similar movements in market rates, in particular into interest rates at shorter maturities which influence, via the expectations channel, interest rates at longer maturities. The development of money market rates is important for two reasons: first, they provide a price signal for many other interest rates in the economy and second, they constitute an important part of banks' funding cost thus affecting lending and deposit rates offered to firms and households, with an ultimate impact on savings and investment decisions and real economic activity.[3]

The financial turmoil that erupted in summer 2007 and intensified in September 2008 with the collapse of Lehman Brothers, caused financial markets in Sweden to experience considerable stress as interest rate spreads shot up and financial institutions' access to funding was constrained. In October 2008 the Riksbank, the Swedish central bank, started a sequence of cuts in the policy rate, the repo rate, which brought it down by 450 basis points.[4] Moreover, the Riksbank implemented a wide range of additional non-conventional monetary policy measures to support the functioning of money and financial markets. This paper aims at contributing to the assessment of monetary policy in Sweden during the global financial crisis by investigating how the interest rate pass-through worked from the repo rate to retail rates from the onset of the crisis to the end of 2009.

There is a long-standing literature on interest rate pass-through, which expanded on the back of the global financial crisis. One branch focuses on country-specific factors to explain the heterogeneity of interest rate pass-through across countries: Cottarelli and Kourelis (1994) estimate the short- and long-run pass-through from money market rates to retail rates for 31 countries and explain it with a number of

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1. This working paper was produced in the context of the preparation of the 2011 OECD Economic Survey of Sweden. The working paper was written when both authors were employed with the Country Studies Branch of the OECD Economics Department. The opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the OECD or its member countries.

2. The authors are indebted to Niels Blomquist, Boris Cournède, Andres Fuentes, Jesper Hansson, Clovis Kerdrain, Vincent Koen, Stéphanie Jamet, Makoto Minegishi, Diego Moccero, Artur Radziwill and Luke Willard for very useful comments and suggestions. They are also grateful to Anna Lidberg, Johanna Nilsson and Albina Soultanaeva from the Riksbank for providing data for Swedish mortgage rates and CDS premia. Thomas Chalaux is thanked for excellent statistical assistance. All the usual disclaimers apply.

3. For a more complete review of the monetary transmission mechanism see *e.g.* Cournède *et al.* (2008).

4. The first interest rate cut was implemented in October 2008 in a coordinated action with the Bank of England, the Bank of Canada, the European Central Bank, the Federal Reserve and the Swiss National Bank.

structural variables such as the existence of barriers to competition, financial market development and banking system ownership structure. Another branch of the literature assesses whether various economic events altered the pass-through of interest rates. A prominent example is the introduction of the euro: Toolsema *et al.* (2001) and de Bondt (2005) analyse whether a change in the pass-through in the euro area had occurred with the introduction of the euro. They find some evidence for a faster interest rate pass-through after the introduction of the euro. More recently, a number of studies have investigated whether the global financial crisis altered the interest rate pass-through (Jobst and Kwapil, 2008; Deutsche Bundesbank, 2009; ECB, 2009). A general finding is that the pass-through from money market to bank lending and deposit rates has worked relatively well during the financial crisis even if banks have tightened their credit supply to some extent. Nevertheless, the ability of central banks to steer short-term interest rates has been impaired due to dysfunctional money markets as evidenced by elevated and volatile risk premia (Minegishi and Cournède, 2010). Central banks assumed the role of an important intermediary over certain periods as unsecured lending broke down almost completely and even secured lending in the repo market was severely hampered.

Against this background, the main findings of this paper are as follows:

- Before the onset of the financial crisis the Riksbank controlled short-term money market rates well, ensuring an effective transmission of monetary policy decisions to the money market. Indeed, there was a low and stable spread between money market rates and expected policy rates. However, during the financial crisis the link between the repo rate and money market rates weakened owing to large and volatile risk premia caused by the considerable stress in global financial markets. Risk premia and money market volatility in Sweden, however, increased less than in the euro area, United Kingdom and United States.

- Prior to the crisis the pass-through from the money market to the retail rates was sluggish but complete in the long term. Retail rates faced by non-financial companies adjusted faster than the rates faced by households. The financial turmoil did not affect the pass-through to short-term interest rates, but the pass-through to longer-term interest rates appears to have been impaired, likely reflecting constraints on financial institutions' access to long-term funding.

The paper proceeds as follows. Section 2 describes the pass-through from the repo rate to short-term money market rates and analyses how this link was affected by the financial turmoil. Section 3 analyses the pass-through from money market rates to retail rates before and during the financial crisis and discusses the price-setting behaviour of financial institutions in Sweden. Section 4 concludes.

The pass-through from policy rates to money market rates

Controlling short-term money market rates is the initial and an important step in the transmission of monetary policy decisions to yields and interest rates in financial markets more relevant for investment and savings decisions of firms and households. That is, changes in the policy rate directly affect rates with the shortest maturities in the interbank market, while longer-term money market rates are affected more by expectations of future repo rate changes, inflation expectations and other economic developments. Similarly, changes in the policy rate also affect interest rates for government securities with longer maturities. In most macroeconomic models it is assumed that changes in the policy rate lead to proportional changes in money market rates. While this might be a reasonable assumption during normal times, it does not necessarily hold during periods of financial stress.

This section focuses on the pass-through from the repo rate to money market rates in Sweden before and during the financial crisis.[5] Money market rates have moved closely together over the decade preceding the global financial crisis with occasionally larger deviations *e.g.* around the international financial turbulence in 1997-98 (the LTCM crisis) and around the time of the bursting dotcom bubble in 2000-01 (Figure 1). However, as the financial turbulence started in summer 2007 these various interest rates started to differ more implying that a part of the cuts in the repo rate did not translate into lower funding costs for banks and mortgage institutions.

The increased financial risk in the money market during the crisis can be illustrated by studying the spread between unsecured interbank lending and Treasury bill rates, the so-called TED spread, which provides a measure for the extra return that an investor requires for lending to a bank rather than to the government. Figure 2 shows the increased stress in the money market from summer 2007 onwards, culminating in autumn 2008 after the bankruptcy of Lehman Brothers, when the TED spread soared to more than 160 basis points in October 2008, from an average of 20 basis points over the decade prior to summer 2007.

To analyse the development in the TED spread more closely it is useful to decompose it into two components (Holmfeldt *et al.*, 2009):

$$\textit{TED spread} = TED - spread = (\textit{T-bill} - OIS) + (OIS - Stibor)$$ *(Stibor - OIS rate) + (OIS rate - T-bill rate)*

The *first* component is the difference between the unsecured interbank rate (Stibor)[6] and the overnight indexed swap rate (OIS), also called the basis spread. The Stibor is considered more risky than the OIS, as it is a measure of the rate at which a bank is willing to lend unsecured to other banks. In contrast the OIS rate is risk free as the parties in an OIS contract only swap a floating interest rate (tied to the overnight rate) for a fixed one. Hence, the basis spread provides a measure of credit and liquidity risk.[7] The *second* component is the difference between the OIS rate and the rate of a Treasury bill. In general both the OIS and the T-bill rate are considered to be risk-free rates and are mainly determined by demand and supply, but in times of increased uncertainty investors seek high-quality collateral thus increasing demand and the price for government securities. As a result the spread between the expected policy rate and the T-bill rate increased substantially in autumn 2008. Even though money market spreads had receded from these exceptionally high levels by late 2009, they were still 10 to 15 basis points above the average levels that prevailed before summer 2007.

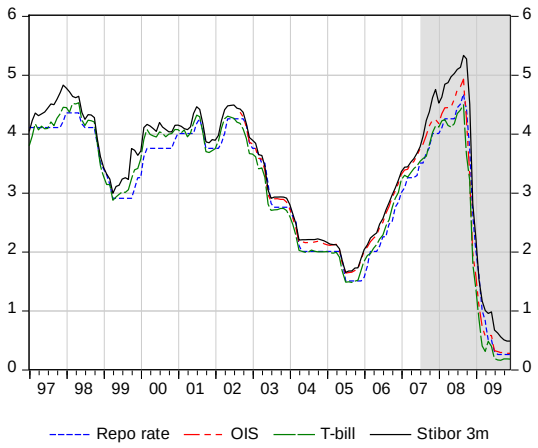
5. The analysis partly follows Hopkins *et al.* (2009).

6. Stibor stands for *Stockholm Interbank Offered Rate* and is the Swedish counterpart to Euribor and Libor.

7. Credit risk is the risk that the borrowing bank will fail to meet its obligations in accordance with agreed terms (Basel Committee on Banking Supervision, 1999). Liquidity risk is the risk that the lending bank will not be able to fund increases in assets and meet obligations as they become due (Basel Committee on Banking Supervision, 2000).

Figure 1. Money market interest rates

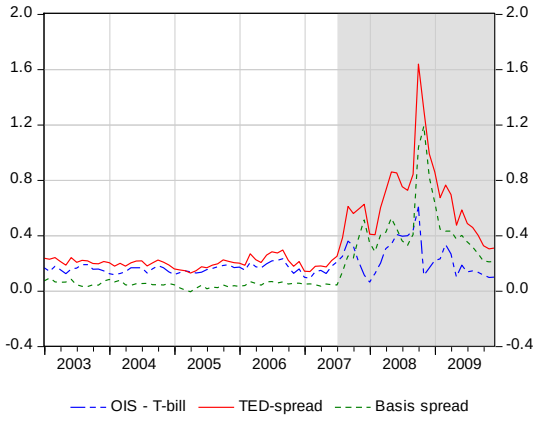
Percent



Note: Stibor = 3-month unsecured interbank rate; T-bill=3-month treasury bill rate; OIS = 3-month overnight indexed swap rate.

Figure 2. Money market spreads

Percentage points



Note: TED spread = 3-month Stibor – 3-month treasury bill rate; basis spread = 3-month Stibor – 3-month OIS rate.

Source: The Riksbank; Reuters.

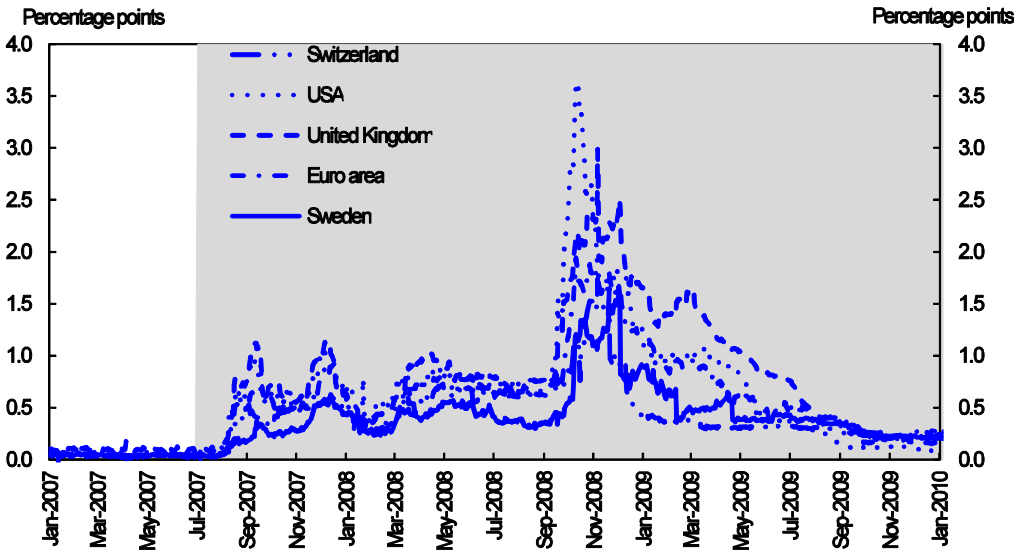
Figure 2 shows that most of the increase in the TED spread is explained by the risk premium (the basis spread), *i.e.* by rising credit and liquidity risk. Soultanaeva and Strömqvist (2009) further decompose the basis spread, and find that up until early 2009 liquidity risk accounted for most of the basis spread, but thereafter credit risk accounted for the largest part. The resulting impairment of the interest rate channel has been a global phenomenon across OECD countries during the crisis, as market participants' uncertainty over their own liquidity needs and aversion towards credit risk exposure grew (Minegishi and Cournède, 2010).

Compared to the euro area, the United Kingdom and the United States the increase in the risk premium in Sweden was relatively modest measuring up to 142 basis points (bp) compared to 366 bp and 360 bp in the United States and the United Kingdom, respectively (Figure 3). Of the countries compared in Figure 3 only risk premia in Switzerland displayed a similar development during the crisis.

A relatively low increase in Swedish banks credit risk is part of the explanation. Cross-country variations in the risk premium can be caused by differences in the perceived credit risk. Such differences are expected to show up in variations in premia on credit default swaps (CDS). Premia on Swedish CDS did indeed stay on a lower level *vis-à-vis* the euro area and the United States during most of 200709 (Figure 4) reflecting that Swedish banks only had little exposure to subprime loans (Finansinspektionen, 2007). In spring 2009 Swedish CDS premia nevertheless rose above the levels in the euro area and in the United States. This happened as the deep recession in the Baltic States, where Swedish banks have large market shares, caused an idiosyncratic shock to Swedish banks' credit risks. However, as only around 5% of total lending by Swedish banks is to the Baltic economies (Sveriges Riksbank, 2010e) the shock was absorbed without systematic consequences, and by autumn 2009 the elevated CDS premia had receded (IMF, 2011).

Figure 3. Risk premia measured by basis spreads across countries

Percentage points

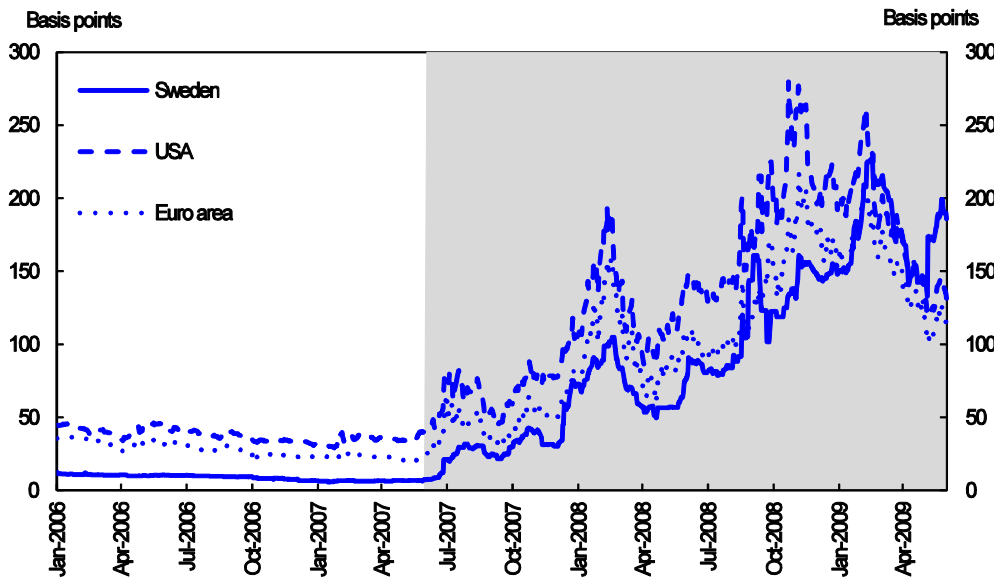


Note: Basis spread: three-month interbank rate – three-month OIS swap rate.

Source: Central bank data; Bloomberg.

Figure 4. International CDS spreads

Basis points



Note: For Sweden an average of the CDSs for the four largest banks is used, for the Euro area the iTraxx Finance index is used and for the United States the CDX index.

Source: Soultanaeva and Strömqvist (2009).

A comparatively low rise in the perceived liquidity risk also reduced the increase in the basis spread. Generally, a lower degree of money market volatility should reduce the uncertainty of banks' future

funding situation and thereby dampen their liquidity risk. Indeed, the results in Table 1 show that the Swedish money market experienced a relatively low volatility during the crisis.

Table 1. Money market volatility

	Euro area	**Sweden**	Switzerland	UK	US
Jan 2004 – July 2007	0.09	**0.09**	0.07	0.08	0.08
July 2007 – Dec 2009	0.21	**0.19**	0.08	0.31	0.36

Note: For each period with an unchanged policy rate a separate mean of the three-month interbank rate (Libor) is computed. The volatility is computed as the standard deviation of the three-month interbank rate with respect to this time-varying mean.

Source: OECD (2009); Central bank data; Own calculations.

The conduct of monetary policy could explain some of the differences in the basis spread through its impact on money market volatility. In Switzerland, the Swiss National Bank (SNB) directly targets the three-month interbank rate. This may have reduced volatility in the Swiss money market and, in turn, the liquidity risk faced by banks (OECD, 2009). In Sweden, the Riksbank uses the repo rate to indicate what the overnight interest rate will be one week ahead. Besides a 150 bp corridor[8], where the corridor bounds form the interest rates of the standing facilities (lending and deposit rate), the Riksbank in practice keeps the overnight rate much closer to the repo rate by means of daily fine tuning operations carried out at the repo rate +/- 10 bp. This narrow corridor may have contributed to overall lower money market volatility in Sweden during the period from July 2007 until the end of 2009 relative to the euro area, the United States and the United Kingdom. The Riksbank's publication of own interest rate projections is probably less important for money market volatility (Holmsen *et al.* 2008; Andersson and Hofmann, 2010).

Although the increase was limited in relative terms the basis spread did still rise substantially in Sweden, in particular after the turmoil intensified in September 2008. Dollar liquidity shortage is likely to have played an important role in this development. During the crisis non-US financial institutions increasingly had to rely on currency swaps in order to borrow US dollar funds (ECB, 2008). Higher counterparty risk caused the rates of these swaps to rise and the market to become less liquid, which in turn implied higher interbank rates outside the United States. Indeed, analysis by Soultanaeva and Strömqvist (2009) suggests that this spilled over to the Swedish money market contributing to an increase in the basis spread.[9]

Overall, monetary policy in Sweden during the crisis may have been tighter than intended. *First*, the basis spread was high in absolute terms and this dampened the impact of the interest rate cuts. Compensating for this elevated spread by lowering interest rates further was made even more challenging as the policy rate approached the lower bound. *Second*, the deviation in market expectations from the expected repo rate path contributed to a tighter than intended monetary stance. *Third*, as financial institutions in Sweden and abroad became reluctant to take on counterparty risk access to credit was impaired, especially at longer maturities.

8. Between autumn 2008 and July 2010 the symmetric corridor was narrowed to 100 bp. With the simultaneous increase of the repo rate to 0.5 per cent and the widening of the corridor to 150 bp the deposit rate continues to stay at -0.25 per cent.

9. Soultanaeva and Strömqvist (2009) find that the correlation between risk premia in the Swedish money market and risk premia in the euro area and US money markets exceeded 0.9 during the most turbulent periods of the crisis.

Against this backdrop the Riksbank has launched a number of non-conventional measures since autumn 2008 aimed at improving the functioning of the money market and more generally financial markets (see Annex A1 for a detailed description of the measures):[10]

- *Liquidity in foreign currency:* To provide access to sufficient US dollar liquidity the Riksbank signed a swap agreement with the US Federal Reserve and later established a credit facility providing US dollar loans to financial institutions in Sweden. Under the latter programme, the Riksbank allotted loans totalling $73.3 billion between October 2008 and March 2010. The Riksbank also signed a swap agreement with the European Central Bank to ensure access to liquidity in euros, and a total of €3 billion was borrowed in the context of this agreement. In addition to this, the Riksbank provided support to the central banks of Estonia, Latvia and Iceland via swap agreements in euro and SEK.

- *Provision of long-term funding:* As financial institutions' access to funding at long maturities was severely impaired during the crisis the Riksbank extended the maximum maturity of its liquidity-providing operations to one year. Between October 2008 and March 2010 the Riksbank allotted a total of SEK 958.5 billion in loans with maturities up to 12 months.

- *Relaxation of collateral requirements and increased number of eligible counterparts:* To meet the increased demand for liquidity the Riksbank eased the access to liquidity by widening the range of eligible assets in refinancing and payment system operations. In addition the Riksbank expanded the list of eligible counterparties to ensure that all Swedish credit institutions had access to sufficient funding during the period of malfunctioning credit markets. This was done as the initial requirements kept many Swedish credit institutions from accessing the Riksbank's facilities.[11]

- *Support to specific institutions:* To safeguard financial stability the Riksbank provided special liquidity assistance to Kaupthing Bank and Carnegie Investment Bank AB in September 2008. Within four months the former loan was repaid by the bank that acquired Kaupthing Bank and the latter was replaced by a loan from the National Debt Office.

In sum, the Riksbank used a wide range of non-conventional instruments during the crisis (Table 2), but unlike other OECD central banks (such as the US Federal Reserve, the Bank of England and more recently the European Central Bank) it did not intervene directly in certain financial market segments. The Riksbank did however indirectly support the commercial paper market as it allowed counterparts to use commercial papers as collateral in its credit operations (Sellin, 2009) and reduced the limitations on the use of covered bonds as collateral.

The expanded provision of loans caused the central bank balance sheets to increase markedly from autumn 2008 (Figure 5). Although the balance sheet of the Riksbank grew substantially compared to other central banks, the Swedish monetary base increased the least of the central banks compared in Figure 5. This stems from the fact that the Riksbank absorbed the excess liquidity through fine-tuning operations and issuance of debt certificates (Minigishi and Cournède, 2010).

10. See also Minegishi and Cournède (2010) for a comprehensive overview of the measures used by central banks during the crisis. See Borio and Disyatat (2009) for a taxonomy.

11. Initially, only participants in the Riksbank's system for large-value payments (RIX) were eligible to become monetary counterparties. This meant that as of April 2009 just 16 credit institutions were monetary counterparties. The number of Swedish banks alone was 118 (at the end of 2008) (Swedish Bankers Association, 2010b).

Table 2. Non-conventional measures taken as of June 2010

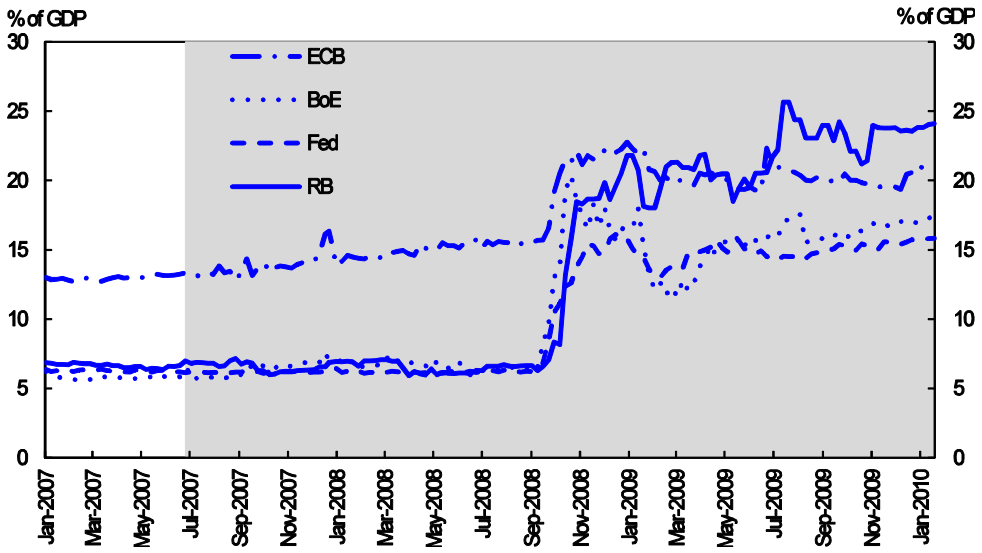
	Fed	ECB	BoJ	BoE	BoC	RB	SNB
Increased liquidity provision to financial institutions	X	X	X	X	X	X	X
Direct intervention in certain financial market segments	X	X	X	X			X
Purchase of government bonds	X	X	X	X			
Support to specific institutions	X		X	X		X	X

Notes: Fed refers to US Federal Reserve, ECB to the European Central Bank, BoJ to Bank of Japan, BoE to Bank of England, BoC to Bank of Canada, RB to the Riksbank and SNB to the Swiss National Bank.

Source: Minegishi and Cournède (2010); ECB (2010).

Figure 5. Central banks' balance sheet

Total assets as percent of GDP



Notes: Fed refers to US Federal Reserve, ECB to the European Central Bank, BoE to Bank of England and RB to the Riksbank.

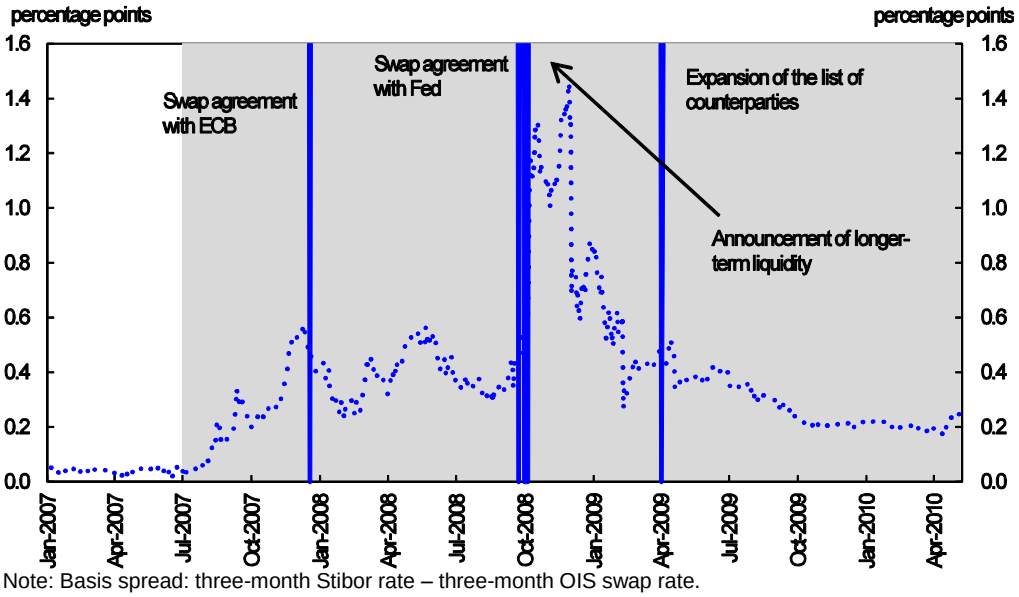
Source: Sveriges Riksbank (2010a).

Assessing the impact of these non-conventional measures on money market conditions is not trivial, not least because the international dimension of the crisis may have limited the control of the Riksbank over money market spreads (Hopkins *et al.*, 2009). However, available studies suggest that announcements of macroeconomic and financial sector policies can reduce risk premia.[12] In the Swedish case it is hard to identify an immediate effect of the announcements of measures by the Riksbank (Figure 6). However, money market conditions appear to have largely normalised since late 2009, thus facilitating the transmission of the repo rate declines into lower funding costs for banks and mortgage institutions.

12. See Minegishi and Cournède (2010) for a review.

Figure 6. Basis spread and announcements by the Riksbank

Percentage points



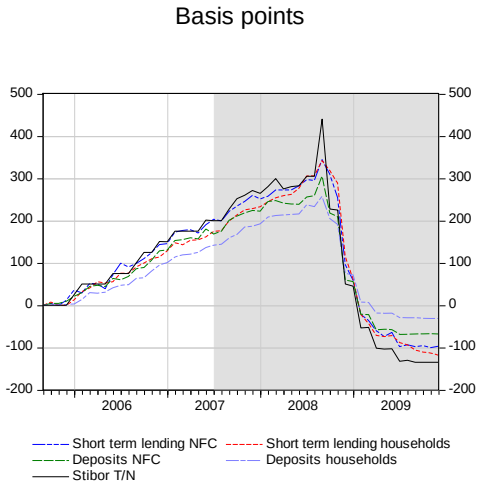
Note: Basis spread: three-month Stibor rate – three-month OIS swap rate.

Source: The Riksbank; Reuters.

The pass-through from money market to retail rates

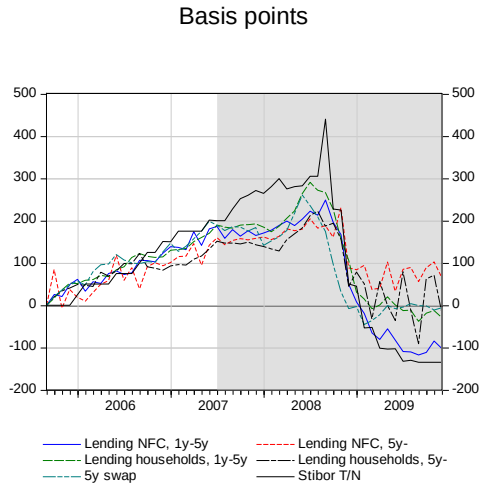
The pass-through from money market to retail rates constitutes the second step of the interest rate channel. In this section estimates of this pass-through in Sweden are presented and discussed, and it is investigated to what extent this part of the transmission mechanism has been affected by the financial crisis. Specifically, it is studied how the decline in money market rates has been transmitted to retail rates from autumn 2008 to the end of 2009. Since a detailed set of Swedish bank lending and deposit rate data is available only from 2005, *i.e.* not even covering a full interest rate cycle, the analysis is confined to a relatively narrow selection of interest rates (see Annex A2 for a detailed data description).

Figure 7. Changes in money market and short-term retail lending and deposit rates



Notes: Stibor T/N is the tomorrow-next unsecured interbank lending rate. Short-term lending rates are rates offered by monetary and financial institutions with an interest rate fixation period below three months. NFC stands for non-financial companies.

Figure 8. Changes in money market rates and long-term retail lending rates



Note: 5y swap is the yield on a five-year swap rate.

Source: The Riksbank; Statistics Sweden.

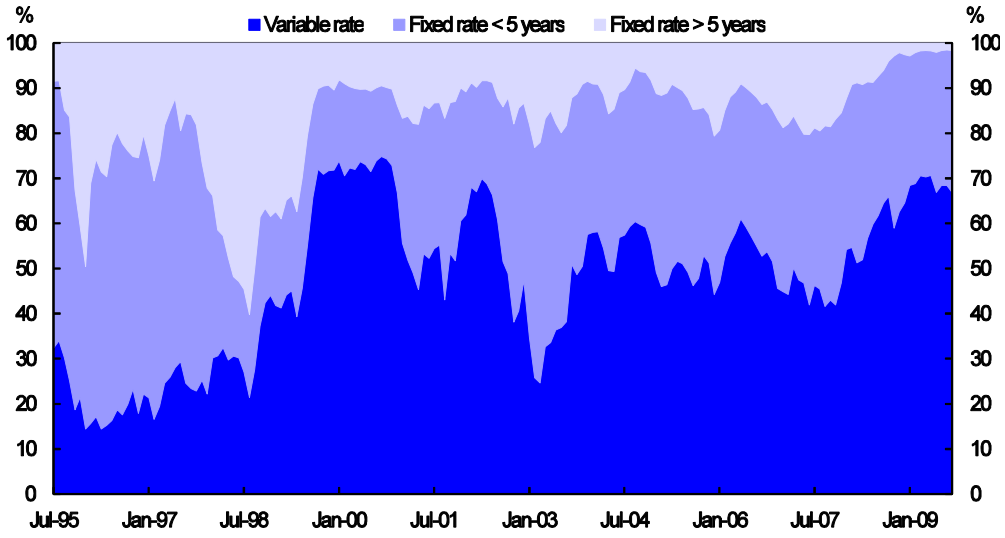
Historically, retail rates in Sweden have moved relatively closely with short-term money market rates as witnessed by the monthly changes in the tomorrow-next unsecured interbank lending rate and a number of selected retail interest rates (Figures 7 and 8). Retail rates followed the upward trend in policy and money market rates closely prior to autumn 2008 and they have fallen quickly as money market rates declined afterwards. However, during the period of interest rate increases until 2007 short-term bank lending rates increased less than short-term money market rates (Figure 7), which caused interest rate spreads between retail and money market rates to decline. Moreover, since spring 2009 some long-term interest rates do not seem to have followed long-term money market rates as closely as before (Figure 8; Figure A.1-A.10; Table A.2).

Below the pass-through from money market rates to mortgage rates in Sweden is studied in more detail. Swedish mortgage institutions fund themselves through issuance of bonds and certificates (Swedish Bankers' Association, 2010a), with interest rates that usually are closely linked to those in the money market. The largest mortgage institutions in Sweden are owned by banks and can therefore also achieve funding through bank lending on the money market. Hence, money market rates are indicative of a major share of the funding costs for both banks and mortgage institutions in Sweden.

The pass-through from money market rates to mortgage rates has become increasingly important for monetary policy in recent years. The majority of household debt stems from mortgage loans,[13] and the use of loans with variable interest rates has become more widespread implying that these loans today make up for the largest portion of households' new mortgage loans (Figure 9). Hence, consumers are now affected faster by changes in interest rates (Sveriges Riksbank, 2010d).

13. Lending from housing credit institutions accounted for 63% of all household lending from monetary financial institutions in 2009 (Statistics Sweden, 2009).

Figure 9. Households' new mortgage loans broken down by interest rate fixation period



Note: A loan with a variable rate is defined as a loan with an interest rate fixation of three months or shorter.

Source: Sveriges Riksbank (2010a).

To investigate the interest rate pass-through in Sweden before the onset of the financial turbulence estimates of interest rate pass-through prior to July 2007 are presented in Table 3 (see Annex A3 for a discussion of the method). The estimates suggest that the pass-through of money market rates to household mortgage rates was sluggish in the short run but complete in the long run. Moreover, short-term mortgage rates faced by households seemed to adjust more slowly than those faced by non-financial companies. Overall, these findings are similar to those for the euro area and Germany (de Bondt, 2005; von Borstel, 2008; ECB, 2009).

Table 3. Estimated pass-through from money market to retail rates prior to July 2007

	Retail bank rate	Immediate pass-through	Long-term pass-through	Adjustment coefficient	Complete pass-through?		Money market rate used in model
					In the long run	In the short run	
	Households						
	Listed mortgage rates, monthly frequency						
(1)	3 months	0.66**	1.00**	0.28**	Yes**	No**	Stibor 3m
(2)	5 years	0.20**	0.98**	0.16**	Yes**	No**	Swap 5y
	Housing credit institutions interest rates, quarterly frequency						
(3)	3 months	0.49**	1.08**	0.64**	Yes**	No**	Stibor 3m
(4)	3 months – 1 year	0.64**	0.95**	0.60**	Yes**	No**	Stibor 6m
(5)	1 year – 5 year	0.75**	1.08**	0.32**	Yes**	No**	Swap 2y
	Non-financial companies						
	Housing credit institutions rates, quarterly frequency						
(6)	3 months	0.51**	1.01**	0.90**	Yes**	No**	Stibor 3m
(7)	3 months – 1 year	0.61**	1.02**	0.95**	Yes**	No**	Stibor 6m
(8)	1 year – 5 year	0.65**	0.99**	0.33**	Yes**	No**	Swap 2y

Notes: ** and * denotes significance at the 5 % and 1 % level, respectively. (1) is estimated for the period 1997M1 to 2007M6, (2) is estimated on data from 1994M1 to 2007M6 and (3)-(8) are estimated on data from 1996Q2 to 2007Q2. The test for complete pass-through in the long run tests whether the long-term pass-through equals one. The test for the short run does the same for the immediate pass-through.

Source: Statistics Sweden; the Riksbank; authors' estimates.

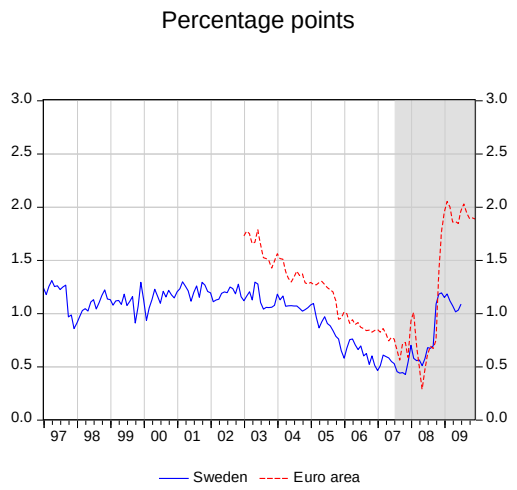
Competition in the market for mortgage loans could be part of the explanation for the high degree of pass-through. Money market rates represent the funding cost of loans (Gropp *et al.*, 2007), accounting for a major share of marginal costs for credit institutions (Ausubel, 1991). A high degree of competition could therefore be reflected in a high degree of pass-through and low spreads between money market and retail rates. In fact, similar to developments in the euro area the margins between mortgage and money market rates in Sweden had been narrowing between 2004 and the onset of the turmoil in July 2007 (Figures 10 and 11). Strong competition in the mortgage housing market has been contributing to this development but also lower costs of providing housing finance (Nordman, 2005; Sveriges Riksbank, 2007). In particular the Basel-II regulation implemented new capital adequacy norms in 2007, but retail rates may have been already affected earlier as financial institutions anticipated these changes (Sveriges Riksbank, 2007).

The high degree of pass-through and low interest rate spreads prior to the crisis may also have been fostered by low volatility in the money market. In general banks are exposed to interest rate risk when supplies of deposits and demands for loans do not emerge simultaneously. Banks may thus face a reinvestment risk in those cases when deposits arrive before loans are demanded as the additional deposits would have to be placed for a short time in the money market generating relatively lower returns. On the other hand they may face a refinancing risk when loan demand increases before an increase in deposits can be obtained and they have to borrow additional funds in the money market. Therefore, volatility in the money market is expected to increase interest rate margins as banks would require higher risk premia to compensate for the additional interest rate risk (Gropp *et al.*, 2007). In fact, money market volatility measured by the standard deviation of the 3-month Stibor over the period January 2002 to July 2007 declined to 0.09, down by 5 bp compared to the five-year period before.

Short-term stickiness in retail interest rates has also been found for other countries (*e.g.* de Bondt, 2005) and appears to differ across loan types in Sweden. Notably, similar to results found for the euro area (ECB, 2009), Swedish household mortgage rates with shorter maturities adjust slower than interest rates offered to non-financial companies (see the adjustment coefficients in Table 3). With a view to risk-sharing, banking institutions are likely to smooth movements in retail rates over the business cycle to insulate customers from volatile market developments with the aim of keeping a long-term customer relationship (ECB, 2009; Berger and Udell, 1992).

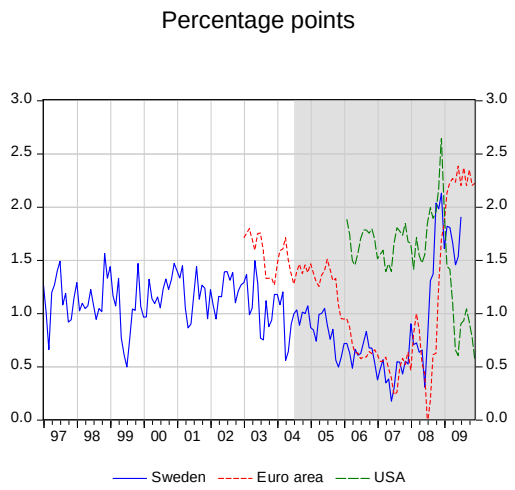
The paper now turns to an investigation of the pass-through during the global financial crisis. At the onset of the crisis in summer 2007 spreads between mortgage and money market rates started to increase across OECD countries (Figures 10 and 11). Higher money market volatility exposed banks to higher credit and interest rate risk (Table 1), and the worsened economic outlook increased further the credit risks which caused financial institutions to increase their risk premia for retail lending. Spreads jumped up further as the turmoil intensified in autumn 2008, but eased somewhat as financial conditions improved in 2009. However, spreads in Sweden, and in the euro area, remained above levels seen prior to the crisis. In contrast spreads eased considerably in the United States, where the Federal Reserve intervened directly in the mortgage market by purchasing mortgage-backed securities (Minegishi and Cournède, 2010).

Figure 10. Spreads between money market rates and mortgages rates to households, short-term lending



Notes: Sweden: mortgage rate with three-month interest rate fixation - Stibor three-month rate. Euro area: interest rate for house loans with maturity up to one year - Euribor six-month rate.

Figure 11. Spreads between money market rates and mortgages rates to households, long-term lending



Notes: Sweden: mortgage rate with five-year interest rate fixation - five-year swap rate. USA: conventional mortgage bond (30 years) - Treasury bond yield (30 years). Euro area: interest rate for a house loans with maturity from one year and up to five years – two-year swap rate.

Source: Datastream; Central bank data.

The financial tensions have caused large distortions in financial markets with likely consequences for the stability of monetary transmission in general and interest rate pass-through in particular. To investigate this further a method that can account for instability is used. The parameters of the long-run pass-through from money to retail rates are estimated recursively using an autoregressive distributed lag (ARDL) model through the period of the turmoil (see Annex A3 for details on the methodology). The recursive estimates are presented in Figures 13 and 14, and suggest that the long-run pass-through to mortgage loans with a short interest rate fixation period has been broadly unchanged during the financial turmoil. However, the figures indicate that the pass-through to mortgage loans with a long interest fixation period has been impaired since the turbulence started.

Figure 13. Estimated long-run pass-through to household mortgage rates

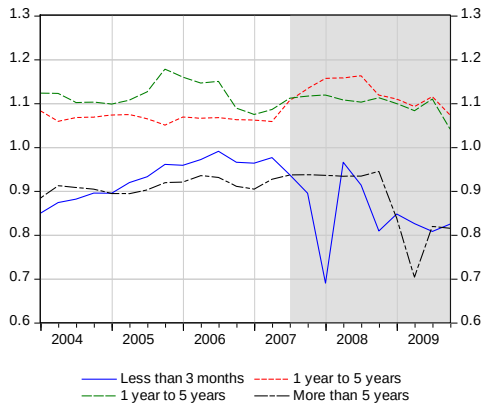
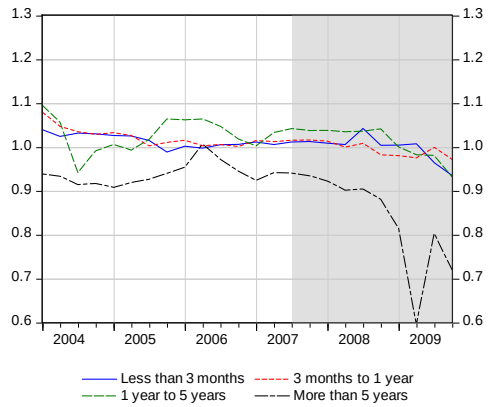


Figure 14. Estimated long-run pass-through to non-financial companies mortgage rates



Note: The long-run pass-through using a recursive ARDL model (see Annex A2).

Source: Statistics Sweden; authors' estimates.

Following ECB (2009) the robustness of these findings is assessed by means of a prediction exercise in order to investigate how, since autumn 2008, declining money market rates have been transmitted to bank lending rates. Figures 15 and 16 provide a comparison of the actual retail rates since September 2008 with the counterfactual retail rates that would have prevailed in the presence of an unchanged pass-through mechanism. The counterfactual retail rates are constructed using the actual money market rates since September 2008 and the estimated pass-through mechanism in Table 3 (see Annex A3).

The results show that the mortgage rates with an interest rate fixation of three months evolved as implied by the pre-crisis pass-through mechanism (Figure 15). Hence, after possibly initially restoring interest margins to some extent mortgage institutions seem to have passed on reductions in money market rates to loans with a short interest rate fixation period almost in the same fashion as prior to the financial turmoil.

On the other hand, Figure 16 suggests that the transmission mechanism for mortgage rates with an interest rate fixation of five years has been hampered as these mortgage rates decreased less than would have been implied by an unchanged pass-through mechanism. This is likely to be caused by the restrained access to long-term funding experienced by financial institutions during the crisis. Therefore, due to the increasing and more volatile spreads between the yield of five-year mortgage bonds and the five-year swap rate the usually tight link between money market rates and mortgage institutions funding costs weakened significantly.

Swedish financial institutions' access to long-term loans was particularly restrained because of scarce availability of foreign funding (Blomberg, 2009). This caused short-term funding to become more dominant and brought about a shift in the financial institutions' funding structure towards shorter maturities, which contributed to a de-coupling the long-term retail rates from the corresponding money market rates. Access to long-term funding improved in 2009, notably due to the Riksbank's lending at longer maturities, which may have contributed to the observed improvements in the transmission mechanism (Figure 16). However, for households this deficiency was less important as most new mortgage loans to households currently are based on variable loan rates (as shown in Figure 8).

Figure 15. Predicted and actual interest rate for households, three-month fixation

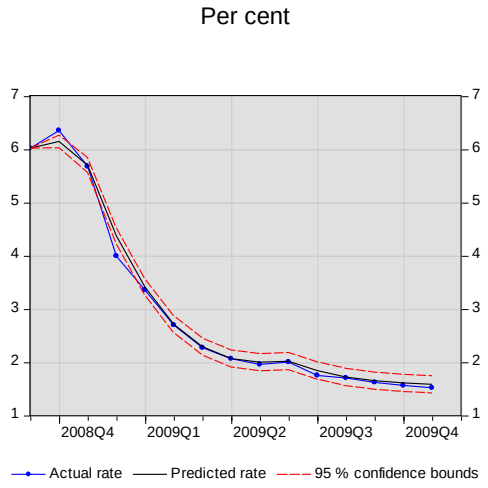
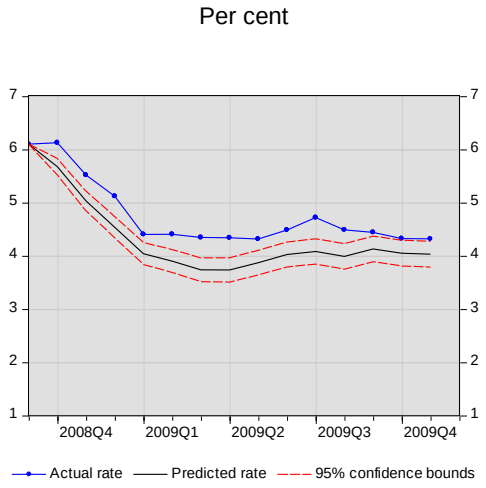


Figure 16. Predicted and actual interest rate for households, five-year fixation



Note: Counterfactual and actual mortgage rates from 2008m9. The counterfactuals have been constructed using the estimated pre-crisis interest rate pass-through (Table 3). Asymptotic confidence bands of 95%. See Annex 2 for discussion of method.

Source: Statistics Sweden; authors' estimates.

The results for Sweden presented above are generally in line with the results found in other studies on interest rate pass-through in OECD countries during the financial turmoil (Table 5). The available studies all suggest that the crisis did not impair the pass-through to short-term retail rates, while results are ambiguous for interest rates at longer maturities.

Table 4. Studies of the pass-through from money market to retail rates during the crisis

		Did the crisis impair interest rate pass-through?			
Region	Crisis sample	Households [1]		Non-financial companies	
		Short-term	Long-term	Short-term	Long-term
Euro area	2007M7-2009M5	No	[2]	No	[1]
Germany	2007M9-2009M3	No	NA [3]	No	NA [2]
Austria	2007M7-2008M10	No	No	No	No

Notes:

1) Loans for house purchase.

2) The ECB concludes that the crisis in general did not impair the pass-through. However, in the second half of 2007, and most of 2008, the long-term interest rate for non-financial companies did hover above the level predicted by an unchanged pass-through. Similarly, the long-term rate for housing purchases was above the predicted level in the first quarter of 2009.

3) The Bundesbank does not investigate the pass-through to long-term lending but notes that "there probably has been a decline in the importance of the capital market for banks refinancing and, therefore, in the relevance of the yield on bank bonds, which typically represent the starting point for studies on the pass-through of interest rates."

Source: Jobst and Kwapil (2008); ECB (2009); Deutsche Bundesbank (2009).

Although the financial turmoil did not appear to cause a general impairment of interest rate pass-through from money market rates to lending rates, it was associated with a quantity effect in the market for loans. On the supply side, surveys suggest that credit standards in Sweden for both households and companies have been tightened since early 2008 (ALMI, 2010), and total lending to households and firms slowed down sharply from late 2007 (Figure 17). However, the overall slowdown in Sweden was less

pronounced than in the United States and the euro area owing to a relatively modest decline in the growth rate of lending to households (Figure 18) as household borrowing was supported by low interest rates and the high fraction of variable rate mortgage loans. Since mid-2009 bank lending to households has picked up, and the Riksbank's company survey from December 2009 suggests that companies' access to loans was improving, although the situation had not yet normalised (Sveriges Riksbank, 2010a).

Figure 17. MFIs lending to companies and households across countries

Annual percentage change

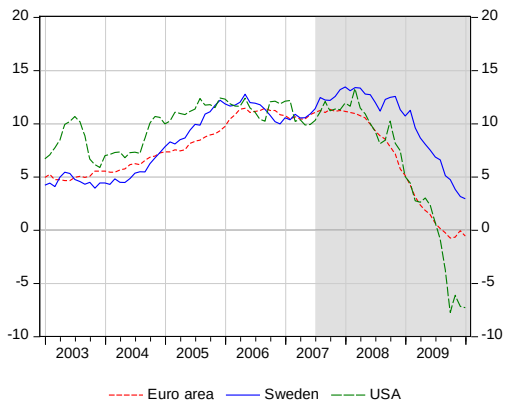
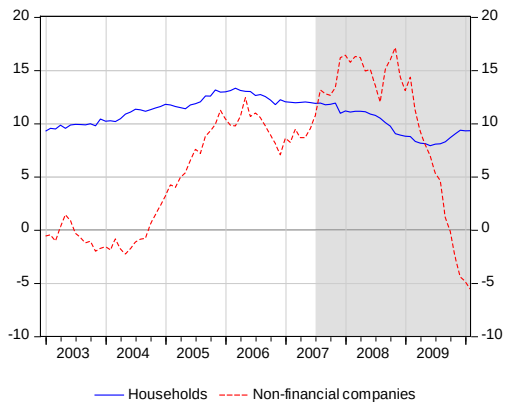


Figure 18. MFIs lending to companies and households in Sweden

Annual percentage change



Source: OECD (2010); Sveriges Riksbank (2010a).

Conclusions

The evidence presented in this paper suggests that the Riksbank effectively controlled money market rates at the shortest maturities prior to the start of the financial turmoil in summer 2007. In addition, the pass-through from money market rates to housing credit institutions' lending rates was complete in the long run although sluggish in the short run. The pass-through was faster for loans offered to non-financial companies than to households.

During the period from 2004 to summer 2007, the spreads between retail and money market rates shrank. This may have been facilitated by increased competition in the banking sector, a low degree of volatility in money market rates and institutional changes, such as easier access to securitisation, which decreased the costs of providing housing credit. Lacking longer time series data it can only be conjectured that these results may be valid at least qualitatively for a broader set of retail interest rates. As the financial crisis started in 2007 interest rate spreads began increasing in summer and have remained above pre-crisis levels so far.

The ability of the Riksbank to affect retail rates in the economy weakened during the financial turmoil. Higher risk premia in money and financial markets hampered the transmission of monetary policy decisions to money market rates, through less so than in the euro area, the United Kingdom and the United States. Since 2009 money market conditions have eased globally and in Sweden, which has facilitated the transmission of policy rate reductions to lower funding costs of banks and mortgage institutions. During the crisis the pass-through from money market to retail rates continued to work well for short-term lending, but appears to have been impaired for lending at long maturities as financial institutions' access to long-term funding was restrained. However, since long-term funding picked up in 2009 the behaviour of longer lending rates has normalised somewhat.

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ANNEX A1. NON-CONVENTIONAL MEASURES TAKEN BY THE RIKSBANK

As of July 2010 the Riksbank had taken the following measures:

Provision of longer-term liquidity

- Longer-term credit facilities at a variable rate

  Since February 2009 loans at a variable rate with a maturity of three and six months were provided to counterparties. In May 2009 it was decided to add loans with a maturity of 12 months to the programme. These longer-term loans replaced the regular one-week loan facility that was in place until autumn 2008.

  In February 2010 the Riksbank announced that it would cease to offer loans with a maturity of 12 months, and the last auction offering these loans was held the same month. At the same occasion the Riksbank increased the premium for loans with maturities of three and six months.

  In April 2010 the Riksbank announced that it would cease to provide loans at maturities of three and six months. These loans were replaced by loans with a maturity of 28 days.

  In July 2010 the Riksbank increased the price of 28-day loans by raising the supplement over and above the average repo rate by 0.50 percentage points.

- Longer-term credit facility at a fixed rate

  Between October 2008 and February 2009, loans with maturities of three and six months were provided. The interest rates were decided through single price auctions.

  Since July 2009 loans with a maturity of 11 and 12 months at a fixed rate with a premium on the repo rate were provided. All these loans matured during 2010 and have not been renewed.

- Credit facility against commercial paper as collateral

  To facilitate the supply of credit to non-financial companies, a credit facility where counterparts can use commercial paper with a maturity of up to one year as collateral was started in October 2008. The facility was closed in September 2009 due to lack of demand.

Relaxation of collateral eligibility requirements

- Reduced collateral requirements

  In September 2008 the limitation on the share of covered bonds, issued by the borrower or by an institution with close links to the borrower that can be used as collateral in the payment system was relaxed, and in October 2008 the limitation was removed altogether. Also the minimum credit rating requirement for long-term securities was lowered.

Expansion of the list of counterparties to central bank operations

- Extension of eligible counterparties

In April 2009 the group of eligible counterparties was extended to give all financial institutions with a registered office in Sweden the opportunity to become restricted counterparties with access to the temporary credit facilities.

Liquidity provisions in foreign currency

- Swap agreements with:

  The US Federal Reserve Bank. A swap liquidity line which gave the Riksbank the right to borrow up to $30 billion was established in September 2008. The line was prolonged in June and February 2009 and expired in February 2010.

  The European Central Bank. A swap liquidity agreement of up to €10 billion was signed in December 2007. The agreement gave the Riksbank the right to borrow up to €10 billion against Swedish kronor. In the context of this agreement, €3 billion were borrowed in June 2009. The loan was repaid in September 2009.

  The Icelandic central bank. In May 2008 the Riksbank, jointly with the Danish and Norwegian central banks, signed a swap liquidity agreement with the Icelandic central bank. The agreement gave the latter the right to borrow up to €500 million from the Riksbank against Icelandic krona.

  The Latvian central bank. The Riksbank in December 2008, jointly with the Danish central bank, signed a swap liquidity agreement with the Latvian central bank. The agreement entitled the Latvian central bank to borrow up to €500 million against Latvian lats. The share of the Riksbank accounted for €375 million. The agreement was prolonged in August 2009.

  The Estonian central bank. A swap liquidity agreement giving the Estonian central bank the right to borrow up to SEK 10 billion against Estonian kroons was signed in February 2009.

- Longer-term credit facility in US dollars

  In September 2008 the Riksbank offered counterparties loans in US dollars for a term of one and three months. The programme was phased out in December 2009 due to lack of demand.

- Strengthening of the foreign exchange reserves

  The Riksbank in May 2009 borrowed the equivalent of SEK 100 billion in foreign currency to be able to provide sufficient foreign currency to Swedish financial institutions. The currency was borrowed though the National Debt Office.

Supporting specific institutions

- Special liquidity assistance to:

  Kaupthing Bank Sverige AB. The Riksbank provided a loan of up to SEK 5 billion in October 2008. The loan was repaid by Ålandsbanken which acquired Kaupthing Bank in February 2009.

  Carnegie Investment Bank AB. A loan of up to SEK 5 billion was provided in October 2008. This was replaced in November 2008 by a loan from the Swedish National Debt Office as the Financial Supervisory Authority revoked the bank's license to conduct banking operations.

Other measures

- Issuance of Riksbank Certificates (debt certificates)

In October 2008 the Riksbank started issuing debt certificates with a maturity of seven days. This measure was taken to absorb the liquidity surplus in the money market. Subsequently it has issued certificates of longer maturity

Note: Classification follows Minegishi and Cournède (2010).

Source: Sveriges Riksbank (2010b).

ANNEX A2. DATA DESCRIPTION AND TESTS

Tables

A.1. Money market and retail rates

A.2. Contemporaneous correlation of retail and money market rates, levels

A.2. Contemporaneous correlation of retail and money market rates, first differences

A.3. Determination of integration order for selected interest rate series

A.4. Tests for co-integration

Figures

A.1-A.4 Retail and money market rates for various interest rate fixation periods, non-financial companies

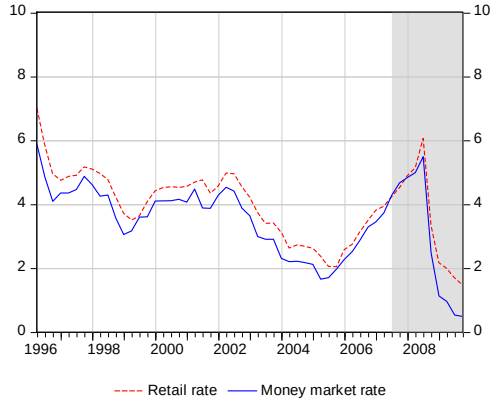
A.5-A.10 Retail and money market rates for various interest rate fixation periods, households

Table A.1. Money market and retail rates

	Abbreviation	Description	Source	Sample
Money market rates				
	Stibor t/n	Interbank rate for lending from tomorrow to following day	The Riksbank	1998M6-2009M12
	Stibor 1w	Interbank rate for lending with a maturity of 1 week	The Riksbank	1998M6-2009M12
	Stibor 1m	Interbank rate for lending with maturity of 1 month	The Riksbank	1998M6-2009M12
	Stibor 3m	Interbank rate for lending with maturity of 2 months	The Riksbank	1987M9-2009M12
	Stibor 6m	Interbank rate for lending with maturity of 6 months	The Riksbank	1998M6-2009M12
	Stibor 9m	Interbank rate for lending with maturity of 9 months	The Riksbank	1998M6-2009M12
	Stibor 12m	Interbank rate for lending with maturity of 12 months	The Riksbank	1998M6-2009M12
	Swap 2y	Money market swap rate with maturity of 2 years	The Riksbank	1998M6-2009M12
	Swap 5y	Money market swap rate with maturity of 5 years	The Riksbank	1998M6-2009M12
	Stina 1m	Money market swap rate with maturity of 1 month	Ecowin	2002M9-2009M12
	Stina 2m	Money market swap rate with maturity of 2 months	Ecowin	2002M9-2009M12
	Stina 3m	Money market swap rate with maturity of 3 months	Ecowin	2002M9-2009M12
	Stina 6m	Money market swap rate with maturity of 6 months	Ecowin	2002M9-2009M12
	Stina 12m	Money market swap rate with maturity of 12 months	Ecowin	2002M9-2009M12
Retail rates				
	rr 3m	Listed mortgage rate for households with 3 months of interest rate fixation	The Riksbank	1997M1-2009M11
	rr 5y	Listed mortgage rate for households with 5 years of interest rate fixation	The Riksbank	1992M1-2009M11
	rrq7	Housing credit institution's lending rate to non-financial companies, interest rate fixation less than 3 months, new agreements	Statistics Sweden	1996Q2-2009Q4
	rrq8	Housing credit institution's lending rate to non-financial companies, interest rate fixation 3 months to 1 year, new agreements	Statistics Sweden	1996Q2-2009Q4
	rrq9	Housing credit institution's lending rate to non-financial companies, interest rate fixation 1 year to 5 years, new agreements	Statistics Sweden	1996Q2-2009Q4
	rrq13	Housing credit institution's lending rate to households, interest rate fixation less than 3 months, new agreements	Statistics Sweden	1996Q2-2009Q4
	rrq14	Housing credit institution's lending rate to households, interest rate fixation 3 months to 1 year, new agreements	Statistics Sweden	1996Q2-2009Q4
	rrq15	Housing credit institution's lending rate to households, interest rate fixation 1 year to 5 years, new agreements	Statistics Sweden	1996Q2-2009Q4
	dep_nfc	Bank's deposit rate to non-financial companies, all accounts	Statistics Sweden	1996Q2-2009Q4
	dep_hh	Bank's deposit rate to households, all accounts	Statistics Sweden	1996Q2-2009Q4

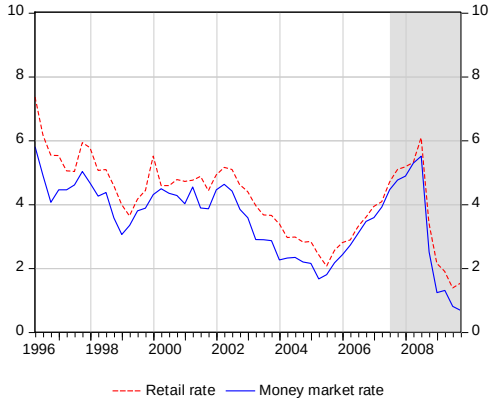
Retail and money market rates for various interest rate fixation periods, non-financial companies

Figure A.1. Fixation period less than 3 months



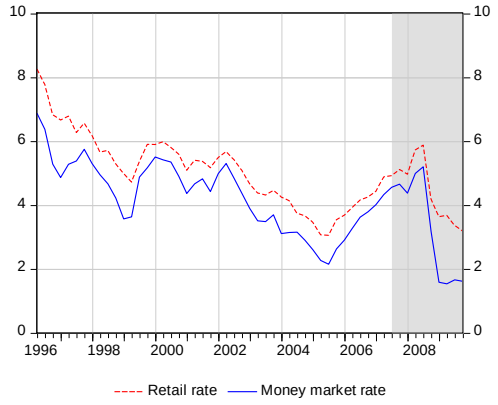
Note: Money market rate is Stibor 3m.

Figure A.2. Fixation period between 3 and 12 months



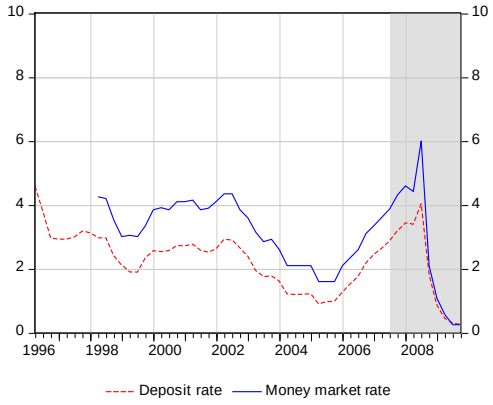
Note: Money market rate is Stibor 6m.

Figure A.3. Fixation period between 1 and 5 years



Note: Money market rate is Swap 2y.

Figure A.4. Deposit rate



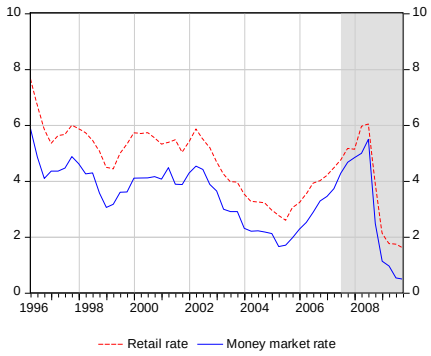
Note: Money market rate is Stibor t/n

Note: All retail rates are lending rates for new agreements in housing credit institutions.

Source: Statistics Sweden; The Riksbank.

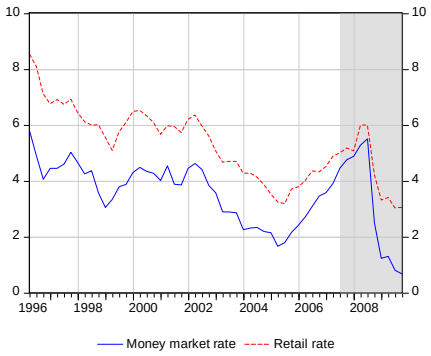
Retail and money market rates for various interest rate fixation periods, households

Figure A.5. Fixation period less than 3 months



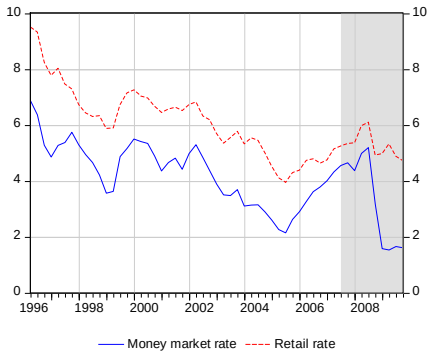
Note: Money market rate is Stibor 3m.

Figure A.6. Fixation period between 3 and 12 months



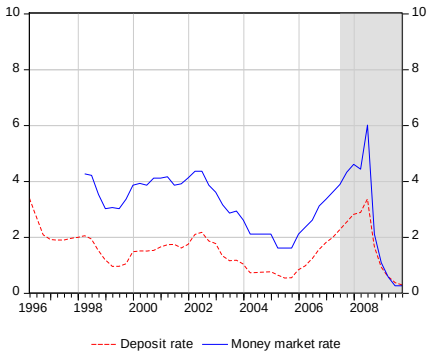
Note: Money market rate is Stibor 6m.

Figure A.7. Fixation period between 1 and 5 years



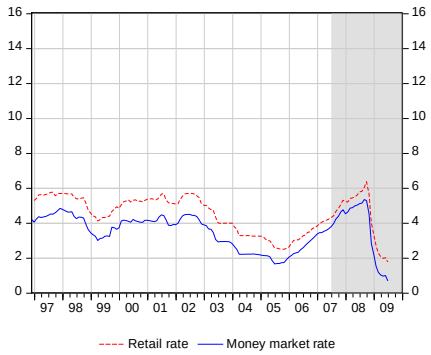
Note: Money market rate is Swap 2y.

Figure A.8. Deposit rate



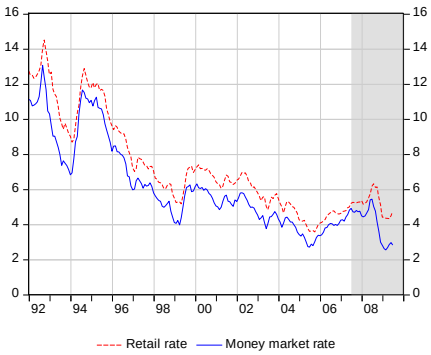
Note: Money market rate is Stibor tn.

Figure A.9. Fixation period of 3 months



Notes: Retail rate is the listed mortgage rate for households. Money market rate is Stibor 3m

Figure A.10. Fixation period of 5 years



Notes: Retail rate is the listed mortgage rate for households. Money market rate is Swap 5y.

Note: All retail rates are lending rates for new agreements in housing credit institutions.

Source: Statistics Sweden; The Riksbank

Table A.2. Contemporaneous correlation between retail and money market rates, levels

Mortgage rate	Money market rate	Correlation			
		Pre-turmoil		Post-turmoil	
Households					
3 months fixation	Stibor 3m	0.98	(1997M1-2007M6)	0.99	(2007M7-2009M11)
5 years fixation	Swap 5y	0.99	(1994M1-2007M6)	0.82	(2007M7-2009M11)
Non-financial companies					
Up to 3 months fixation	Stibor 3m	0.97	(1996q2-2007q2)	0.99	(2007q3-2009q4)
3 months - 1 year fixation	Stibor 6m	0.96	(1996q2-2007q2)	0.99	(2007q3-2009q4)
1 year - 5 years fixation	Swap 2y	0.94	(1996q2-2007q2)	0.98	(2007q3-2009q4)
Deposit rates	Stibor tn	0.98	(1996q2-2007q2)	0.99	(2007q3-2009q4)
Households					
Up to 3 months fixation	Stibor 3m	0.68	(1996q2-2007q2)	0.99	(2007q3-2009q4)
3 months - 1 year fixation	Stibor 6m	0.88	(1996q2-2007q2)	0.99	(2007q3-2009q4)
1 year - 5 years fixation	Swap 2y	0.82	(1996q2-2007q2)	0.80	(2007q3-2009q4)
Deposit rates	Stibor tn	0.92	(1996q2-2007q2)	0.99	(2007q3-2009q4)

Table A.3. Contemporaneous correlation between retail and money market rates, first differences

Mortgage rate	Money market rate	Correlation			
		Pre-turmoil		Post-turmoil	
Households					
3 months fixation	Stibor 3m	0.82	(1997M1-2007M6)	0.97	(2007M7-2009M11)
5 years fixation	Swap 5y	0.59	(1994M1-2007M6)	0.40	(2007M7-2009M11)
Non-financial companies					
Up to 3 months fixation	Stibor 3m	0.91	(1996q2-2007q2)	0.99	(2007q3-2009q4)
3 months - 1 year fixation	Stibor 6m	0.84	(1996q2-2007q2)	0.99	(2007q3-2009q4)
1 year - 5 years fixation	Swap 2y	0.87	(1996q2-2007q2)	0.97	(2007q3-2009q4)
Deposits	Stibor tn	0.94	(1996q2-2007q2)	0.98	(2007q3-2009q4)
Households					
Up to 3 months fixation	Stibor 3m	0.86	(1996q2-2007q2)	0.91	(2007q3-2009q4)
3 months - 1 year fixation	Stibor 6m	0.82	(1996q2-2007q2)	0.94	(2007q3-2009q4)
1 year - 5 years fixation	Swap 2y	0.75	(1996q2-2007q2)	0.69	(2007q3-2009q4)
Deposits	Stibor tn	0.88	(1996q2-2007q2)	0.97	(2007q3-2009q4)

Table A.4. Determination of integration order for selected interest rate series

	Level			First differences			Selected order of integration
	ADF[a]	PP[b]	KPSS[c]	ADF[a]	PP[b]	KPSS[c]	
Retail rates							
Households							
3 months fixation	-1.59	-1.15	0.68**	-6.45***	-6.52***	-0.11	I(1)
5 years fixation	-1.83	-1.83	1.56***	-8.76***	-8.76***	0.09	I(1)
Non-financial companies							
Up to 3 months fixation	-1.90	-2.97**	0.62**	-4.22***	-4.22***	0.27	I(1)
3 months - 1 year fixation	-2.96**	-2.91*	0.67**	-6.18***	-6.19***	0.26	I(1)
1 year - 5 years fixation	-2.52	-2.90*	0.73**	-4.77***	-4.72***	0.34	I(1)
Households							
Up to 3 months fixation	-1.88	-2.61*	0.66**	-4.15***	-4.13***	0.23	I(1)
3 months - 1 year fixation	-2.26	-2.56	0.74**	-4.51***	-4.51***	0.27	I(1)
1 year - 5 years fixation	-2.79*	-2.69*	0.75***	-4.70***	-4.71***	0.25	I(1)
Money market rates							
Stibor tn	-1.71	-1.24	0.41*	-5.65***	-5.60***	0.12	I(1)
Stibor 3m	-1.51	-1.17	1.78***	-18.69***	-19.38***	0.06	I(1)
Stibor 6m	-2.36	-2.44	0.57**	-5.47***	-5.45***	0.22	I(1)
Swap 2y	-2.22	-1.96	1.43***	-8.53***	-8.53***	0.07	I(1)
Swap 5y	-1.98	-1.85	1.52***	-8.60***	-8.57***	0.06	I(1)

Notes:

*, ** and *** denote significance on 10, 5 and 1 percent level, respectively.

a. Augmented Dickey Fuller test for the existence of a unit root (Dickey and Fuller, 1979). Critical values are from MacKinnon (1996).

b. Phillips and Perron unit root test (Phillips and Perron, 1988). Critical values are from MacKinnon (1996).

c. Test for stationarity proposed by Kwiatkowski *et al*. (1992).

The number of lags in the test specifications in the ADF and PP tests was determined using the Schwartz Information Criteria.

The specifications included a constant. However, augmenting with a trend did not change the conclusions.

Table A.5. Tests for co-integration

Mortgage rate	Money market rate	Trace statistics	Cointegration rank
Households			
3 months fixation	Stibor 3m	34.26***	1
5 years fixation	Swap 5y	25.18***	1
Non-financial companies			
Up to 3 months fixation	Stibor 3m	54.67***	1
3 months - 1 year fixation	Stibor 6m	39.19***	1
1 year - 5 years fixation	Swap 2y	44.89***	1
Households			
Up to 3 months fixation	Stibor 3m	50.19***	1
3 months - 1 year fixation	Stibor 6m	48.12***	1
1 year - 5 years fixation	Swap 2y	38.01***	1

Notes:

Tests for co-integration were proposed by Johansen (1991, 1995). Critical values are simulated in CATS.

a. A trend is included in the co-integrated relationship for the period 2004M1 to 2007M7.

ANNEX A3. MODEL SPECIFICATIONS AND EMPIRICAL STRATEGY

A number of econometric methods have been applied in the literature to investigate the pass-through from money market rates to retail rates. In this paper two are used: an Autoregressive Distributed Lag model (ARDL) and an error correction model (ECM). Each method has its drawback and virtues. The ARDL approach does not require imposing any restriction on the long-term relationship between the variables, thus avoiding the risk of imposing inappropriate co-integration restrictions that can lead to biased estimates (Pesaran and Shin, 1999; Hamilton, 1994). Such a relationship is imposed in the ECM, but this model has the virtue of yielding very intuitive estimates of the immediate pass-through, the long-term pass-through and the speed by which the retail rate adjusts to changes in money market rates.

In order to estimate the models presented below it is initially necessary to pair each retail rate with the relevant money market rate. The pairing is motivated by correlation analysis (Table A.2 – A.3).

Autoregressive distributed lag models

Following Cottarelli and Kourelis (1994) an ARDL model has been used to estimate the pass-through for each each set of retail and money market rate:[14]

$$rr_t = \beta_0 + \beta_1 rr_{t-1} + \beta_2 mr_t + \beta_3 mr_{t-1} + \ldots + \beta_{n+2} mr_{t-n} + \beta_{n+3} dum_t^{04-07} + u_t$$

β_2 is the impact multiplier, *i.e.* the immediate effect on the retail rate of a change in the money market rate of 100 basis points. Following Cottarelli and Kourelis (1994) the estimate of the long-run pass-through can be derived to be $\frac{1}{1-\beta_1}\sum_{i=0}^{n}\beta_{2+i}$.

The equations have been estimated using ordinary least squares and robust Newey-West standard errors are used. The number of lags have been chosen as to avoid serial correlation. Estimates and tests are reported in Table A.6.

To analyse whether the pass-through has been affected through the financial turmoil the ARDL models have been estimated recursively, as in Toolsema *et al.* (2001).

Error correction models

ECMs have also been applied extensively in the pass-through literature (Borstel, 2008; de Bondt, 2005, ECB, 2009). They have the advantage of yielding an estimate for the long-term pass-through as well as an estimate of the speed at which the retail rate adjusts to a change in the money market rate. The following ECM equation was estimated for each set of retail and money market rates:

$$\Delta rr_t = -\alpha_1\left(rr_{t-1} - \beta_1 - \beta_2 dum_t^{04-07} - \beta_3 mr_{t-1}\right) + \sum_{j=1}^{p}\phi_{11j}\Delta rr_{t-j} + \sum_{k=0}^{p}\phi_{12k}\Delta mr_{t-k} + \varepsilon_t$$

The variables of interest in this model are: (1) β_3, which is the long-term pass-through, (2) α_1 which is a measure of the speed at which the retail rate adjusts to a shock to the money market rate, and (3) $\phi_{12k}\phi_{12k}$ which is the immediate pass-through from the money market to the corresponding retail rate.

[14] This approach yields consistent results in spite of the I(1) property of the time series, since the two variables are co-integrated (Pesaran and Shin, 1999). To account for the decrease in spreads between retail and money market rates described above a trend is included from January 2004 to June 2007.

The equations are estimated as a single error correction model using non-linear least squares.[15] In the estimation procedure the lag length is determined using the Schwartz Information Criteria. To account for possible heteroscedasticity Newey-West standard errors are used. Estimates and tests are presented in Table A.7.

Tests of the coefficients are done by applying simple Wald procedures. However, a test of the long-term pass-through is also done via a dynamic ordinary least square (DOLS) approach, as suggested by Stock and Watson (1993). The stability of parameter estimates has been assessed through recursive estimations. These indicate stability over the estimation period.

To assess whether the reductions in money market rates since autumn 2008 were translated into lower retail rates, the ECM estimates are used to predict the development of retail rates. Comparing these predictions with the actual development of retail rates makes it possible to assess whether the transmission mechanism has been impaired.

Robustness checks

To investigate the robustness of the findings of the paper, a comparison of predicted and actual rates has also been carried out for the quarterly mortgage rates for non-financial co-operations and households, respectively.[16] These series do not offer enough observations to get a large number of predictions, but the results are in line with the conclusions above. The analysis has also been repeated on a richer set of monthly interest rates, which is only available from September 2005. This analysis confirmed the result of no impairment for the short-term retail rates, but analysis using this data set is problematic due to a low number of observations available for estimation. Also, spreads were declining throughout this period potentially leading to bias in the prediction exercise. The yield on government bonds with a maturity of five years was used as an alternative measure for long-term money market rates and this also showed impairment of the pass-through during the crisis for long-term rates. Finally, to control for international interest rate impulses the money market rates from the euro area were included in the ECMs. This did not change the conclusions.

15. The equations have also been estimated as a part of a restricted Vector Error Correction Model (Juselius, 2007) in which only the retail rate was allowed to error correct. The two approaches did not produce different conclusions.

16. The estimated pass-throughs from the money market to these rates are presented in Table 3.

Table A.6. ECM estimates and tests

	Dependent variable							
	rr 3m	rr 5y	rrq7	rrq8	rrq9	rrq13	rrq14	rrq15
Regressors								
ECM_{t-1}	-0.28 [0.06]	-0.16 [0.05]	-0.90 [0.16]	-0.95 [0.21]	-0.33 [0.11]	-0.64 [0.12]	-0.60 [0.13]	-0.32 [0.08]
mr_{t-1}	1.00 [0.03]	0.98 [0.02]	1.01 [0.02]	1.02 [0.05]	1.00 [0.11]	1.08 [0.04]	0.95 [0.06]	1.08 [0.07]
Δmr_t	0.66 [0.05]	0.20 [0.02]	0.51 [0.05]	0.61 [0.10]	0.65 [0.08]	0.49 [0.05]	0.64 [0.07]	0.75 [0.06]
Sample	1997M7-2007M6	1994M1-2007M6	1997Q1-2007Q2	1997Q1-2007Q2	1997Q1-2007Q2	1997Q1-2007Q2	1997Q1-2007Q2	1997Q1-2007Q2
R^2	0.80	0.91	0.93	0.74	0.81	0.91	0.88	0.87
SIC[a]	-2.54	-2.02	-1.61	0.49	-0.39	-1.52	-0.87	-0.73
LM-test[b]	0.94	0.23	0.43	0.33	0.21	0.44	0.16	0.17

Notes:

a. Schwartz Information Criterion.

b. Breusch-Godfrey test for serial correlation.

Table A.7. ARDL estimates and tests

	Dependent variable							
	rrq2	rrq3	rrq4	rrq5	rrq7	rrq8	rrq9	rrq10
Regressors								
rr_{t-1}	-0.17 [0.19]	-0.17 [0.17]	0.65 [0.07]	0.63 [0.10]	0.03 [0.11]	0.09 [0.15]	0.65 [0.10]	0.55 [0.13]
mr_t	0.58 [0.08]	0.58 [0.08]	0.72 [0.06]	-0.31 [0.22]	0.51 [0.05]	0.60 [0.10]	0.65 [0.07]	0.52 [0.17]
mr_{t-1}	0.49 [0.12]	0.49 [0.15]	-0.44 [0.13]	0.15 [0.17]	0.50 [0.09]	0.28 [0.16]	-0.33 [0.16]	-0.22 [0.24]
mr_{t-2}	0.02 [0.11]	0.02 [0.13]	0.05 [0.08]	-0.03 [0.11]	-0.00 [0.09]	-0.05 [0.16]	-0.06 [0.16]	0.12 [0.18]
mr_{t-3}	0.03 [0.08]	0.03 [0.11]	0.04 [0.06]		-0.02 [0.05]	0.09 [0.11]	0.10 [0.06]	0.01 [0.12]
mr_{t-4}	-0.02 [0.07]	-0.02 [0.08]						
Sample	1997Q2-2007 Q2	1997Q2-2007 Q2	1997Q2-2007 Q2	1997Q2-2007 Q2	1997Q2-2007 Q2	1997Q2-2007 Q2	1997Q2-2007 Q2	1997Q2-2007 Q2
R^2	0.97	0.84	0.98	0.96	0.99	0.95	0.98	0.95
LM-test[a]	0.84	0.23	0.11	0.34	0.64	0.26	0.06	0.43

Note:

a. Breusch-Godfrey test for serial correlation.

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