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Analysis of Sovereign Risk Market Indicators: The Case of the Czech Republic*

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Abstract

In this article we discuss the credit default swap (CDS) as an indicator for measuring sovereign credit risk and the relationship between the sovereign CDS market and government bond market. We analyze the links between the sovereign CDS and sovereign yield spread and try to determine which of these markets is the leading one in the price discovery process in the case of the Czech Republic. We then apply quantile analysis to sovereign CDS spreads to demonstrate the cross-country spillover effects. The results of the first analysis suggest that movements in the Czech sovereign CDS spread preceded movements in the sovereign yield spread during the global crisis. The results of the second analysis indicate that the shock arising from the current debt crisis was transmitted to the Czech sovereign credit premium, although the fundamental or market factors driving its level dominated. The results of the Czech case are compared to selected European countries with different sovereign risks.

1. Introduction

Sovereign risk has become a highly debated issue in the last few years, particularly since the global financial crisis transformed into a sovereign debt crisis in a number of Western countries. Sovereign markets have witnessed unprecedented repricing of credit risk as the market-perceived probability of a default event in the case of sovereigns has risen above very low or zero.[1] The last few years have seen quite a significant change in market perception and interpretation of sovereign risks and fiscal fundamentals. A previously homogeneous group of countries in respect of sovereign risk premiums has suddenly become characterized by significant diversion (*Figure 1*) and unusual variability in the balance between interest rate and credit risk (*Figure 2*).

In general, the sovereign credit risk premium required by market participants should mainly reflect the fiscal position of the country and its (un)sustainability in the future. However, there is evidence that some high deficit, high debt countries, such as the United States and Japan, enjoy much lower interest rates and lower sovereign risk premiums than some other countries with comparable or better fiscal

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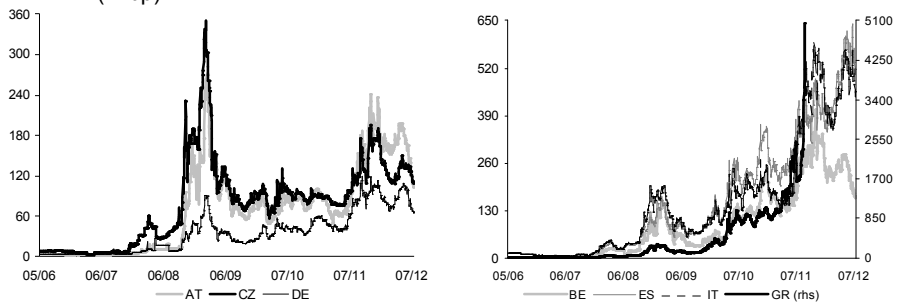
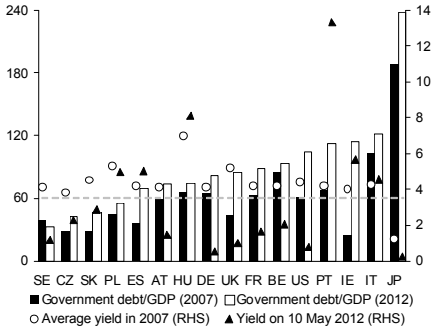
[1] Sovereign risk modeling (e.g., in term structure analysis) is typically oriented toward interest rate risk or liquidity risk rather than default risk. This is due to the widely used assumption that government bonds provide a good proxy for the long-horizon (default-)risk-free rate (Fontana and Scheicher, 2010).

Figure 1 Five-year Sovereign CDS Spreads of Selected European Governments (in bp)



Source: Bloomberg LP.

Figure 2 Comparison of Government Debts and Their Yields for Selected Advanced Economies (in %)



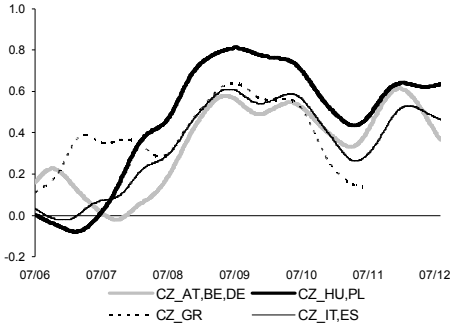
Notes: Average yield for 2007 (for SK as from 12 April 2007). The average yield is calculated from the 5Y generic benchmark government bond of the relevant country. RHS—right-hand scale.

Source: CNB, 2012.

fundamentals, such as the Czech Republic (Figure 2, CNB, 2012). At the beginning of the current crisis only some sovereigns were under real fiscal pressure due to banking or fiscal troubles, but all European government bond markets and their CDS markets, including the Czech ones, became more volatile. This phenomenon was observed after the collapse of Lehman Brothers in 2008 and again in 2010 due to concerns about Greece's inability to meet its debt obligations (*Figure 1*), when negative sovereign risk perceptions spread even to countries whose financial systems had until then been affected by the crisis either not at all, or—as in the case of the Czech Republic—only marginally.[2] The average correlation between European

[2] Between 2008 and 2009 several advanced countries provided government guarantees for banks' liabilities. This resulted in a fall in bank CDS spreads because the default risk was transferred from banks' balance sheets to fiscal balance sheets. The sovereign CDS spreads of the governments providing such financial guarantees therefore increased. Since 2010, the government bond market has experienced high price volatility and investors have been reducing their exposures to avoid being exposed to other large losses. This has led to a reduction of exposures in government bond markets in general and a significant decrease in their market liquidity. Sovereign CDS spreads have been widening significantly.

Figure 3 Average Correlation between Sovereign CDS Spreads of Selected Economies and the Czech Republic



Notes: The average correlation of logarithmic changes in 5Y CDS spreads was calculated using the exponentially weighted moving average (EWMA) with decay constant 0.94. The average correlation expresses the unweighted mean of the correlations of selected countries with the Czech Republic, which was subsequently smoothed using the HP filter.

Source: Bloomberg LP, Thomson Reuters, authors' calculation.

sovereign risk premiums has increased sharply, for a time even with respect to the market and economic fundamentals of often structurally different countries. Such evidence can be seen in the case of the Czech Republic (*Figure 3*)—the Czech sovereign risk premium has to a certain extent been contaminated during the current financial and debt crisis by shocks originating in countries experiencing banking or sovereign crises[3] even though Czech financial and fiscal fundamentals have been stable.

The above facts raise the question of to what extent fiscal fundamentals are relevant in assessing the sovereign risk premium and to what extent the pricing of sovereign risk premiums is governed by other factors, such as common aggregate time-varying risk factors, spillover risk factors, or investors' perceptions of various announced or implemented policy stimulus measures.

For both the public and the private sector it is necessary to better understand sovereign credit risk and its premium, the sources that fuel their dynamics, and the associated market uncertainty and volatility. Since market sovereign risk indicators are determined by various time-varying factors there is also a need for policy authorities to be prudent in analyzing and interpreting the evolution of such market indicators.

The literature on the sovereign risk premium and factors that might explain its behavior is quite plentiful. Explanatory factors were analyzed by Fontana and Scheicher (2010) for ten euro area countries over 2006–2010, by De Santis (2012) for ten euro area countries over 2008–2011, and by Caceres and Unsal (2011) for 11 Asian countries in the period from 2005 to 2010. Fontana and Scheicher (2010) found that the main determinants of spreads on CDS and the underlying government bonds are common factors, some of which proxy for changes in investor risk appetite. De Santis (2012) found three factors that can explain the behavior of sovereign

[3] All the countries listed in *Figure 3* (AT, BE, DE, ES, GR, HU, IT, and PL) experienced certain banking or fiscal troubles during the period analyzed.

spreads of selected euro area countries: (i) an aggregate regional risk factor, (ii) the country-specific credit risk, and (iii) the spillover effect from Greece. Caceres and Unsal (2011) found that for the vast majority of Asian economies in their sample, sovereign risk spillovers were the main drivers of developments in sovereign spreads.

The sovereign risk premium can be represented by two market indicators: sovereign CDS spread and sovereign yield spread. Since the two indicators should provide similar information about sovereign risk, there should be a close relationship between the two premiums. A number of authors have analyzed the relationship between the two premiums and tried to explain the differences in their dynamics. A lead-lag analysis of bond and CDS spreads was carried out by Fontana and Scheicher (2010) and Coudert and Gex (2011). Fontana and Scheicher (2010) analyzed sovereign spreads in ten euro area countries for the period from 2006 to 2010. They found that since the Lehman collapse, market integration for bonds and CDS has varied across the selected countries. In half of the sample countries, price discovery took place in the CDS market, and in the other half, price discovery was observed in the bond market. Coudert and Gex (2011) analyzed the links between CDS and bond spreads for 17 financials and 18 sovereigns for the period from 2007 to 2010. They showed that the CDS market had a lead over the bond market over the whole sample, but a decomposition of the sample showed that this result held for financials as well as for the high-yield emerging sovereigns. The bond market drove the CDS market for the sovereigns in the core of the euro area. A similar conclusion was reached by Delatte et al. (2012) on a sample of 11 European sovereigns over 2008–2010. Zhu (2004) compares the pricing of credit risk in the corporate bond market and the fast-growing CDS market by analyzing 1,400 samples of European and American corporate CDS. His empirical findings confirm the theoretical prediction that bond spreads and CDS spreads move together in the long run, whereas in the short run this relationship does not always hold. By looking into the dynamic linkages between the CDS and bond spreads, he finds that the CDS market often moves ahead of the bond market in price adjustment, particularly for US corporate entities.

Most analyses are centered on the study of sovereign spreads for the euro area, the US or Asia. The main contribution of this paper to the existing literature is that it provides a comprehensive analysis of sovereign risk premiums focusing on the Czech case. The main aim of the present article is to analyze and discuss the impact of market correlations in terms of the spillover effect between the Czech sovereign CDS market and the Czech government bond market and between the Czech sovereign CDS market and selected euro area countries with different default risks. We take a country very near to default (Greece), two countries viewed as risky (Italy and Spain), a core euro area economy (Germany), and two countries that are parents in respect of the Czech banking sector (Austria and Belgium). For the purposes of the analysis we choose two metrics, five-year sovereign bond yields and five-year sovereign CDS spreads, since the average maturity of the Czech government debt is close to five years. The data are in daily frequency using end-of-day values.

The article is organized as follows. Section 2 discusses the credit default swap as an indicator for measuring credit risk. Section 3 focuses on analysis of the sovereign CDS market and the relationship to its cash market (the government bond market). Section 4 applies quantile analysis of cross-country spillover effects based on sovereign CDS spreads. Finally, Section 5 concludes.

2. The Credit Default Swap as a Credit Risk Indicator

The interest of debt securities holders in marketable insurance against debtor default in the form of credit default swaps (CDS) increased with the onset of the global financial crisis. The CDS spread is the price that the CDS buyer is willing to pay for protection against a reference entity's credit event to the seller of such protection. The CDS seller undertakes to cover the loss that the protection buyer would incur as a result of the credit event. CDS contracts are traded in the largely unregulated over-the-counter market[4] as bilateral contracts involving counterparty risk. CDS derivatives were originally created for the purpose of hedging against credit risk. Over time, though, they started to be used for speculative transactions as well.

According to the fundamental approach, the value of a CDS spread is a function of the probability of default (PD) of the reference entity and the loss given default (LGD). However, CDS spreads can also be made up of other premiums, such as a liquidity risk premium, a systemic risk premium, or a jump-to-default risk premium (ECB, 2009). In quiet times, jump-to-default risk and systemic risk usually account for a negligible part of the CDS spread. But at times of heightened uncertainty these two risks gain in importance.[5] Additional risk premiums that arise from the definition of credit event can also be a part of CDS spreads.[6]

As a market indicator of sovereign credit risk, the sovereign CDS spread started to represent an alternative to the previously predominant definition of the sovereign risk premium as the difference between the yields on a government bond and a risk-free benchmark (the "sovereign yield spread", for example the yield on Czech government debt versus that on German government debt). Theoretically, the two premiums should be equal since both express the premium on sovereign credit risk. If this is not the case, arbitrage opportunities arise. Empirical evidence, however, shows that developments on the two markets usually reflect more factors and risks than pure sovereign credit risk, although this risk should be the principal one. This causes the two risk premiums to differ for a short time, or even persistently, thus limiting the arbitrage.

Firstly, part of the demand for sovereign CDS contracts is in reality due to hedging against the risk of another reference entity for which the credit event probability is highly correlated with the credit event of the state.[7] In such case, the overall demand for sovereign CDS can be much more sensitive to changes in various factors than demand for government bonds. Secondly, since demand in the sovereign CDS market is relatively restricted and strongly concentrated around a few

[4] Compared to the total derivatives market, the market in this type of derivative is relatively small (approximately 7%). However, there is still no exact data on the size of the credit default risk transferred by these instruments (www.isda.org gives a 2009 Q1 estimate of USD 31 trillion).

[5] The collapse of Lehman Brothers in September 2008 is an example of sudden default. Owing to growth in systemic risk due to the balance-sheet links between individual financial institutions, the risk of sudden default increased for most other banks after the collapse of this bank. A similar concern arose in connection with Greek credit events during spring 2009 and turned into a sovereign debt crisis in spring 2010.

[6] In the case of the banking system, nationalization, for example, could be a credit event.

[7] This may be due to the non-existence of relevant CDS or to their high price. Take, for example, the purchase of CDS for national debt, where in reality the CDS buyer holds a bond issued by the bank of the relevant country or, say, by the state energy company.

active global dealers,[8] an insufficiently flexible response of the supply of CDS contracts to increased demand might cause the CDS spread to deviate from the sovereign yield spread. Thirdly, more permanent effects, such as the well known phenomena of flight-to-liquidity and flight-to-quality, which were frequently observed in government bond markets during the global crisis, might influence the relationship between the two risk premiums. Finally, limited arbitrage between the two markets might also occur when participants on the two markets are very different (e.g., domestic investors on the government bond market and foreign investors on its sovereign CDS market).

Although the CDS spread has certain limitations and CDS and bond yield spreads might incorporate slightly different sovereign risk premiums and might be influenced by slightly different factors, it can still be considered a suitable indicator for measuring sovereign credit risk. However, these specifics should be taken into account when interpreting the two indicators.

CDS contracts are associated with both social benefits and social costs. Stulz (2009) concludes that the CDS market did not cause the dramatic events of the credit crisis and summarizes the standard arguments among economists supporting the use of CDS contracts, i.e., (i) they make it easier for credit risks to be borne by those who are in the best position to bear them, (ii) they enable financial institutions to make loans they would not otherwise be able to make, (iii) their trading reveals useful information about credit risk to market participants. From the practical point of view it is evident that the possibility of trading credit risk can, for a while, be profitable to both creditor and debtor. If a debt creditor has the option of hedging against the debt position, he/she will remain willing to buy debt even if the debtor's position deteriorates significantly. This can foster higher liquidity, activity, and price stability on the underlying cash market. On the other hand, there is a consensus about the costs of using CDS, in line with the argument that CDS contributed to the global financial (debt) crisis, i.e., (i) CDS made possible the credit boom that ended in the credit crisis,[9] (ii) CDS markets are oversized and financial institutions have gigantic positions in CDS (high concentrations of market dealers), which have created or at least contributed to systemic risk (examples include the indirect bailout of Bear Stearns and the direct bailout of AIG) and have led to a crisis of confidence in financial institutions, and (iii) the CDS market shows a lack of transparency, which has made it possible for market participants to manipulate this market, making some financial institutions look much weaker than they are in reality.

A related question to the discussion of whether the sovereign CDS market contributed to the debt crisis is whether the sovereign CDS spread can be manipulated with the aim of influencing the underlying government bond market. It could be disturbing if CDS market anomalies were to transmit to its cash market to

[8] Furthermore, the concentration can increase. If, for example, the link between the hedged risk (sovereign credit risk) and the counterparty risk (the credit risk of the bank as the seller) strengthens as a result of, for example, measures introduced to support the banking sector, demand can be concentrated into an even smaller group. This is because the protection buyer naturally rules out as a counterparty any institution to which such measures directly or indirectly relate.

[9] The argument that debt hedging will lead to an increase in the debt itself does not hold much water, since increased interest in hedging increases the hedging price, i.e., CDS spreads or the reference entity's PD.

the extent that it caused stress on the cash market.[10] In such a case, an increased sovereign CDS spread would increase the yield on that particular government bond without any negative change in fiscal fundamentals having occurred. We argue that such a spillover effect between the CDS market and its cash market might be possible. However, this effect tends to be associated with the psychological transmission channel (market herding) rather than the technical transmission channel (real sovereign exposures hedged with sovereign CDS). Several substantiating arguments can be proffered. Owing to credit risk, the seller on the CDS market and the buyer on the cash market are in the same situation. The supply of CDS contracts is usually low, which can exert upward pressure on CDS spreads (credit risk), whereas the demand for debt is usually high, which, by contrast, can put downward pressure on the credit premium. Hence, the contagion between those two markets is more or less restricted. Another contagion effect is often associated with the speculative trading strategies of (a) CDS sellers hedging on the cash market by means of speculative short selling, or (b) CDS buyers trying to increase CDS prices[11] in order to hedge their existing short positions on the cash market (naked CDS buying).[12] This case of contagion is similar to previous one, as it would only be possible under the assumption of insufficient demand for the underlying asset and the possibility of a few sellers exerting market power over buyers. Given that the sovereign CDS market is considerably smaller than the government bond market (ISDA, 2010; Fontana and Scheicher, 2010, Chart 1), this contagion channel is very limited.[13] The last argument is related to the role of fundamental analysis. If we assume the absence or very low participation of investors who do not assess the risks themselves on the basis of their own fundamental analyses, the transmission of anomalies from the CDS market to its cash market should be limited.

Contagion is more likely at times of higher uncertainty, when fundamental analysis of the underlying asset is more difficult to undertake.[14] To a certain extent, therefore, an excessive change in sovereign CDS spreads can affect investors' perceptions of sovereign credit risk. However debatable the spillover effect between the CDS market and its cash market (see section 3) may be, the same effect has been observed across various CDS markets of single countries and across the same CDS markets of different countries (see section 4). One can follow how sovereign CDS spreads grew in countries affected by the financial crisis. Credit risk was transferred either from

[10] The problem of manipulation of the government bond market via the sovereign CDS market was discussed mainly in connection with increasing yields on Greek government debt at the beginning of the government debt crisis in spring 2010.

[11] i.e., trying to influence investor perceptions of the reference entity's credit risk

[12] It is because of naked CDS that a debate is now going on about introducing regulation of the CDS market or completely prohibiting naked CDS. Naked CDS are often compared to taking out fire insurance on one's neighbor's house. The CDS holder then profits from his neighbor's misfortune or even tries to get his neighbor's house to burn down. Naked short-selling transactions and naked CDS in government bonds of euro area countries have been prohibited by the Federal Financial Supervisory Authority (BaFin), for example.

[13] *Figure 7* and *Figure 8* show the relative size of the CDS market with respect to the underlying government debt.

[14] At times of increased uncertainty, participants might make decisions based on the worst case scenario due to sudden impossibility to attach probabilities to different states of the world market (Banque de France, 2008).

the banking sector to the government sector (banking-sovereign contagion) or from the government sector of one country to another government sector of a different country (sovereign-sovereign contagion). While the banking-sovereign contagion was mainly of a fundamental nature, since the cost of the banking crisis was expected to be borne by governments, the sovereign-sovereign contagion was due to psychological factors, especially during the first phase of the global crisis.

3. Analysis of Sovereign CDS and its Relationship to the Czech Government Bond Market

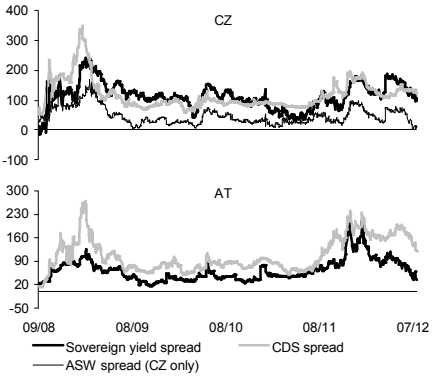
In the previous sections of this article we argue that the two premiums—the sovereign CDS spread and sovereign yield spread—should, under normal conditions, be (almost) equal, hence they should display very similar dynamics in the longer term. The aim of this section is to empirically analyze the relationship between the two markets, i.e., the sovereign CDS market and the government bond market. Specifically, the aim is to determine whether one of the two premiums/ /markets is in the leading position in the price discovery process, and, if so, under what conditions. Empirical studies (see, for example, Coudert and Gex, 2011, Delatte et al., 2012, and Fontana and Scheicher, 2010) analyzing the relationship between the two premiums—primarily on euro area government bond markets[15]—have found that the government bond market usually plays the leading role for low-yield bonds (fiscally stable countries), while the sovereign CDS market plays a leading role for high-yield and fiscally troubled countries. The main reasons for this result mentioned in these studies are (i) high and different sensitivity of prices of the two markets to joint market factors (e.g., a change in market conditions), and (ii) significant market barriers and structural changes, which limit arbitrage and slow the movement of capital and thus prevent the fast equalization of sovereign premiums on the two types of markets.

Our analysis of the relationship between the sovereign CDS market and the government bond market is based on five-year generic government bonds and five-year sovereign CDS spreads in 2008–2012 for the Czech Republic (and for comparison also for AT, BE, IT, ES, and GR). The German bund is considered the risk-free benchmark for the analyses of euro area countries, while the swap (IRS) yield curve is used for the Czech Republic.[16] The plots of the two premiums (CDS spread and sovereign yield spread/asset swap spread) over the entire period under review reveal a close long-term relationship but quite frequent divergences in their levels (see *Figures 4–6*). The largest difference occurred after the failure of Lehman Brothers, when market and funding liquidity fell sharply. This period was characterized by a flight-to-liquidity, with fire sales of some assets (including selected government bonds), and by an increase in risk aversion. As a result, the number of arbitrageurs fell significantly (Fontana and Scheicher, 2010). A flight-to-quality

[15] The relationship between the premium on the CDS market and that on its cash market was previously also analyzed for financial and non-financial corporations (Blanco et al., 2003; Zhu, 2004).

[16] As the Czech Republic is not a euro area country, the swap yield curve, which is also routinely used in the literature as the risk-free benchmark, was taken as an alternative to the German bund. The difference between the yield on a representative government bond and the yield on the German bund of the same maturity is called the sovereign yield spread, and the difference between the yield on a representative government bond and the IRS yield of the same maturity is called the asset swap spread (ASW spread).

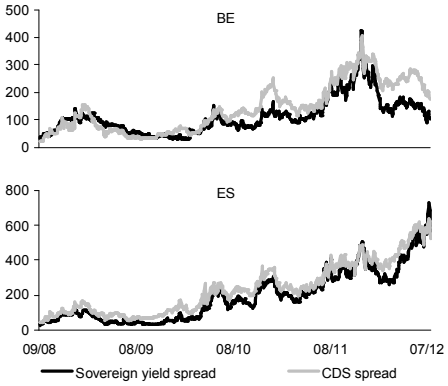
Figure 4 Credit Premiums on the Government Bond and CDS Markets of the Czech Republic and Austria (in bp)



Notes: Owing to the non-existence of a 5Y benchmark bond for the Czech Republic its yield was approximated between August 2009 and the start of 2010 in this figure.

Source: Bloomberg LP, authors' calculation.

Figure 5 Credit Premiums on the Government Bond and CDS Markets of Belgium and Spain (in bp)



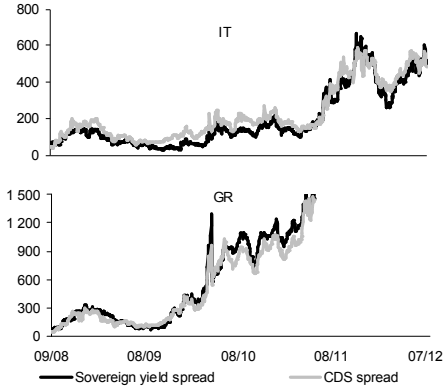
Sources: Bloomberg LP; authors' calculation.

rather than a flight-to-liquidity started to emerge in spring 2010. Investors, especially foreign ones, started to diversify more between Central European countries and ranked the Czech Republic among the countries with a more stable fiscal outlook. The difference between the premiums under review therefore shrank in the Czech Republic.

Since the theory suggests that there should be a close long-term relationship between the two premiums,[17] the cointegration approach is employed. Similarly to the recent studies mentioned above, the Vector Error Correction Model (VECM) is used to analyze the relationship between the CDS and bond markets:[18]

[17] See Zhu (2004) for a more detailed discussion on the theoretical relationship between the two premiums.

Figure 6 Credit Premiums on the Government Bond and CDS Markets of Italy and Greece (in bp)



Note: For GR, the period under review ends in May 2011.
Sources: Bloomberg LP; authors' calculation.

$$\Delta bond_t = \lambda_1 \left(cds_{t-1} - \alpha - \beta bond_{t-1} \right) + \sum_{j=1}^{p} \gamma_{1,j} \Delta cds_{t-j} + \sum_{j=1}^{p} \phi_{1,j} \Delta bond_{t-j} + \varepsilon_{1,t} \qquad (1)$$

$$\Delta cds_t = \lambda_2 \left(cds_{t-1} - \alpha - \beta bond_{t-1} \right) + \sum_{j=1}^{p} \gamma_{2,j} \Delta cds_{t-j} + \sum_{j=1}^{p} \phi_{2,j} \Delta bond_{t-j} + \varepsilon_{2,t} \qquad (2)$$

where $\Delta bond_t$ represents the change in the risk premium in the government bond market at time t; Δcds_t is the change in the risk premium in the CDS market at time t, and the error correction term ($cds_{t-1} - \alpha - \beta bond_{t-1}$) describes the long-run relationship between the two markets. λ_1 and λ_2 are the key coefficients determining the speed of adjustment of the bond and CDS markets when a deviation from their long-run relationship occurs, coefficients $\gamma_{1,j}$, $\gamma_{2,j}$, $\varphi_{1,j}$, $\varphi_{2,j}$ are the short-run effects of the changes in the risk premiums on the CDS market and the bond market, respectively, at time $t–j$, and $\varepsilon_{1,t}$, $\varepsilon_{2,t}$ are error terms. In order to account for the heteroskedasticity in the data, we employ a bivariate VECM with a GARCH error structure, thus effectively a VECM-GARCH model is estimated.[19]

[18] In order to employ cointegration analysis, the augmented Dickey-Fuller test was used to test for the unit root of the individual time series, with the Akaike information criterion (AIC), the Schwarz information criterion (SIC), and the Hannan-Quinn Criterion (HQ) used to determine the number of lags. The test rejected the null hypothesis of unit root for the Czech CDS series for the period 9/2008–7/2012 using the AIC criterion at the 5% significance level, while the SIC and HQ led to positive results.

[19] The VECM-GARCH approach to modeling the long-run relationship between financial time series was applied, for example, by Alizadeh (2008) for the analysis of the spot and future prices of energy commodities additionally enriched by allowing for regime switches. The conditional means of changes of risk premiums on the CDS and government bond markets are represented by the VECM, and the conditional second moments are modeled as bivariate GARCH(1,1) assuming the specification of the conditional covariance matrix to be diagonal BEKK (Engle and Kroner, 1995). The error terms are assumed to follow a conditional *t*-distribution rather than a conditional normal distribution similarly to Kavussanos and Nomikos (2000). This should better correspond with the leptokurtic characteristic of the data.

According to the theory, the coefficients of the error correction term should be in the form of a lagged basis spread, i.e., $\alpha = 0, \beta = 1$. We test the hypothesis that there is a one-to-one relationship between the CDS and bond market premiums ($\beta = 1$). We do not impose any identifying restriction on coefficient α, which might capture some institutional differences between the two markets.

The coefficients λ_1 and λ_2 are the measures of the speed of adjustment back to the long-run relationship if a deviation from the long-run relationship occurs. Generally, the leading market, which dominates in the price discovery process, should exhibit lower speed of adjustment. If both markets contribute to the price discovery process, both coefficients should be statistically significant, while λ_1 should be positive and λ_2 negative. In this case, a larger (smaller) coefficient λ_1 relative to λ_2 in absolute terms implies slower adjustment of the CDS market (government bond market) back to the long-run relationship. Therefore, the CDS market (government bond market) is leading. The commonly used measure of the relative importance of each market in price discovery is the Gonzalo-Granger measure[20] $\lambda_1/(\lambda_1-\lambda_2)$. The Gonzalo-Granger measure ranges between 0 and 1, and a value above (below) 0.5 suggests a leading role of the CDS market (government bond market). If λ_1 (λ_2) is statistically significant and positive (negative) and at the same time λ_2 (λ_1) is statistically insignificant, the government bond market (CDS market) has to adjust to the price set on the CDS market (government bond market), since the CDS market (government bond market) is unresponsive to the deviation from the long-run relationship and the adjustment process is ensured solely by the government bond market (CDS market). In this case, the price discovery process takes place solely via the CDS market (government bond market), hence the CDS market (government bond market) is leading.[21]

The results of the cointegration analysis are presented in *Table 1*. The Johansen cointegration test suggests the existence of a cointegration relationship between the CDS and government bond markets for the Czech Republic and the other selected countries. Imposing the restriction $\beta = 1$ on the cointegration vector seems to be suitable only in the case of Italy and Spain. For the other countries, a one-to-one relationship between the CDS market and the bond market is rejected.

The adjustment coefficients λ_1 and λ_2 determining the lead-lag relationship between the CDS and government bond markets are shown in the second part of *Table 1*. The results for the Czech Republic put the Gonzalo-Granger measure at 0.8, indicating that the sovereign CDS market was the leading market over the period of the global financial and debt crisis. The Gonzalo-Granger measure of 0.57 for Austria indicates similar strength of the two markets, although the CDS market slightly dominated in the price discovery process. In the cases of Belgium, Greece, and Italy, the results suggest that the price discovery process took place solely via the CDS market. The λ_1 and λ_2 coefficients for Spain turn out to be insignificant at conventional significance levels.

[20] See, for instance, Blanco et al. (2003), Zhu (2004), Fontana and Scheicher (2010) or Delatte et al. (2012).

[21] If λ_1 (λ_2) were statistically significant and negative (positive) and at the same time λ_2 (λ_1) were statistically insignificant, there would be no adjustment back to the long-run relationship.

Table 1 Results of the Leading Relationship Analysis (9/2008–7/2012)

	Johansen cointegration test				VECM-GARCH		Residuals Diagnostics			
	Lags	$r = 0$	$r = 1$	H0: $\beta = 1$	λ_1	λ_2	$Q_C(30)$	$Q_B(30)$	$Q^2_C(30)$	$Q^2_B(30)$
AT	3	27.641***	6.715	5.994**	0.008***	-0.006*	38.643	26.170	10.800	3.241
BE	1	20.033*	3.834	8.459***	0.010***	0.000	42.163*	10.349	32.926	5.252
GR	1	21.305**	2.691	6.221**	0.012*	-0.001	26.611	29.068	28.722	41.564*
IT	1	27.262***	2.168	2.369	0.011*	0.001	24.876	27.394	31.436	16.119
ES	1	21.805**	2.556	0.523	0.010	-0.003	28.332	22.875	30.164	3.537
CZ	3	38.629***	4.221	10.344***	0.020***	-0.005*	28.639	20.795	29.514	7.253
CZ $_{\text{finan. crisis}}$	1	22.279**	3.466	10.549***	0.022***	0.004	25.997	23.975	21.869	1.788

Notes: The period under review is shorter for Greece (9/2008–5/2011). The financial crisis period in the case of the Czech Republic is defined as 9/2008–7/2009.

The Johansen trace statistic suggests a cointegration relationship between the CDS premium and the bond market premium if the $r = 0$ hypothesis is rejected and the $r = 1$ hypothesis cannot be rejected. The number of lags (short-run effects) is determined primarily by the SIC taking into account also the autocorrelation functions of the residuals of the estimated models. Moreover, if the restriction $\beta = 1$ using the likelihood ratio test cannot be rejected, the restricted version of the error correction term is used in the joint estimation of the conditional mean and the conditional variance (VECM–GARCH model). Otherwise, the normalized cointegration vector is taken.

The Ljung-Box *Q*-statistic test for the remaining serial correlation of the standardized residuals (Q) and standardized squared residuals (Q^2) of the estimated models up to lag 30. The lower indexes *C* and *B* denote the equations where the dependent variable is Δ*cds* and Δ*bond*, respectively.

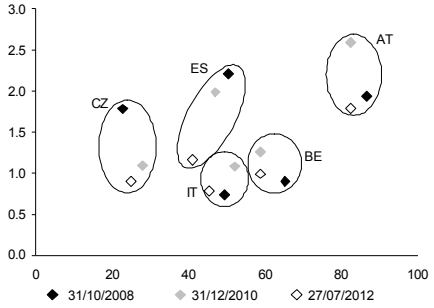
***, **, * stand for the 1%, 5%, and 10% significance level, respectively.

Additionally, the model was estimated separately for the Czech Republic for the financial crisis period, when the Czech CDS market and government bond market were both under significant pressure. The results suggest that during this period the price discovery process took place solely via CDS market, hence the CDS market was the leading market in the Czech Republic and the government bond market followed it, ensuring the correction of price discrepancies with respect to the long-run relationship.

The analysis suggests that the resulting leading position of the CDS market in the case of the Czech Republic was particularly important in the financial crisis period, when the Czech sovereign CDS spread increased significantly and exceeded even those countries which are currently in fiscal trouble (see *Figures 4–6*). There are several factors that might have contributed to the leading position of the CDS market. The first factor, which can be more or less generalized for any country, falls into the category of aggregate risks. Specifically, the fact that the sovereign CDS premium and the government bond premium might incorporate slightly different risks at the same point in time may influence the CDS market–bond market relationship (see section 2). The second factor is connected with phenomena such as the flight-to-liquidity and flight-to-quality effects, which might have contributed to a decrease in liquidity on the Czech government bond market in favor of demand for government debt of stable Western countries and hence might have influenced the relationship between the two premiums in the Czech Republic.

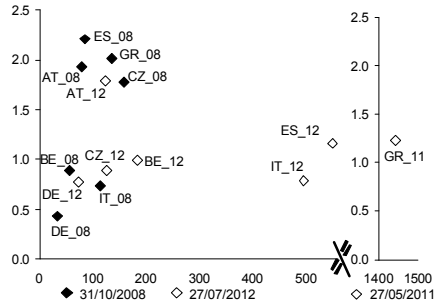
A third possible factor, which is more country specific, is connected with market size and the type of market participants on the sovereign CDS market. Due to the relatively small size of the Czech sovereign CDS market (see *Figure 7* and *Figure 8*), where the vast majority of active participants are foreigners, who are

Figure 7 Sovereign CDS Net Notional Amounts Outstanding versus Government Bonds Held by Foreign Investors (in %)
(x-axis: share of government bonds of given country held by foreign investors; y-axis: share of CDS net notional amounts outstanding in total government debt)



Note: The figures for Germany and Greece are not available.
Sources: CNB, DTCC, EIU, Eurostat, authors' calculation.

Figure 8 Credit Premiums on the Sovereign CDS Markets of the Analyzed Countries
(x-axis: sovereign CDS spread in bp; y-axis: share of CDS net notional amounts outstanding in total government debt in %)

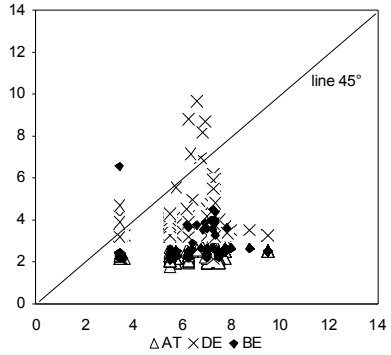


Note: For GR, the entire period under review ends in May 2011.
Sources: Bloomberg LP, DTCC, EIU, authors' calculation.

highly sensitivity to uncertainty about global developments and are unwilling or unable to distinguish between individual countries in detail, the Czech sovereign CDS market might have reacted to adverse market news hastily and more strongly than the Czech government bond market.

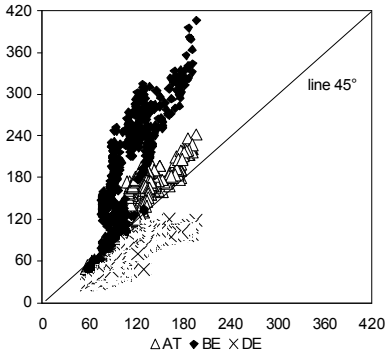
Both the market size and the type of investors might be influenced by the holding structure of the underlying government debt. For example, Austria has a relatively high share of government bonds held by foreign investors in comparison to the Czech Republic, thus interest in hedging Austrian debt differs from that in the Czech Republic (see *Figure 7* and *Figure 8*). A large part of Czech government debt is held by domestic financial institutions (the "home bias effect") and is often categorized as held-to-maturity, hence these investors may be less motivated to hedge via sovereign CDS contracts. Therefore, it can be assumed that sovereign CDS premiums are created mostly by more information-sensitive foreign entities.

Figure 9 Pre-Crisis Relationship of Sovereign CDS Spreads between Selected Country Groups and the Czech Republic (in bp)
(x-axis: CZ; y-axis: selected country groups; May 2006–August 2007)



Note: 5Y CDS spreads were used for the comparison.
Sources: Bloomberg LP; authors' calculation.

Figure 10 Relationship of Sovereign CDS Spreads between Selected Country Groups and the Czech Republic during the Debt Crisis (in bp)
(x-axis: CZ; y-axis: selected country groups; March 2010–July 2012)

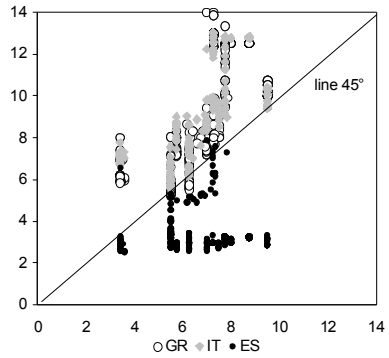


Note: 5Y CDS spreads were used for the comparison.
Sources: Bloomberg LP; authors' calculation.

4. Quantile Analysis of Cross-Country Spillover Effects Based on CDS Sovereign Spreads

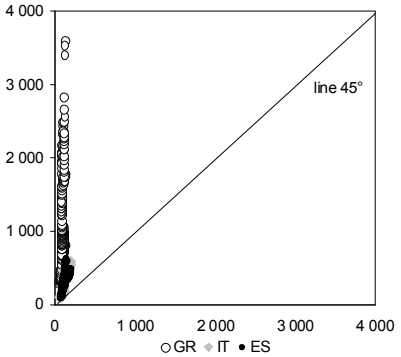
This part of the article addresses a phenomenon that lies at the centre of what we are currently experiencing: the phenomenon of sovereign-sovereign spillover. Financial spillover in general refers to a situation whereby instability in a specific market is transmitted to one or several other markets. Pure home contagion risk should be addressed if data or analytical tools show sizeable spillover risks and there is no convincing evidence that this is caused primarily by economic fundamentals or common shocks (Constancio, 2012). This part of the article is aimed at demonstrating to what extent the fiscal events on the periphery of the euro area have been

Figure 11 Pre-Crisis Relationship of Sovereign CDS Spreads between Selected Country Groups and the Czech Republic (in bp)
(x-axis: CZ; y-axis: selected country groups; May 2006–August 2007)



Note: 5Y CDS spreads were used for the comparison.
Sources: Bloomberg LP; authors' calculation.

Figure 12 Relationship of Sovereign CDS Spreads between Selected Country Groups and the Czech Republic during the Debt Crisis (in bp)
(x-axis: CZ; y-axis: selected country groups; March 2010–July 2012)



Note: 5Y CDS spreads were used for the comparison.
Sources: Bloomberg LP; authors' calculation.

transmitted to Czech sovereign risk, or, more precisely, to what extent the Czech sovereign risk premium—represented by the Czech sovereign CDS spread—is affected by the default risk of other sovereigns and to what extent by common market and fundamental factors. We followed the IMF (2009) quantile analysis method,[22] which is a suitable technique for explaining apparent non-linearities in data. It is clear from *Figures 9–12* that the co-movement of the sovereign risk premiums of the Czech Republic and the selected country is non-linear, as in the period of higher

[22] There are other available methods that can be used to investigate the contagion effect (e.g., Constancio, 2012). The transmission of negative shocks to the Czech Republic has already been analyzed by Claeys et al. (2012). Using a method based on a vector autoregression model, they concluded that up to 44% of the dynamics of Czech credit premiums can be explained by the dynamics of foreign premiums.

sovereign risk (expertly characterized as the period of crisis—see *Figures 10* and *12*) the Czech sovereign risk premium reacts more or less than proportionately to movements in the sovereign risk premium of the other country by comparison with the period when the sovereign risk level is lower (expertly described as the period of calm; see *Figures 9* and *11*).

Figures 9–12 show that the slopes of the notional regression functions between the Czech sovereign risk premium (x-axis) and the other selected sovereigns' premiums (y-axis) became steeper during the crisis (*Figures 10* and *12*). This increasing co-movement can be explained to some extent by rising market volatility or by other common market factors in crisis periods. Nevertheless, the magnitude of the change in slope across countries and time are also significant factors. The charts clearly show a flatter slope of the notional regression equation for fiscally stable countries (DE) and a small change in that slope across periods, and conversely a steeper slope for fiscally troubled countries (GR) or potentially fiscally troubled countries (ES, IT) and a relatively large change in slope across periods.

To obtain a more precise knowledge of the relationships between the sovereign credit premiums of the selected countries under review across periods we ran the regression equation (3) separately for five separate quantiles and estimated the risk transmission parameter ($\beta_{\tau,j}$). Ordinary least squares is the standard technique for estimating the required parameter. However, it provides information only about the mean relationship between the variables over the entire period of analysis and does not yield additional information on any change in the relationship within a non-standard time period such as a financial crisis. Quantile regression allows us to split the conditional distribution at the quantile and thus obtain the corresponding cross-section of the conditional distribution (Koenker and Basset, 1978). Using quantile regression makes it possible to evaluate the reaction of the dependent variable within particular segments of the conditional distribution (IMF, 2009). This situation manifests itself in an increased difference between the relationship obtained in the 1^{st}–5^{th} quantile relative to the 95^{th}–100^{th} quantile, or in a greater deviation from the mean of the distribution function. Intuitively, when the sovereign CDS spreads of a particular country are in their 5^{th} quantile (the left tail of their distribution), this suggests that the country is experiencing an extremely calm regime, whereas when the sovereign CDS spreads are in their 95^{th} quantile (the right tail), this suggests that the country is experiencing a depressed regime. We correct the co-movement of sovereign risk premiums for the effect of common aggregate risk factors such as market indicators of liquidity, volatility, and the business cycle as in IMF (2009, p. 16) in an effort to obtain purer sovereign spillovers.[23] Daily data on the five-year sovereign CDS spreads of the countries under review for the period of May 2006 to July 2012 were used to express the sovereign risk premiums. Following Adrian and Brunnermeier (2008) the sovereign spillover effect was measured using the following equation:

$$CDS_{CZ} = \alpha_{\tau} + \sum_{CZ}^{K} \beta_{\tau,CZ} R_{CZ} + \beta_{\tau,j} CDS_j \qquad (3)$$

[23] Unlike the average correlation presented in *Figure 3*, which reflects all the factors (fundamental, spillover, and common aggregate, without exception) affecting the co-movement of sovereign default risks.

Table 2 Co-movement of Sovereign Default Risks of Various Countries and the Czech Republic ($\beta_{\tau,j}$)

CZ	Quantile (τ)				
	5th	25th	50th	75th	95th
AT	0.85	0.75	0.66	0.58	0.49
BE	0.70	0.62	0.55	0.60	0.62
DE	0.98	0.96	0.87	0.75	0.65
ES	0.69	0.60	0.51	0.47	0.47
IT	0.84	0.77	0.75	0.74	0.78
GR	0.52	0.45	0.34	0.42	0.45

Note: The results are significant at the 1% level.
Sources: Bloomberg LP, authors' calculation.

where the Czech sovereign risk premium (CDS_{CZ}) is expressed as a function of the sovereign risk premium of country j (CDS_j) after correcting for the effect of the common aggregate risk factors (R_k) for different quantiles (τ). In other words, the estimated risk transmission parameter ($\beta_{\tau,j}$) expresses how the sovereign default risk of country j affects the Czech sovereign default risk (directly and indirectly) in different quantiles.

The results of the estimated parameter ($\beta_{\tau,j}$) (see *Table 2*) confirmed a non-linear regression relationship between the monitored sovereign risk premiums across quantiles, while in the period of calm (defined as the 5th percentile) the regression coefficients turned out to be higher across all the relationships analyzed than those for the case of market stress (defined as the 95th percentile). The co-movement of the sovereign risk premiums under review decreases with increasing percentile number. This might be related to a fundamental reassessment of the default risk of country sovereigns. Commonly, default is treated as a very low probability event in the valuation of debt issued by sovereigns. In the years before the crisis, the sovereign CDS markets were used rather sporadically for developed countries, including the Czech Republic, and were developed rather as a sideshow to the real markets for hedging sovereign exposures. Market investors, supported by the mechanics of the Basel II capital requirements (where the standardized approach assigns a risk weight of zero to domestic government debt), regarded government bonds as risk-free assets. As a result, market modeling (e.g., in term structure analysis) did not incorporate defaults among developed country governments. Previous research focused more on CDS on emerging market debt and, in the case of developed economies, on CDS on corporate debt and the determinants of government bond yields. Thus, besides the zero risk weight for sovereign risk, common aggregate risk-driving factors played a minor role. Overall, in the period of calm, market participants viewed developed sovereigns as a nearly homogeneous group of risk-free countries, and this led to underpricing of sovereign risks. Therefore, we can expect the estimated risk transmission parameters ($\beta_{\tau,j}$) to attain high levels in the 5th quantile.

However, due to the massive financial interventions and prolonged deep recession in the last few years, the public sector deficits and sovereign debts in many developed countries have increased to record-high levels and the risk of these countries defaulting has become real. This has led globally to a significant reassessment of sovereign risk and an increase in CDS trading, implying higher liquidity and

also volatility of sovereign premiums. This suggests the presence of common aggregate risk factors that have increased the cross-border co-movements of premiums, reflected in a higher average correlation among sovereign premiums (see *Figure 3*). However, sovereign risk premiums are affected by a multiplicity of factors. Besides common aggregate risk factors, fundamentals (the sustainability of sovereign fiscal positions) or strong flight-to-quality or flight-to-liquidity effects may be driving the sovereign risk premiums. As fundamentals (country-level effects) in particular have become more important in driving risk premiums during the debt crisis, along with increased risk aversion among investors (increasing $\beta_{\tau,CZ}$ with increasing percentile number) and portfolio shifting toward liquid safe-haven assets, the pure sovereign spillover effect ($\beta_{\tau,j}$) has decreased (the 95th quantile). This reflects the fact that market participants have perceived differences in the fiscal situations and economic outlooks of individual countries.

The estimated risk transmission parameters ($\beta_{\tau,j}$) turned out to be lower across all the relationships in the period of market stress. However, the Czech sovereign risk premium reacts differently to the premiums of the selected countries, i.e., it displays different sensitivity to the current adverse market situation compared to the other countries under review. This can be interpreted in simple terms as meaning that the Czech Republic is viewed neither as a "safe haven" (e.g., DE), nor as fiscally troubled (e.g., GR, ES, IT). The onset of the crisis was accompanied by the market effects of flight-to-quality and flight-to-liquidity by investors, and the government bond markets of fiscally stable countries (e.g., DE) faced increased demand by comparison with other countries, giving rise to a sharp decline in their credit premiums. On the other hand, countries with a high future probability of debt restructuring or potential fiscal problems (e.g., GR, ES, IT) saw an increase in their risk premiums.

From the information above one can tentatively conclude that the shock arising from the current European debt crisis was transmitted to the Czech sovereign risk premium. However, the fundamental or market factors driving its level dominated. Nonetheless, this market channel of sovereign risk transmission is clearly relevant and would probably increase in significance if market perceptions of the Czech Republic's sovereign risk were to take a turn for the worse.

5. Conclusion

This article analyzed the sovereign risk indicators for the Czech Republic—sovereign CDS spreads and sovereign yield spreads—and the relationship between them. In addition, we analyzed the sovereign-sovereign spillover effect based on sovereign CDS spreads to find out if the Czech sovereign risk premium is vulnerable to the current debt crisis event.

In the first part, we discussed the CDS spread as an indicator for measuring sovereign credit risk and the relationship between the CDS market and its cash market. We argued that contagion of an anomalous effect between the sovereign CDS market and the government bond market tends to be associated with the psychological transmission channel rather than the technical transmission channel. We identified three main limitations of the technical realization of contagion between those two markets.

Subsequently, in the second part, we tried to determine which of the two markets (the sovereign CDS market or the government bond market) is leading and which of them adjusts. The results showed that in the financial stress period a change in adverse news was reflected first in the sovereign CDS market and then in the government bond market in the case of the Czech Republic, hence the sovereign CDS market was the leader and contributed to price discovery.

In the final part of the paper, we analyzed the transmission of the European fiscal troubles (mainly from the periphery of the euro area) to the Czech sovereign credit premium based on quantile analysis. We concluded that the shock arising from the current debt crisis was transmitted to the Czech sovereign credit premium. However, the fundamental or market factors driving its level dominated. Moreover, the Czech premium reacts differently to the premiums of the selected countries, i.e., it displays different sensitivity to the current adverse market situation compared to the countries perceived as "safe havens" and the countries perceived as fiscally troubled.

REFERENCES

Adrian T, Brunnermeier MK (2008): CoVaR. *Federal Reserve Bank New York. Staff Report*, no. 348.

Alizadeh AH, Nomikos NK, Pouliasis PK (2008): A. Markov regime switching approach for hedging energy commodities. *Journal of Banking & Finance*, 32(9):1970–1983

Banque de France (2009): *Financial Stability Review*, Box 1. September.

Banque de France (2012): *Financial Stability Review.* April.

Blanco R, Brennan S, Marsh IW (2003): An empirical analysis of the dynamic relationship between investment-grade bonds and credit default swaps. *Bank of England, Working Papers*, no. 211.

Caceres C, Unsal DF (2011): Sovereign Spreads and Contagion Risks in Asia. *IMF Working Paper,* no. 11/134.

Claeys P, Vašíček B (2012): Measuring Sovereign Bond Spillover in Europe and the Impact of Rating News. *Czech National Bank, Working Paper*, no. 7/2012.

Constancio V (2012): Contagion and the European debt crisis. *Banque de France, Financial Stability Review.*

Cottarelli C (2012): Fiscal outlook and fiscal sustainability risks. *Banque de France, Financial Stability Review.*

Coudert V, Gex M (2011): The Interactions between the Credit Default Swap and the Bond Markets in Financial Turmoil. *Centre d'Etudes Prospectives et d'Informations Internationales*, no. 2011–02.

Czech National Bank (2012): *Financial Stability Report 2011/2012*. July.

Delatte AL, Gex M, López-Villavicencio A (2012): Has the CDS market influenced the borrowing cost of European countries during the sovereign crisis? *Journal of International Money and Finance*, 31(3):481–497.

Engle RF, Kroner KF (1995): Multivariate Simultaneous Generalized Arch. *Econometric Theory*, 11(1):122–150

European Central Bank (2009): *Credit default swaps and counterparty risk*.

Fontana A, Scheicher M (2010): An Analysis of Euro Area Sovereign CDS and Their Relation with Government Bonds. *ECB Working Paper*, no. 1271.

International Monetary Fund (2009): *Global Financial Stability Report*. April.

International Swaps and Derivatives Association (2010): *Comments on Sovereign CDS, News Release*. http://www.isda.org/media/press/2010/press031510.html.

Janáček K, Komárková Z, Hlaváček M, Komárek L (2012): Impact of the Sovereign default Crisis on the Czech Financial Sector. In: Czech National Bank: *Financial Stability Report 2011/2012*. July, pp. 118–128.

Kavussanos MG, Nomikos NK (2000): Constant vs. time-varying hedge ratios and hedging efficiency in the BIFFEX market. *Transportation Research Part E: Logistics and Transportation Review,* 36(4):229–248.

Koenker R, Basset G (1978): Regression Quantiles. *Econometrica*, 46(1):33–50.

Praet P (2012): *European financial integration in times of crisis.* Speech at the ICMA Annual General Meeting and Conference 2012, Milan, 25 May 2012.

Santis RA de (2012): The Euro Area Sovereign Debt Crisis Safe Haven, Credit Rating Agencies and the Spread of the Fever from Greece, Ireland and Portugal. *ECB Working Paper*, no. 1419.

Stulz RM (2009): Credit Default Swaps and the Credit Crisis. *NBER Working Papers*, no 15384.

Zhu H (2004): An Empirical Comparison of Credit Spreads between the Bond Market and the Credit Default Swap Market. *BIS Working Paper*, no. 160.