The relation between sovereign credit default swap premium and banking sector risk in Poland

Łukasz Gątarek, Marcin Wojtowicz
The relation between sovereign credit default swap premium and banking sector risk in Poland

Łukasz Gątarek, Marcin Wojtowicz
Łukasz Gątarek – University of Łódź
Marcin Wojtowicz – INE PAN

We would like to thank seminar participants at Narodowy Bank Polski for comments and suggestions. This research project was conducted under the NBP Economic Research Committee's open competition for research projects to be carried out by the NBP staff and economists from outside the NBP and was financed by the NBP.
# Contents

1 Introduction 5  
2 The CDS market 9  
3 Data 12  
4 Empirical Analysis 13  
   4.1 Preliminaries 13  
   4.2 Causality between sovereign CDSs and bank equity returns 17  
   4.3 Discussion on price discovery and causality 21  
   4.4 Commonality in sovereign CDS premium and bank equity returns 22  
5 Conclusions 28
Abstract

We investigate causality between returns on sovereign CDSs and bank equities for Poland between 2004 and 2014 to provide evidence on contagion between sovereign and banking sector risk pricing. We find some evidence of contagion from Polish sovereign CDS returns to bank equity returns during the crisis period. We benchmark the results for Poland against a sample of Western European countries. We document strong negative correlation between sovereign CDS and bank equity returns for individual countries as well as strong commonality of both sovereign and banking sector risks across different countries. We do not however find a clear pattern of contagion between these two markets across European countries. To further investigate drivers of CDS and bank equity returns, we conduct principal component analysis and we find that first three principal components explain as much as 97% of variation with the third principal component mostly associated with Poland-specific risk.

JEL Classification: G01, G12, G14, G19, G21

Keywords: Contagion, sovereign CDS, bank equity returns, financial crisis.
Chapter 1

1. Introduction

The 2007-2009 financial crisis and the subsequent European sovereign debt crisis have clearly demonstrated the interconnectedness between credit risk of sovereign states and credit risk of their banking sectors. The financial crisis was precipitated by problems in the US subprime mortgages, which were widely used as collateral in structured finance products. The decline in value of structured finance products was propagated and transmitted throughout the financial system and led to unprecedented panic in the financial markets, particularly with the bankruptcy of Lehman Brothers on September 15, 2008. The financial systems in many countries reached the brink of collapse and were only saved by massive bailouts and guarantees by governments as well as unprecedented liquidity provisions by central banks.

The costs of bailouts were huge across many countries. The most expensive bailout of a single firm was AIG, which cost US government over $180 billion (Financial Crisis Report, 2011). In Ireland, the bailout programs had an upfront cost of almost 20% of the Irish GDP and the bailout announcement was made on September 30, 2008 (Acharya et al., 2011), just two weeks after the Lehman collapse. Saving a single bank, Anglo Irish, required up to EUR25 billion or as much as 11.26% of the country’s GDP (Acharya et al., 2011). Acharya et al. (2011) also point out that upon the bailout announcement in Ireland, the CDS premium on Irish banks fell quickly from 400 bps to 150 bps. However, the CDS premium for Ireland has quadrupled over the next month to over 100 bps and after six months reached 400 bps, which was the starting level of bank CDSs level (Acharya et al., 2011). Eventually Ireland was itself bailout out by other European countries.

The case of Ireland demonstrates an important relation between the risks of a sovereign state and its banking sector. Motivated by the Irish case, Acharya et al. (2011) provides a theoretical model with a two-way feedback between the financial and sovereign credit risk, which works as follows. If the financial system becomes highly undercapitalized or insolvent, the government has to take action because the continued weakness or even collapse of the financial system, which is at the center of any modern economy, would have dire economic consequences. The bailout is at least partly funded by diluting the existing government bondholders (increase in sovereign debt), which leads to an increase in credit risk of the sovereign. This in turn reduces the value of the guarantees granted
to the financial system and also reduces the value of government bonds held by banks (Acharya et al., 2011). Acharya et al. (2011) finds empirical confirmation of this two-way feedback by documenting the emergence of substantial co-movement between bank CDSs and sovereign CDSs after bank bailouts.

The relation between the risk of the banking sector and the sovereign state was very pronounced in the case of Ireland, which had a very large banking sector compared to the size of its GDP. Yet the same relation qualitatively, although less pronounced quantitatively, can be observed for almost every other Western European country as demonstrated by Acharya et al. (2011). However, compared to most other European countries, the case of Poland is unique. Banks in Poland did not require bailouts. This was largely due to the fact that Poland did not experience a large lending boom that later turned into a bubble. Moreover, banks in Poland were better capitalized and did not have on their balance sheets sophisticated structured finance products that incurred heavy losses during the crisis. For the aforementioned reasons analyzing the case of Poland is interesting because it will inform us whether the relationship between sovereign risk of Poland and its banking sector is much different compared to countries incurring more substantial problems during the crisis. Moreover, analyzing the relation between bank equity returns and sovereign CDS returns is interesting on its own. It extends the literature on contagion and price discovery between financial markets. For example, it follows Longstaff (2010) who uses weekly return data to analyze contagion between the mortgage market (ABX indices) and other markets including Treasury bonds, S&P financials and corporate bonds (Moody’s bond indices).

Since there are no credit default swaps traded on most Polish banks, we use equity returns instead of bank CDS returns to capture banking sector risk. This is of course not a direct measure of credit risk, but equity performance is highly dependent on bank conditions since equity is the residual claim on firm value after bondholders are repaid. Also, stock prices of banks largely determine the cost of capital for banks and their ability to raise new capital. For a measure of sovereign credit risk, we use sovereign CDS premium as in Acharya et al. (2011).

In Figure 1 we plot Poland’s sovereign CDS premium, WIG20 stock index (i.e. price index of 20 companies with largest capitalization listed on the Warsaw Stock Exchange) and WIG-Banks (subindex tracking total return of listed banks). In the pre-crisis period,
the sovereign CDS premium remained low and both stock indices rose steadily. When
the crisis started, we can observe emergence of a very pronounced inverse relationship
between the sovereign CDS premium and both stock indices. We can also observe that
the bank index fell more than WIG20 index during the large increase in sovereign risk in
2008 and 2009, but after the market bottom is reached, the banking sector recovered much
more than large-cap stocks.\(^1\) In Figure 2 we show the same data as in Figure 1, but in each
subplot we include only two series, which makes it easier to observe an almost perfectly
inverse relationship in the top two panels between Poland’s sovereign risk, WIG20 index
and WIG-Banks index.

Motivated by the strong pattern of the inverse relationship between Poland’s sovereign
CDS premium and Wig-Banks index shown in Figures 1 and 2, we investigate the direc-
tion of contagion between Polish sovereign CDS and bank returns. Investigating which
market moves first and Granger-causes returns in the other market is important because

\(^1\)Note that WIG20 index does not include dividends, while WIG-Banks does include dividends. How-
ever, the drop in bank prices is much larger during the crisis compared to WIG20 index than what could be
explained by differences in dividends.

Figure 1: This figure depicts the evolution of Poland’s sovereign CDS premium (solid
black line), stock index Wig20 (blue dash-dot line) and subindex of bank stocks WIG-
banks (dashed red line).
it leads to better understanding of the possible two-way feedback relation between the sovereign risk and the banking risk. It also contributes to our understanding of price discovery between financial markets and their response to global economic shocks. In the paper, we identify several periods when we expect the relation between credit risk of sovereigns and banks to change due to varying economic conditions. We also compare the relationship between sovereign CDS returns and bank returns for Poland to that for other European countries. In particular, we analyze the extent to which Polish sovereign and banking risks are driven by common factors extracted using principal component analysis.

The rest of this paper is organized as follows. Section 2 provides background on the CDS market, while Section 3 describes the data. Section 4 presents the results of the empirical analysis. Section 5 concludes.

Figure 2: This figure depicts the evolution of Poland’s sovereign CDS premium, stock index WIG20 and subindex of bank stocks WIG-banks. Each pair of the three series is plotted separately.
2. The CDS market

A credit default swap is a financial swap agreement between two parties whereby one party is a protection buyer (long position) and pays a periodic fee known as CDS premium to the other party known as protection seller (short position). The CDS contract stipulates that in exchange for receiving the periodic fee the protection seller is obliged to compensate the protection buyer for any losses associated with default or in some cases other credit events of the underlying obligor, which in the context of this study are bonds of a sovereign state.

The history of credit default swaps dates back to 1994 when they were first used by JP Morgan (Financial Times, 2006). The market grew rapidly and the notional outstanding of CDSs reached $300 billion in 1998 and $3.8 trillion in 2003, while the record level of $62.2 trillion was reached by the end of 2007 according to ISDA (2010). The credit default swap market has also expanded in terms of assets used as underlying securities such that not only default risks of corporate, municipal or sovereign bonds could be insured. Market participants have begun using credit default swaps to transfer credit risk of corporate loans or even more complicated financial structures such as asset backed securities or tranches of CDOs. Credit default swaps on sovereign states have become a major market only recently when concerns about sovereign credit risk increased during the financial crisis.

Credit default swaps have played an important role during the financial crisis. They have become a leading indicator of default risk present in the economy and particularly the risk of collapse of the banking sectors and sovereign states. From the previously rather esoteric financial instruments, credit default swaps have become an indicator commonly quoted in the popular press. Probably the most reported CDS instrument was that on the Greek government debt, which in the beginning of 2012 was quoted at above the staggering 20,000 bps. This was a clear indication that the market was expecting an imminent default, which did occur on March 9, 2012 (ISDA, 2012a). The credit default swaps have also been put into spotlight earlier when AIG has found itself on the brink of collapse being unable to post collateral on its massive positions in credit default swaps. AIG has accumulated $533 billion of CDS positions of which $79 billion were referencing mortgage backed securities (Financial Crisis Report, 2011). When the value of AIG’s
positions started to rapidly turn negative, the company could not meet margin calls for collateral and was effectively bankrupt. Due to the fear of contagion and the collapse of the financial system, the federal government has conducted the largest ever bailout of a private company, which in the case of AIG eventually totaled over $180 billion (Financial Crisis Report, 2011).

The main advantage of credit default swaps is that they allow for transferring pure default risk in a simple and convenient manner that is unconstrained by the issuance and liquidity of underlying bonds or assets. Another advantage is that it facilitates taking short positions in credit risk, which is more complicated in bond markets or other markets for physical assets. Furthermore, bonds are most often less liquid than credit default swaps. That is partly because various bonds issued by the same entity typically have different characteristics along several dimensions, while credit defaults swaps are largely standardized. Moreover, from a modeling perspective, extraction of the pricing of credit risk from bond prices is dependent on the choice of the risk-free rate, while credit default swaps provide direct pricing of credit risk.

Credit default swap markets have developed as largely unregulated markets since they are over-the-counter markets dominated by large dealer banks and other financial institutions. The International Swaps and Derivatives Association has set up rules on how the CDS markets operate including many legal aspects of CDS contracts and various rules on what constitutes a default or how recovery rates are determined. The CDS market is dominated by G-14 dealers, which are the largest fourteen dealers in OTC derivatives. For example, in 2011 this group comprised of Bank of America-Merrill Lynch, Barclays Capital, BNP Paribas, Citigroup, Credit Suisse, Deutsche Bank AG, Goldman Sachs & Co., HSBC Group, J.P. Morgan, Morgan Stanley, The Royal Bank of Scotland Group, Societe Generale, UBS AG, and Wells Fargo. According to DTCC over 97% of contracts have a G-14 dealer as at least one party (Chen et al., 2011).

The CDS markets have sustained its prominent role in the financial system throughout and after the 2007-2009 financial crisis. Although the CDS notional outstanding have declined from a peak of over $60 trillion to about a half of that amount in 2010, the decline was largely attributable to trade compressions that eliminate unnecessary counterparty risk from the system (The Economist, 2009). Trade compressions replace existing contracts with a new set of contracts preserving net risk exposure, but with fewer contracts
and less interconnectedness between different parties. This reduces counterparty risk because in the event of default of a major player in the market the amount of resulting payments are not dependent on the net CDS positions of a defaulted party, but its gross positions. Introducing trade compressions was one of the first moves that the industry has undertaken in response to the financial crisis. Another measure to further reduce counterparty risk was the gradual move towards central clearing although that was at the cost of creating systemic risk at the level of central counterparty clearing houses. The market participants have also introduced a number of standardization measures and settlement rules known as the CDS Big-Bang for North American markets and CDS Small-Bang for European markets. These measures standardized coupon levels and coupon payment dates and also facilitated handling defaulted CDSs via auctions among other changes. The regulators are also considering introducing obligatory trade reporting in the CDS markets to improve transparency, but due to concerns about adverse effect of such measures on liquidity provision by dealers they have been temporarily postponed.
3. Data

The data used for this study includes quotes of sovereign CDS premia, stock indices and indices of banking stocks of the analyzed countries. We choose the sample period from 02-01-2004 due to data availability because the sovereign CDS market was not liquid prior to that period. The end date of the sample is 27-06-2014. The sample consists of data for Poland and 14 other European countries (Netherlands, France, Belgium, Denmark, Finland, Sweden, Austria, Switzerland, United Kingdom, Ireland, Italy, Spain, Portugal, Greece), which have been chosen based on data availability. Note that for a number of countries we have data available only for part of the sample period.

Sovereign credit default swap premia are taken from Datastream. We choose contracts with 5 year maturity because they are the most liquid. We also choose contracts on senior unsecured debt, which is the most common. The currency of denomination is Euro since we analyze European countries. For each country we match data available from two sources within Datastream. The first source is the CMA data provider, which has CDS quotes available until 01-10-2010 in Datastream and for the remaining period we use data from Thomson Reuters. This matching is necessary because there is no continues series of data over our entire sample period from a single data source. The sovereign CDS premia used in the study are quoted in the ‘running-spread only’ convention.²

DataStream is also the source of large-cap stock indices and banking-subindices data for European countries as well as the remaining series: S&P 500 index, S&P 500 financials index, VIX index, spreads on iTraxx and CDX corporate indices, 3 month Wibor rate (i.e. Polish Libor) and US repo rate.

---

²“The CDS price can be quoted as a combination of an upfront payment and a quarterly coupon. Since different coupons can be used for various CDSs or even for CDS contracts on the same reference entity, the comparison of CDS pricing is done by converting the upfront payment into equivalent future coupon payments. This is done by finding the coupon level that has the same present value as the upfront payment when discounted using the risk-neutral default survival curve. The details of the procedure are explained in ISDA (2012b). This coupon-only quotation is also known as the running spread convention to quote CDS prices” (Wojtowicz, 2014).
4. **Empirical Analysis**

4.1. **Preliminaries**

We start the empirical analysis by a more detailed graphical analysis of the data. In Figure 3 we replicate Figure 1 presenting Polish sovereign CDS premium and stock indices, but we add vertical lines at dates corresponding to major events during the crisis, which mark changes in market environment and sentiment. These events are identified based on the behavior of CDS premium and stock market indices as well as by various reports about market developments. A good overview of market developments during the crisis is given by the Federal Reserve Bank of St. Louis on its ‘Timeline of Events and Policy Actions’ of the financial crisis.3

The first vertical line when looking from the left is on 31-07-2007 when Bear Stearns liquidated its two hedge funds that invested in subprime mortgage backed securities. We can see that this event triggered a substantial decline in stock indices, which recovered rather quickly, while the sovereign CDS premium did not change significantly. The second (thick dotted) vertical line is on 01-11-2007 when “financial market pressures intensified, reflected in diminished liquidity in interbank funding markets” (FED, 2009). We can see that this point in time was the beginning of a large decline in stock prices and a substantial increase in Poland’s sovereign CDS premium. The third vertical line is on 15-09-2008 when Lehman Brothers collapsed upon which the markets continued its decline but at a much faster rate. The fourth vertical line on 27-02-2009 marks the peak of the financial crisis and the start of the period when markets begin recovery. According to FED (2009), on this day the US Treasury Department announced capital injections into 28 US banks and agreed to convert $25 billion of preferred stocks of Citigroup into common equity. Also earlier in February of 2009, the US Treasury Department injected hundreds of millions of dollars to a few dozen banks (FED, 2009). The fifth vertical line further to the right on 01-06-2011 marks the beginning of an escalation of the sovereign crisis, which is demonstrated in the rapid increase in sovereign CDS premia. In May the eurozone countries and the IMF approved a $75 billion rescue package for Portugal, while the overall market sentiment deteriorated. Eurozone ministers decided that Greece

3See FED’s website at http://timeline.stlouisfed.org/index.cfm?p=timeline#.
must impose new austerity measures before receiving more funding (BBC, 2012). Talks about exit of Greece from the Eurozone became abound (BBC, 2012). In June Greece was downgraded by Standard & Poor’s to CCC, which made it the lowest-rated sovereign state in the world (Britannica, 2012). The last line on 01-06-2012 marks the beginning of a period when market recovery takes place. This is after Spain’s fourth largest bank asked the government for $18 billion Euros on May 16th and Spain itself announced that it will make a request for up to $100 billion from the eurozone countries on May 25th (BBC, 2012).

In the Figures section after the main text, in set A we present figures analogues to

![Figure 3: This figure depicts the evolution of Poland’s sovereign CDS premium (solid black line), stock index Wig20 (blue dash-dot line) and subindex of bank stocks WIG-banks (red dashed line).](image)

In Table 1 we show the value of these variables before the crises (second vertical line in Figure 3), at the peak of the financial crisis (fourth vertical line) and at the turn of the sovereign crisis (sixth vertical line). We can see that just before the crisis the sovereign CDS on Poland was 11.7 bps, which was very low as this was the period of historically low credit spreads (although Polish CDS premium was still higher compared to other countries including Ireland, Portugal and Greece). At the peak of the financial crisis, the CDS on Poland increased to 362.5 bps, which was the highest in the sample followed by Ireland (359.69 bps), Greece (255 bps) and Austria (235 bps). The lowest CDS spread was on Germany and France, respectively, 85.86 bps and 89 bps. It is surprising that Poland’s sovereign CDS spread was higher than that of other countries despite the fact that Polish banking sector and its economy did not experience significant problems.

In Table 1 we can also see that at the peak of the financial crisis stock indices in all countries were a fraction of their pre-crisis levels. Poland’s WIG20 index was only 35% of its pre-crisis level, while the subindex of banks was only 29% of its pre-crisis level. The deviations from the pattern arise for countries facing insolvency during the sovereign crisis such as Ireland or Greece. We can also see on the graphs that for countries that were at the center of the sovereign crisis, i.e. Ireland, Italy, Spain, Portugal and Greece, the CDS premia during the peak of the sovereign crisis (6th line) are much larger than sovereign CDS premia during the peak of the financial crisis (4th line), while for countries that did not experience problems with government debt financing the financial crisis was the more severe one.

To further investigate the behavior of sovereign CDS premia and stock market indices across countries and economic cycles, in Table 1 we show the value of these variables before the crises (second vertical line in Figure 3), at the peak of the financial crisis (fourth vertical line) and at the turn of the sovereign crisis (sixth vertical line). We can see that just before the crisis the sovereign CDS on Poland was 11.7 bps, which was very low as this was the period of historically low credit spreads (although Polish CDS premium was still higher compared to other countries including Ireland, Portugal and Greece). At the peak of the financial crisis, the CDS on Poland increased to 362.5 bps, which was the highest in the sample followed by Ireland (359.69 bps), Greece (255 bps) and Austria (235 bps). The lowest CDS spread was on Germany and France, respectively, 85.86 bps and 89 bps. It is surprising that Poland’s sovereign CDS spread was higher than that of other countries despite the fact that Polish banking sector and its economy did not experience significant problems.
Empirical Analysis

Figure 3 for other European countries. We can observe a strong pattern of commonality in CDS premia and stock indices.\(^4\) In particular, we can see that pivotal dates marking new phases of the crisis or recovery match almost perfectly for each country during the financial crisis. For example, the fourth vertical line on 27-02-2009 marks precisely the (local) maximum of sovereign CDS premium for each country. While the magnitudes of changes in CDS premia or stock indices can vary between countries, the timing of peaks and trends is mostly the same across Europe. Deviations from the pattern arise for countries facing insolvency during the sovereign crisis such as Ireland or Greece. We can also see on the graphs that for countries that were at the center of the sovereign crisis, i.e. Ireland, Italy, Spain, Portugal and Greece, the CDS premia during the peak of the sovereign crisis (6th line) are much larger than sovereign CDS premia during the peak of the financial crisis (4th line), while for countries that did not experience problems with government debt financing the financial crisis was the more severe one.

To further investigate the behavior of sovereign CDS premia and stock market indices across countries and economic cycles, in Table 1 we show the value of these variables before the crises (second vertical line in Figure 3), at the peak of the financial crisis (fourth vertical line) and at the turn of the sovereign crisis (sixth vertical line). We can see that just before the crisis the sovereign CDS on Poland was 11.7 bps, which was very low as this was the period of historically low credit spreads (although Polish CDS premium was still higher compared to other countries including Ireland, Portugal and Greece). At the peak of the financial crisis, the CDS on Poland increased to 362.5 bps, which was the highest in the sample followed by Ireland (359.69 bps), Greece (255 bps) and Austria (235 bps). The lowest CDS spread was on Germany and France, respectively, 85.86 bps and 89 bps. It is surprising that Poland’s sovereign CDS spread was higher than that of other countries despite the fact that Polish banking sector and its economy did not experience significant problems.

In Table 1 we can also see that at the peak of the financial crisis stock indices in all countries were a fraction of their pre-crisis levels. Poland’s WIG20 index was only 35% of its pre-crisis level, while the subindex of banks was only 29% of its pre-crisis level. The

\(^4\)Note that for some countries, e.g. Denmark or Sweden, CDS premia behave erratically prior to 2006, which is evidence of low data quality in that period. However, CDS data appears consistent from 2006 onwards.
Table 1: The levels of sovereign CDS premia, general stock indices and bank sub-indices across countries and time-periods.

This table shows the evolution of sovereign CDS premia, general stock indices and bank subindices, which in columns (2)–(4) are reported in levels on 01-11-2007, i.e. just before the financial crisis. The next three columns report these variables at the peak of the financial crisis, i.e. 27-02-2009. The rightmost columns report the same data at the end of the sovereign crisis, i.e. 01-06-2012. Note that in the ‘Financial-crisis’ and ‘Sovereign-crisis’ parts of the table we report CDS premia in levels (bps), but stock indices are reported as fractions of the pre-crisis levels.

<table>
<thead>
<tr>
<th></th>
<th>Pre-crisis</th>
<th>Financial-crisis</th>
<th>Sovereign-crisis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cds  stock index  bank ind.</td>
<td>cds stock ind. (frac. pre-cris.)  bank ind. (frac. pre-cris.)</td>
<td>cds  stock ind. (frac. pre-cris.)  bank ind. (frac. pre-cris.)</td>
</tr>
<tr>
<td>POLAND</td>
<td>11.7  3877.62  8888.59</td>
<td>362.5  0.35  0.29</td>
<td>243.76  0.53  0.6</td>
</tr>
<tr>
<td>GREECE</td>
<td>9.5   5334.5   7751.08</td>
<td>255   0.29  0.17</td>
<td>14904.36  0.09  0.02</td>
</tr>
<tr>
<td>AUSTRIA</td>
<td>2.5   4871.71  318.22</td>
<td>235   0.3   0.18</td>
<td>132.58  0.38  0.32</td>
</tr>
<tr>
<td>BELGIUM</td>
<td>4.1   4441.82  1235.69</td>
<td>138.68 0.38  0.2</td>
<td>190.33  0.46  0.22</td>
</tr>
<tr>
<td>DENMARK</td>
<td>4.3   507.92   2036.43</td>
<td>134.73 0.48  0.29</td>
<td>122.46  0.83  0.41</td>
</tr>
<tr>
<td>FRANCE</td>
<td>2.9   5847.95  1220.44</td>
<td>89    0.46  0.3</td>
<td>104.7   0.5   0.3</td>
</tr>
<tr>
<td>SWEDEN</td>
<td>8.08  384.15   1253.45</td>
<td>140    0.51  0.4</td>
<td>58.03   0.78  0.68</td>
</tr>
<tr>
<td>NETHERL.</td>
<td>5.9   15890.5  1603.8</td>
<td>145    0.48  0.35</td>
<td>448.2   0.38  0.27</td>
</tr>
<tr>
<td>IRELAND</td>
<td>2.2   547.85   1253.08</td>
<td>119.54 0.4   0.2</td>
<td>128.27  0.52  0.25</td>
</tr>
<tr>
<td>GERMANY</td>
<td>6.3   7911.12  12533.58</td>
<td>359.69 0.26  0.02</td>
<td>610.41  0.38  0.01</td>
</tr>
<tr>
<td>PORTUGAL</td>
<td>2.7   4046.29  576.4</td>
<td>85.86  0.47  0.18</td>
<td>46.85   0.77  0.25</td>
</tr>
<tr>
<td>SWEDEN</td>
<td>8.6   4128.11  1697.41</td>
<td>133.26 0.49  0.26</td>
<td>1179.82 0.45  0.07</td>
</tr>
</tbody>
</table>
performance of Polish stock market was better than that of, e.g. Greece (respectively 29% and 17%), but worse than e.g. Sweden (respectively 51% and 40%). Finally, at the peak of the sovereign crisis, CDS on Poland was 243.76 bps, which was generally higher compared to non-crisis afflicted Western countries (e.g. Netherlands at 128.28 bps), but much lower compared to crisis-afflicted countries (e.g. Ireland 610.41 bps). The stock markets have generally recovered moderately compared to the previous period for non-crisis afflicted countries, while they reached bottom for crisis-afflicted countries (e.g. Greece). Poland’s WIG20 index was at 53% of its pre-crisis level, while banks were at 60%. We can see that Polish banks recovered relatively the most except for Sweden, while the Polish WIG20 index was in the mid-range compared to other countries. Overall, the data indicates that Poland experienced a very substantial increase in sovereign CDS premium and a large decline in stock prices during the crises, which were quantitatively similar to countries in Western Europe, despite the fact that Poland did not have to bail out its banks and its sovereign solvency was not severely undermined as the economy sustained growth. Poland’s economy has likely benefited from its depreciating currency, which however implies that in dollar- or euro-terms the stock market in Poland performed far worse. A likely explanation is that global financial markets experienced flight-to-quality and foreign investors sold Polish stocks leading to large price declines. In any case, the performance of Polish stock market and sovereign CDSs points out to vulnerability of Poland’s capital markets and sovereign financing to global economic shocks. It is therefore interesting to analyze whether there is contagion from sovereign CDS market to bank equity returns and possibly vice-versa.

4.2. Causality between sovereign CDSs and bank equity returns

Motivated by the strong pattern of correlation between sovereign CDS premium on Poland and its stock indices, we investigate causality between the sovereign CDS premium and the subindex of bank stocks. This analysis aims to answer the question of whether there are spillovers from one market to another, which are consistent with (possibly mutual) contagion between these markets as proposed by (Acharya et al., 2011). Investigating the case of Poland is interesting because Poland was the only EU economy not to experience a recession throughout the crisis and did not require bank bailouts.
The relation and possible contagion between sovereign CDS premium and bank stocks might be to a large extent determined by the type of investors active in each market. The market for CDSs is dominated on the buy-side by hedge funds, asset managers and banks (Chen et al., 2011). The stock market is dominated by private individuals and institutional investors such as pension funds and asset managers. Therefore, investors active in each market might have different risk appetites, investment styles and investment purposes. They are also to a different extent influenced by redemptions from clients and thus necessity to reduce positions. Investigating the case of Poland in this context is also interesting because Polish capital markets are less integrated to global capital markets than those of Western Europe.

To investigate causality between CDS spread on Poland and (rescaled) subindex of Polish banks, we rely on the methodology proposed by Longstaff (2010). From the data on sovereign CDS premium and banking stock index, we construct weekly returns as the log difference of the series considered. These returns are directly used in our further analysis of contagion. This follows Longstaff (2010) who also uses data at weekly frequency to investigate contagion between returns on ABX indices referencing subprime mortgages and returns in other markets such as the Treasury bond market.

We implement the econometric test for Granger causality, see Longstaff (2010) for application to similar problem. The simplest approach to test whether a particular observed series $y_t$ causes $x_t$, $t \in \{1, \ldots, T\}$ can be based on autoregressive specification. To this end, we assume a particular autoregressive lag length $p$ and estimate by OLS the parameters of time series regression:

\[ x_t = c_1 + \sum_{i=1}^{p} \alpha_i x_{t-i} + \sum_{i=1}^{p} \beta_i y_{t-i} + u_t. \]

Then we conduct the F test of the Null:

\[ H_0 : \beta_1 = \beta_2 = \ldots = \beta_p = 0. \]

To implement the test we calculate the sum of squared residuals from the above regression

\[ RSS_1 = \sum_{i=1}^{T} \hat{u}_{t}^2 \]
Empirical Analysis

The relation and possible contagion between sovereign CDS premium and bank stocks might be to a large extent determined by the type of investors active in each market. The market for CDSs is dominated on the buy-side by hedge funds, asset managers and banks (Chen et al., 2011). The stock market is dominated by private individuals and institutional investors such as pension funds and asset managers. Therefore, investors active in each market might have different risk appetites, investment styles and investment purposes. They are also to a different extent influenced by redemptions from clients and thus necessity to reduce positions. Investigating the case of Poland in this context is also interesting because Polish capital markets are less integrated to global capital markets than those of Western Europe.

To investigate causality between CDS spread on Poland and (rescaled) subindex of Polish banks, we rely on the methodology proposed by Longstaff (2010). From the data on sovereign CDS premium and banking stock index, we construct weekly returns as the log difference of the series considered. These returns are directly used in our further analysis of contagion. This follows Longstaff (2010) who also uses data at weekly frequency to investigate contagion between returns on ABX indices referencing subprime mortgages and returns in other markets such as the Treasury bond market.

We implement the econometric test for Granger causality, see Longstaff (2010) for application to similar problem. The simplest approach to test whether a particular observed series \( y_t \) causes \( x_t \), \( t \in \{1, \ldots, T\} \), can be based on autoregressive specification. To this end, we assume a particular autoregressive lag length \( p \) and estimate by OLS the parameters of time series regression:

\[
    x_t = c_0 + \sum_{i=1}^{p} \gamma_i x_{t-i} + \epsilon_t
\]

and compare it with the sum of squared residuals of a univariate autoregression for \( x_t \)

\[
    RSS_0 = \sum_{i=1}^{T} \hat{e}_t^2
\]

where

\[
    x_t = c_0 + \sum_{i=1}^{p} \gamma_i x_{t-i} + \epsilon_t
\]

is estimated by OLS, as well. If the test statistic

\[
    S = T \frac{RSS_0 - RSS_1}{RSS_1}
\]

is greater than the critical value of the test statistic (\( \chi^2(p) \) distributed), then we reject the Null. In order to achieve more certainty in the results, we run a sequence of tests for \( p = 1, \ldots, 8 \) for two choices of statistical significance levels, 5 and 10%, respectively.

In Figure 4, we present the analysis of Granger causality between bank returns and sovereign CDS returns within different periods defined based on pivotal moments during the financial and sovereign crises. Note that a similar approach in the context of analyzing contagion in different periods characterized by distinct market circumstances is also used by Acharya et al. (2011). The cut-offs of periods used in this paper are represented by dotted vertical lines in Figure 3. We define five periods. The first one is the pre-crisis period until 31-07-2007 (2nd line). The second one is the financial crisis period, which starts after the first period and lasts until 27-02-2009 when financial market pressures reach a peak (4th line). The third one is the financial crisis recovery period until 01-06-2011 (5th line). The fourth period is the sovereign crisis period until 01-06-2012 (6th line). The fifth period is the recovery from the financial crisis that follows until the sample end. On the graphs, we depict the value of the test-statics for different number of lags and we also plot the lines depicting the critical values of the test statistics corresponding to significance levels of 5% and 10%.

In the top panel of Figure 4, we show the results on whether bank stock returns Granger cause returns on Polish sovereign CDS premium, while in the bottom panel we analyze the reverse causality. In the bottom panel, we can observe that there is strong evidence of causality from CDS returns to bank returns in period 2 (crisis period) as the
green line is far above the critical value of the test statistic at the 5% significance level starting from lag 3. This is consistent with the notion that as the crisis was centered on

![Graph 1: POLAND: Causality from BANKS to CDS](image1)

![Graph 2: Causality from CDS to BANKS](image2)

Figure 4: This figure summarizes the results of testing for Granger causality between bank returns and CDS sovereign returns in different periods based on weekly data. The top panel tests for causality from bank returns to CDS returns, while the bottom panel tests for the reverse causality. Period 1 is the pre-crisis period; period 2 is the financial crisis; period 3 is the financial crisis recovery; period 4 is the sovereign crisis period; and finally period 5 is the recovery from the financial crisis that followed until the sample end. The colored lines show the value of the test statistic plotted against the number of lags in the Granger test for each period. We also depict the critical values at 5% and 10% significance levels. The test confirms Granger causality if the value of the test statistic is above the line indicating critical value.

4.3. Discussion on price discovery and causality

We have found evidence of contagion or information spillovers from sovereign CDS returns to bank equity returns for Poland in period 2 (financial crisis). This result is observed for the other European countries as well. The finding of causality from bank returns to sovereign CDS returns during the sovereign crisis is interesting because Polish banks did not require bailouts that would justify such causality, but it might be related to information transmission.
Empirical Analysis

the US (and also European) banking sectors, the CDS market, which has a larger share of international investors, moved first, while Polish bank returns reacted with a lag. This could be because of a share of domestic investors in the stock market (e.g. pension funds or investment funds) that continued buying shares as the crisis started. Another explanation could be that as the Polish sovereign CDS premium became quite high at the peak of the financial crisis representing a rather negative outlook on Poland’s economy, it became a mechanism of information transmission to equity markets and pricing of banks in particular. The bottom panel also provides some evidence of causality from CDS returns to bank returns in period 3 (financial crisis recovery), but the test statistic exceeds the critical value starting at five lags (5 weeks). In the analysis of weekly data, it is therefore less reliable as we are mostly interested in the first four lags, which constitute a sensible time-horizon for market spillovers. In the top panel, we can also observe the reverse causality from bank to sovereign CDS returns, but again it is only significant starting from the fifth lag. Finally, in the top panel we can see a strong pattern of causality from bank returns to CDS returns in period 5 (recovery from the sovereign crisis) indicating that banking sector recovery led the sovereign market recovery. We also find evidence of a weak pattern of causality in period 4 (sovereign crisis). The finding of causality from bank returns to sovereign CDS returns during the sovereign crisis is interesting because Polish banks did not require bailouts that would justify such causality, but it might be related to information transmission.

In the set B of the Figures section after the main text, we present figures analogues to Figure 4 for other European countries. We can observe that there is no clear pattern of causality that would be typical across most countries. However, the same direction of causality from sovereign CDS returns to bank returns in period 2 (crisis period) as observed for Poland can be clearly observed in crisis-afflicted countries (Ireland, Portugal, Greece) and weakly observed in Denmark and Sweden. Also, causality from bank returns to sovereign CDS returns in period 5 (sovereign crisis recovery) is seen in Austria, Italy, Spain and Portugal.

4.3. Discussion on price discovery and causality

We have found evidence of contagion or information spillovers from sovereign CDS returns to bank equity returns for Poland in period 2 (financial crisis). This result is ob-
tained using the VAR approach as in Longstaff (2010). The causes of contagion from the sovereign CDS market to bank equity returns can be multiple. Longstaff (2010) considers three channels of contagion: correlated-information channel, liquidity channel and risk-premium channel, which are non-exclusive. In the correlated-information channel news arrives in one market and it is promptly incorporated in the other market, which is consistent with large contemporaneous correlation between sovereign CDS returns and bank returns. The liquidity channel and the risk-premium channel can lead to a delayed response in some markets that would be consistent with our finding of contagion for Poland in period 2, see Longstaff (2010) for a discussion of contagion related to mortgage-backed securities and other markets. Note that both the sovereign CDS market and the equity markets are highly liquid, but different types of investors are active in each. Our study finds that it is the CDS market, which is dominated by large institutional investors such as hedge funds, asset managers and banks that is leading bank equities during the crisis period. This can be due to the fact that the crisis developed in other countries, which likely led to the increase of perceived risk of sovereigns, while bank equity prices in Poland declined subsequently as a result of flight-to-quality and with a delayed response due to a smaller share of international investors in this market.

4.4. Commonality in sovereign CDS premium and bank equity returns

Motivated by the strong pattern of commonality across sovereign CDS premia and bank returns demonstrated in Figure 3 and set A of Figures after the main text, we investigate to what extent CDS premia as well as bank returns are driven by common risk factors. In line with the approach of Longstaff et al. (2011), we conduct principal component analysis of CDS premia and equity returns. The analysis is conducted using daily data for our sample of countries although we exclude Greece because its CDS premium was first characterized by extreme variability and subsequently Greece defaulted.

In Figure 6, we present the first three computed principal components of sovereign CDS premia. We focus on the first three components because the first component explains as much as 84% of variation in CDS premia, the second 11% and the third 2%, while the remaining components no more than 1%. In the next step, we decompose the variance
explained by each of three components relative to the total variance explained for each country by the first three components. The results are presented in Table 2.

We can observe that for Poland the first principal component explains 62% of variation, the second PC explains only 4%, while the third PC explains 34%. The first principal component is highly associated with the sovereign risk of ‘safe’ and robust economies such as those of Austria, Germany, Sweden, Denmark, Netherlands, and United Kingdom. For these countries, the first principal component explains nearly 100% of the variation explained by the first 3 principal components. For countries that experienced problems with sovereign solvency (Ireland, Italy, Spain), the first factor explains between 52% to 73% of variation in CDS premia (the only exception is Portugal for which the first PC explains 100% of variation). The second principal component appears to explain a sub-

![Figure 5: This figure depicts the three main principal components of CDS premia.](image)
Table 2: Proportion of variation in sovereign CDS premium explained by each of the first three principal components.

<table>
<thead>
<tr>
<th>Country</th>
<th>1st PC</th>
<th>2nd PC</th>
<th>3rd PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLAND</td>
<td>0.62</td>
<td>0.04</td>
<td>0.34</td>
</tr>
<tr>
<td>AUSTRIA</td>
<td>0.98</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>BELGIUM</td>
<td>0.57</td>
<td>0.39</td>
<td>0.05</td>
</tr>
<tr>
<td>DENMARK</td>
<td>0.99</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>FINLAND</td>
<td>0.90</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>FRANCE</td>
<td>0.96</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>SPAIN</td>
<td>0.56</td>
<td>0.43</td>
<td>0.01</td>
</tr>
<tr>
<td>NETHERLANDS</td>
<td>0.93</td>
<td>0.07</td>
<td>0.00</td>
</tr>
<tr>
<td>IRELAND</td>
<td>0.73</td>
<td>0.27</td>
<td>0.00</td>
</tr>
<tr>
<td>GERMANY</td>
<td>0.98</td>
<td>0.00</td>
<td>0.01</td>
</tr>
<tr>
<td>PORTUGAL</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>SWEDEN</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>UNITED KINGDOM</td>
<td>0.98</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>ITALY</td>
<td>0.52</td>
<td>0.47</td>
<td>0.01</td>
</tr>
</tbody>
</table>

A substantial amount of variance (well over 20%) for countries afflicted by the sovereign crisis (Spain, Ireland, Italy) and also Belgium. Interestingly, for Poland this factor explains only 4% of variation. Finally, the third principal component explains as much as 34% of variation in CDS premium of Poland and very little for any other country (for Belgium 5%, France 3% and 1% or 0% for other countries). These results are surprising. The variation in sovereign risk of Poland, which did not experience large problems with its banking system or sovereign solvency, is only in 62% explained by the first principal component that appears to be associated with the risk of the safest countries. A large fraction of over 34% of variation in Polish sovereign CDS can be explained by the factor that appears to be strongly and exclusively associated with the Polish sovereign risk. It demonstrates the unique position of Poland and its distinguishing risk profile, which is likely associated with its status as a transition economy. Note that not all countries in the sample are in the Eurozone, for example the United Kingdom is not, but still over 98% of British sovereign CDS variation is explained by the first PC. Altogether, the principal component analysis clearly differentiates between the core countries (Germany, UK, France), the periphery or
crisis-countries (Italy, Spain), while a large part of variability in Poland’s sovereign CDS appears not to be associated with risk of other European countries.

Having demonstrated that sovereign risk can be largely explained by common factors across European countries, we also conduct a principal component analysis on bank returns. In Figure 5 we plot the first three principal components of banking returns across European countries, while in Table 3 we attribute the total variation explained jointly by the first three components amongst them.

Table 3: Proportion of variation in equity returns explained by each of the first three principal components.

<table>
<thead>
<tr>
<th>Country</th>
<th>1st PC</th>
<th>2nd PC</th>
<th>3rd PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLAND</td>
<td>0.70</td>
<td>0.27</td>
<td>0.03</td>
</tr>
<tr>
<td>AUSTRIA</td>
<td>0.34</td>
<td>0.17</td>
<td>0.49</td>
</tr>
<tr>
<td>BELGIUM</td>
<td>0.48</td>
<td>0.45</td>
<td>0.07</td>
</tr>
<tr>
<td>DENMARK</td>
<td>0.94</td>
<td>0.03</td>
<td>0.04</td>
</tr>
<tr>
<td>FINLAND</td>
<td>0.71</td>
<td>0.02</td>
<td>0.27</td>
</tr>
<tr>
<td>FRANCE</td>
<td>0.14</td>
<td>0.86</td>
<td>0.00</td>
</tr>
<tr>
<td>SPAIN</td>
<td>0.09</td>
<td>0.33</td>
<td>0.57</td>
</tr>
<tr>
<td>NETHERLANDS</td>
<td>0.00</td>
<td>0.97</td>
<td>0.03</td>
</tr>
<tr>
<td>IRELAND</td>
<td>0.35</td>
<td>0.49</td>
<td>0.16</td>
</tr>
<tr>
<td>GERMANY</td>
<td>0.47</td>
<td>0.52</td>
<td>0.01</td>
</tr>
<tr>
<td>PORTUGAL</td>
<td>0.00</td>
<td>0.12</td>
<td>0.88</td>
</tr>
<tr>
<td>SWEDEN</td>
<td>0.83</td>
<td>0.15</td>
<td>0.02</td>
</tr>
<tr>
<td>UNITED KINGDOM</td>
<td>0.00</td>
<td>0.30</td>
<td>0.70</td>
</tr>
<tr>
<td>ITALY</td>
<td>0.89</td>
<td>0.08</td>
<td>0.03</td>
</tr>
</tbody>
</table>

We find that bank equity returns are to a far lower degree explained by common factors (PCs) compared to sovereign CDS premia, which confirms the same findings of Longstaff et al. (2011) who examines a different (not only European) sample of countries. We find that for equity returns, the first five principal components explain respectively, 28%, 24%, 13%, 7%, and 6% of the total variation in equity returns. In Table 3 we show that for equity bank returns, the first three principal components cannot be attributed to the risks associated with specific groups of countries. For Poland, 70% of variation explained by
the first three PCs is due to the first principal component, which also explains, for example, 94% of variation in Danish bank returns and 89% of variation in Italian bank returns. Altogether, we can conclude that while sovereign CDS premia can be largely explained by principal components, suggesting large commonality in CDS variation across countries, bank returns cannot be explained to the same degree by common factors.

In Table 4 we try to gain additional economic interpretation of the first three principal components in the sovereign CDS market. We analyze if the PCs can be explained by changes in the major indices that are known to reflect various types of risk. In the reported regressions, we individually regress the respective principal components on a set of independent variables. In the first two columns, we can see that PCs are not explained by returns on S&P or S&P Financials indices. In the remaining columns, we can observe that

![Figure 6: This figure depicts the three main principal components of bank returns.](image-url)
Empirical Analysis

the first PC is significantly associated with the other variables with the largest explanatory power attributable to the emerging market CDS index and US repo rates. The second PC is mostly associated with the VIX index and CDX investment grade index. The third PC explaining a large part of variation in Polish sovereign CDS is strongly associated with the iTraxx corporate index and the emerging market CDX index. This provides some support for the hypothesis that this factor is specifically related to the risk of emerging countries.

Table 4: Regressions of sovereign CDS principal components on a set of economic and risk measures.

This table regresses the first three principal components derived from sovereign CDS data on a number of major economic variables associated as standard risk factors. S&P is the return on S&P500 index, S&P Fin. is the return on financials in the S&P 500 index, VIX is self-explanatory, iTraxx is the spread on the iTraxx portfolio of European corporates, CDX IG is the spread on the CDX portfolio of American corporates, CDX EM is the spread on the EM portfolio of corporates, WiborPL3M is the 3-month Wibor rate (i.e. ‘Polish Libor’) and finally US repo is self-explanatory.

<table>
<thead>
<tr>
<th>PC1</th>
<th>S&amp;P</th>
<th>S&amp;P Fin.</th>
<th>VIX</th>
<th>iTraxx</th>
<th>CDX IG</th>
<th>CDX EM</th>
<th>WiborPL3M</th>
<th>US repo</th>
</tr>
</thead>
<tbody>
<tr>
<td>coef</td>
<td>15.04</td>
<td>3.52</td>
<td>1.16</td>
<td>-0.23</td>
<td>-5.70</td>
<td>-3.40</td>
<td>13.22</td>
<td>11.69</td>
</tr>
<tr>
<td>SE</td>
<td>88.88</td>
<td>40.89</td>
<td>0.14</td>
<td>0.03</td>
<td>0.71</td>
<td>0.15</td>
<td>1.13</td>
<td>0.73</td>
</tr>
<tr>
<td>pVal</td>
<td>0.87</td>
<td>0.93</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>R-Sq</td>
<td>0.00</td>
<td>0.00</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.21</td>
<td>0.07</td>
<td>0.12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PC2</th>
<th>S&amp;P</th>
<th>S&amp;P Fin.</th>
<th>VIX</th>
<th>iTraxx</th>
<th>CDX IG</th>
<th>CDX EM</th>
<th>WiborPL3M</th>
<th>US repo</th>
</tr>
</thead>
<tbody>
<tr>
<td>coef</td>
<td>-17.53</td>
<td>-53.58</td>
<td>5.07</td>
<td>0.24</td>
<td>-18.79</td>
<td>-1.45</td>
<td>18.65</td>
<td>-4.93</td>
</tr>
<tr>
<td>SE</td>
<td>184.77</td>
<td>84.99</td>
<td>0.28</td>
<td>0.06</td>
<td>1.45</td>
<td>0.35</td>
<td>2.39</td>
<td>1.60</td>
</tr>
<tr>
<td>pVal</td>
<td>0.92</td>
<td>0.53</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>R-Sq</td>
<td>0.00</td>
<td>0.00</td>
<td>0.15</td>
<td>0.01</td>
<td>0.08</td>
<td>0.01</td>
<td>0.03</td>
<td>0.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PC3</th>
<th>S&amp;P</th>
<th>S&amp;P Fin.</th>
<th>VIX</th>
<th>iTraxx</th>
<th>CDX IG</th>
<th>CDX EM</th>
<th>WiborPL3M</th>
<th>US repo</th>
</tr>
</thead>
<tbody>
<tr>
<td>coef</td>
<td>262.15</td>
<td>73.65</td>
<td>-2.12</td>
<td>4.65</td>
<td>12.34</td>
<td>23.59</td>
<td>-14.33</td>
<td>-97.25</td>
</tr>
<tr>
<td>SE</td>
<td>553.51</td>
<td>254.64</td>
<td>0.90</td>
<td>0.15</td>
<td>4.52</td>
<td>0.90</td>
<td>7.27</td>
<td>4.28</td>
</tr>
<tr>
<td>pVal</td>
<td>0.64</td>
<td>0.77</td>
<td>0.02</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>R-Sq</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.33</td>
<td>0.00</td>
<td>0.26</td>
<td>0.00</td>
<td>0.21</td>
</tr>
</tbody>
</table>
5. Conclusions

We have demonstrated substantial commonality in sovereign CDS premia and equity returns across European countries. We have shown that key pivotal dates marking new phases of crisis and recovery periods are the same across all European countries. We have also found evidence of contagion from Polish sovereign CDS return to bank returns during the crisis period. Finally, we have conducted principal component analysis and found that variation in Polish sovereign CDS can be mostly attributed to a component associated with the risk of the safest European countries and to a lower, but substantial degree to a component that is specific to Poland. We also find that the principal component relevant for crisis-afflicted countries (Ireland and southern Europe) explains only a very small percentage of variation in Polish CDS. While the first three principal components explain almost 100% of variation in sovereign CDSs demonstrating large commonality across sovereign CDS returns, we find that it is not the case for bank returns.
5. Conclusions

We have demonstrated substantial commonality in sovereign CDS premia and equity returns across European countries. We have shown that key pivotal dates marking new phases of crisis and recovery periods are the same across all European countries. We have also found evidence of contagion from Polish sovereign CDS returns during the crisis period. Finally, we have conducted principal component analysis and found that variation in Polish sovereign CDS can be mostly attributed to a component associated with the risk of the safest European countries and to a lower, but substantial degree to a component that is specific to Poland. We also find that the principal component relevant for crisis-affected countries (Ireland and southern Europe) explains only a very small percentage of variation in Polish CDS. While the first three principal components explain almost 100% of variation in sovereign CDSs demonstrating large commonality across sovereign CDS returns, we find that it is not the case for bank returns.

References


Figures

Set A of Figures: Figures analogous to Figure 1 for other European countries.

NETHERLANDS

- General stock index
- Bank stock index (rescaled)
- Sovereign CDS
Figures
Figures
Figures
Figures

PORTUGAL

- General stock index
- Bank stock index (rescaled)
- Sovereign CDS

Sovereign CDS premia in bps

Index value

Jun05 Nov06 Apr08 Aug09 Dec10 May12 Sep13 Feb15

0 400 800 1200 1600 2000

0 2100 4200 6300

200 400 600 800 1000 1200 1400 1600 1800 2000

Sovereign CDS premia in bps

General stock index
Bank stock index (rescaled)
Sovereign CDS

Jun05 Nov06 Apr08 Aug09 Dec10 May12 Sep13 Feb15
Analyzing causality between bank stock returns and sovereign CDS returns at weekly horizon.

**NETHERLANDS: Causality from BANKS to CDS**

<table>
<thead>
<tr>
<th>Period</th>
<th>Critical Values at 5%</th>
<th>Critical Values at 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Causality from CDS to BANKS**

**Set B of Figures:** Figures analogous to Figure 4 for other European countries.
Set B of Figures: Figures analogous to Figure 4 for other European countries. Analyzing causality between bank stock returns and sovereign CDS returns at weekly horizon.
FRANCE: Causality from BANKS to CDS

Critical Values at 5%
Critical Values at 10%

BELGIUM: Causality from BANKS to CDS

Causality from CDS to BANKS
FRANCE: Causality from BANKS to CDS

BELGIUM: Causality from BANKS to CDS

Causality from CDS to BANKS
DENMARK: Causality from BANKS to CDS

Period 1
Period 2
Period 3
Period 4
Period 5

Critical Values at 5%
Critical Values at 10%

Causality from CDS to BANKS

FINLAND: Causality from BANKS to CDS

Period 1: no data
Period 2: no data
Period 3: no data
Period 4
Period 5

Critical Values at 5%
Critical Values at 10%
Figures

FINLAND: Causality from BANKS to CDS

Causality from CDS to BANKS

Graphs showing Granger test statistics for different periods and lags, with critical values at 5% and 10%.
SWEDEN: Causality from BANKS to CDS

Causality from CDS to BANKS
Figures

AUSTRIA: Causality from BANKS to CDS

Causality from CDS to BANKS
UNITED KINGDOM: Causality from BANKS to CDS

Causality from CDS to BANKS
UNITED KINGDOM: Causality from BANKS to CDS

Period 1: no data
Period 2
Period 3
Period 4
Period 5
Critical Values at 5%
Critical Values at 10%

IRELAND: Causality from BANKS to CDS

Period 1
Period 2
Period 3
Period 4
Period 5
Causality from CDS to BANKS

Number of Lags in Granger Test
Granger Test Statistics
ITALY: Causality from BANKS to CDS

<table>
<thead>
<tr>
<th>Period</th>
<th>Granger Test Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>no data</td>
</tr>
<tr>
<td>2</td>
<td>no data</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Critical Values at 5%
Critical Values at 10%

Causality from CDS to BANKS

SPAIN: Causality from BANKS to CDS

<table>
<thead>
<tr>
<th>Period</th>
<th>Granger Test Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>no data</td>
</tr>
<tr>
<td>2</td>
<td>no data</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Critical Values at 5%
Critical Values at 10%
ITALY: Causality from BANKS to CDS

Period 1: no data
Period 2: no data
Period 3
Period 4
Period 5

Critical Values at 5%
Critical Values at 10%

SPAIN: Causality from BANKS to CDS

Period 1
Period 2
Period 3
Period 4
Period 5

Critical Values at 5%
Critical Values at 10%

Causality from CDS to BANKS

Granger Test Statistics
Number of Lags in Granger Test

Granger Test Statistics
Number of Lags in Granger Test

Figures
PORTUGAL: Causality from BANKS to CDS

Causality from CDS to BANKS

Graphs showing the Granger test statistics for periods 1 to 5 with critical values at 5% and 10% for PORTUGAL and GREECE.
Figures

GREECE: Causality from BANKS to CDS

Causality from CDS to BANKS