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**Working Paper**

# Liquidity of Danish government and covered bonds: Before, during and after the financial crisis. Preliminary findings

Danmarks Nationalbank Working Papers, No. 70

**Provided in Cooperation with:**
Danmarks Nationalbank, Copenhagen

*Suggested Citation:* Buchholst, Birgitte Vølund; Gyntelberg, Jacob; Sangill, Thomas (2010) : Liquidity of Danish government and covered bonds: Before, during and after the financial crisis. Preliminary findings, Danmarks Nationalbank Working Papers, No. 70, Danmarks Nationalbank, Copenhagen

This Version is available at:
https://hdl.handle.net/10419/82357

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DANMARKS NATIONALBANK

# DANMARKS NATIONALBANK WORKING PAPERS

## 2010 • 70


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# Liquidity of Danish Government and Covered Bonds – Before, During and After the Financial Crisis – Preliminary Findings


September 2010

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ISSN (trykt/print) 1602-1185

ISSN (online) 1602-1193

## Abstract[1]

We present preliminary findings on the liquidity of the government and covered bond markets in Denmark before, during and after the 2008 financial crisis. The analysis focuses on wholesale trading in benchmark bonds in the two markets and is based on an up to now unused transaction level dataset for the period from January 2005 until May 2010. We find that even though trading continued during the crisis, both markets experienced substantial declines in liquidity and significantly increased liquidity risk. Overall, our findings suggest that Danish benchmark covered bonds by and large are as liquid as Danish government bonds during periods of market stress. The findings also suggest that before the crisis government bonds were slightly more liquid than covered bonds in both the short- and long-term market segments. For the period after the crisis, the two markets appear to have had more or less the same level of liquidity for short-term as well as long-term bonds.

[1] The authors would like to thank Jens Dick-Nielsen, Ib Hansen, Kristian Kjeldsen, Jesper Lund, Birgitte Søgaard Holm and Christian Upper for useful comments and discussions. All errors are attributable to the authors.

## Non-technical summary

This paper presents preliminary findings on the liquidity of the Danish government and covered bond markets before, during and after the 2008 financial crisis. The analysis focuses on wholesale trading in benchmark bonds in the two markets and is based on an up to now virtually unused high-frequency transaction dataset for the period from January 2005 until May 2010. To our knowledge the only previous study which has used transaction level data to analyse the liquidity of Danish bonds is Nyholm (1999).

Overall, our findings suggest that Danish benchmark covered bonds by and large are as liquid as Danish government bonds during periods of market stress. Our findings also suggest that before the crisis government bonds were slightly more liquid than covered bonds in both the short- and long-term market segments. For the period after the crisis, our findings suggest that the two markets have had more or less the same level of liquidity for short-term as well as long-term bonds. This conclusion is supported by standard liquidity indicators such as the turnover rate, median trade size, the Roll (1984) bid-ask spreads and the Amihud (2002) price impact measure of illiquidity.

Concerning the variability of liquidity or liquidity risk, we find a notable increase during the crisis for short-term government and long-term fixed-rate callable covered bonds. This is consistent with theories of liquidity risk which suggest that both the level of liquidity and idiosyncratic liquidity risk contribute to expected returns of securities (Acharya and Pedersen (2005)). The notable increase in the liquidity risk measures could reflect that the funding constraints of capital constrained traders become binding during the crisis (Brunnermeier and Pedersen (2009)).

Perhaps surprisingly, we also find that relative to the period before the crisis, liquidity risk decreased during the crisis for short-term covered bonds and long-term government bonds. It suggests that these markets saw less dramatic price moves in response to trades – consistent with our finding that liquidity was higher in these market segments during the crisis. Finally, we find that liquidity risk of the short-term covered bond market has remained low in the period after the crisis, while it has increased for short-term government bonds. In contrast, liquidity risk in long-term bond markets have been higher after than before the crisis for both covered and government bonds.

## 1. Introduction

In contrast to several other mortgage and securitisation bond markets, trading continued in the Danish covered bond market during the crisis. Both the government and the covered bond markets, however, did experience substantial declines in liquidity.

In Denmark the outstanding volume of government bonds correspond to around 35 per cent of GDP while the outstanding volume of covered bonds or mortgage bonds is around 140 per cent of GDP. Both government and covered bonds are included as eligible securities in the collateral base used by the Danish central bank.

This paper presents preliminary findings on the liquidity of the Danish government and covered bond markets before, during and after the 2008 financial crisis. The analysis focuses on wholesale trading in benchmark bonds in the two markets and is based on an up to now virtually unused high-frequency transaction dataset for the period from January 2005 until May 2010. To our knowledge the only previous study which has used transaction level data to analyse the liquidity of Danish bonds is Nyholm (1999).

Our findings suggest that Danish benchmark covered bonds by and large are as liquid as Danish government bonds during periods of market stress. In addition, we also find that although liquidity did decline substantially, both the covered and government bonds on average continued to be fairly liquid during the crisis. There is little indication that the covered bond market saw a more significant decline in liquidity than the government bond market. During the peak of the crisis in September-October 2008 the Amihud illiquidity measure rose sharply for long-term covered bonds as well as short- and long-term government bonds. In contrast, it increased only slightly for short-term covered bonds.[2]

Before the crisis government bonds were slightly more liquid than covered bonds in both the short- and long-term market segments. For the period after the crisis, the two markets have had more or less the same level of liquidity for both short- and long-term bonds. These conclusions are supported by standard liquidity indicators such as the turnover rate, median trade size, the

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[2] The median price impact of trade measures during the crisis imply that a trade of EUR 5,000,000 for an average bond moves the price by just below 0.04 per cent for both short-term covered and government bonds. In the long-term bond markets our price impact of trade liquidity measure implies that a trade of EUR 5,000,000 moves the price of an average covered bond by 0.11 per cent and an average government bond by 0.086 per cent. In comparison, Dick-Nielsen et al. (2009) find that in the US corporate bond market a trade of $300,000 in an average bond moves the price by roughly 0.13 per cent.

Roll (1984) bid-ask spreads and the Amihud (2002) price impact measure of illiquidity.

Concerning the variability of liquidity or liquidity risk we find a notable increase during the crisis for short-term government and long-term covered bonds. This is consistent with theories of liquidity risk which suggest that both the level of liquidity and idiosyncratic liquidity-risk contribute to expected returns of securities. The notable increase in the liquidity risk measures suggests that the funding constraints of capital constrained traders become binding during the crisis. Perhaps surprisingly, we also find that relative to the period before the crisis, liquidity risk decreased during the crisis for short-term covered bonds and long-term government bonds. It suggests that these markets saw less dramatic price moves in response to trades – consistent with our finding that liquidity was higher in these market segments during the crisis. This finding may be explained by flight-to-quality. Finally, we find that the short-term covered market liquidity risk has remained low in the period after the crisis, while it has increased for short-term government bonds. In contrast, liquidity risk in long-term bond markets have been higher after than before the crisis for both covered and government bonds.

The following section provides a brief overview of developments in the Danish markets during the financial crisis. Section 3 provides summary statistics for the two markets and briefly describes the transaction dataset. Section 4 defines the liquidity measures we use in the following analysis. Section 5 compares the liquidity of short-term covered and government bonds. Section 6 compares the liquidity of long-term covered and government bonds. Section 7 considers the liquidity risk or variability of liquidity in the four different market segments. The final section concludes.

## 2. The financial crisis and Danish bond markets

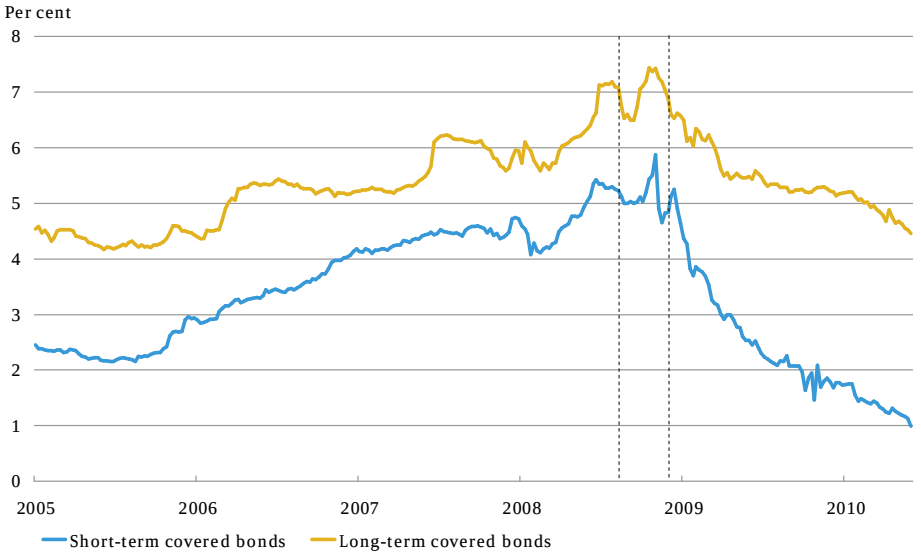
The Danish covered bond market has been affected by the escalation of the financial crisis, with yields on both short- and long-term covered bonds increasing considerably in September and October 2008 (Chart 1). At the same time, the spread to government yields widened (Chart 2). These price developments clearly suggest that during this crisis period there was significantly reduced liquidity in the covered bond market.

During this period two policy measures were put in place. The first measure, which was concluded on 31 October 2008, was an agreement between the Danish Insurance Association and the Ministry of Economic and Business Affairs targeting the pension area. The aim was to ensure that the widening of the spread between covered bonds and government bonds would not

force pension funds to divest covered bonds from their portfolios. The agreement focused on long-term covered bonds as the pension funds primarily invest in long-term bonds.

The second measure, which was announced in the beginning of November 2008, was that the Social Pension Fund (SPF) would invest around EUR 3 billion in short-term covered bonds in the December 2008 auctions with the aim of covering the central-government interest-rate risk related to the financing of subsidised housing.[3]

YIELDS ON DANISH COVERED BONDS — Chart 1




Note: Weekly observations. The yields on covered bonds are average yields to maturity, the short-term yield being based on 1-2-year non-callable covered bonds, the long-term yield on 30-year callable covered bonds, cf. the Association of Danish Mortgage Banks.
Source: Association of Danish Mortgage Banks.

Although this relatively small second measure was attributed to the government's interest-rate risk management, it was widely interpreted by the market players as a signal that the government was ready to support the market in case of further turmoil related to the crisis. Ultimately the SPF invested around EUR 3.6 billion in short-term covered bonds at the auctions in December 2008 and around EUR 6 billion the following year (Danmarks Nationalbank (2009, 2010)).

The combination of these measures helped restore confidence among market participants which was reflected in sharp declines in yields for both long- and short-term covered bonds (Chart 1) as well as the yield spread to government bonds (Chart 2).

[3] The SPF is managed by Danmarks Nationalbank on behalf of the government.

In the following, we define the period before the crisis to be from January 2005 until end-July 2008. We define the crisis period as being the period from early August 2008 until end-November 2008, i.e. the period in which the pricing of the Danish bonds was most clearly affected by the financial crisis. It includes in particular Fannie Mae and Freddie Mac being taken into conservatorship by the US Government, the AIG bailout and the failure of Lehmann Brothers (Fender and Gyntelberg (2008)). Finally, the period after the crisis runs from start December 2008 until end-May 2010.

OPTION-ADJUSTED YIELD SPREAD BETWEEN LONG-TERM GOVERNMENT AND COVERED BONDS

Chart 2

Source: Nordea Analytics.

## 3. The bond markets and the data

Our analysis focuses on wholesale trades in short- and long-term benchmark bonds. We define wholesale trades as trades with a nominal value of at least DKK 10 million. Benchmark or large bonds are defined as bonds with an outstanding nominal amount of at least EUR 1 billion. For covered bonds we restrict the analysis to short-term bullet bonds and long-term fixed-rate callable bonds issued by specialised mortgage-credit banks. Thus we do not analyse the floating rate segment of the covered bond market. Nor do we analyse covered bonds issued by universal banks.

### 3.1. Short-term bonds

Short-term covered bonds are fixed-rate bullet bonds while short-term government bonds are defined as bonds with a time to maturity of maximum five years.

The fixed-rate bullet covered bonds are issued with up to ten years to maturity. However, the majority of the bonds are issued with only one year to maturity as they provide funding for adjustable-rate mortgages of which most have their interest rate reset once a year. Therefore the bonds do not reach an outstanding amount of EUR 1 billion until the time to maturity is considerably shorter than ten years. In fact the only covered bond in our sample of large bonds with time to maturity of more than five years is a bond which expires 1 January 2015 and is included from August 2009.

Our focus on large bonds in the two markets implies that we cover on average 77 per cent of the outstanding amount in the covered bond market whereas we include almost all of the government bond market (Table 1). In the covered bond market our focus on large bonds excludes 190 small bonds on average. These small bonds have an average size of only EUR 110 million. Especially in the covered bond market the selection on wholesale trades exclude a very large number of retail trades. Despite this, we actually include 93 per cent of the turnover in the large covered bonds.

SHORT-TERM COVERED AND GOVERNMENT BONDS – SUMMARY STATISTICS — Table 1

| | | Covered bonds | | Government bonds | |
|---|---|---|---|---|---|
| | | Large bonds | Small bonds | Large bonds | Small bonds |
| Average total outstanding amount (EUR bn) | | **74** | 22 | **46** | 1 |
| Average number of bonds | | **17** | 190 | **8** | 4 |
| Average bond size (EUR bn) | | **4.44** | 0.11 | **6.08** | 0.27 |
| Average monthly turnover (EUR bn) | Wholesale | **19.58** | 6.35 | **5.41** | 0.26 |
| | Retail | 1.45 | 0.98 | 0.13 | 0.00 |
| Average monthly number of trades | Wholesale | **1,102** | 695 | **407** | 18 |
| | Retail | 12,410 | 7,695 | 712 | 81 |
| Average trade size (EUR mill.) | Wholesale | **17.76** | 9.13 | **13.28** | 14.66 |
| | Retail | 0.12 | 0.13 | 0.18 | 0.06 |
| Median trade size (EUR mill.) | Wholesale | **6.24** | 3.34 | **8.03** | 5.11 |
| | Retail | 0.06 | 0.05 | 0.04 | 0.01 |

Note: Large bonds are defined as bonds with an outstanding amount of at least EUR 1 billion. Wholesale trades are defined as trades with a nominal turnover of at least DKK 10 million (EUR 1.3 million).
Source: Nasdaq OMX, Danish FSA and Danmarks Nationalbank.

## 3.2. Long-term bonds

The long-term covered bond market is defined as callable fixed-rate bonds. By May 2010 the total outstanding nominal amount was EUR 96 billion.

Again the focus on wholesale trades excludes a large number of retail trades. However, the wholesale trades comprise more than 80 per cent of the turnover in the large bonds.

There are on average around 1,250 different callable fixed-rate bonds and their average time to maturity is around 12 years by May 2010. Of the 1,250

bonds only 29 bonds on average have a nominal outstanding amount of at least EUR 1 billion (Table 2). These large bonds, however, make up on average 60 per cent of the total outstanding nominal amount of long-term covered bonds. The large number of very small callable fixed-rate bonds reflects that mortgage-credit banks for regulatory reasons issue bonds with cash flows that match those of their lending portfolio. A covered bond cannot be removed from the exchange until all borrowers having their mortgages funded by this specific bond have paid off their mortgages completely.

This is very different from the government bond market where the debt is actively managed in order to obtain a relatively small number of larger and more liquid bonds.

LONG-TERM COVERED AND GOVERNMENT BONDS – SUMMARY STATISTICS Table 2

| | | Covered bonds | | Government bonds | |
|---|---|---|---|---|---|
| | | Large bonds | Small bonds | Large bonds | Small bonds |
| Average total outstanding amount (EUR bn) | | **70** | 45 | **43** | 0.3 |
| Average number of bonds | | **29** | 1221 | **6** | 2 |
| Average bond size (EUR bn) | | **2.43** | 0.04 | **6.84** | 0.13 |
| Average monthly turnover (EUR bn) | Wholesale | **10.65** | 4.35 | **6.94** | 0.07 |
| | Retail | 2.29 | 1.69 | 0.17 | 0.00 |
| Average monthly number of trades | Wholesale | **1,479** | 927 | **677** | 7 |
| | Retail | 16,150 | 13,157 | 767 | 9 |
| Average trade size (EUR mill.) | Wholesale | **7.20** | 4.69 | **10.24** | 10.05 |
| | Retail | 0.14 | 0.13 | 0.22 | 0.10 |
| Median trade size (EUR mill.) | Wholesale | **3.64** | 3.14 | **5.67** | 5.56 |
| | Retail | 0.10 | 0.07 | 0.07 | 0.01 |

Note: Large bonds are defined as bonds with an outstanding amount of at least EUR 1 billion. Wholesale trades are defined as trades with a nominal turnover of at least DKK 10 million (EUR 1.3 million).
Source: Nasdaq OMX, Danish FSA and Danmarks Nationalbank.

The long-term government bond market is defined as government bonds with a time to maturity of more than or equal to five years (i.e. the part of the market that is not defined as short-term). Nearly all of these bonds have an outstanding nominal amount larger than EUR 1 billion. The outstanding amount of long-term government bonds with a principal of at least EUR 1 billion has increased slowly since January 2005 until November 2008 from around EUR 30 to EUR 40 billion. In November 2008 it increased sharply primarily due to a new issuance of a bond with 30 years to maturity. The initial outstanding amount of this issue was EUR 7 billion.

### 3.3. Transaction data

The analysis is based on transaction data from Nasdaq OMX Copenhagen A/S and the Danish Financial Supervisory Authority (FSA) covering the period from January 2005 until May 2010. The transaction data from both

sources have been combined with contractual information for each bond from VP Securities A/S.

All covered bonds issued by Danish mortgage-credit banks are listed on Nasdaq OMX Copenhagen A/S to which all trades – including OTC – are reported. Before November 2007 all trades in government bonds were also reported to Nasdaq OMX Copenhagen A/S. However, following the November 2007 implementation of new MiFID regulations Danish government bonds have been exempted for post trade publication requirements. For government bonds we have, therefore, obtained transaction data from the Danish FSA covering the period from November 2007 until May 2010.[4]

We have excluded a small number of transactions in government bonds where the price was not between 50 and 150. For the data from the FSA we have found it necessary to manually examine all price changes of at least 2 percentage points in order to identify possible errors.

As from November 2007 repurchase transactions in neither the covered nor the government bond market are required to be reported.[5] In both markets, we have identified and removed a relatively large number of repurchase transactions.

In the data cleaning process we have generally focused on transactions used in the following analysis – i.e. wholesale trades in large bonds, cf. the above definitions.

## 4. Liquidity measures

We consider four different liquidity measures or proxies.

### 4.1. Median trade size

The monthly ***median trade size*** is calculated as the median of the market value of each large trade in a given month. The market value is calculated as: (clean price*nominal quantity)/100.

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[4] Following MiFID all transactions executed by an investment firm in any financial instrument admitted to trading on a regulated market shall be reported to the competent authority.

[5] Before November 2007 repurchase transactions reported to Nasdaq OMX Copenhagen A/S were clearly labelled as such.

### 4.2. Turnover rate

The ***turnover rate*** is the sum of the market value of all large trades in a given month divided by the average of the outstanding nominal amounts at the beginning and the end of the month.

### 4.3. Bid-ask spread (Roll)

As the data do not contain quotes or bid-ask spreads, we use the finding of Roll (1984) that under certain conditions the bid-ask spread equals two times the square root of minus the covariance between adjacent price changes:

$$Roll_t = 2\sqrt{-\mathrm{cov}(\Delta P_i, \Delta P_{i-1})}$$

where $t$ is the period for which the measure is calculated.

Following Dick-Nielsen et. al. (2009) we calculate a daily Roll measure using a rolling window of 21 trading days. The monthly Roll bid-ask spread is defined as the median of all daily measures within the month. There are a number of caveats one should keep in mind when considering the Roll measure. First, as shown in Stoll (1989), in the presence of adverse selection or inventory effects it may underestimate the actual bid-ask spread. Second, as pointed out by Choi (1988), it may be biased if the number of bid and offer transactions is not balanced. Given the available data it is, however, not obvious how one can account for these possible sources of bias.

In the calculation of the Roll measure we define price changes as the difference between adjacent prices. This implies that the bid-ask spread is defined as the price difference between bid and ask prices.[6]

### 4.4. Trade price impact measure (Amihud)

To take into account that large trades may have a higher price impact than relatively small trades we also calculate the illiquidity measure suggested in Amihud (2002). Amihud's illiquidity measure is defined as:

$$Amihud_t = \frac{\left| \frac{P_j - P_{j-1}}{P_{j-1}} \right|}{Q_j}$$

where $Q_j$ is the trading volume (in EUR million) in trade $j$ and $P_j$ is the price on trade $j$. Following a slightly modified version of the approach in Dick-Nielsen et. al. (2009), we calculate the monthly Amihud illiquidity measure as the median of nonzero measures within the month. This is done

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[6] Note that this measure does not capture trading costs in return terms. This requires using percentage returns when estimating the bid-ask spread.

in part to avoid having the measure reflect possible errors in the government bond data.

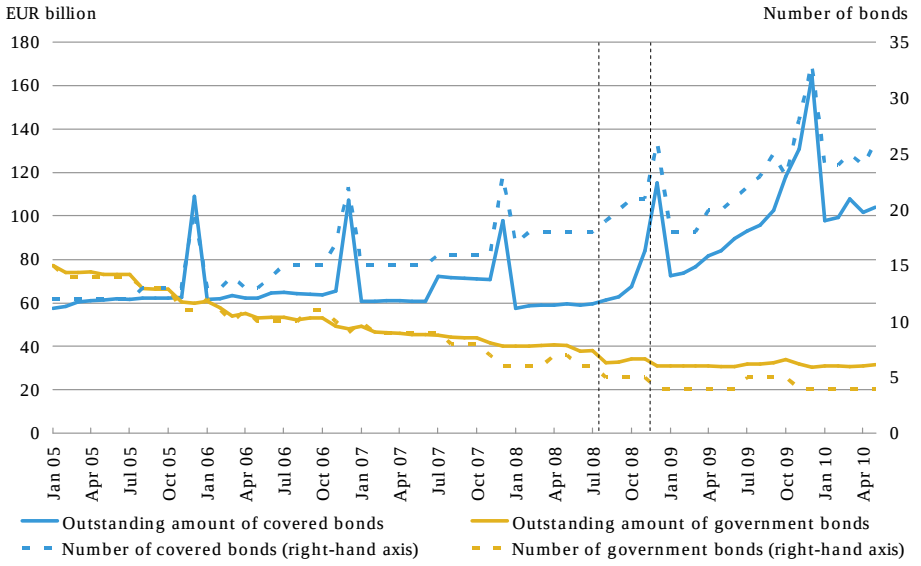
## 5. Liquidity in short-term bonds

### 5.1. Market size

The short end of the Danish covered bond market is defined as fixed-rate bullet covered bonds (cf. Section 3.1). Most bullet bonds are sold at large auctions during December with settlement on 1 January the following year and maturity on 1 January one year later. For this reason the total outstanding amount of bullets increases throughout December and declines sharply in January. As the market has increased in size, the issuing mortgage-credit banks have started to spread the auctions on more dates starting already in November. Furthermore, other maturity dates are gradually being introduced.

The outstanding nominal amount of short-term covered bonds has (apart from the temporary increases related to refinancing) remained stable around EUR 60 billion from January 2005 until 4th quarter 2008 (Chart 3), but has increased steadily since end-2008. By May 2010 the total outstanding nominal amount was roughly EUR 100 billion. The increase can to a large extent be attributed to a steep yield curve (Chart 3) making adjustable-rate mortgages more attractive to borrowers. In 2005 the outstanding nominal amounts of short-term covered bonds and government bonds were close in size. However, this picture has changed dramatically and in 2010 the total outstanding nominal amount of short-term government bonds was only around EUR 30 billion – less than one third of the total outstanding nominal amount of short-term covered bonds.

SHORT-TERM BONDS – OUTSTANDING AMOUNT AND NUMBER OF BONDS Chart 3




Note: Only bonds with an outstanding nominal amount of at least EUR 1 billion have been included.
Source: Danmarks Nationalbank.

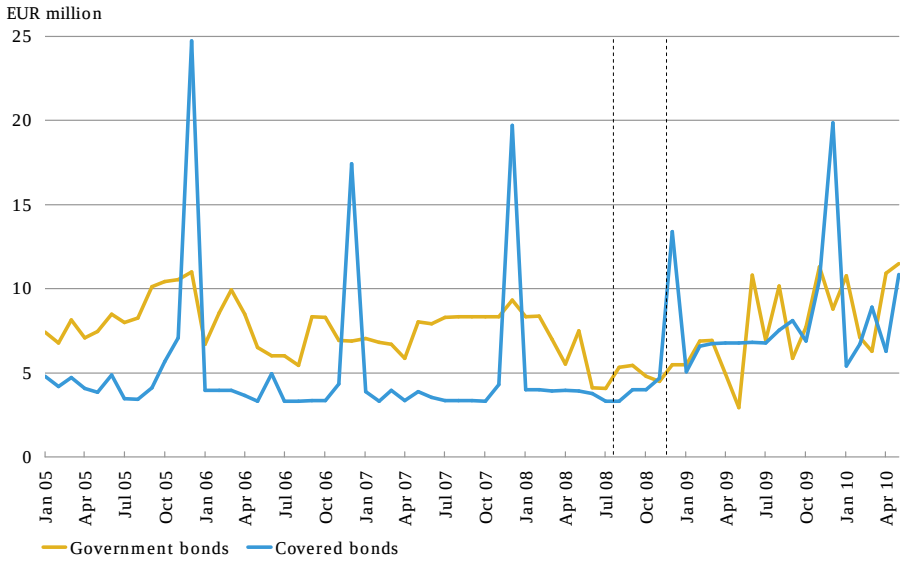
## 5.2. Trade size

Our first liquidity indicator is the median trade size. Before the second half of 2008 (disregarding the month of December where short-term loans are rolled over) the median trade size in the covered bond market was stable around DKK 25 million (EUR 3.4 million) (Chart 4).[7] However, the median trade size in the covered bond market began to increase significantly from 2009. In several months of 2009 it was close to DKK 50 million (EUR 6.7 million) indicating that the standard trading size in the wholesale covered bond market has actually doubled.

Before the crisis, the median trade size in the government bond market was considerably larger than in the covered bond market. The median trade size in the government bond market was more than twice as large as the median trade size in the covered bond market in several months of 2007. This pattern ended in 2008 as the median trade size in the government bond market began to decline.

[7] The large median trade size in December may reflect that the market is dominated by commercial banks and institutional investors.

SHORT-TERM BONDS – MEDIAN TRADE SIZE Chart 4




Note: Only bonds with an outstanding nominal amount of at least EUR 1 billion and trades of at least DKK 10 million have been included.
Source: Nasdaq OMX, Danish FSA and Danmarks Nationalbank.

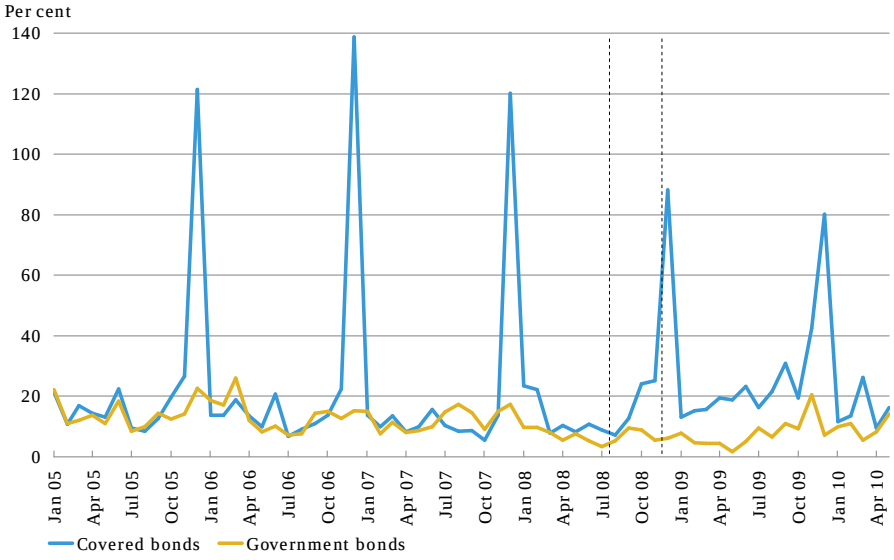
## 5.3. Turnover rate

The second liquidity indicator is the turnover rate, i.e. total turnover divided by the nominal outstanding amount.

As can be seen from Chart 5, the turnover rate was roughly the same in the two markets before the crises. Except from the month of December the turnover rates of the two markets have been relatively close until September 2008. From September 2008 and until end 2009 it was markedly higher in the covered bond market than in the government bond market. By early 2010 the difference between the turnover rates in the two markets had virtually disappeared, with both markets having higher stable turnover rates than before the crisis.

The spike in the turnover rate in March 2010 reflects that one of the mortgage-credit banks began to gain considerable volume in a bond with maturity on 1 April. This is also reflected in the temporary increase in the outstanding nominal amount in March 2010 in Chart 3.

SHORT-TERM BONDS – MONTHLY TURNOVER RATE Chart 5

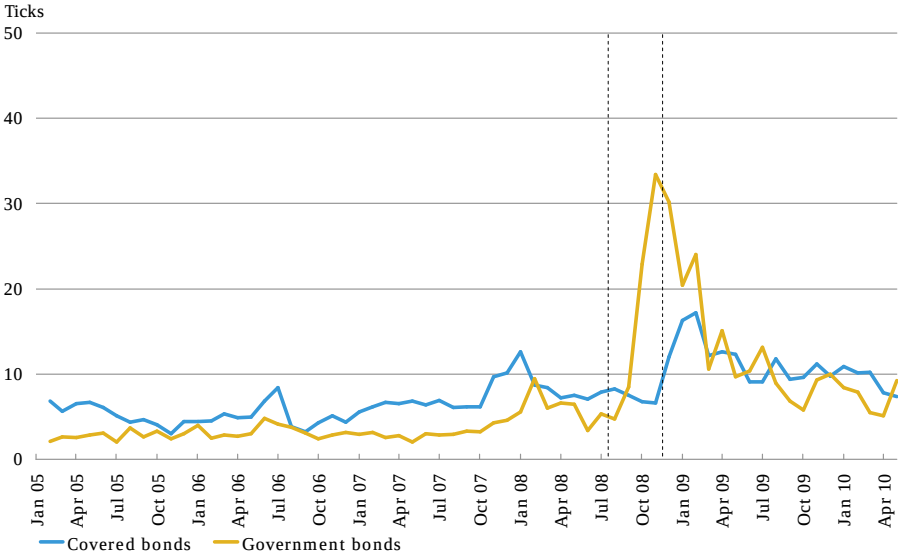



Note: Only bonds with an outstanding nominal amount of at least EUR 1 billion and trades of at least DKK 10 million have been included.
Source: Nasdaq OMX, Danish FSA and Danmarks Nationalbank.

## 5.4. Bid-ask spreads

The Roll measure indicates that both markets have traded with bid-ask spreads in the interval 5-10 ticks before the crisis (Chart 6). During the crisis the bid-ask spreads for government bonds jumped to 20 ticks in October and then over 30 ticks in November 2008.

SHORT-TERM BONDS – BID-ASK SPREAD (ROLL) Chart 6




Note: Only bonds with an outstanding nominal amount of at least EUR 1 billion and trades of at least DKK 10 million have been included.
Source: Nasdaq OMX, Danish FSA and Danmarks Nationalbank

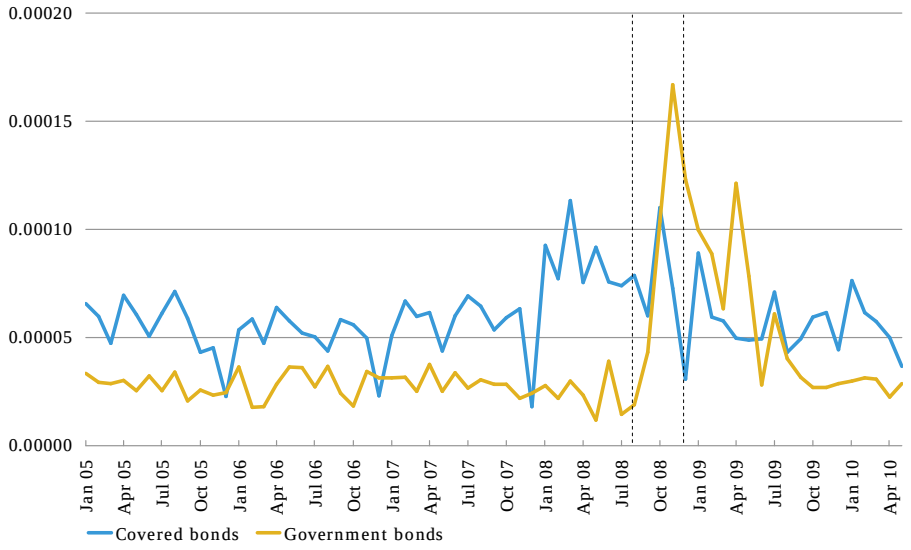
In contrast, the bid-ask spreads for covered bonds remained stable during the crisis. Afterwards bid-ask spreads in both markets increased in the early months of 2009, but have since stabilised around 10 ticks, somewhat higher than the bid-ask spreads that prevailed before the crisis.

## 5.5. Price impact of trade

Before the crisis the Amihud illiquidity measures of both government and covered bonds have been relatively stable (Chart 7). The Amihud measure of the covered bonds has generally been a little higher than that of the government bonds – except for the month of December where liquidity in the covered bond market increases temporarily. In 2008 there is a clear tendency that the Amihud illiquidity measure of the covered bonds is higher than in the three previous years.

Before the crisis the price impact of trades was higher for short-term covered bonds than for government bonds. During the crisis, however, the price impact measure for government bonds increased rapidly, reaching a much higher level than was seen for covered bonds (Chart 7). After the crisis period, the price impact measure remained higher for government bonds than for covered bonds until June 2009. Thus, although the price impact of trades in the short-term covered bond market is higher than for government bonds, our findings suggest that the liquidity is less likely to deteriorate in periods of market stress.

SHORT-TERM BONDS – PRICE IMPACT OF TRADE (AMIHUD) Chart 7




Note: Only bonds with an outstanding nominal amount of at least EUR 1 billion and trades of at least DKK 10 million have been included.
Source: Nasdaq OMX, Danish FSA and Danmarks Nationalbank.

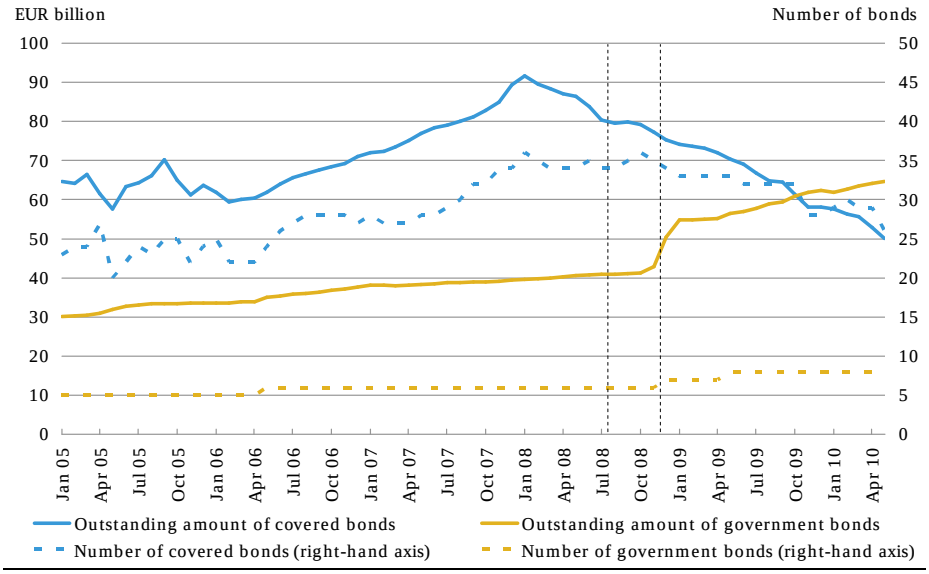
## 6. Liquidity in long-term bonds

In this section we compare the liquidity of long-term covered and government bonds. (See Section 3.2 for definitions of the two market segments.)

### 6.1. Market size

The outstanding amount of long-term covered bonds increased gradually from EUR 65 billion in January 2005 to a peak of around EUR 90 billion in January 2008 (Chart 8). Since then the outstanding amount has continued to decline reaching around EUR 50 billion by end-May 2010.

LONG-TERM BONDS – OUTSTANDING AMOUNT AND NUMBER OF BONDS Chart 8

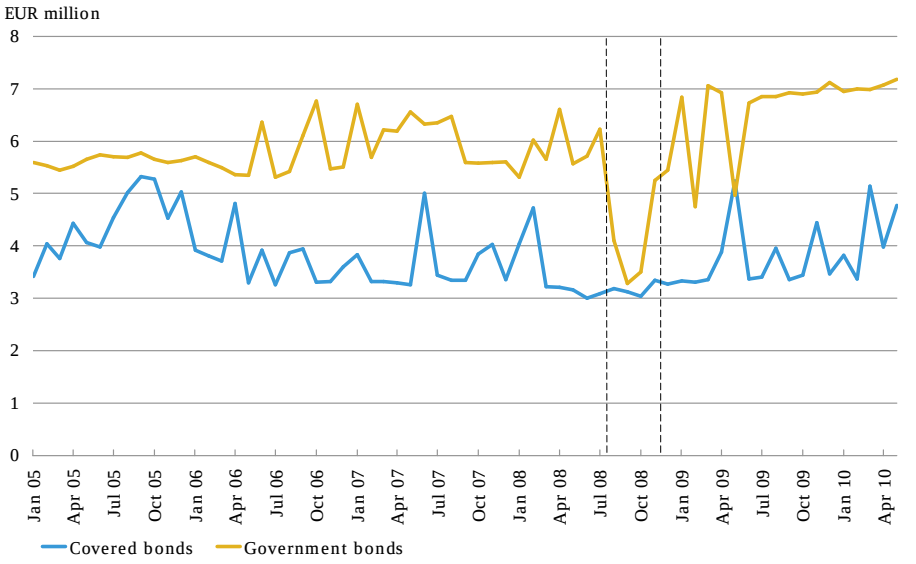



Note: Only bonds with an outstanding nominal amount of at least EUR 1 billion have been included.
Source: Danmarks Nationalbank.

### 6.2. Trade size

Before the crisis, the median trade size for government bonds was EUR 5-7 million (Chart 9). It nearly halved during the crisis period and only slowly increased after the crisis. By mid 2009 it stabilised around EUR 6-7 million (DKK 50 million). In October 2008, the median trade size began to increase again, suggesting that liquidity improved.

LONG-TERM BONDS – MEDIAN TRADE SIZE Chart 9




Note: Only bonds with an outstanding nominal amount of at least EUR 1 billion and trades of at least DKK 10 million have been included.
Source: Nasdaq OMX, Danish FSA and Danmarks Nationalbank.

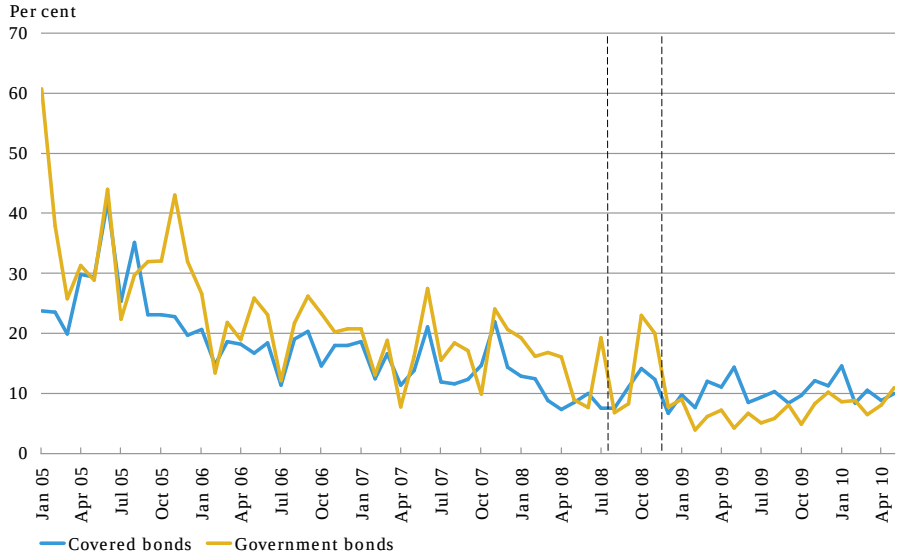
For the covered bonds the median trade size has been remarkable stable close to EUR 3 million throughout most of 2008 and the beginning of 2009. This is a little lower than both before and after the crisis. However, the decrease in trade size during the crisis has been much less pronounced for covered bonds than for government bonds.

## 6.3. Turnover rate

Before the crisis the turnover rate for both covered and government bonds declined quickly during 2005, and has since then remained in the interval 15-25 per cent for most of the period until late 2007 (Chart 10). Since late 2007, including during the crisis, the turnover rate for covered bonds has been fairly stable around 10 per cent. In the same period, the government bond turnover rate, although less stable, has also declined and has stabilised a little below that for covered bonds. During the crisis, however, the turnover rate did spike upwards to around 20 per cent for government bonds.

The higher turnover rate for covered than for government bonds since the beginning of 2009 may reflect the large increase in outstanding amount of government bonds at the end of 2008 due to the new issuance of a government bond with 30 years to maturity. The turnover rate for this bond has been smaller than that for other long-term government bonds, as more than 80 per cent of the outstanding amount is held by pension funds.

LONG-TERM BONDS - MONTHLY TURNOVER RATE Chart 10

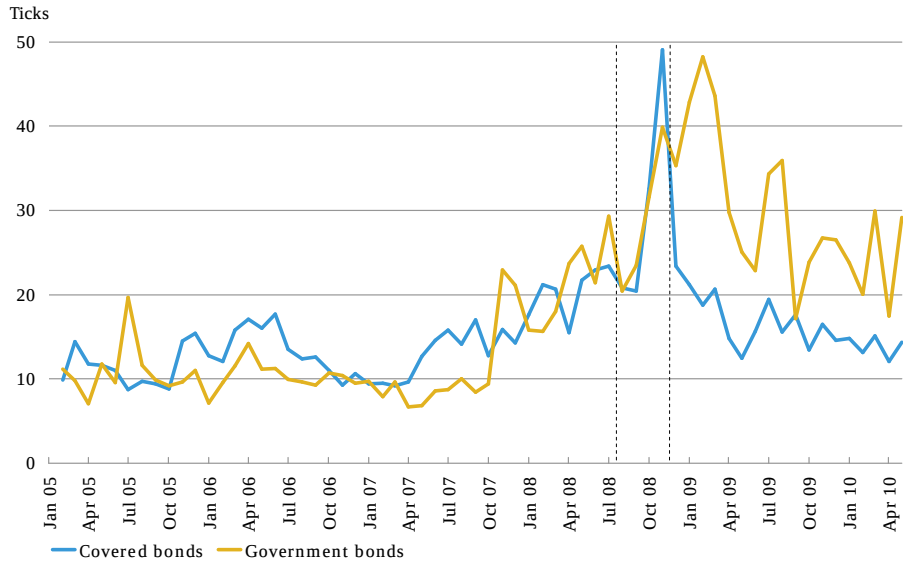



Note: Only bonds with an outstanding nominal amount of at least EUR 1 billion and trades of at least DKK 10 million have been included.
Source: Nasdaq OMX, Danish FSA and Danmarks Nationalbank.

## 6.4. Bid-ask spreads

Roll's measure indicates that both markets have traded with bid-ask spreads around 10-20 ticks before the crisis (Chart 11). The spreads increase in the period leading up to the crisis and peak at around 50 ticks for the covered bonds in November 2008.

LONG-TERM BONDS – BID-ASK SPREAD (ROLL ) Chart 11




Note: Only bonds with an outstanding nominal amount of at least EUR 1 billion and trades of at least DKK 10 million have been included.
Source: Nasdaq OMX, Danish FSA and Danmarks Nationalbank.

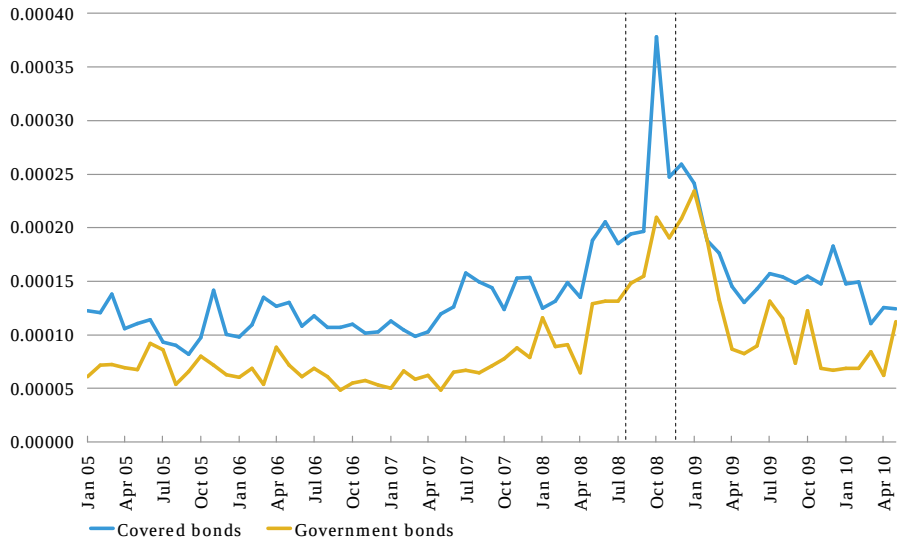
The peak is also around 50 ticks for government bonds. This peak was reached in February 2009 instead of during the crisis. In October 2008 the spreads were almost equal with the spread being just 1 tick higher for covered bonds. The spread for the covered bond market seems to have stabilised around 15 ticks whereas the spread for government bonds is both higher and more volatile.

### 6.5. Price impact of trade

The Amihud measure has been higher for covered bonds than for government bonds with the exception of a brief period in early 2009 (Chart 12). During the peak of the crisis in October 2008 and the period leading up to the crisis there was a notable increase in the illiquidity measure in both markets.

The increase is somewhat higher for covered bonds than for government bonds. The trade price impact measure decreased rapidly in the period after the crisis. By April 2009 it stabilised in both markets at slightly higher levels than before the crisis.

LONG-TERM BONDS – PRICE IMPACT OF TRADE (AMIHUD) Chart 12




Note: Only bonds with an outstanding nominal amount of at least EUR 1 billion and trades of at least DKK 10 million have been included.
Source: Nasdaq OMX, Danish FSA and Danmarks Nationalbank.

## 7. Liquidity risk

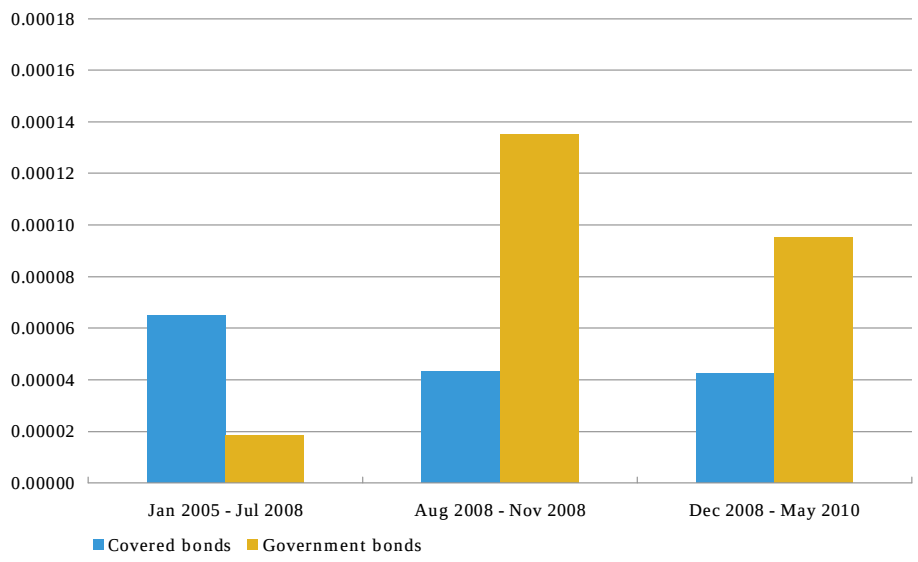
In addition to the level of liquidity the level of liquidity risk or variability of liquidity is also of interest as recent studies such as Acharya and Pedersen (2005) and Brunnermeier and Pedersen (2009) suggest that both the level of

liquidity as well as idiosyncratic liquidity-risk contribute to expected returns.

Here we find that the variability of the Amihud measure increased notably during the crisis for short-term government and long-term covered bonds (Chart 13 and 14). As suggested in Brunnermeier and Pedersen (2009), the notable increase in the liquidity risk measures suggests an increase in the frequency of non-linear price moves in response to trades, which could reflect that the funding constraints of capital constrained traders become binding during the crisis.

We also find that relative to the period before the crisis, the variability of the Amihud measure decreased during the crisis for short-term covered bonds and long-term government bonds. It suggests that these markets saw less frequent non-linear price moves in response to trades – consistent with our finding that liquidity was higher in these market segments during the crisis.

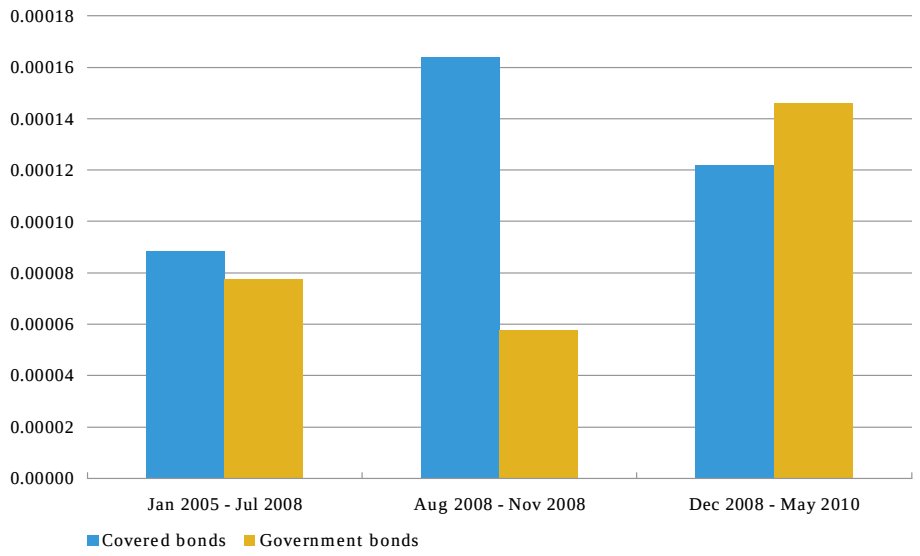
SHORT-TERM BONDS – AMIHUD RISK Chart 13




Note: Only bonds with an outstanding nominal amount of at least EUR 1 billion and trades of at least DKK 10 million have been included. The liquidity risk measure is the difference between the 95th and the 5th percentile of the Amihud measure. See Appendix 1 and 2 for detailed tables.
Source: Nasdaq OMX, Danish FSA and Danmarks Nationalbank.

Finally, we find that the short-term covered market liquidity risk has remained low in the period after the crisis, while it has increased for short-term government bonds (Chart 13). We also find that the liquidity risk in long-term bond markets has been higher after than before the crisis for both covered and government bonds.

LONG-TERM BONDS – AMIHUD RISK Chart 14




Note: Only bonds with an outstanding nominal amount of at least EUR 1 billion and trades of at least DKK 10 million have been included. The liquidity risk measure is the difference between the 95th and the 5th percentile of the Amihud measure. See Appendix 1 and 2 for detailed tables.
Source: Nasdaq OMX, Danish FSA and Danmarks Nationalbank.

## 8. Concluding remarks

We have presented preliminary findings on the liquidity of the government and covered bond markets in Denmark before, during and after the 2008 financial crisis. Going forward, the intention is to analyse in more detail which specific factors can help explain the level of liquidity of different market segments as well as individual bonds.

Based on other findings in the literature on market liquidity one could consider factors such as overall market and bond series size and credit quality.[8] Here one could also see if there are larger differences between on- and off-the-run bonds during the crisis period than in the periods before and after.

Furthermore it would be interesting to analyse how the level of liquidity and liquidity risk affect the returns of the different bonds, both within and across the two markets.

In addition, it would be relevant to see if the type of market participant(s) in a trade has an impact on the various liquidity measures. This aspect could include making a distinction between inter-market-maker trades and market maker/nonmarket-maker trades.

[8] Amihud et al. (2005) provides a comprehensive survey.

The covered bonds generally have a positive yield spread to government bonds. Thus the covered bonds are more likely to attract leveraged investors. These investors normally build up their positions gradually over a longer period of time. However, large (abrupt) price changes can force them to liquidate their positions over a very short period. It would therefore be interesting to see if the share of leveraged or speculative investors in different segments of the markets can help explain the variation in the liquidity measures.

Finally, one could also analyse the impact on liquidity and liquidity risk measures if trades of less than DKK 10 million are included.

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# Appendix 1 – Summary of liquidity measures for short-term bonds

SUMMARY STATISTICS FOR LIQUIDITY MEASURES – SHORT-TERM BONDS Table A.1

| | Maximum, minimum and percentiles | Amihud (Per cent) | | Roll (Ticks) | | Turnover rate (Per cent) | |
|---|---|---|---|---|---|---|---|
| | | Covered bonds | Gov. bonds | Covered bonds | Gov. bonds | Covered bonds | Gov. bonds |
| Before the crisis (Jan 2005 – Jul 2008) | Max | 0.0113 | 0.0039 | 12.62 | 9.47 | 138.67 | 25.90 |
| | 95th | 0.0090 | 0.0037 | 9.63 | 6.41 | 110.72 | 21.77 |
| | 75th | 0.0066 | 0.0032 | 6.90 | 3.91 | 19.15 | 14.96 |
| | **50th** | **0.0059** | **0.0028** | **6.16** | **3.05** | **13.39** | **11.96** |
| | 25th | 0.0050 | 0.0024 | 4.73 | 2.73 | 9.71 | 8.54 |
| | 5th | 0.0025 | 0.0018 | 3.86 | 2.11 | 7.84 | 5.68 |
| | Min | 0.0018 | 0.0012 | 2.99 | 2.07 | 5.60 | 3.27 |
| During the crisis (Aug 2008 – Nov 2008) | Max | 0.0110 | 0.0167 | 8.26 | 33.40 | 25.06 | 9.42 |
| | 95th | 0.0105 | 0.0157 | 8.15 | 31.83 | 24.90 | 9.34 |
| | 75th | 0.0087 | 0.0119 | 7.69 | 25.53 | 24.26 | 9.03 |
| | **50th** | **0.0076** | **0.0073** | **7.12** | **15.70** | **18.32** | **7.15** |
| | 25th | 0.0070 | 0.0037 | 6.72 | 7.56 | 11.30 | 5.38 |
| | 5th | 0.0062 | 0.0023 | 6.64 | 5.33 | 8.04 | 5.31 |
| | Min | 0.0060 | 0.0019 | 6.62 | 4.77 | 7.22 | 5.29 |
| After the crisis (Dec 2008 – May 2010) | Max | 0.0089 | 0.0123 | 17.22 | 30.15 | 88.16 | 20.48 |
| | 95th | 0.0078 | 0.0122 | 16.42 | 24.95 | 81.32 | 15.16 |
| | 75th | 0.0061 | 0.0075 | 12.12 | 12.50 | 25.45 | 9.87 |
| | **50th** | **0.0054** | **0.0032** | **10.54** | **9.50** | **19.07** | **7.41** |
| | 25th | 0.0049 | 0.0029 | 9.44 | 8.03 | 15.35 | 5.20 |
| | 5th | 0.0036 | 0.0026 | 7.77 | 5.10 | 11.38 | 4.05 |
| | Min | 0.0031 | 0.0023 | 7.35 | 5.10 | 9.47 | 1.76 |

Source: Nasdaq OMX and Danish FSA; calculations by Danmarks Nationalbank.

# Appendix 2 – Summary of liquidity measures for long-term bonds

SUMMARY STATISTICS FOR LIQUIDITY MEASURES – LONG-TERM BONDS Table A.2

| | Maximum, minimum and percentiles | Amihud (Per cent) | | Roll (Ticks) | | Turnover rate (Per cent) | |
|---|---|---|---|---|---|---|---|
| | | Covered bonds | Gov. bonds | Covered bonds | Gov. bonds | Covered bonds | Gov. bonds |
| Before the crisis (Jan 2005 – Jul 2008) | Max | 0.0205 | 0.0131 | 23.40 | 29.32 | 41.95 | 60.67 |
| | 95th | 0.0182 | 0.0128 | 21.71 | 23.64 | 29.78 | 42.51 |
| | 75th | 0.0136 | 0.0080 | 15.84 | 13.59 | 21.50 | 27.04 |
| | **50th** | **0.0119** | **0.0067** | **13.14** | **9.97** | **18.04** | **20.78** |
| | 25th | 0.0105 | 0.0061 | 10.70 | 9.44 | 12.46 | 16.53 |
| | 5th | 0.0094 | 0.0050 | 9.20 | 7.05 | 8.58 | 9.03 |
| | Min | 0.0082 | 0.0048 | 8.72 | 6.66 | 7.35 | 7.69 |
| During the crisis (Aug 2008 – Nov 2008) | Max | 0.0378 | 0.0210 | 49.09 | 39.86 | 14.18 | 23.01 |
| | 95th | 0.0358 | 0.0207 | 46.61 | 38.62 | 13.90 | 22.56 |
| | 75th | 0.0280 | 0.0195 | 36.69 | 33.64 | 12.79 | 20.75 |
| | **50th** | **0.0222** | **0.0172** | **26.66** | **27.51** | **11.68** | **14.16** |
| | 25th | 0.0196 | 0.0153 | 20.69 | 22.71 | 10.16 | 7.94 |
| | 5th | 0.0194 | 0.0149 | 20.49 | 20.88 | 8.04 | 7.02 |
| | Min | 0.0194 | 0.0148 | 20.45 | 20.43 | 7.51 | 6.79 |
| After the crisis (Dec 2008 – May 2010) | Max | 0.0259 | 0.0234 | 23.38 | 48.23 | 14.55 | 10.98 |
| | 95th | 0.0244 | 0.0212 | 21.52 | 44.30 | 14.45 | 10.30 |
| | 75th | 0.0171 | 0.0129 | 18.47 | 35.07 | 11.24 | 8.52 |
| | **50th** | **0.0149** | **0.0088** | **15.32** | **27.97** | **9.93** | **7.53** |
| | 25th | 0.0143 | 0.0070 | 14.43 | 23.77 | 8.57 | 5.95 |
| | 5th | 0.0122 | 0.0066 | 12.41 | 17.44 | 7.54 | 4.18 |
| | Min | 0.0110 | 0.0062 | 12.07 | 17.17 | 6.71 | 3.89 |

Source: Nasdaq OMX and Danish FSA; calculations by Danmarks Nationalbank.