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**Empirical assessment**

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# Risk Premiums in Slovak Government Bonds

## Empirical assessment<sup>1</sup>

L'udovít Ódor, Pavol Povala<sup>2</sup>

### Abstract

We study risk premiums in Slovak government bonds. We focus on the country-specific part of yields which we associate with the spread to overnight-indexed swaps. In the period 2009-2015, we decompose the term structure of spreads to credit risk premium, liquidity premium, safety/convenience demand, and segmentation effects. While the level of the term structure of spreads is mostly related to sovereign credit risk, non-default components are related to the second principal component of spreads. We also identify a sizeable effect of public sector purchase programme conducted by the European Central Bank with a magnitude in excess of 60 basis points for the ten-year bond. To study determinants of spreads in a longer sample 2000-2015, we construct credit spreads from international euro-denominated bonds. We find that debt-to-GDP ratio together with global financial variables explain a substantial fraction of spread variation.

**Keywords:** Risk premiums, yield curve models, sovereign credit risk, liquidity

**JEL Classification:** F3, G1, G17

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## 1 Introduction

We study risk premiums on Slovak government bonds in the period between 2000 and 2015, which is the longest available sample. Slovak government bond market is an interesting case among sovereign issuers for a number of reasons.

First, while it was classified as an emerging market in the 1990s, Slovakia became a poster child for structural reforms at the beginning of the twenty-first century and managed to join the club of advanced countries by adopting the euro in January 2009, during the Great Recession. Analysis of sovereign risk premiums can help to understand the most important factors at play not only during the convergence process but also in periods of market stress triggered by the Eurozone debt crisis. Relative importance of global versus local determinants of sovereign spreads might provide new insights for future entrants to the euro area. Yields and risk premiums on local government debt play a key role in the euro adoption process. One of the Maastricht criteria for euro adoption is a numerical limit to sovereign spreads on ten-year government bonds compared to the three best performing countries in the euro area.

Second, unlike most of the emerging market debt issuers, the Slovak Republic has never defaulted on its debt obligations which is partly due to the fact that it started from a relatively low public and private debt levels in 1993, its first year as an independent sovereign issuer.

Third, Slovak debt market is an ideal case to study non-default components of sovereign risk premiums. Due to the relatively small size of the Slovak government bond market, liquidity premiums or unconventional monetary policy by the ECB could explain a significant fraction of sovereign spreads, providing useful lessons for debt management.

The rest of the paper is structured as follows. Section II briefly reviews the related literature. Section III describes the data we use, while Section IV—the core of our paper—identifies the main drivers of sovereign risk premiums in Slovakia. We take two perspectives on modelling risk premiums in Slovak government bonds. First, in order to use the longest available sample, we use the ten-year coupon bond spread of international euro-denominated Slovak government bonds (*vis-a-vis* its German counterpart). Second, a more detailed decomposition of risk premiums is feasible in the sample 2009–2015, where we use spreads to overnight-indexed swaps as a proxy for the risk-free rate. Finally, Section V concludes.

## 2 Related literature

Our work is related to a number of areas in the literature. First, a large literature studies emerging market sovereign yield spreads and their determinants. Hilscher and Nosbusch (2010) study the determinants of spreads on external emerging market debt. They evaluate the relative importance of country-specific and global factors, finding a substantial role for macroeconomic fundamentals in addition to global factors such as the VIX index or the TED spread. Du and Schreger (2015) construct local currency credit spreads with the help of cross-currency swaps. These local currency credit spreads are free of currency risk and, as a result, lower than foreign currency spreads. Importantly, they show that foreign currency spreads are more correlated across countries and with global risk factors than the local currency spreads. Longstaff et al. (2011) study sovereign CDS data and show that most of the variation in sovereign credit risk can be linked to global factors. Sovereign credit spreads are more related to the U.S. stock and high yield markets than to local economic fundamentals. Relatedly, Amstad et al. (2016) document that the extent to which credit spreads are driven by global factors depends on the classification of the respective bond market as “emerging market”. This observation is consistent with the index-tracking behavior of investors being a powerful driver of returns in emerg-



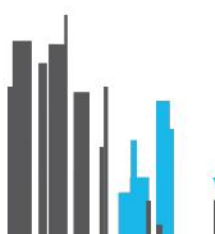
ing market bonds. One of the early contributions to modelling the term structure of emerging market sovereign credit spreads is Duffie et al. (2003) who model the Russian sovereign debt. Parts of our work are methodologically similar to the emerging market bond literature in that we explain spreads variation within a simple linear model considering a combination of local macro variables and global financial variables.

Second, a number of papers discusses the evolution of sovereign yields during and after the euro adoption. Ehrmann et al. (2011) study the convergence of the four largest bond markets within the Eurozone: France, Germany, Italy, and Spain. In the period 1993 through 2008, they find a strong evidence of convergence in the sovereign bond markets. Also, they document the convergence in long-term inflation expectations, as measured by far-ahead forward rates. Interestingly, the convergence in sovereign bond markets is not achieved by the common currency itself but rather by the anticipation of the adoption of a unified monetary policy and elimination of the exchange rate risk, with the case in point being the Danish sovereign bond market. Despite the convergence in the Eurozone sovereign yields, Canova et al. (2007) find little evidence of convergence in real economies. D'Agostino and Ehrmann (2013) study the spreads of G7 sovereign bonds and find a time-varying importance and substantial asymmetry in the importance of local country fundamentals. Interestingly, Codogno et al. (2003), Geyer et al. (2004) document that yield differentials within the Eurozone are mainly driven by the common default risk factor related to the corporate credit spread, while the liquidity differentials play a marginal role.

Third, a stream of literature that has grown rapidly due to the Eurozone crisis looks into decomposing sovereign spreads into credit, liquidity, convenience, and potentially other risk premiums. Pericoli and Taboga (2015) study Italian and Spanish sovereign credit spreads in the period 2007-2012 and find that most of the variation in spreads of these countries is due to the fluctuating credit premium. Monfort and Renne (2014) estimate a no-arbitrage term structure model jointly using government-guaranteed agency bonds, government bonds, and overnight-indexed swaps. More recently, Ejsing et al. (2015) quantify the credit and liquidity risks in German and French government bonds.

Finally, a set of papers documents the behavior of government bond yields around unconventional monetary policy measures implemented by the ECB and aims at understanding the effects of these measures on government bonds. Krishnamurthy et al. (2015) use a broad range of asset prices to quantify the ECB government bond purchases. They find that the default risk premium and segmentation effects were the main channels through which the ECB lowered sovereign yields. Eser and Schwaab (2016) assess the ECB's Securities Markets Programme (SMP) in 2010-11. Based on the panel regression approach, they find significant announcement effects in addition to non-negligible flow effects. In terms of channels, default, liquidity, and segmentation premiums were reduced through the SMP. Rodriguez-Moreno and Corradin (2015) study the basis between EUR-denominated and USD-denominated government bonds issued by the Eurozone governments. They find that USD-denominated bonds are persistently cheaper and that the basis is strongly influenced by the non-conventional monetary policy of the ECB.

Overall, focus of the literature to date has been relatively narrow both in the geographical sense (largest Eurozone countries) and in terms of sample period studied (Eurozone crisis). We provide unique insights to the literature on sovereign debt by documenting key facts about how the transition of a small open economy from an emerging market category to a member of the Eurozone influences its government bond yields.



### 3 Data

We obtain macroeconomic and financial data from various sources as described below.

#### *Macroeconomic data*

We compute the debt-to-GDP ratio at a quarterly frequency sourcing the data on public debt from the Ministry of Finance. Given that the debt data are available at quarterly frequency starting from 2007, we use annual data in the period 2000-2007. We compare debt levels to the rolling last twelve months nominal GDP obtained from the Slovak Statistical Office (SSO). In the period 2000-2007, we interpolate annual public debt data to a quarterly frequency. We obtain the terms-of-trade index from the SSO at monthly frequency and use the end-of-quarter months in the model. Monthly data on cash tax income are from the Ministry of Finance and are aggregated to a quarterly frequency. Exchange rate of Slovak koruna against the euro is from Bloomberg and the data on foreign exchange reserves was provided by the National Bank of Slovakia. Data on policy uncertainty are constructed by Baker et al. (2015) and are available on their website.<sup>1</sup> These data are available at a monthly frequency and aim to measure policy-related uncertainty.

#### *International bonds*

We use international government bonds issued by the Slovak Republic in euro currency to measure the credit spread to German government bond yields. Specifically, we consider mostly ten-year bonds listed in Table 3.1 to construct the credit spread back to 2000 when the first euro bond was issued. These bonds are selected such that we cover the whole period 2000-2015 with international euro bonds with maturity being as close as possible to the ten-year maturity. To construct the spread, we match Slovak bonds with the German coupon bonds of the same maturity.

**Table 3.1: International euro bonds issued by the Slovak government**

The table lists selected euro-denominated international bonds issued by the Slovak government. These bonds are combined to create a coupon bond credit spread versus German government bonds. The period for which we consider each of the bonds is determined by the issue date of the subsequent bond, i.e. we always consider the most recently issued bond.

| Selected international euro bonds |            |            |        |                          |          |
|-----------------------------------|------------|------------|--------|--------------------------|----------|
| ISIN                              | Issue date | Maturity   | Coupon | Amount issued (mil. EUR) | Currency |
| DE0001074763                      | 14/04/2000 | 14/04/2010 | 7.375  | 500                      | EUR      |
| XS0192595873                      | 20/05/2004 | 20/05/2014 | 4.500  | 1000                     | EUR      |
| XS0299989813                      | 15/05/2007 | 15/05/2017 | 4.375  | 1000                     | EUR      |
| XS0430015742                      | 21/05/2009 | 21/01/2015 | 4.375  | 2000                     | EUR      |
| XS0249239830                      | 27/03/2006 | 26/03/2021 | 4.000  | 1000                     | EUR      |

International bonds issued by Slovak Republic have similar credit profile as the domestic government bonds. This is consistent with findings in Reinhart and Rogoff (2011) who document that in case of sovereign defaults neither foreign nor domestic bond holders have done consistently better.

<sup>1</sup><http://www.policyuncertainty.com/>





### *Zero-coupon government bond yields*

We obtain the zero-coupon yields for Slovak government bonds from the Ministry of Finance.<sup>2</sup> The zero-coupon curve is estimated from fixed-coupon bonds by applying a parsimonious parametric method proposed in Svensson (1994). German zero-coupon yields are obtained from Deutsche Bundesbank's website.<sup>3</sup> Zero-coupon yields are consistently available from one-year up to ten-year maturity. Given the well-known liquidity issues at the short-end and the long-end of government yield curves in many markets, we perform our analysis on this segment of the curve. German zero-coupon yield curve is obtained by applying the same methodology as the Slovak curve. Zero-coupon yields on US Treasuries are from the dataset by Gürkaynak et al. (2006) and maintained by the Federal Reserve Board.

### *Overnight-Indexed Swaps*

Overnight-Indexed Swap (OIS) is an interest rate swap whose floating rate leg is tied to the overnight rate, i.e. EONIA in the Eurozone. Unlike the swaps linked to the Libor rate, OIS do not reflect the credit risk of the banking system. Similar to conventional swaps, there is no exchange of the principal at maturity. Additionally, fixed and floating cash flows are exchanged at matched maturities which also minimizes the counterparty credit risk. We obtain OIS data from Bloomberg at daily frequency and bootstrap a zero-coupon OIS curve from the OIS swap rates. The data are consistently available starting from July 2005, when the ten-year OIS swap rate becomes available. OIS curve represents a good proxy for the risk-free rate in the Eurozone. This is because the credit risk is minimal and given the "non-cash" nature of the OIS, they do not provide any convenience/safety or store-of-liquidity services to investors. Due to the demand for liquidity and safety, yields on government bonds in countries with low sovereign credit risk will be lower than the corresponding OIS swap rates. The difference between these two mainly reflects the safety and liquidity premium. Krishnamurthy and Vissing-Jorgensen (2012) offer a thorough discussion of safety/liquidity premiums and their identification.

### *Credit Default Swap (CDS) and other financial data*

Daily prices of sovereign credit default swaps for Slovakia and Germany are from Bloomberg. We focus on swaps quoted in US dollars with maturities five and ten years. The five-year CDS is usually the most liquid, followed by the ten-year CDS. The data are daily and cover the period January 2009 through December 2015. We work with these two points on the CDS curve and describe the credit curve by its level (five-year CDS spread) and the slope (ten-year minus five-year CDS spread). We obtain three-month Euribor rates, three-month German Treasury bill, VIX index, and MOVE (Merrill Lynch Option Volatility Estimate) index from Bloomberg. MOVE index is constructed from implied volatilities of options on US Treasury futures for underlying maturities of two, five, ten, and 30 years. It is a close counterpart to the VIX index for the fixed income market. Barclays EUR aggregate corporate option-adjusted spreads which are used to measure corporate credit spreads are also available on Bloomberg.

<sup>2</sup><http://www.finance.gov.sk/Default.aspx?CatID=10501>

<sup>3</sup>[https://www.bundesbank.de/Navigation/EN/Statistics/Time\\_series\\_databases/Macro\\_economic\\_time\\_series/its\\_list\\_node.html?listId=www\\_s140\\_it03b](https://www.bundesbank.de/Navigation/EN/Statistics/Time_series_databases/Macro_economic_time_series/its_list_node.html?listId=www_s140_it03b).



## 4 A decomposition of Slovak government bond yields

Yield on a zero-coupon government bond of a Eurozone country  $j$  with maturity  $n$ -years, denoted by  $y_{t,j}^{(n)}$ , can be written as:

$$y_{t,j}^{(n)} = \frac{1}{n} \sum_{i=1}^n E_t i_{t+i} + t p_t^{(n)} + def_{t,j}^{(n)} + liq_{t,j}^{(n)} + saf_{t,j}^{(n)} + seg_{t,j}^{(n)}, \quad (1)$$

where the first component represents the expected path of the short rate, proxied by the EO-NIA rate in the Eurozone, and  $t p_t^{(n)}$  represents the term premium corresponding to the  $n$ -period bond. The term premium is a compensation for the uncertainty surrounding the future path of the short rate. Note that the first two components in (1) are common to all government bonds in the Eurozone as they all share the single monetary policy determined by the ECB. Expected path of the short rate and the term premium can be jointly identified from the OIS zero-coupon curve. Expression  $def_{t,j}^{(n)}$  represents the sovereign credit risk premium for country  $j$  consisting of expected loss given default and the corresponding risk premium attached to the possibility of such an event.<sup>4</sup>  $liq_{t,j}^{(n)}$  denotes the liquidity premium which compensates investors for the exposure to the liquidity risk. The liquidity premium is a function of government bond market structure, size, and investor base in the respective country.  $saf_{t,j}^{(n)}$  represents the safety/convenience premium. Safety/convenience premium is driven by the price-inelastic demand for safe assets from corporations, banks, and other investors. Finally,  $seg_{t,j}^{(n)}$  represents market segmentation effects arising from the differential regulatory treatment, heterogeneity in investor base, short-selling constraints, issuer profile, and other related effects. The last four components in (1) are specific to each Eurozone government bond market, given by the differences in the credit risk profile, substantial variation in liquidity across national government bond markets and also heterogenous regulatory and safety demand driving the cross-country variation in safety premium  $saf_{t,j}^{(n)}$ .

To make the decomposition given by (1) operational, we use the OIS curve to jointly identify the expected short rate and the term premium. Future path of short rate  $i_t$  and the term premium are largely external to Slovakia given the small size of Slovak economy relative to rest of the Eurozone. Consequently, it is intuitive to split the analysis of Slovak government bond yields into understanding the Eurozone monetary policy and, more importantly, the spread to OIS curve which largely reflects the country-specific risk premiums. In subsequent sections, we focus on identifying the variation in  $def_{t,j}^{(n)}$ ,  $liq_{t,j}^{(n)}$ ,  $saf_{t,j}^{(n)}$ , and  $seg_{t,j}^{(n)}$  from the spread between yields on Slovak government bonds and the OIS curve. For illustration, Figure 4.1 shows yields on Slovak government bonds together with the OIS yields. While for most of the sample period the variation in spreads to the OIS curve played an important role, its contribution has decreased substantially toward the end of the sample.

### 4.1 Decomposing the OIS curve

A substantial fraction of the variation in yields on Slovak government bonds is driven by the term structure of risk-free rates that is common to all Eurozone bonds. We proxy the term structure of risk-free rates with the OIS zero-coupon curve. To better understand the drivers, we decompose the OIS curve to risk-neutral short rate expectations and the term premium.

<sup>4</sup>At this point, we do not distinguish between the risk-neutral expected loss given default and the corresponding risk premium attached to that loss.





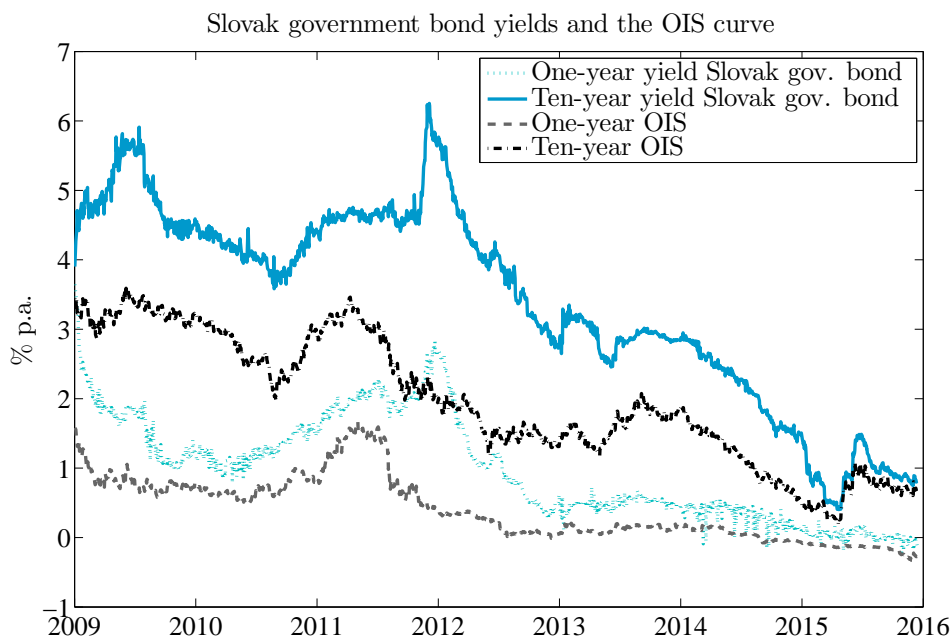


Figure 4.1: Yields on Slovak government bonds and the OIS curve, 2009-2015

The figure shows one- and ten-year yield on Slovak government bonds together with the OIS yields of corresponding maturities. Data are daily. The sample period is January 1, 2009 through December 14, 2015.

To this end, we apply the methodology developed in Adrian et al. (2015). It is effectively a three-step linear regression approach that can handle a large number of factors. We consider three pricing factors which we associate with the first three principal components.<sup>5</sup> The data are monthly and start in July 2005 when the ten-year OIS swap becomes available.

Figure 4.2 shows the decomposition of the one-year (Panel *a*) and the ten-year (Panel *b*) OIS zero-coupon swap yield. As one would expect, the short-term yield is dominated by the variation in short rate expectations while the ten-year yield is mostly driven by the term premium. The term premium has been on a declining trend since the financial crisis and has recently reached lows around -50 basis points around the launch of the QE by the ECB in January 2015.

## 4.2 Risk premiums in the Slovak government bonds

We take two perspectives on modelling risk premiums in Slovak government bonds. This choice is motivated by (i) the data availability, (ii) a structural break caused by the adoption of the euro in January 2009, and (iii) to study linkages between credit spreads and macro variables one needs sufficient cyclical variation which is not the case for the 2009-2015 sample. First, in order to study credit spreads and their determinants in the longest possible period, we construct a coupon-bond credit spread from international euro-denominated bonds starting from April 2000. In this period, however, we are not able to study the term structure of credit spreads and separate credit and liquidity premiums. This is because zero-coupon yields on Slovak government bonds are available from January 2003 and the OIS curve became consistently available in 2005. Second, in the period that starts with the adoption of euro, we perform the full decomposition of Slovak government bond yields as indicated in (1) with the help of

<sup>5</sup>We experimented with four and five principal components and concluded that adding these does not change the results significantly. For parsimony, we work with three principal components.



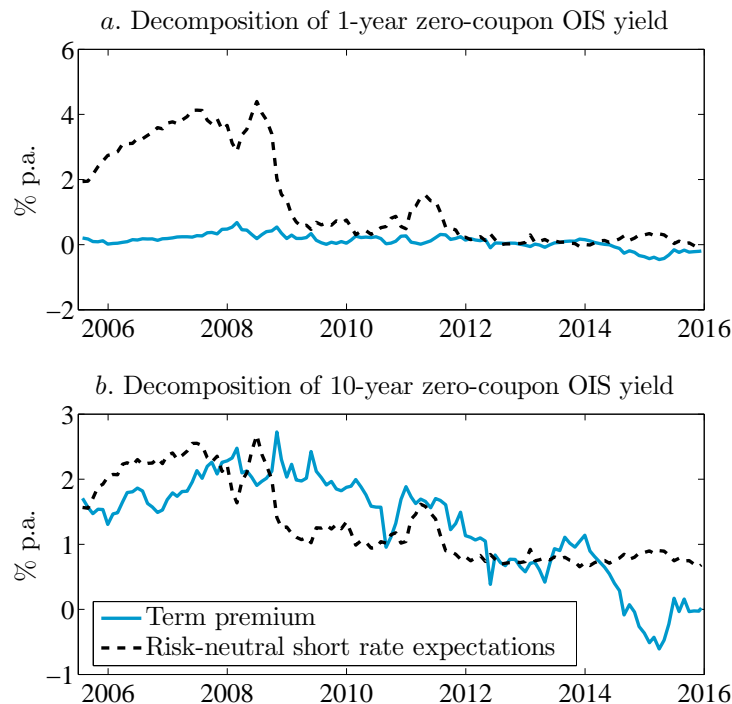


Figure 4.2 : Decomposition the OIS curve, 2005-2015

The figure shows the decomposition of one-year (Panel *a*) and ten-year (Panel *b*) OIS zero-coupon swap yield to risk neutral short rate expectations and the term premium. The decomposition is performed with the methodology proposed in Adrian et al. (2015). The sample period is July 2005 through December 2015, the data are monthly. The sample period is determined by the availability of OIS data.

zero-coupon curve for domestic Slovak government bonds, the OIS curve, and the zero-coupon curve for German government bonds.

#### 4.2.1 Credit spread in 2000-2015

Measurement of credit risk premium from domestic Slovak government bonds in the period 2000–2008 is complicated by the adoption of Euro on January 1, 2009. Prior to this date, the spread versus German government bonds is distorted by fluctuations in the exchange rate of the Slovak koruna against the euro. This can be seen in Figure 4.3, which superimposes the coupon bond spread obtained from international euro-denominated bonds issued by the Slovak Republic with the zero-coupon spread calculated from domestic government bonds.

The evolution of credit spread shown in Figure 4.3 can be split into several periods. The initial part of the 2000-2015 sample period is shaped by the convergence process leading to the membership in the European Union. The euro adoption in January 2009 coincided with the global financial crisis 2008-2009. Subsequently, the key determinant of yields and risk premiums in the second part of the sample has been the European debt crisis which culminated in 2011-2012. Intuitively, credit spreads obtained from international and domestic government bonds roughly coincide in the period after the euro adoption. The only significant discrepancy is at the outset of the financial crisis at the end of 2008. Then, the credit spreads in international bonds reacted faster and the reaction was more extreme. This is likely due to different investor types holding domestic and international government bonds.



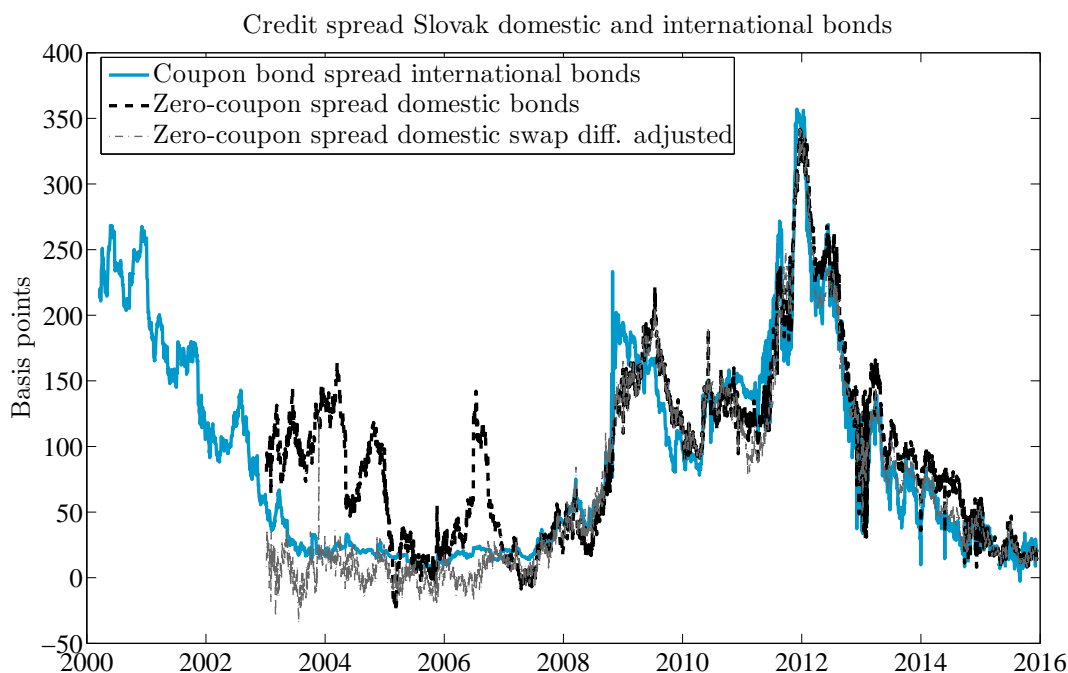


Figure 4.3: Credit spreads of Slovak government bonds, domestic and international

The figure superimposes the coupon bond credit spread of international euro-denominated Slovak government bonds (blue bold line) with the zero-coupon spread of domestic government bonds (black dashed line). We use yield to maturity on the most recently issued ten-year government bond to construct the credit spread of international bonds. These are then matched with the yield on a German coupon bond of the corresponding maturity. The sample period for international bonds starts in April 2000 when the first ten-year international bond was issued. The sample period for zero-coupon yields is January 2003 and is determined by the availability of the zero-coupon yield data. The maturity of zero-coupon spreads is matched to the maturity of coupon bond spread of international bonds. For comparison, the figure shows the five-year zero-coupon spread adjusted with the five-year swap differential between Slovak koruna and euro (grey dash-dotted line). This adjustment corrects for exchange rate fluctuations of local currency spreads.

An alternative to looking at spreads of international bonds would be to adjust local currency spreads with the differential in Slovak koruna and euro swap rates as suggested in Favero et al. (1997), Gomez-Puig (2006). This adjustment is designed to correct the spread for exchange rate movements. We obtain the swap differential for the five-year maturity from Bloomberg and adjust the local currency spread to remove exchange rate effects. Figure 4.3 shows the adjusted local spread. While the swap differential brings the local spread closer to the spread on international bonds, it seems to overcompensate the exchange rate risk making the adjusted spread occasionally negative in the period 2003-2007. In addition to the potential overcompensation, there are two data-related reasons for which we choose to proceed with the spread obtained from international bonds. First, swap differentials for other maturities are not available, thus studying the term structure of spreads, which would have been the advantage of using adjusted local currency spreads, is not possible in the sample 2003-2015. Second, international spreads reach back to 2000, which adds three years worth of data to the sample 2003-2015.

We explain the credit spread on Slovak government bonds with a set of domestic and global variables. For domestic variables we include the debt-to-GDP ratio and terms of trade index, both of which have been shown to explain a significant fraction of credit spreads in emerging market sovereign bonds, see e.g. Hilscher and Nosbusch (2010). We also include cash tax in-



come as an explanatory variable. Global variables are represented by the TED spread which is a difference between three-month Euribor and the corresponding German Treasury bill yield, capturing the degree of stress in the banking system, VIX index as a proxy for global risk aversion, long-term German government yield, yield curve slope for the US and Germany, and indices of policy uncertainty for the US and the EU. Finally, we include the Slovak koruna/euro exchange rate multiplied by a dummy variable that takes a value of one in the pre-2009 period and zero afterwards. The regression results are reported in Table 4.1.

**Table 4.1: Explaining credit spread on Slovak international bonds**

The table reports the results for a regression of credit spread on Slovak international government bond on domestic variables: (1) Debt-to-GDP ratio, (2) Terms-of-Trade index, (3) Cash tax income, and a set of global variables (4) TED spread for EUR, i.e. the difference between three-month Euribor and three-month German Tbill yield, (5) implied volatility measured by the VIX index, (6) ten-year German government bond yield, (7) slope of the US Treasury curve, (8) slope of the German government curve, (9) policy uncertainty index for the US, (10) policy uncertainty index for the EU, and (11) EUR/SKK exchange rate before December 2008 and zero afterwards. Robust t-statistics are reported in parentheses. The data are quarterly with the sample period Q1:2000 through Q2:2015.

| Determinants of credit spreads, 2000-2015 |                |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |
|---|----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|   | (1)            | (2)              | (3)              | (4)              | (5)              | (6)              | (7)              | (8)              | (9)              | (10)             | (11)             |
| Debt-to-GDP ratio                         | 2.12<br>(1.38) | 2.00<br>(1.28)   | 1.89<br>(1.27)   | 4.37<br>(3.31)   | 4.24<br>(3.28)   | 5.31<br>(3.64)   | 5.39<br>(4.07)   | 5.81<br>(4.91)   | 5.29<br>(4.05)   | 5.53<br>(4.43)   | 5.15<br>(4.62)   |
| Terms-of-Trade index                      |                | -0.01<br>(-0.95) | -0.01<br>(-0.85) | -0.00<br>(-0.36) | -0.01<br>(-0.51) | -0.01<br>(-0.57) | -0.01<br>(-0.65) | -0.01<br>(-1.22) | -0.01<br>(-0.81) | -0.00<br>(-0.52) | -0.00<br>(-0.65) |
| Cash tax income                           |                |                  | -0.58<br>(-0.72) | -1.42<br>(-2.00) | -1.08<br>(-1.45) | -0.42<br>(-0.67) | -0.42<br>(-0.66) | -0.00<br>(-0.00) | 0.12<br>(0.27)   | -0.00<br>(-0.01) | -0.60<br>(-1.41) |
| TED spread EUR                            |                |                  |                  | 1.29<br>(3.26)   | 0.98<br>(1.80)   | 1.09<br>(1.81)   | 1.05<br>(1.76)   | 1.12<br>(2.47)   | 0.85<br>(1.80)   | 0.83<br>(1.73)   | 0.74<br>(1.70)   |
| VIX                                       |                |                  |                  |                  | 0.02<br>(1.60)   | 0.02<br>(1.30)   | 0.03<br>(1.59)   | 0.02<br>(1.85)   | 0.01<br>(0.93)   | 0.01<br>(1.15)   | 0.02<br>(1.33)   |
| $y_{t,GER}^{(10)}$                        |                |                  |                  |                  |                  | 0.14<br>(1.42)   | 0.11<br>(1.32)   | 0.15<br>(2.31)   | 0.20<br>(2.89)   | 0.14<br>(2.10)   | 0.35<br>(3.44)   |
| Slope US                                  |                |                  |                  |                  |                  |                  | -0.11<br>(-1.44) | -0.44<br>(-4.28) | -0.39<br>(-3.55) | -0.37<br>(-3.52) | -0.34<br>(-4.02) |
| Slope Ger                                 |                |                  |                  |                  |                  |                  |                  | 0.63<br>(4.73)   | 0.45<br>(2.60)   | 0.40<br>(2.40)   | 0.24<br>(1.50)   |
| Pol. uncert. US                           |                |                  |                  |                  |                  |                  |                  |                  | 0.01<br>(2.31)   | 0.01<br>(3.09)   | 0.01<br>(2.25)   |
| Pol. uncert. EU                           |                |                  |                  |                  |                  |                  |                  |                  |                  | -0.00<br>(-1.70) | -0.00<br>(-1.03) |
| EUR/SKK × Dummy <sub>EUR</sub>            |                |                  |                  |                  |                  |                  |                  |                  |                  |                  | -0.02<br>(-3.37) |
| $\bar{R}^2$                               | 0.05           | 0.04             | 0.04             | 0.36             | 0.40             | 0.42             | 0.44             | 0.57             | 0.60             | 0.61             | 0.66             |

A combination of local macroeconomic determinants and global financial variables explains around 66% of the variation in the credit spread. Based on a variance decomposition and counting the exchange rate as a local variable, domestic variables account for 40% of explained variation in credit spreads with the remaining part being attributed to global variables. The most significant determinants are debt-to-GDP ratio which loads with a positive sign, the TED spread, VIX, together with the slope of the German and the US yield curves. Both the TED spread and the VIX index have a positive sign which is consistent with the previous literature on emerging market debt. An increased stress in the banking system or in the equity markets translates into higher credit spreads for Slovak government bonds. Interestingly, the slope of



the US curve enters the regression with a similar magnitude but an opposite sign compared to the German slope. This suggests that what matters for Slovak credit spreads is the difference between the two slopes. Note that the difference in slopes largely captures the difference in near-term expectations about the path of monetary policy in the US and the Eurozone. Terms-of-trade index, despite being a significant determinant of sovereign credit spreads in typical emerging markets, does not seem to play any role for credit spreads of Slovak government bonds. Similarly, one of variables carrying a significant explanatory power for emerging market sovereign spreads is the level of foreign exchange reserves. We include foreign exchange reserves as an explanatory variable in a shorter sample starting in 2004, which is due to the data availability constraints. The level of foreign exchange reserves was not statistically significant and for the sake of brevity we do not report the results in the shorter sample. Instead, a collection of variables that are proxies for general uncertainty such as the VIX index, TED spread or policy uncertainty index play a prominent role in explaining the variation in the credit spread. Exchange rate in the period prior to joining the Eurozone is a significant determinant of the credit spread. It loads with a negative sign which is intuitive in the context of the convergence process. Weaker Slovak koruna makes local currency government bonds more attractive and investors are willing to accept lower credit spreads to buy Slovak government bonds.

Results reported above provide several key takeaways. First, they underscore the importance of global factors in determining spreads on Slovak government bonds. Second, the pronounced effect of non-Eurozone global variables such as the VIX index or the U.S. yield curve illustrates the global interconnectedness which needs to be taken into account when designing the strategy for managing government debt. Sensitivity to global variables has likely been to some extent driven by the fact that foreign investors hold a large fraction of Slovak government bonds. Finally, the results single out the debt-to-GDP ratio as an important domestic determinant of spreads.

### 4.2.2 Risk premiums in 2009-2015

In the period starting in January 2009, we are able to study the term structure of risk premiums. We construct credit spreads with respect to the German government curve and to the OIS curve which should be less distorted by safety, liquidity, and credit risk premiums than the German curve used in the previous section. Table 4.2 reports descriptive statistics for both versions of spreads. The table shows that both the level of spreads and their volatility increase with maturity. Spreads to the OIS curve are on average smaller than the spreads to German bund curve up to five-year maturity which indicates significant liquidity and safety premiums priced in German government bonds while the credit risk premium of German bunds at short maturities is most likely negligible.<sup>6</sup> Moving to long maturities, spreads to the OIS curve are on average higher than the spreads to German government yield curve which is consistent with the fact that long-term German government bonds reflect a non-negligible credit risk despite being the safest bonds in the Eurozone. The ten-year CDS on German sovereign fluctuated between 20 and 140 basis points in the period 2009-2015. The interplay between sovereign credit risk and safety/liquidity demand reflected in German bund yields is illustrated in Panel C of Table 4.2. Investors pay approximately ten basis points on average for safety and liquidity features of German government bonds. This effect is overwhelmed by the credit risk at the long end where the average bund-OIS spread is positive around 14 basis points. Other potential source of positive spread between the long-term German government bond and the OIS yield is the impact of post-crisis regulation, e.g. leverage ratio and supplementary leverage ratio

<sup>6</sup>Note that there are no reliable short-term CDS pricing data e.g. one-year CDS on German sovereign.





which make the provision of repo more expensive. For more details see Jermann (2016). These non-trivial magnitudes confirm the importance of the OIS curve for understanding various risks reflected in Slovak government bond yields.

**Table 4.2: Descriptive statistics for spreads to German government and OIS curves**

The table reports descriptive statistics for spreads of Slovak government zero-coupon yields relative to the OIS zero-coupon curve (Panel A) and relative to German government zero-coupon yields (Panel B). For comparison, we report descriptive statistics for spreads of German government bonds to the OIS curve in Panel C. Data are in basis points and are reported for maturities one to ten years. The sample period is January 1, 2009 through December 14, 2015, and the data are daily.

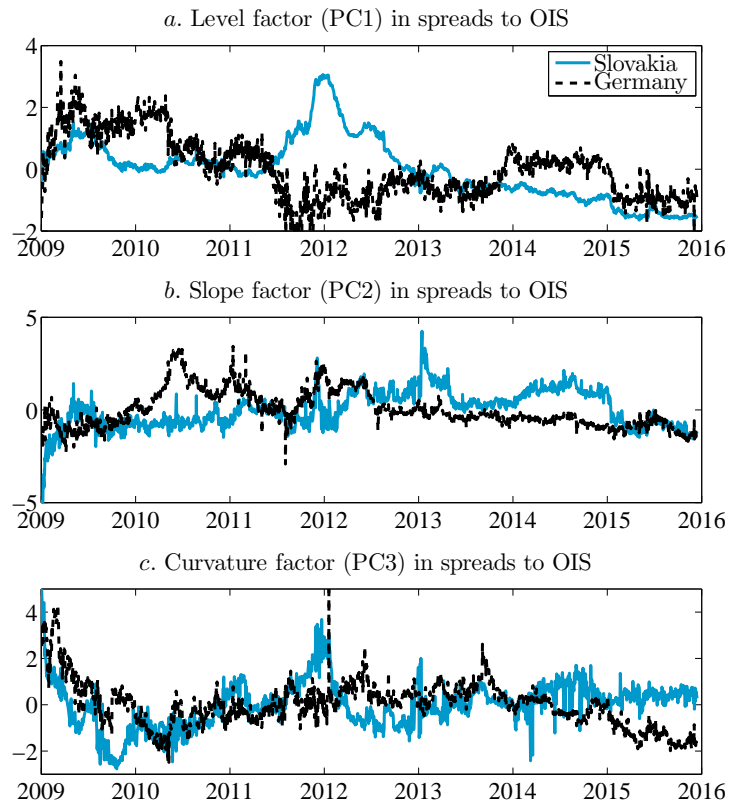
|   | 1Y     | 2Y     | 3Y     | 4Y     | 5Y     | 6Y     | 7Y     | 8Y     | 9Y     | 10Y    |
|---|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>Panel A. Slovak government bond spreads to the OIS curve</b> |        |        |        |        |        |        |        |        |        |        |
| Mean  | 58.35  | 78.31  | 92.44  | 103.24 | 112.27 | 120.11 | 127.26 | 133.83 | 139.66 | 144.50 |
| Median  | 43.84  | 78.72  | 94.83  | 106.94 | 115.31 | 121.09 | 127.45 | 132.18 | 136.94 | 140.17 |
| St. dev.  | 44.39  | 55.91  | 64.10  | 68.54  | 71.04  | 72.32  | 73.46  | 74.37  | 75.04  | 75.18  |
| Min.  | -24.45 | -15.97 | -3.58  | -7.88  | -10.58 | -10.69 | -9.33  | -6.11  | -3.46  | 0.38   |
| Max.  | 242.92 | 267.92 | 294.75 | 311.17 | 321.22 | 330.64 | 346.02 | 367.02 | 383.24 | 394.77 |
| <b>Panel B. Spreads Slovak-German government curve</b>          |        |        |        |        |        |        |        |        |        |        |
| Mean  | 67.58  | 86.63  | 99.79  | 109.12 | 115.91 | 120.88 | 124.51 | 127.12 | 128.95 | 130.22 |
| Median  | 51.27  | 82.87  | 100.12 | 106.95 | 109.96 | 111.70 | 113.14 | 112.25 | 112.77 | 113.30 |
| St. dev.  | 48.67  | 58.01  | 65.46  | 69.80  | 72.15  | 73.36  | 73.86  | 73.90  | 73.61  | 73.10  |
| Min.  | -22.79 | -3.90  | 1.71   | 7.05   | 7.50   | 8.25   | 7.67   | 7.43   | 7.91   | 9.00   |
| Max.  | 280.65 | 295.07 | 315.84 | 330.99 | 341.80 | 352.09 | 363.49 | 373.77 | 384.70 | 389.14 |
| <b>Panel C. German bund spreads to the OIS curve</b>            |        |        |        |        |        |        |        |        |        |        |
| Mean  | -9.23  | -8.31  | -7.35  | -5.88  | -3.63  | -0.77  | 2.75   | 6.71   | 10.71  | 14.28  |
| Median  | -9.19  | -9.99  | -8.93  | -7.21  | -4.84  | -1.77  | 1.51   | 5.46   | 9.27   | 13.01  |
| St. dev.  | 10.85  | 10.48  | 9.73   | 11.00  | 12.79  | 14.21  | 15.15  | 15.92  | 16.49  | 16.88  |
| Min.  | -39.96 | -34.79 | -30.45 | -43.80 | -39.95 | -59.35 | -40.28 | -36.68 | -32.32 | -29.33 |
| Max.  | 28.25  | 33.87  | 31.49  | 32.07  | 35.02  | 40.00  | 49.54  | 59.46  | 65.72  | 71.60  |

Differences between Slovak and German spreads are illustrated in Figure 4.4 which compares the first three principal components of spreads to the OIS curve for Slovakia and Germany. None of the three principal components in Slovakia is closely positively related to the German counterpart. The highest correlation with a magnitude of 0.5 is observed between the PC1 of the Slovak spreads and PC2 of the German curve. These observations are consistent with the fact that most of the spreads to OIS in Germany is driven by other effects than sovereign credit risk which is the main driver of the level of spreads in Slovak government bonds. The positive correlation between the level of the Slovak curve and the slope of the German curve indicates the presence of some credit risk in the long-term German bonds which will be discussed further below.

Next, we describe the term structure of spreads through principal components, which we then relate to macroeconomic and financial variables. First three principal components of spreads have the usual loadings across maturities. The first principal component represents the level, the second component captures the slope, and finally the third component has curvature-like loadings. First three principal components cumulatively explain more than 99% of the spread variation. The first principal component captures 95.22% (94.38%), the second principal component explains 3.74% (4%), and the third component contributes 0.90% (1.13%) of the variation







**Figure 4.4: Principal components of spreads to OIS, Slovakia and Germany, 2009-2015**

Panel *a* shows the first principal component (level) of spreads to the OIS curve for Slovakia and Germany, respectively. Panel *b* shows the second principal component (slope) and Panel *c* shows the third principal component (curvature). The sample period is January 1, 2009 through December 14, 2015, the data are daily and all data are standardized for easier comparison.

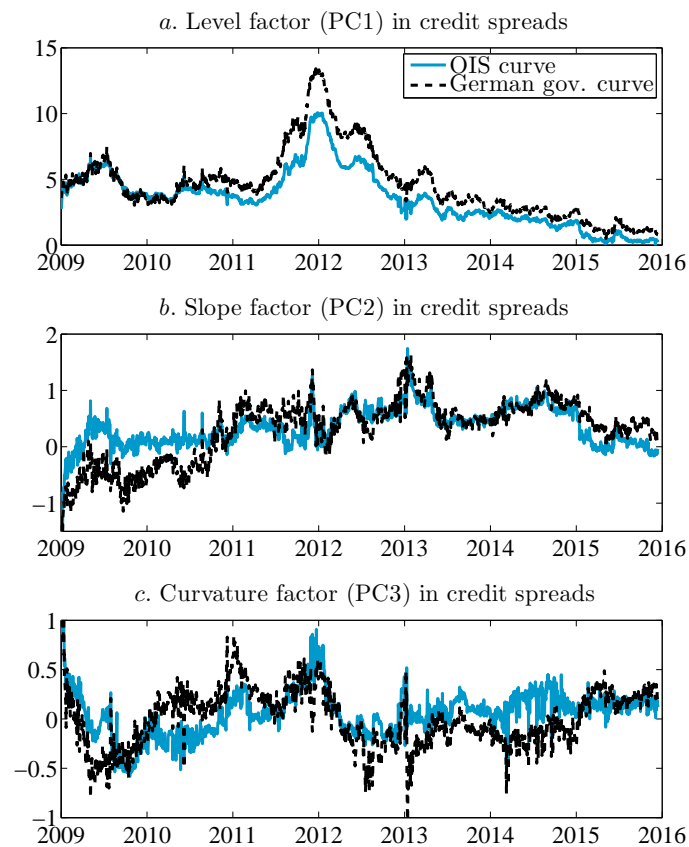
in spreads to OIS (German government) curve. Figure 4.5 shows the first three principal components of spreads. Each panel displays spreads to the OIS and the German government curve, respectively.

The level of spreads on Slovak government bonds, which we associate with the first principal component, has two key sources of variation. First, it is trending down throughout the sample period. Second, there are two episodes of elevated spreads, in 2009 and 2011-2012, both attributed to various stages of the Eurozone crisis.

#### 4.2.3 Liquidity and safety premiums in Slovak government bonds, 2009-2015

We first show that the term structure of spreads either to the OIS or German government yield curve is driven by factors that go beyond those reflecting the default risk premium as measured by the sovereign CDS. Comparing Panels A and B of Table 4.3 shows that CDS spreads explain a significant fraction of variation in the first principal component of spreads but very little of variation in higher order principal components. Adding various proxies for liquidity, risk aversion, monetary policy conditions substantially increases explained variation for the slope and the curvature of credit spreads. Notably, while the dummy indicating the ECB's quantitative easing period is highly significant for both the level and the slope of the credit





**Figure 4.5 : Principal components of credit spreads of Slovak government bonds, 2009-2015**

Panel *a* shows the first principal component (level) of spreads to the OIS and German government curve, respectively. Panel *b* shows the second principal component (slope) and Panel *c* shows the third principal component (curvature). The sample period is January 1, 2009 through December 14, 2015, the data are daily.

curve, its impact on the slope is by several magnitudes higher. This suggests an uneven impact of the quantitative easing across the curve, with the long end being impacted the most. Given the differentiated impact of non-default variables on the credit curve reported in Table 4.3 above, it is intuitive to decompose the term structure of spreads into (i) credit risk premium; (ii) liquidity premium; (iii) safety and liquidity demand; (iv); segmentation effects; (v) effect of quantitative easing by the ECB, as outlined in equation (1). We estimate a linear regression of spreads on proxies for each of the risk premiums. The regression is estimated without an intercept as each of the proxies, discussed below, has an appropriate magnitude.

We use five- and ten-year CDS spreads to measure credit risk premium. We use noise illiquidity measure proposed in Hu et al. (2013) as a proxy for the variation in the liquidity of Slovak government bonds. To represent the safety and liquidity demand, we use the spread between the three-month German T-bill and the corresponding OIS yield. Both of these assets have negligible credit risk and due to the non-cash nature of the OIS contract, it does not provide any liquidity or store-of-value services for investors while short-term government bonds do. To further capture the safety flows related to the Eurozone crisis, we include a simple average of five-year sovereign CDS spreads of Italy, Spain, and France.<sup>7</sup> We capture the effect of ECB's

<sup>7</sup>We exclude the sovereign CDS spreads of Greece, Ireland, and Portugal for several reasons. First, the CDS



**Table 4.3 : Determinants of the term structure of spreads: Slovakia**

The table reports the regression results for determinants of principal components of Slovak government bond spreads to the OIS curve. Panel A reports the results for sovereign CDS and Panel B shows the output for sovereign CDS and other determinants of credit spreads described below. The left part of each panel reports the results for spreads to the OIS curve and the right side of both panels reports the results for spreads to the German curve. First regressor is the five-year sovereign CDS spread which is the most liquid maturity. "Slope CDS curve" is defined as a difference between the ten-year and a five-year CDS spread. "EUR Corp. spread" is the Barclays EUR aggregate corporate option-adjusted spread. "MOVE" measures the option-implied volatility of US Treasuries. The index is calculated by Merrill Lynch. "Illiq. measure" represents the illiquidity measure for Slovak government bonds as proposed in Hu et al. (2013). "Slope OIS curve" is defined as a difference between the ten-year and a one-year OIS yield. "Slope US" is a difference between the ten- and one-year zero-coupon US Treasury yield. "Euribor-OIS spread" is a difference between the three-month Euribor and OIS yield. "Liq. demand" denotes the yield differential between the three-month German T-bill and the OIS. "ECB QE dummy" take a value of one in the period after January 22, 2015 when the quantitative easing programme by the ECB was announced. Data are daily, from January 2009 through December 2015. All variables are standardized and the magnitudes of coefficients are directly comparable. t-statistics in parentheses are adjusted via Newey-West with 22 lags.

|  | PC1 OIS          | PC2 OIS          | PC3 OIS          | PC1 DE           | PC2 DE           | PC3 DE           |
|--|------------------|------------------|------------------|------------------|------------------|------------------|
| <b>Panel A. Determinants of credit spreads: sovereign CDS</b>                        |                  |                  |                  |                  |                  |                  |
| CDS SK 5Y  | 0.74<br>(13.69)  | 0.16<br>( 2.11)  | 0.34<br>( 2.49)  | 0.85<br>(15.35)  | 0.19<br>( 2.99)  | 0.07<br>( 0.61)  |
| Slope CDS curve  | -0.33<br>(-4.85) | 0.54<br>( 8.04)  | 0.28<br>( 2.33)  | -0.12<br>(-2.03) | 0.73<br>(11.22)  | -0.13<br>(-1.23) |
| $\bar{R}^2$  | 0.78             | 0.27             | 0.14             | 0.80             | 0.49             | 0.02             |
| <b>Panel B. Determinants of credit spreads: sovereign CDS + additional variables</b> |                  |                  |                  |                  |                  |                  |
| CDS SK 5Y  | 0.39<br>( 4.49)  | 0.20<br>( 1.30)  | -0.21<br>(-1.46) | 0.45<br>( 4.98)  | 0.04<br>( 0.36)  | -0.09<br>(-0.58) |
| Slope CDS curve  | -0.08<br>(-1.67) | 0.20<br>( 2.86)  | 0.40<br>( 3.99)  | -0.01<br>(-0.21) | 0.27<br>( 3.45)  | -0.11<br>(-1.60) |
| EUR Corp. spread   | -0.02<br>(-0.17) | 0.37<br>( 2.40)  | 0.29<br>( 1.57)  | -0.02<br>(-0.19) | 0.26<br>( 1.63)  | -0.13<br>(-0.57) |
| VIX  | -0.18<br>(-3.09) | -0.19<br>(-2.34) | -0.26<br>(-2.54) | -0.22<br>(-3.68) | -0.19<br>(-1.47) | 0.02<br>( 0.16)  |
| MOVE   | 0.03<br>( 0.46)  | -0.14<br>(-1.53) | -0.02<br>(-0.22) | 0.04<br>( 0.66)  | -0.15<br>(-2.18) | -0.12<br>(-0.95) |
| Illiq. measure   | 0.12<br>( 2.68)  | 0.21<br>( 2.86)  | 0.19<br>( 3.16)  | 0.12<br>( 3.02)  | 0.17<br>( 3.01)  | -0.03<br>(-0.32) |
| Slope OIS curve  | 0.41<br>( 5.54)  | -0.43<br>(-4.36) | -1.00<br>(-6.89) | 0.34<br>( 4.86)  | -0.60<br>(-5.81) | -0.36<br>(-2.26) |
| Slope US   | -0.23<br>(-3.28) | 0.07<br>( 0.62)  | 0.50<br>( 3.78)  | -0.32<br>(-4.40) | 0.08<br>( 0.65)  | 0.41<br>( 2.70)  |
| Euribor-OIS spread   | 0.23<br>( 2.21)  | -0.49<br>(-2.77) | 1.04<br>( 6.00)  | 0.16<br>( 1.55)  | -0.27<br>(-1.61) | 0.35<br>( 1.85)  |
| Liq. demand  | -0.14<br>(-2.82) | 0.18<br>( 2.65)  | 0.04<br>( 0.60)  | -0.25<br>(-5.07) | -0.16<br>(-2.40) | -0.53<br>(-5.19) |
| ECB QE dummy   | -0.19<br>(-6.52) | -0.56<br>(-8.33) | -0.01<br>(-0.22) | -0.19<br>(-7.26) | -0.31<br>(-5.93) | 0.30<br>( 5.45)  |
| $\bar{R}^2$  | 0.91             | 0.69             | 0.58             | 0.91             | 0.72             | 0.53             |

data are not consistently available throughout the sample. Second, these countries went through some form of debt restructuring process. Finally, these countries are small relatively to other peripheral countries that are included.



QE through a dummy variable which takes a value of zero before January 22, 2015 and one afterwards. Finally, the segmentation effects will be the unexplained residual. Table 4.4 reports the results of this decomposition for Slovakia (Panel A) and Germany (Panel B).

**Table 4.4: Decomposing the spreads to the OIS curve**

The table reports the regression results for spreads of Slovak (Panel A) and German (Panel B) government bond yields to the OIS curve. The regressions serve as a decomposition of the term structure of spreads into (i) credit risk premium which is captured by the first three regressors in each panel; (ii) liquidity premium which is represented by the noise illiquidity measure as proposed in Hu et al. (2013); (iii) safety and liquidity demand proxied by the spread between the three-month German T-bill and the three-month OIS yield; (iv) ECB quantitative easing captured by a dummy variable taking value of one since January 22, 2015 when the quantitative easing was announced and zero before. For Germany, we add the average of Italian, French, and Spanish five-year sovereign CDS to account for safe-haven flows to German sovereign debt at times of elevated peripheral sovereign credit risk. Data are daily, sample period is January 1, 2009 through December 14, 2015. Newey-West t-statistics (22 lags) are reported in parentheses. In both panels, the regressions are estimated without an intercept.

|  | 1Y                | 2Y                | 3Y                | 4Y                | 5Y                | 6Y                | 7Y                | 8Y                | 9Y                | 10Y               |
|--|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| <b>Panel A. Explaining spreads to OIS curve Slovakia</b> |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |
| CDS SK 5Y  | 0.58<br>( 6.85)   | 1.01<br>( 6.51)   | 1.17<br>( 5.01)   | 1.26<br>( 4.58)   | 1.30<br>( 4.51)   | 1.29<br>( 4.52)   | 1.26<br>( 4.49)   | 1.22<br>( 4.46)   | 1.16<br>( 4.39)   | 1.10<br>( 4.31)   |
| CDS SK 5Y sq. $\times 10^{-2}$                           | 0.00<br>( 0.11)   | -0.13<br>(-3.68)  | -0.18<br>(-3.81)  | -0.20<br>(-3.73)  | -0.20<br>(-3.62)  | -0.19<br>(-3.51)  | -0.18<br>(-3.28)  | -0.17<br>(-3.09)  | -0.15<br>(-2.90)  | -0.14<br>(-2.76)  |
| Slope CDS curve  | -0.22<br>(-2.65)  | -0.87<br>(-7.50)  | -1.05<br>(-7.11)  | -1.00<br>(-6.11)  | -0.83<br>(-5.06)  | -0.62<br>(-3.89)  | -0.40<br>(-2.59)  | -0.21<br>(-1.38)  | -0.04<br>(-0.28)  | 0.10<br>( 0.71)   |
| Illiq. measure   | 1.69<br>( 4.41)   | 1.85<br>( 3.33)   | 2.21<br>( 3.16)   | 2.63<br>( 3.33)   | 3.02<br>( 3.56)   | 3.31<br>( 3.78)   | 3.53<br>( 3.99)   | 3.69<br>( 4.23)   | 3.78<br>( 4.47)   | 3.80<br>( 4.72)   |
| Safety/liq. demand                                       | -0.89<br>(-5.48)  | -0.81<br>(-4.54)  | -0.62<br>(-2.71)  | -0.45<br>(-1.70)  | -0.36<br>(-1.24)  | -0.32<br>(-1.09)  | -0.35<br>(-1.14)  | -0.40<br>(-1.30)  | -0.48<br>(-1.54)  | -0.57<br>(-1.85)  |
| ECB QE dummy   | -11.60<br>(-3.40) | -11.88<br>(-3.07) | -16.29<br>(-3.54) | -23.44<br>(-4.69) | -31.69<br>(-6.09) | -39.88<br>(-7.40) | -47.33<br>(-8.40) | -53.21<br>(-9.09) | -57.33<br>(-9.50) | -59.74<br>(-9.72) |
| CDS periphery sov.                                       | -0.18<br>(-4.58)  | -0.09<br>(-1.86)  | -0.03<br>(-0.43)  | -0.01<br>(-0.15)  | -0.01<br>(-0.16)  | -0.01<br>(-0.15)  | -0.01<br>(-0.10)  | 0.00<br>( 0.03)   | 0.02<br>( 0.24)   | 0.04<br>( 0.49)   |
| $\bar{R}^2$  | 0.85              | 0.87              | 0.84              | 0.82              | 0.82              | 0.83              | 0.84              | 0.84              | 0.85              | 0.86              |
| <b>Panel B. Explaining spreads to OIS curve Germany</b>  |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |
| CDS DE 5Y  | 0.43<br>( 4.15)   | 0.39<br>( 4.68)   | 0.32<br>( 4.15)   | 0.48<br>( 4.94)   | 0.71<br>( 6.74)   | 0.94<br>( 8.88)   | 1.14<br>(10.74)   | 1.31<br>(12.39)   | 1.45<br>(13.47)   | 1.56<br>(14.03)   |
| CDS DE 5Y sq. $\times 10^{-2}$                           | -0.13<br>(-1.70)  | -0.09<br>(-1.33)  | -0.14<br>(-2.78)  | -0.32<br>(-5.42)  | -0.51<br>(-7.55)  | -0.68<br>(-9.18)  | -0.81<br>(-10.01) | -0.91<br>(-10.55) | -0.98<br>(-10.91) | -1.04<br>(-10.98) |
| Slope CDS curve  | 0.10<br>( 1.31)   | -0.01<br>(-0.15)  | -0.11<br>(-1.76)  | -0.21<br>(-4.03)  | -0.29<br>(-5.74)  | -0.33<br>(-6.22)  | -0.36<br>(-6.01)  | -0.36<br>(-5.49)  | -0.36<br>(-4.98)  | -0.32<br>(-4.18)  |
| Illiq. measure   | 0.06<br>( 0.61)   | 0.24<br>( 2.15)   | 0.28<br>( 2.97)   | 0.29<br>( 3.29)   | 0.31<br>( 3.21)   | 0.30<br>( 2.94)   | 0.33<br>( 2.90)   | 0.38<br>( 3.13)   | 0.43<br>( 3.33)   | 0.47<br>( 3.39)   |
| Safety/liq. demand                                       | 0.41<br>( 4.89)   | 0.29<br>( 4.12)   | 0.19<br>( 3.58)   | 0.18<br>( 3.18)   | 0.19<br>( 2.91)   | 0.19<br>( 2.65)   | 0.20<br>( 2.57)   | 0.22<br>( 2.59)   | 0.24<br>( 2.79)   | 0.27<br>( 3.02)   |
| ECB QE dummy   | -2.74<br>(-2.11)  | -2.64<br>(-2.21)  | -3.82<br>(-3.85)  | -4.65<br>(-4.61)  | -5.69<br>(-5.17)  | -7.30<br>(-6.18)  | -9.05<br>(-7.30)  | -10.78<br>(-8.15) | -12.06<br>(-8.61) | -12.72<br>(-8.43) |
| CDS periphery sov.                                       | -0.11<br>(-4.97)  | -0.11<br>(-5.95)  | -0.08<br>(-5.07)  | -0.08<br>(-4.73)  | -0.08<br>(-5.15)  | -0.09<br>(-5.83)  | -0.10<br>(-6.13)  | -0.10<br>(-6.12)  | -0.10<br>(-5.80)  | -0.10<br>(-5.54)  |
| $\bar{R}^2$  | 0.66              | 0.65              | 0.65              | 0.68              | 0.70              | 0.71              | 0.72              | 0.71              | 0.71              | 0.70              |

There are several interesting observations. First, a relatively small number of variables explains most of the variation in spreads in both countries. While for Slovakia the explained variation climbs toward 90%, it is marginally lower for Germany. This has likely to do with the much



lower magnitude of German spreads and thus a relatively larger role of noise or measurement errors. Second, we observe an important non-linearity in credit risk premium in Germany where a square of the five-year CDS spread contributes significantly to the explained variation at the long end of the curve. One explanation for this is that certain aspects of risk premiums get activated only in periods of financial stress. Third, we observe significant liquidity/safety premium in German spreads. Quite differently the safety/liquidity proxy has a negative sign for Slovak spreads indicating that Slovak government bonds do not attract safety flows. Relatedly, the sovereign CDS spreads of France, Italy, and Spain play an important role in explaining the spread of German bunds to the OIS curve across maturities. However, they load with a negative sign suggesting that increased credit risk premiums triggers inflows into German bunds thus lowering the spread to the OIS curve. We observe a similar albeit marginal effect for Slovak government bonds at the short end of the curve. Finally, the QE programme has a more pronounced effect on Slovak than on German spreads, mainly at the long end of the curve.

To assess the magnitude of each component of spreads, we plot the decomposition of the two year spread in Figure 4.6 and of the ten-year spread in Figure 4.7. Relative to the decomposition presented in Table 4.4, we exclude the non-linear effects of CDS spread, proxied by the square of the five-year CDS spread, and also the sovereign CDS for peripheral countries. Both of the excluded variables are only marginally contributing to explained variation in spreads. For both maturities, credit risk is the biggest component of spreads followed by the illiquidity. Not surprisingly, the ECB's QE programme has a large impact on the ten-year spread lowering it by more than 60 basis points. In contrast, the QE has no visible effect on the two-year bond. The results indicate that the QE programme lowered the level and the slope of the credit risk premium as well as the illiquidity premium.

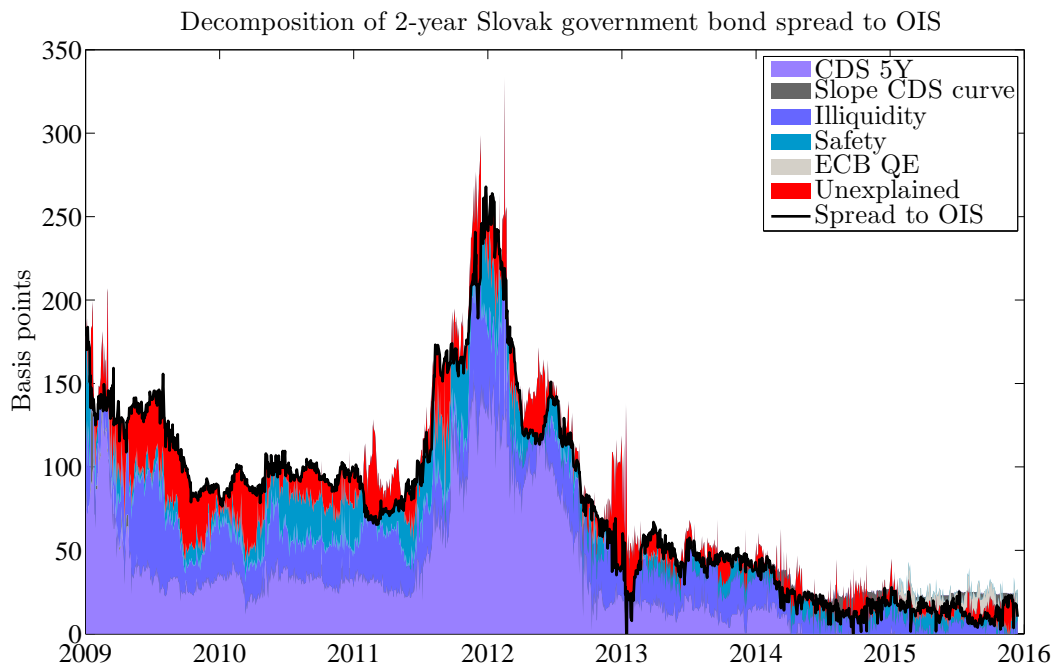
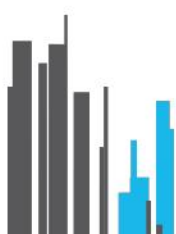


Figure 4.6 : Decomposition of the two-year spread to OIS, 2009-2015

The figure shows a decomposition of the two-year spread of Slovak government bonds to OIS. The decomposition is performed via linear regression given in Table 4.4. The sample period is January 2009 through December 2015, the data are daily.



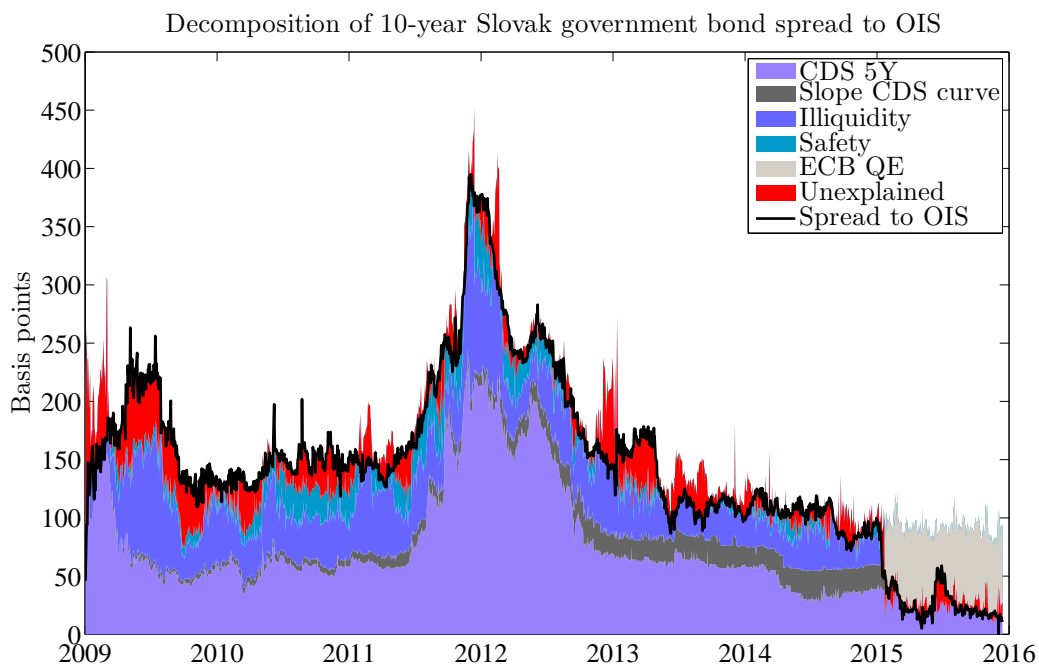


Figure 4.7: Decomposition of the ten-year spread to OIS, 2009-2015

The figure shows a decomposition of the ten-year spread of Slovak government bonds to OIS. The decomposition is performed via linear regression given in Table 4.4. The sample period is January 2009 through December 2015, the data are daily.

Table A.1 in the Appendix provides descriptive statistics for estimated components of all components of Slovak government bond yields including the risk neutral expectations about the ECB's policy rate and the term premium.





## 5 Conclusions

This paper decomposes the spread on Slovak government bonds relative to the OIS curve to economic quantities such as credit, liquidity, safety premiums, and segmentation effects. We document that effects unrelated to sovereign credit risk such as illiquidity drive a substantial fraction of variation in spreads. We have also identified sizable effects of the ECB's PSPP programme which are visible mainly at the long end of the yield curve. In the longer sample that goes back to 2000, we find that debt-to-GDP ratio is the key determinant of credit spread together with global variables such as funding conditions in the interbank market or measures of uncertainty. Overall, global variables drive more than 50% of explained variation in credit spreads.

The empirical analysis presented in this paper can be taken further in a number of ways. First, one could make the spread decomposition more precise by gaining a better understanding of what drives the variation in Slovak CDS spreads. Second, it would be interesting to study the monetary policy transmission mechanism in light of the decomposition outlined in this paper. Finally, the decomposition is a useful input for simulations and scenario building for debt management purposes.



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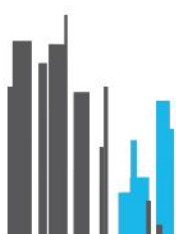


Appendix A Additional tables

**Table A.1: Descriptive statistics for estimated components of Slovak government bonds**

The table reports descriptive statistics for estimated components of yields on Slovak government bonds. The sample period is January 2009 through December 2015. All quantities are in basis points.

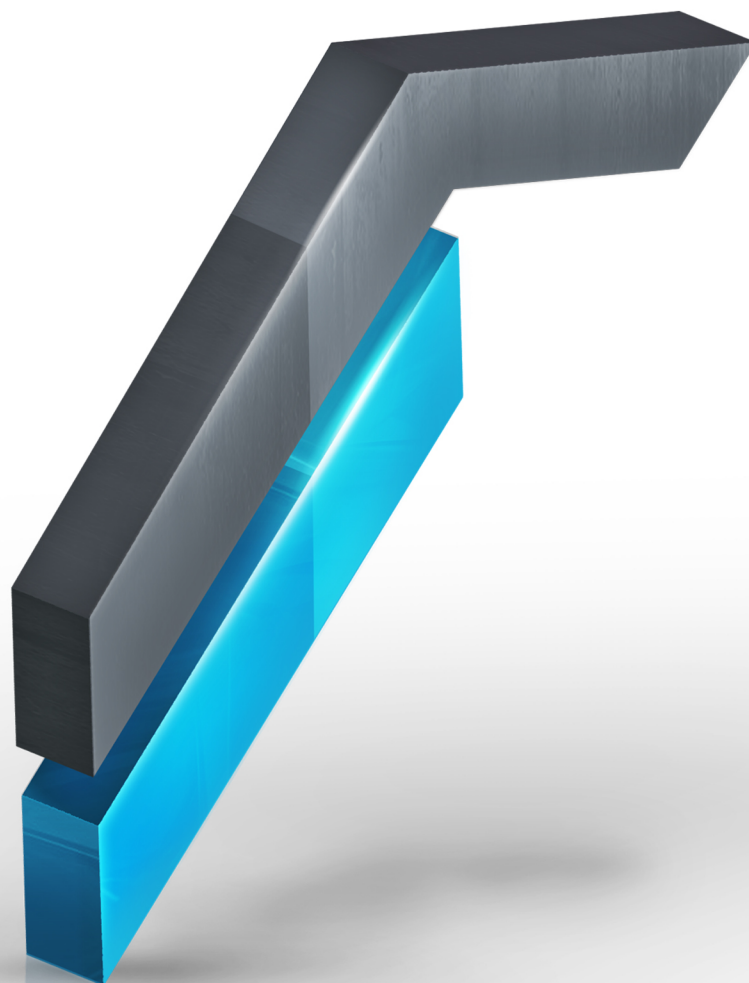
|  | 1Y     | 2Y     | 3Y     | 4Y     | 5Y     | 6Y     | 7Y     | 8Y     | 9Y     | 10Y    |
|--|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>Panel A. Risk neutral short rate expectations</b> |        |        |        |        |        |        |        |        |        |        |
| Mean   | 36.47  | 46.27  | 55.98  | 64.34  | 71.33  | 77.17  | 82.10  | 86.32  | 89.95  | 93.12  |
| Median   | 27.29  | 39.90  | 47.23  | 54.67  | 61.10  | 66.76  | 71.99  | 76.71  | 80.86  | 84.51  |
| St. dev.   | 37.13  | 38.61  | 37.57  | 35.58  | 33.34  | 31.12  | 29.01  | 27.06  | 25.27  | 23.64  |
| Min.   | -11.81 | -2.83  | 8.08   | 19.68  | 30.21  | 39.39  | 47.32  | 54.20  | 60.20  | 65.42  |
| Max.   | 151.68 | 164.69 | 170.55 | 171.72 | 170.90 | 169.26 | 167.34 | 165.36 | 163.43 | 161.60 |
| <b>Panel B. Term premium</b>                         |        |        |        |        |        |        |        |        |        |        |
| Mean   | 2.74   | 8.43   | 17.82  | 29.71  | 42.80  | 56.03  | 68.44  | 79.78  | 90.01  | 99.31  |
| Median   | 5.22   | 11.92  | 17.86  | 28.30  | 41.51  | 55.21  | 68.44  | 80.99  | 92.53  | 103.06 |
| St. dev.   | 18.88  | 32.89  | 45.57  | 55.26  | 62.28  | 67.44  | 71.07  | 73.54  | 75.32  | 76.84  |
| Min.   | -45.96 | -66.93 | -72.91 | -75.37 | -74.37 | -71.92 | -68.79 | -65.93 | -63.25 | -60.79 |
| Max.   | 34.09  | 71.71  | 110.81 | 143.11 | 169.16 | 190.43 | 207.17 | 221.07 | 232.84 | 242.51 |
| <b>Panel C. Level of the Slovak CDS curve</b>        |        |        |        |        |        |        |        |        |        |        |
| Mean   | 41.79  | 51.76  | 59.61  | 65.12  | 68.88  | 71.17  | 72.98  | 74.10  | 74.70  | 74.54  |
| Median   | 32.97  | 40.84  | 47.03  | 51.38  | 54.35  | 56.16  | 57.58  | 58.46  | 58.94  | 58.81  |
| St. dev.   | 27.02  | 33.46  | 38.54  | 42.10  | 44.53  | 46.01  | 47.18  | 47.90  | 48.29  | 48.19  |
| Min.   | 15.19  | 18.81  | 21.66  | 23.66  | 25.03  | 25.87  | 26.52  | 26.93  | 27.15  | 27.09  |
| Max.   | 139.49 | 172.76 | 198.95 | 217.34 | 229.90 | 237.55 | 243.58 | 247.31 | 249.32 | 248.80 |
| <b>Panel D. Slope of the Slovak CDS curve</b>        |        |        |        |        |        |        |        |        |        |        |
| Mean   | -13.59 | -19.16 | -18.40 | -15.01 | -10.52 | -5.24  | -0.03  | 4.89   | 9.38   | 13.47  |
| Median   | -16.31 | -22.98 | -22.07 | -18.01 | -12.62 | -6.28  | -0.03  | 5.87   | 11.26  | 16.16  |
| St. dev.   | 8.50   | 11.98  | 11.51  | 9.39   | 6.58   | 3.28   | 0.02   | 3.06   | 5.87   | 8.42   |
| Min.   | -36.37 | -51.25 | -49.23 | -40.17 | -28.15 | -14.02 | -0.08  | -13.26 | -25.45 | -36.53 |
| Max.   | 36.87  | 51.95  | 49.90  | 40.72  | 28.53  | 14.21  | 0.08   | 13.08  | 25.11  | 36.04  |
| <b>Panel E. Illiquidity</b>                          |        |        |        |        |        |        |        |        |        |        |
| Mean   | 18.19  | 26.22  | 31.67  | 36.38  | 40.06  | 42.29  | 43.50  | 44.03  | 43.84  | 43.07  |
| Median   | 15.58  | 22.46  | 27.12  | 31.16  | 34.31  | 36.22  | 37.26  | 37.71  | 37.55  | 36.89  |
| St. dev.   | 10.56  | 15.22  | 18.38  | 21.12  | 23.25  | 24.55  | 25.25  | 25.56  | 25.45  | 25.00  |
| Min.   | 1.87   | 2.70   | 3.26   | 3.74   | 4.12   | 4.35   | 4.48   | 4.53   | 4.51   | 4.43   |
| Max.   | 76.69  | 110.55 | 133.52 | 153.38 | 168.88 | 178.31 | 183.40 | 185.65 | 184.85 | 181.59 |
| <b>Panel F. Safety</b>                               |        |        |        |        |        |        |        |        |        |        |
| Mean   | 11.65  | 17.85  | 18.08  | 15.88  | 13.86  | 12.97  | 13.03  | 14.06  | 15.85  | 18.19  |
| Median   | 9.55   | 14.64  | 14.83  | 13.02  | 11.37  | 10.64  | 10.69  | 11.53  | 13.00  | 14.91  |
| St. dev.   | 7.63   | 11.69  | 11.84  | 10.40  | 9.08   | 8.50   | 8.53   | 9.21   | 10.38  | 11.91  |
| Min.   | -0.23  | -0.35  | -0.36  | -0.31  | -0.27  | -0.25  | -0.26  | -0.28  | -0.31  | -0.36  |
| Max.   | 45.08  | 69.07  | 69.96  | 61.44  | 53.63  | 50.19  | 50.42  | 54.38  | 61.32  | 70.38  |
| <b>Panel G. ECB QE</b>                               |        |        |        |        |        |        |        |        |        |        |
| Mean   | -0.03  | -1.32  | -2.62  | -3.77  | -4.84  | -5.88  | -6.83  | -7.64  | -8.29  | -8.74  |
| Median   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   |
| St. dev.   | 0.08   | 3.41   | 6.75   | 9.74   | 12.49  | 15.18  | 17.63  | 19.72  | 21.39  | 22.56  |
| Min.   | -0.25  | -10.11 | -20.04 | -28.89 | -37.04 | -45.05 | -52.29 | -58.50 | -63.46 | -66.92 |
| Max.   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   |



**Table A.2: Determinants of the term structure of spreads: Germany**

The table reports the regression results for determinants of principal components of German government bond spreads to the OIS curve. Panel A reports the results for sovereign CDS and Panel B shows the output for sovereign CDS and other determinants of credit spreads described below. First regressor is the five-year sovereign CDS spread which is the most liquid maturity. "Slope CDS curve" is defined as a difference between the ten-year and a five-year CDS spread. "EUR Corp. spread" is the Barclays EUR aggregate corporate option-adjusted spread. "MOVE" measures the option-implied volatility of US Treasuries. The index is calculated by Merrill Lynch. "Illiq. measure" represents the illiquidity measure for Slovak government bonds as proposed in Hu et al. (2013). "Slope OIS curve" is defined as a difference between the ten-year and a one-year OIS yield. "Slope US" is a difference between the ten- and one-year zero-coupon US Treasury yield. "Euribor-OIS spread" is a difference between the three-month Euribor and OIS yield. "Liq. demand" denotes the yield differential between the three-month German T-bill and the OIS. "ECB QE dummy" take a value of one in the period after January 22, 2015 when the quantitative easing programme by the ECB was announced. Data are daily, from January 2009 through December 2015. All variables are standardized and the magnitudes of coefficients are directly comparable. t-statistics in parentheses are adjusted via Newey-West with 22 lags.

|  | PC1 OIS          | PC2 OIS          | PC3 OIS          |
|--|------------------|------------------|------------------|
| <b>Panel A. Determinants of credit spreads: sovereign CDS</b>                        |                  |                  |                  |
| CDS DE 5Y  | -0.19<br>(-2.34) | 0.54<br>( 7.22)  | 0.40<br>( 3.81)  |
| Slope CDS curve DE   | -0.63<br>(-9.68) | -0.06<br>(-0.60) | 0.07<br>( 0.62)  |
| $\bar{R}^2$  | 0.44             | 0.29             | 0.17             |
| <b>Panel B. Determinants of credit spreads: sovereign CDS + additional variables</b> |                  |                  |                  |
| CDS DE 5Y  | -0.10<br>(-1.51) | 0.79<br>( 7.56)  | -0.14<br>(-0.88) |
| Slope CDS curve DE   | -0.48<br>(-7.01) | -0.40<br>(-3.82) | 0.45<br>( 4.60)  |
| EUR Corp. spread   | 0.21<br>( 1.72)  | -0.21<br>(-0.87) | 0.70<br>( 5.50)  |
| VIX  | -0.01<br>(-0.20) | -0.08<br>(-0.42) | -0.01<br>(-0.12) |
| MOVE   | -0.17<br>(-2.84) | -0.16<br>(-1.60) | 0.31<br>( 3.09)  |
| Illiq. measure   | 0.10<br>( 3.25)  | 0.06<br>( 1.01)  | -0.11<br>(-2.58) |
| Slope OIS curve  | 0.07<br>( 0.95)  | 0.29<br>( 2.22)  | -0.32<br>(-2.58) |
| Slope US   | 0.32<br>( 4.28)  | -0.04<br>(-0.31) | 0.02<br>( 0.18)  |
| Euribor-OIS spread   | -0.12<br>(-1.34) | -0.55<br>(-2.40) | 0.15<br>( 1.11)  |
| Liq. demand  | 0.31<br>( 7.39)  | -0.38<br>(-2.96) | 0.35<br>( 3.65)  |
| ECB QE dummy   | -0.24<br>(-6.54) | -0.17<br>(-2.26) | -0.48<br>(-7.50) |
| $\bar{R}^2$  | 0.80             | 0.58             | 0.67             |



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