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Essays on government debt financing costs

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I. FOREWORD

I.1. Background, actuality

In the recent years, more and more countries had to face the problem that their government debt / gross domestic product quotients dynamics were not sustainable. The most important factors in this process were smaller growth, bad structural balance of the budget, and high financing costs of the government debt, which is related to the increasing sovereign yields. These three factors are closely related, but we can highlight that on the one hand, raising the growth rate and balancing the budget could be done by using either different (for example positive fiscal stimulus vs. fiscal tightening) or very unpopular measures (like making more flexible working laws, or raising the retirement age). On the other hand, it might be possible to reach success by decreasing the sovereign yields.

The primary market of government bills and bonds is one of the most important fields where financing costs of government debt are evolving. The primary market affects financing costs through the selling price of government bills and bonds. These securities are in many cases – as for example the domestic papers in Hungary - sold through auctions. Nowadays, two auction techniques (discriminatory and uniform-price auctions) are most commonly used for the sale of securities, specifically government bills and bonds. Since the selling price of the papers is influenced by the technique of the auction, a comparison of the discriminatory and uniform-price auctions would be helpful to determine which of the two most commonly used auction formats is the optimal allocation mechanism under given conditions.

The financing costs of the government debt are also strongly related to the country's credit risk, measured mostly through sovereign CDS spreads. This has two reasons. First, the foreign currency denominated bond yields can be decomposed to a risk-free yield (like the sovereign German Euro-yield or the USA Dollar-yield) and the rest of the bond yield, which is called bond spread. The bond spread is generally near to the CDS spread, and CDS spreads tend to

lead bond spreads (Alper et al. [2012]; Varga [2009]). Second, in the case of domestic bonds, the credit risk of the country also has a significant effect on yields on the longer terms. The credit risk premium of the local currency denominated bonds might be somewhat different from CDS spreads, but CDS spreads have a significant co-movement with long term domestic yields (Monostori [2012b], Monostori [2013e]). While sovereign credit risk and CDS spreads are very actual topics also in academia, our research question has some traditional background. Part III's objective is to empirically assess the role of country-specific fundamental determinants in shaping Eastern European relative CDS spreads.

Part IV is an application of the model to the Hungarian CDS spreads. In this case study we identify the country-specific determinants of the last years' processes of Hungarian CDS spreads.

I.2. Methodology

The expected revenue of uniform-price and discriminatory auctions cannot be ranked definitively based on analytical studies; therefore it may be appropriate to approach this issue on an empirical basis. The empirical evidence of real-world auctions provide a robust answer to the question of expected revenue; the uniform-price format coming out as more beneficial for the Treasury. Experiments fall into two categories: in the first case, comparison is enabled by the fact that the auction format of identical goods was changed from a given time, while in the other case, there were other treasuries to auction different products in a close-to-identical time interval with different methods. However, all experiments have been plagued by the identification problem, that is, the change caused by the auction method is difficult to tell apart from the effects of other circumstances. It would be a real scientific breakthrough, though, to set up a real-life experiment in which the same product would be sold simultaneously in both uniform-price and discriminatory auctions. Even though fewer conclusions could be drawn than in the previously proposed arrangement (due to the repetition of auctions), it would be instructive to see an experiment where primary market actors have

to submit bids for both auction formats, then the real format would be decided by drawing lots. We should note, however, that the experiment may increase the 'fog of war', i.e. the strategy space may become even more complicated and the number of possible equilibria may increase to extreme heights. Such an experiment could be a very important step in future work; however, it has to be supported by a bond issuer.

Hence, in Part II our methodology is a comparative analysis through the relevant literature about discriminatory and uniform price auctions. The same methodology is used by such important papers in this topic as Das & Sundaram [1997]; Binmore & Swierzbinski [2000], or in Hungary (Szatmári [1996b]), and the most recent Hungarian study of this subject, (Kondrát [1996]). The latter Hungarian papers focused primarily on models based on the unit demand assumption; whereas researchers have demonstrated that these findings are often not applicable to all of the multi-unit auctions, so a new review might be reasonable.

In Part III we take the traditional and simple methodological approach of Edwards ([1983]; [1985]) and a wealth of publications since to date. We adhere to the literature in assuming that most of the time series variation in CDS spreads are a result of common shocks to the pricing of risk and we concentrate the analysis on the other, cross-sectional aspect of CDS spreads by assessing which fundamental factors have been empirically important in explaining the relative riskiness of countries as proxied by the relative magnitude of these indicators. In terms of estimation methodology we use a time fixed effects panel regression on both the levels and changes of spreads and fundamental variables. We link the short-run dynamics with the relationship between variable levels through an error-correction term.

We lay emphasis on using a dataset that treats some empirical issues that, in previous studies, have often been disregarded. First, we use projections of future variables instead of actual data where possible. CDS spreads (and bond spreads) derive from expected future cash flows during the tenor of the instrument. Therefore it is arguably the expectations of the variables

influencing credit spreads (growth, budget balance, etc.) and not the actual data available at the time that matters. Using actual data instead of expectations introduces a source of error, and it will contaminate inference on how the variable affects spreads. This error will be larger for variables whose expectations are in general more volatile. Also, a mistake can be made in assessing the explanatory power of macroeconomic variables when comparing their actual data with financial time series. Though macroeconomic variables change (or are observed) infrequently, while financial indicators fluctuate on high frequency, it may be the case that the expectation of macroeconomic variables is just as volatile as the financial time series and that this explains more of the latter's variation than actual data. Second, we aim to reduce the adverse effects of variable omissions by including a larger and conceptually wider set of fundamental variables than usual in similar studies. Besides the standard macroeconomic variables, we incorporate data on the banking sector and use a set of political and institutional variables as well.

Principal components and factors are extracted from conceptually similar variables' groups and these are then used in CDS spreads' regressions to overcome problems of multicollinearity and the curse of dimensionality. To further limit adverse effects of variable omission, we attempt to make use of the extra information contained in credit ratings compared to that in our fundamental variable set.

Although we do not explicitly incorporate cross-section and time period heterogeneity of fundamental variables' effects in our baseline model, we do check the robustness of our general results on subsamples. Also, regressions are re-estimated on shorter time windows to gain an intuition on how coefficients have evolved through time.

In Part IV we apply the model from Part III to Hungarian data. We use simple descriptive statistics to analyze the latest developments. To quantify the two distinct effects on the relative Hungarian CDS spread, i.e. the worsening of fundamentals and the shift in investor preferences (the wake-up call effect),

we use the Oaxaca-Blinder decomposition (Blinder [1973]; Oaxaca [1973]). In particular we decompose the difference between the model-implied value for March 2012 due to the 2010-2012 period estimates and the model-implied value for January 2010 due to the full sample estimates.

I.3. Results

In Part II, theoretical models arrive at different rankings for expected revenue; however, they do reveal the relationship between the bids submitted and the auction technique. These results are confirmed both by 'laboratory' experiments and the empirical evidence of real-world auctions. The latter may also provide a robust answer to the question of expected revenue; the uniform-price format coming out as more beneficial for the Treasury. Still, at present the global majority of issuers of government bonds use the discriminatory-price format and central bank instruments also tend to be sold in this format. This is because issuers may have considerations other than expected revenue.

The main advantages of the uniform price auction method might be: higher expected revenue, low markup between the market price and the auction price (in the long-term average), and increased participation in the auctions.

The discriminatory auctions are able to reduce volatility, reveal the true valuations better, and hinder price-manipulations.

In the case of the auction of Hungarian government bonds, maximizing the expected revenue of the issuer may be important. Changing the auction format (or conducting an experiment into such a change) would be relevant if volatility remained persistently low with consistently high bid-to-cover ratios.

In Part III we study the relationship between relative sovereign CDS spreads and a wide array of relative country-specific fundamentals on Eastern European data between July 2008 and March 2012. We find a significant effect of growth expectations, banking system stability, government debt and the institutional-political background in the long-term relationship of relative CDS

spreads. Changes of these fundamental variables mainly affect CDS spreads gradually, through an error-correction mechanism. Contrary to other studies we do not find higher fiscal deficit being associated with higher CDS spreads, which may be a result of reverse causality between credit risk and fiscal balance. Our results suggest that some of the fundamental variable's impacts are time-varying and imply relevance of the wake-up call hypothesis.

In Part IV the model discussed in the previous part attributes the Hungarian CDS spread's relative increase to both a worsening of fundamentals (growth prospects and banking stability) and to a changing in investor preferences: government debt, one of the country's key weaknesses, has become more important in relative sovereign risk assessment.

I.4. Practice

While in Hungary, the Government Debt Management Agency (ÁKK) still uses the discriminatory format, a verification of the auction method might be particularly topical as, following similar steps by other treasuries, the public debt management agency of a country in the Central-Eastern-European region, Poland, switched to the uniform-price system in January 2012. Since a decrease of 1 basis point in the selling yields could spare the budget in the long term yearly more than one billion Hungarian Forints[1], this topic is important. The analysis may also be useful in reconsidering the form of auction for the central bank instruments introduced during the crisis and for the design of the format for the sale of any new instruments to be launched in the future.

Sovereign CDS spreads have received increasing attention in the past several years. The financial crisis of 2007-2008 and the ensuing sovereign crisis of the Eurozone periphery have increased activity in sovereign CDS

[1] The outstanding amount of Forint denominated government bills and bonds was 12 977 billion Forints in June 2013. Source: MNB. http://www.mnb.hu/Root/Dokumentumtar/MNB/Statisztika/mnbhu_statisztikai_idosorok/a-rezidens-kibocsatasu-ertekpapirok-adatai-kibocsatoi-es-tulajdonosi-bontasban/Havi_adatok_hu.xls

markets and broadened the market's scope from emerging markets with large bond portfolios in the pre-crisis era to the smaller emerging markets and eventually to developed economy sovereigns. Market participants used the instrument to either take a speculative position on the credit risk outlook of sovereigns, or to hedge credit risk exposure through bonds; whereas analysts, central banks and the financial media observed the market to gauge the perceived credit risk of sovereigns.

In economic policy debates, it is an often argued point whether the change of sovereign CDS spreads was based on fundamentals in a volatile environment[2]. Our model is able to estimate a relative CDS spread based on fundamentals, so the spread between the model-based and observed CDS spreads might have important information content in these debates.

In our model some coefficients seem to be sensitive to the selection of the country sample. Time-variation of parameters is supported by simple rolling regressions, pointing to an increase of government debt, banking stability and external balance in the assessment of relative riskiness of countries, which might be important in setting economic policy goals.

I.5. Own publications

Part II was discussed at the November 15, 2012 meeting of the Monetary Forum, it has been presented at several conferences and it is published in Hungarian in the Közgazdasági Szemle (Monostori [2013c]) and in English in MNB Occasional Papers (Monostori [2014]).

The author has also other publications concerning government debt financing costs. Monostori [2012b] at Hitelintézeti Szemle is a paper about risk premia of government bond yields. Another paper at Society and Economy (Monostori [2013e]) is about sovereign bond market liquidity developments on the Hungarian market. While the article in MNB Bulletin (Erhart et al. [2013])

[2] Policy makers (also Monetary Council members) often argue that observed CDS spreads will tend to fundamental-based eqilibria in the long term.

is not exactly about government debt financing costs, that topic (central banks' balance sheet strategies) is nowadays also related to the main topic of the dissertation.

Part III and Part IV are published only at conferences this moment (Kocsis – Monostori, [2013a]; Kocsis – Monostori, [2013b]); however another output of the same research will be submitted in the upcoming weeks to Economics of Transition. These parts are results of a common research with Zalán Kocsis (and Zsolt Kuti also had some significant contribution).

Also some further conference publications are worth mentioning. (Monostori [2013a]; [2013b]; [2013d]; [2012a]; [2012c]; [2012d]; [2011a]; [2011b]; [2010]).

I.6. Structure

The structure of the dissertation is as follows.

The main question of the following part (Part II) is: which one of the most commonly used (discriminatory- and uniform price) auction formats has the more beneficial effect on government debt financing costs. This part starts with an introduction, which is followed by theoretical models. Next, empirical (both laboratory and non-laboratory) evidences are presented which is followed by the description of the international practice. The part is finished by summary and conclusions.

In Part III, the main question is: which fundamentals are the most important country-specific determinants of sovereign CDS spreads in Eastern Europe. After the introduction and literature review, data and methodology are described. Next, we present the general results, the varying of the most important factors in time and robustness checks. Finally, we conclude.

Part IV investigates the Hungarian sovereign CDS spread's developments through our model in the last few years. After introducing and presenting the stylized facts, model explanations for the deterioration are shown. Then we give explanations for the residuals of the model, and finally we conclude this part.

Part V gives a summary about the most important results of the dissertation.

II. DISCRIMINATORY VERSUS UNIFORM-PRICE AUCTIONS

The financing costs of government debt are strongly affected by the selling price of government bills and bonds. These securities are in many cases – as for example the domestic papers in Hungary - sold through auctions. The selling price of a paper is influenced by the technique of the auction.

The purpose of this part is to compare the two auction techniques (discriminatory and uniform-price auctions) most commonly used for the sale of securities. Literature tends to analyze methods from the aspect of the expected revenue from the auction. Theoretical models arrive at different rankings for expected revenue; however, they do reveal the relationship between the bids submitted and the auction technique. These results are confirmed both by 'laboratory' experiments and the empirical evidence of real-world auctions. The latter may also provide a robust answer to the question of expected revenue; the uniform-price format coming out as the more beneficial for the Treasury. Still, at present the global majority of issuers of government bonds use the discriminatory-price format and central bank instruments also tend to be sold in this format. This is because issuers may have considerations other than expected revenue.

II.1. Introduction

The purpose of the paper is to give a comprehensive overview of literature to discuss if the uniform-price or the discriminatory auction format is the better allocation mechanism under given conditions. This review is particularly topical as, following similar steps by other treasuries, the public debt management agency of a country in the Central-Eastern-European region, Poland, switched to the uniform-price system in January 2012. The part concludes with a policy recommendation on whether it is expedient for the Government Debt Management Agency (ÁKK) to continue with

discriminatory auctions given the current state of the government bond market and the primary dealer system. The analysis may also be useful in reconsidering the form of auction for the central bank instruments introduced during the crisis and for the design of the format for the sale of any new instruments to be launched in the future.

In most countries around the world, the issued government securities are allocated through auctions, even though subscription-based syndicated issues did survive for quite some time in England and Japan, for instance. The across-the-board popularity of auctions is attributable to the fact that they assure the scheduled, regular, safe financing of public debt at a low cost and at a close-to-market price.

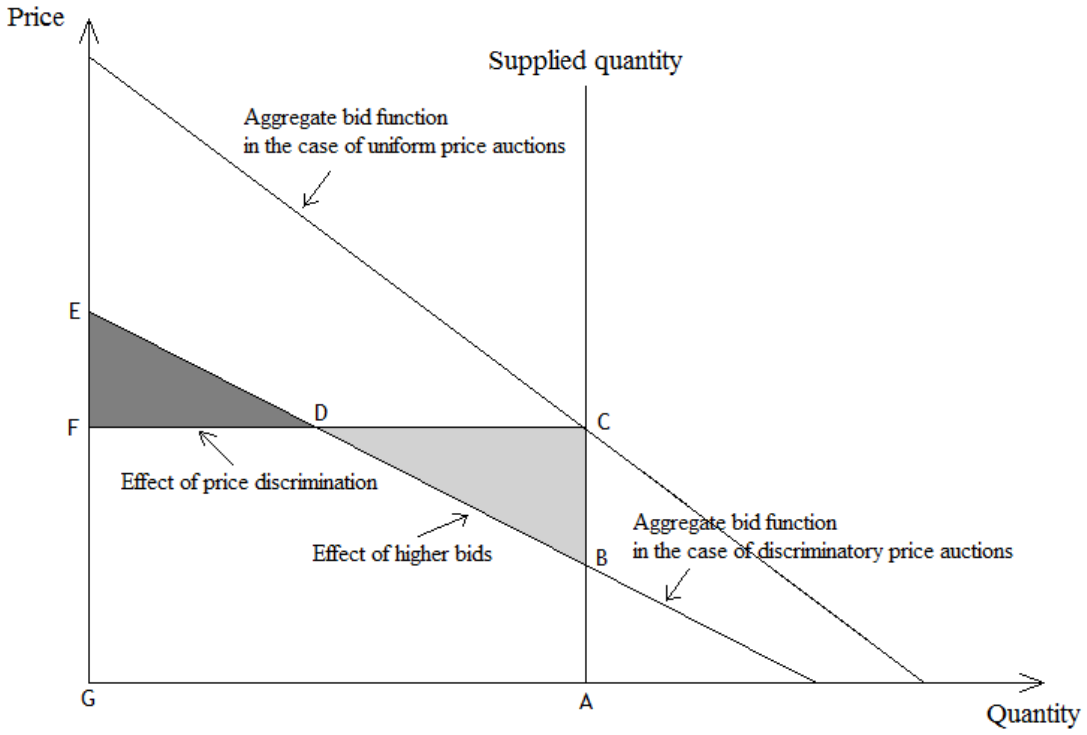
The two auction methods most frequently used in this area are discriminatory and uniform-price auctions. In both cases, the issuer ranks the bids received for the homogeneous products by price, in a descending order. Then it accepts bids in that order, going from highest to lowest, until the intended volume is taken up or all the bids are accepted. (That is, the highest bids for the given volume are accepted.) If at the lowest accepted price the quantity demanded is higher than the residual quantity of issuable products, then the residual quantity is distributed among bidders according to the proportions of their submitted bids at this price. The two formats differ in that while in discriminatory-price auctions financial settlement occurs at the different prices indicated in the bids, in uniform-price auctions the winning bidders all end up paying the price indicated in the highest rejected bid.

These two auction mechanisms have the following impact on the expected revenue of the auctioneer: while participants may be assumed to submit higher bids for uniform-price auctions[3], the average price of the accepted bids at discriminatory auctions may be increased by price discrimination *(Figure 1)*. Thus a switch to the uniform-price auction method may be successful in terms of expected revenue if the area between points BCD is larger than the opportunity cost DEF, therefore the revenue from the uniform-price auction

[3] Almost every accepted bidder pays less than their bid.

(ACFG rectangle) is greater than the revenue from the discriminatory auction (ABEG trapezoid).

***Figure 1*. Expected revenue from uniform-price and discriminatory-price auctions**



Source: own figure, based on (Kondrát [1996])

Even though literature tends to examine auctions mostly from the aspect of the expected revenue of the auctioneer, we should note that the Treasury may have other considerations as well[4]. These may include efficiency (i.e.

[4] As a very simple approximation for the effect on the expected revenue, we can state the following: the amount of the Hungarian Forint denominated government debt is approximately 13 000 billion HUFs (FX denominated debt is not allocated through auctions nowadays in Hungary: FX-bonds are allocated subscription-based at road shows, loans are naturally not auctioned). If another auction method could reduce the yields of the newly issued government debt, every basis point gained in the yearly yields could save around 0.01 percent for the state in the long term (when every previously issued paper ran out), that is ceteris paribus 1.3 billion HUFs yearly.

Later, in the chapter about the real-world empirical evidences, we will see that most authors have found a difference around 1-3 basis points between the revenue of the different auction methods. This might be on the one hand a significant amount for the state; on the other hand, this might be on the same order of magnitude as some distractions (like the change in

whether the goods end up at the participants that place the highest value on them), curtailing the possibility of collusion or other forms of manipulation, promoting competition (i.e., bringing the average auction price closer to the market price) or increasing the number of primary dealers. In the case of central bank instruments, diverting market prices may also be a priority.

Three main practical applications are generally examined in literature where a large volume of homogeneous goods are auctioned off: electricity auctions (e.g. Hudson [2000]), IPOs (e.g. Aussenegg et al. [2006]; Kandel et al. [1999]) and Treasury auctions. In this part I focus on the latter, summarizing the literature on Treasury auctions.

This part is all the more topical as in recent years several debt management agencies have switched from discriminatory-price auctions to uniform-price arrangements to sell government bonds (e.g. Poland in 2012, Korea in 2000 while Italy made the change in respect of government bonds already in 1988 in the wake of an experiment in 1985.) One might ask: should Hungary also make the change?

Furthermore, the comparison of auction methods may also be relevant because central banks tend to use the discriminatory method to auction their instruments; this is also the MNB's format of choice for all its auctioned instruments (1-week and 3-month FX swaps, 6-month variable-interest collateralized loans, FX auction). We should state right in the beginning, though, that different considerations may be relevant for the sale of central bank instruments and government bonds. As another motivation, the most recent Hungarian study of this subject[5] focused primarily on models based on the unit demand assumption (Kondrát [1996]), whereas researchers have demonstrated that these findings are often not applicable to all of the multi-unit auctions.

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liquidity premium which might also be affected by the changing market structure) or the estimation uncertainty.

[5] Important contributions to the Hungarian tradition of research into auctions include Kondrát [1996] as well as Szatmári [1996a; 1996b] and Eső [1997].

II.2. Theoretical results

II.2.1. Theorems for single-unit auctions

There is an ever more marked distinction in literature between single-unit auctions (e.g. art treasures, oil fields, mobile phone frequencies) and multiple-unit auctions (e.g., bonds, stocks, electricity) as the two scenarios may provide different incentives for the behavior of bidders. A number of papers (e.g. Binmore & Swierzbinski [2000]; Das & Sundaram [1997]) start the presentation of theoretical models with single-unit auctions. We also need to lay down some required theorems that will become important mostly for the interpretation of our results concerning multi-unit auctions.

The theorems described below apply to the simplest single-unit model: the non-repeatable auction of a single, indivisible, unique consumption (rather than investment) good where participants can be described by identical parameters, common priors, similar estimators and risk-neutral utility functions, however, their valuations of the good can be described with independent identically distributed random variables. During the auction the auctioneer has no discretion, the rules are set in advance, bidders know the rules and the identical distribution function for the valuations, then they make decisions to maximize their profits. In this scenario, for consumer goods the profit for losing bids is zero while for winning bids it is the difference between the valuation and the price paid. (Later, in the case of models assuming a secondary market, the profit for the winning bidder will be the difference between the selling price achievable on the secondary market and the price paid at the auction[6]. If the secondary market is introduced, the auction becomes a common-value auction.) The following five theorems are well-known in this field, and we will rely on them in later chapters. The first three theorems are illustrated in *Figure 2*.

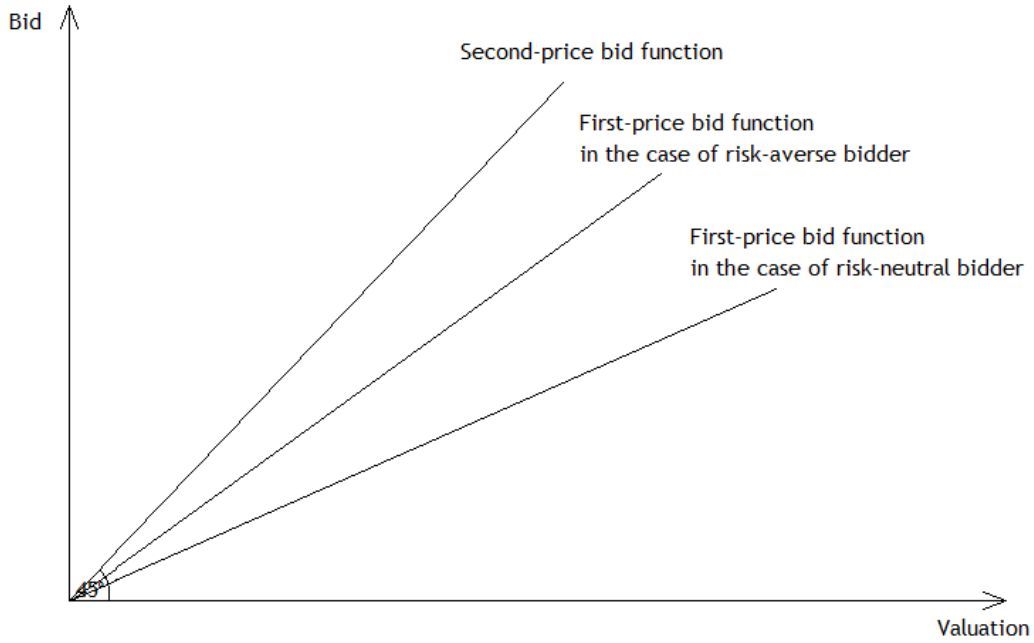
[6] However, this is only an assumption of the models. In reality, by a primary dealing system, primary dealers are not only motivated by the basis points between the selling price achievable on the secondary market and the price paid at the auction. They have rights and obligations as primary dealers, which might also influence their behavior.

- In the case of second price, sealed bid auctions the genuine, honest valuation should be submitted as the bid. (The optimum bid function[7] is the identity function, i.e., the 45 degree half-line.)[8] (Krishna, 2009, p.13.)
- In the case of a first-price sealed-bid auction a bid below the valuation is worth submitting for each valuation. (The optimum bid function on a first price auction yields a value below the identity function for any number of participants, since bidding the true valuation would rule a positive profit out.) (Krishna, [2009], pp. 14-16.)
- If we relax the assumption of risk-neutrality: in the case of a first-price sealed-bid auction the 'cowards are more aggressive' (i.e., at the same valuation, the more risk-averse player submits a higher bid because this way he will win a lower value but with higher probability). This also implies that in the case of risk-aversion, the expected revenue in a first-price auction is greater than that in a second-price auction (Krishna, [2009], pp. 38-39.).

[7] The bid function gives the bid submitted as a function of the valuation.

[8] This is because if a bid below the valuation is submitted, then, in contrast to the 'honest' bid, the participant gives up on cases where he could have closed the auction with a positive profit had he told the truth, while in the case of a bid above the valuation, a negative profit becomes possible. Everything else would be unchanged, so bidding the truth valuation is a weakly dominant strategy.

***Figure 2*. Relative position of bid functions**



Source: own figure

- Revenue equivalence theorem: if a few (not overly strict) additional conditions are satisfied[9], the expected revenue from the auction does not depend on the auction method (that is, for instance, the expected revenue from first-price and second-price auctions is the same, but the theorem has more general application). (Krishna, [2009], p. 28). (See the proof in *Appendix 1.*)
- Despite the equality of expected revenues, the different auction methods lead to different results at a number of points: e.g., the standard deviation of the expected revenue of first-price auctions is lower than that of second-price auctions (Krishna, [2009], p. 19-21).

[9] Conditions: the theorem applies to standard auctions (that is, the highest bidder wins) and the strictly monotonous increase of the bid function is a condition in such a way that participants submit a zero bid for a zero valuation while above that level they always submit a higher bid for a higher (private) valuation. (Their valuations are independent and identically distributed.) Proof of the theorem: (Krishna [2009], p. 28), a wit point of view: (Klemperer [2004]).

II.2.2. Misconceptions in connection with multi-unit auctions

Many economists have tried to apply the theorems stated for single-unit auctions more generally to multi-unit auctions as well, by assuming a similarity of first-price and discriminatory auctions and of second-price and uniform-price auctions. Undoubtedly, there is some similarity but the imperfect separation of single-unit and multi-unit auctions has led to a number of misunderstandings. The most common misconception is that bidders submit their real valuation as the bid in uniform-price auctions as well. The erroneous statements below are critically quoted, inter alia by Ausubel & Cramton [2002] and Binmore & Swierzbinski [2000].

Milton Friedman told the Wall Street Journal: 'A [uniform-price] auction proceeds precisely as [a discriminatory auction] with one crucial exception: All successful bidders pay the same price, the cut-off price. An apparently minor change, yet it has the major consequence that no one is deterred from bidding by fear of being stuck with an excessively high price. You do not have to be a specialist. You need only know the maximum amount you are willing to pay for different quantities.' (Friedman [1991], p. A8.).

In an interview with the New York Times (15 September 1991, 3:13) Merton Miller explained his view that in uniform-price auctions there is no incentive for bid shading: 'All of that is eliminated if you use the [uniform-price] auction. You just bid what you think it's worth.' (Miller [1991], p. 3.).

The Joint Report on the Government Securities Market written for the US Treasury, the SEC and the Fed, lay the ground for changing the auction format for government securities, and also started from the aforementioned misconception: 'Moving to a uniform-price method permits bidding at the auction to reflect the true nature of investor preferences. ... In the case envisioned by Friedman, uniform-price awards would make the auction demand curve identical to the secondary market demand curve.' (Department of the Treasury [1992], p. B21.).

II.2.3. Bid curves submitted in multi-unit auctions

However, several authors (e.g. (Fabra [2003]; Vickrey [1961]) have demonstrated that in the case of multi-unit auctions the uniform-price system does not guarantee bids to show real valuations. What is more: the revenue equivalence theorem is not satisfied in the case of multi-unit auctions. If the simplest single-unit model discussed in point II.2.1 is modified, ceteris paribus, so that a multi-unit auction is held and several types of bidders participate in the auction, then the discriminatory-price auction may result in higher expected auctioneer revenue than a uniform-price format.

This is because on the one hand participants in a discriminatory auction simply submit relatively flat bid curves that have a negative slope based on their marginal profit, which results in bids close to the market price in a competitive market. On the other hand, Back & Zender [1993], LiCalzi & Pavan [2005], Maxwell [1983] and Wilson [1979] have demonstrated, inter alia, that in uniform-price auctions a few large actors known to be well-informed may submit steep bid curves, thereby considerably increasing the marginal cost of other participants (because they would risk their additional demand significantly raising the price), reducing competition and depressing the final price. These results appear to be robust also to the modifications of Ausubel & Cramton [2002], Biais & Faugeron-Crouzet [2002] Engelbrecht-Wiggans & Kahn [1998] and Noussair [1994].

Ausubel and Cramton describe the phenomenon of steep bid curves in the case of uniform price auctions as follows: when the model enables a multi-unit bid for the participants, after the first bid (made on the honest valuation) every additional bid raises the expected price to pay for earlier own bids with a positive probability. Therefore, the bid curves will be steeper than the honest valuations, as the marginal revenue curve of a monopolist is steeper then its demand curve: at a minimal quantity, the two curves meet at the same price, but at every additional quantity the bidden price will be below the honest valuation of the additional unit. As a result of the steep bid curve of large actors, efficiency may also be compromised since in certain cases smaller participants may purchase goods having a lower valuation

relative to the large participants. On the other hand, uniform-price and discriminatory auctions cannot be ranked by efficiency. The extent of the demand reduction is effected by the market power of the biggest participants (Ausubel & Cramton, [2002]).

Viswanathan & Wang [2000] argue that the auction format yielding the highest expected auctioneer revenue depends on the circumstances: if non-competitive bids are submitted for very large amounts[10], the steep aggregate demand increases the expected revenue from uniform-price auctions while otherwise the discriminatory-price format yields higher revenues for the Treasury. Building on the work of Back & Zender [1993], Wang & Zender [2002] demonstrated that the uniform-price format does not dominate over the discriminatory system or vice versa, that is, either auction form may be more profitable than the other depending on the parameters. This was a major theoretical achievement because for a long time the so-called Friedman argument prevailed, considering the uniform-price format to be dominant due to the so-called 'winner's curse'[11] (Friedman [1959])

II.2.4. Winner's curse

In the context of the winner's curse the conditions of uniqueness and the consumption purpose of the auctioned goods are relaxed and we assume that participants bid to obtain investment goods at a price below the secondary market price. We also assume that there are several types of bidders in the market. Large actors (either because of their better analytical capacities or their greater role in the primary or secondary market) can predict the post-auction secondary market price more accurately than smaller ones; the latter shade their bids considerably due to the uncertainty of the expected secondary market price (Ausubel [1997]).

[10] These bids are awarded the same volume irrespective of the eventual price and bidders pay the average yield at the auction. They have priority over competitive bids that specify yields.

[11] Ausubel tried to split the concept into a single-unit scenario (winner's curse) and a multi-unit scenario (the phrase he suggested was 'champion's plague') (Ausubel [1997]). Though the latter phrase is also used by others, literature tends not to separate the two cases and uses the term 'winner's curse' for both.

In this event, in a discriminatory-price auction smaller actors may fear that their valuations (and bids) may be significantly higher than the market valuation; consequently they may sustain large losses on their winning bids. In the case of uniform-price auctions, however, the auction price in this model will not be significantly different from the post-auction secondary market price, and thus smaller actors may feel more confident to participate in the auction. The increased volume demand may send the revenue expected from uniform-price auctions above that of discriminatory-price auctions (Friedman [1959]; Milgrom & Weber [1982]; Bolten [1973])[12].

In connection with the entry of smaller actors in the market, it is worth differentiating between markets depending on whether they have a primary dealer system. While in a number of countries, including the Hungarian government bond market, such a system is in place, and thus very small participants could not enter the market even if the uniform-price system were used, Germany, for instance, has no such system; therefore more actors could be brought into the market by a switch to the uniform-price method. Furthermore, the models examining the winner's curse also fail to take into account the possibility of non-competitive bids, in which case the bidder only states the volume and receives the securities at the average auction price. The use of non-competitive bids is also common in the Hungarian government bond market, which may also mitigate the power of the winner's curse to restrain bids.

II.2.5. Risk aversion

Some studies, like the article of Harris & Raviv [1981] in which the benchmark model is modified by risk aversion of the bidders and multi unit auctions are enabled, also had a profound impact on literature.

Authors in these studies often use several theorems that have only been proven for single-unit auctions. They assume that the revenue equivalence

[12] As another important achievement, the article of Milgrom and Weber [1982] introduced into academic thinking the concept of correlated-value auctions to supplement private-value and common-value auctions.

theorem applies to risk neutral participants. The introduction of risk aversion should not change the optimal strategy (of 'truthfulness': submitting a realistic valuation) in the case of uniform-price auctions while in discriminatory-price auctions, based on the 'cowards are more aggressive' principle, participants will raise their bids to increase their chances to obtain large volumes at a lower profit compared to a risk-neutral scenario. Thus the higher demand results in a higher auction price in the discriminatory-price scenario (Kondrát, [1996]).

Several authors note that the introduction of risk aversion in itself is not necessarily legitimate. First, the profit achieved on auction bids is generally negligible compared to the total balance sheet of the bidding firm, thus risk plays a minor part in their decision. Second, the motivations of the person deciding about the auction bid are not necessarily the same as the motivations of the investor; therefore the principal-agent problem may raise additional questions in the context of risk aversion.

II.2.6. Fog of war

According to Binmore and Swierzbinski [2000], the fog of war is the danger that other players may not act rationally and/or the game has more than one equilibrium, which may make participants cautious. The simplest theoretical example for the fog of war is in the case of private-value, single-unit auctions of consumption goods. In this scenario the second-price system may be more favorable to bidders because irrespective of any other factors, they always need to submit their private valuation as the bid. This certainty showing the right bidding strategy may also intensify auction participation; therefore second-price auctions may be advantageous for the auctioneer as well.

To give an empirical example for the fog of war, there is evidence from auctions of investment goods with uncertain value (e.g., the auction of an oil field with an unknown quantity of oil) that the ascending-price (English, open ascending second-price) auction results in a higher price than the second-price, sealed-bid auction which is considered to be strategically equivalent in theoretical models. This is because bidders at auctions of investment goods

become less cautious if they see that their valuation is not far from the valuation of others. Empirical studies of government bond markets (e.g. Elsinger et al. [2012]) confirm that bids are significantly affected by market uncertainty.

As uncertainty may restrain willingness to participate, the designer of an auction is well advised to make the auction predictable (e.g. by the accurate specification of rules in advance) to increase demand.

However, the preference of second-price auctions cannot be extended to multi-unit auctions as preference of the uniform-price format. Binmore and Swierzbinski argue that uniform-price auctions entail more uncertainty than discriminatory-price auctions (more equilibria possible, a new entrant may cause major price swings, the quantity to be sold can often be changed, participants may employ mixed strategies, and assuming private valuation there is always greater uncertainty as to the outcome of the game), which may reduce demand (Binmore & Swierzbinski 2000).[13]

II.2.7. Secondary market, forward market, collusion

Bikhchandani & Huang [1993] assumed the existence of a secondary market in a model that contains two types of investors: the participants that are also present in the primary market have considerable analytical capacities while final investors only trading on the secondary market are price takers.

The high auction price also results in higher secondary market prices as it is possible to profit from existing own-account (long) positions; consequently, some major participants may have an interest in raising prices. This price raising strategy is much cheaper for a bidder (or a cartel) to implement in a uniform-price auction as a relatively small additional own demand may raise

[13] However we can also argue against the discriminatory auction. The differences and biases of the valuations may have an effect on the expected revenue. In the case of government bonds, bidders may have insider information, and their knowledge about each other (i.e. utility functions, risk aversion vs. profit maximizing) might be asymmetric. These could result in stronger bid shading and underbidding, which might decrease the expected revenue of the discriminatory method.

the price for each winning bidder. Consequently in this model the uniform-price auction yields higher expected revenue (in a single period).

In the longer term, however, it may be a more important consideration that price-increasing manipulations may undermine the efficiency of auctions[14] and deter potential bidders, thereby reducing demand.

A similar model was presented by Viswanathan & Wang [2000], but their version also contained the when-issued forward market, that is, participants could buy or sell securities at predetermined prices. In the United States this market is very important as numerous institutional investors (e.g. pension funds) purchase the quantities they need in advance; consequently, many bidders start the auctions with a short position (as they have not yet purchased what they have sold). In the aforementioned model there are two forces at play: on the one hand, the expected revenue of the auctioneer is higher because the items already sold may increase risk tolerance, while on the other hand the expected revenue may be reduced by the absence of high-valuation actors from the auction as their consumer surplus is absorbed by the participants of the primary market. According to the model, the resultant of these two forces is more favorable for the issuer in the case of discriminatory-price auctions.

The fact that many actors start bidding in a short position if a when-issued forward market exists may make puffing (price-enhancing manipulation) even more attractive because if the puffer manages to obtain a significant part of the securities issued, the actors that are stuck with their short positions will be forced to buy[15], driving prices even higher (short squeeze). A similar manipulation of Salomon Brothers was a major contributor to the launch of an experiment that resulted in the US Treasury introducing the right to change to quantity sold, post-auction re-issuance (where actors left in short positions may buy) and switching to uniform-price auctions. After the so-called

[14] This means that at the end of the day not all bonds are awarded to investors with the highest valuation.

[15] These involuntary post-auction purchases are called the loser's nightmare in literature.

'Salomon squeeze' it was demonstrated empirically that short squeeze was a frequent occurrence in the US market before the reform (Sundaresan [1994])[16]. The uniform-price format was adopted despite the fact that price-enhancing manipulation is cheaper to achieve in the case of uniform-price auctions than in the discriminatory-price format, where free-riders would also enjoy the benefits (Bikhchandani & Huang [1993]; Nyborg & Strebulaev [2004]). The US reform should rather be interpreted as intending to mitigate the winner's curse through the introduction of uniform-price auctions, expecting smaller actors to enter the primary market as a result. Curbing manipulation was much better served by the right to change the volume sold and the introduction of re-issues.

It should be noted that there are also price reducing cartels. In the case of uniform-price auctions collusion requires only the cheap end of the bid curve to be in the low price range. Thus any rogue cartel member can obtain only a small additional amount by submitting a higher bid. In the case of discriminatory-price auctions, however, the price-reducing cartel submits a flat bid curve, thus a rogue cartel member may win the entire volume at a slightly higher price. As price-cutting cartels are more rare (or at least short lived) under discriminatory-price arrangements, in this model this method yields higher expected revenues for the Treasury (Daripa [2001]). We should also note that it is in the interest of the issuer to prevent the rouge cartel member from being exposed, which is an argument for limiting transparency.

However, manipulation can be very effectively combated by reserving the right to change the issued quantity (Back & Zender [2001]; Damianov & Becker [2010]; Damianov et al. [2010]; Keloharju et al. [2005]; Kremer & Nyborg [2004a]; Kremer & Nyborg [2004b]); indeed, in certain cases it can be eliminated altogether (McAdams [2007]).[17]

[16] However, nowadays the repurchase agreements developed the opportunity to defend against short squeezes.

[17] There are situations; however, when the ex post modification of the quantity offered is not possible. Examples include IPO auctions (transparency is required in respect of the number of shares) or certain electricity auctions (no time to change the issued quantity). The study of

II.2.8. Summary of theoretical results

On the whole, the main argument against discriminatory-price auctions is that the fear of the winner's curse makes actors with limited analytical capacities shade their bids (last they win with a too high price) or even stay away from the market, which reduces demand. On the other hand, discriminatory-price auctions offer less room to powerful market players to exercise their market power than uniform-price auctions, which results in steep bid curves. Minor arguments for discriminatory auctions - possibly with weaker theoretical foundations - include the model that introduced risk aversion and the fog of war.

***Table 1*. Theoretical studies comparing uniform-price and discriminatory-price auctions**

Assumption different from the benchmark model	A paper focusing on the problem	Auction method with the higher
Multi-unit auction, steep bid curves	(LiCalzi & Pavan, 2005)	Discriminatory
Winner's curse	(Friedman, 1959)	Uniform-price
Risk aversion	(Harris & Raviv, 1981)	Discriminatory
Fog of war	(Binmore & Swierzbinski, 2000)	Discriminatory
Secondary market, forward market, collusion	(Viswanathan & Wang, 2000)	Discriminatory

Source: author's compilation

Even though there are several arguments for the higher expected revenue from discriminatory-price auctions, a number of studies consider the winner's curse to be the most dominant argument. Little is known about the resultant of these effects; indeed, it may vary depending on the circumstances which auction format brings the highest expected revenue to issuers.

An agent-based simulation reached a similar conclusion: in this study, bidders were able to learn and they were out to maximize long-term profits. Uniform-price and discriminatory-price auctions yield systematic differences in their outcomes and that difference is robust. In respect of the expected

LiCalzi and Pavan [2005] recommends that in such cases the issued quantity is changed according to a predetermined function. There should be a minimum price not much below the expected price, below which no bid is accepted; then as the auction price increases, so should the volume awarded increase (LiCalzi & Pavan [2005]).

revenue, when the bid-to-cover ratio is low, the discriminatory-price format is more favorable for the Treasury. Where the bid-to-cover ratio is high, the uniform-price system is more advantageous. The 'cross-point' (i.e., the level of bid-to-cover ratio where the uniform-price format becomes more advantageous) is sensitive to parameters, which explains the differences in research results (both analytical and empirical) (Koesrindartoto [2004]). A study (examining the telecommunications auctions in Europe) reaches the same conclusion: an auction format that works in one market may not be appropriate for another (Klemperer [2002]). Another paper concludes that uniform-price and discriminatory auctions cannot be ranked definitively based on analytical studies; therefore it may be appropriate to approach this issue on an empirical basis (Ausubel & Cramton [2002]). This is what we will do in the following chapters of this part.

II.3. Laboratory experiments

In laboratory experiments examining uniform-price and discriminatory-price auctions, bidders tend to be university students who receive compensation at the end of the experiment proportionate to the profit achieved in the game. The main problem with such studies is the time and funding constraints limiting experimentation.

Other experiments having quite an impact on literature included set-ups based on the unit demand assumption (Cox et al. [1984]; Damianov et al. [2010]), or where an open-outcry format was used (Mccabe, Rassenti, & Smith, [1990]).

Two experiments that are relevant for securities and that focused on sealed-bid multi-unit auctions are often quoted in literature. Smith's experiment of 1967 established a new school of thought; in this, the value of homogeneous goods was uncertain. Goods were sold on average for 96 percent of the expected value at uniform-price auctions, while at discriminatory-price auctions the corresponding figure was only 88 percent. As another lesson, the dispersion of bids was much higher at uniform-price auctions (steep bid curves) and many bids were above the expected value. However, this

experiment was also severely limited by time and financial constraints as only 18 goods were auctioned and bidders could submit bids for only two units (Smith [1967]). Another frequently quoted experiment was conducted in 1996 to focus on the efficiency of collusion. The main claim of the paper is that when bidders were allowed to communicate, a price-reducing cartel was easier to maintain in the uniform-price format; that is, the discriminatory-price auction yielded a higher expected revenue for the auctioneer. However, when no communication was possible, the uniform-price format resulted in higher prices, like in the previous experiment (Goswami et al. [1996]).

More recent experiments have confirmed that bidders tend to submit steeper bid curves in uniform-price auctions than in the discriminatory-price format (List & Lucking-Reiley [2000]; Engelmann & Grimm [2009]). Another experiment from 2006 that also allowed for changing the quantity offered confirmed that the uniform-price auction brings higher revenues but (to some extent in contravention to theory and other experiments) it also showed that participants formed more efficient cartels in discriminatory-price auctions than in the uniform-price format (Sade et al. [2006]).

The results of laboratory experiments are considerably more uncertain than real market experience as they rely on a number of simplifications: for instance, in most cases bidders were given homogeneous information and a round to simulate the secondary market is often omitted from the experiment. Consequently, actual Treasury auctions are worth analyzing; however, we should note that the steeper bid curves of uniform-price auctions were confirmed under laboratory conditions as well and results mostly showed that the uniform-price format yields higher expected revenues, which coincidence to most real-life observations described in the next chapter.

II.4. Non-laboratory empirical evidence

Comprehensive, international comparative studies of Treasury auctions are less common; there are only three frequently quoted examples in literature. Brenner, Galai, & Sade [2009] and Bartolini & Cottarelli [1997] collected the

bond auction methods used by the various countries while Sareen [2004] described the auctions of 8 countries in detail.

The overwhelming majority of empirical studies summarize the experiences of a single state treasury.

II.4.1. Empirical evidence of uniform-price auctions

Scalia looked at Italian auctions from the 1995-1996 period. He demonstrated that the mark-up of primary market actors at the various auctions depends on the number of participants, competition and the dispersion of bids but no participant can achieve a profit significantly different from 0 in the long term. As another lesson, the introduction of re-issues systematically reduces the volatility of secondary market prices between issues. This is because participants with short positions before the auction will be able to purchase the securities on the primary market later; therefore forcing a short squeeze will not be a profitable strategy for large actors. Even though this is not the focus of the article, it does summarize how the Italian auction arrangements developed. As a result of an experiment in 1985, uniform-price auctions were introduced for longer-term bonds in 1988 while short-term T-bills continued to be sold in the discriminatory format. However, the reliability of lessons to be learned from the switch is compromised by a number of other changes: the MTS system was introduced in the same year and re-issue auctions were started in view of the increased financing requirement and to prevent short squeezes (Scalia [1997]).

Bjonnes analyzed data from Norway to demonstrate that uniform-price auctions lead to underpricing, i.e., the steep bid curves of participants may result in a low price (below the Walrasian equilibrium price) (Bjonnes [2001]).

Keloharju et al. examined the individual demand curves of bidders in uniform-price auctions held in Finland between 1992 and 1999. Despite the low number of bidders (varying between 5 and 10) the authors found that market power only has a small effect on bids in practice; they are much more influenced by volatility in the secondary market: in a volatile environment bid curves are steeper and underpricing is common. The latter finding is

consistent with the results of Nyborg, Rydqvist, & Sundaresan [2002] for Swedish discriminatory-price actions. The observation that the mark-up of primary market actors did not depend on the number of auction participants is attributable to the fact that the Treasury determined the exact volume accepted only after the auction, which made manipulation more difficult. Furthermore, the Finnish Treasury does not determine the price at the point most advantageous for the current auction (maximizing short term profits) but regards issuance as a repeated game, therefore it tends to accept bids close to the estimated market price (Keloharju et al. [2005]).

Kandel et al did not focus on Treasury auctions but they are still much quoted; they examined 27 Israeli IPOs conducted in the 1993-1996 period through uniform-price auctions rather than by subscription. They found that aggregate demand was relatively flat. On the other hand, they observed an abnormal excess yield of 4.5 percent on the first trading day, which could not be explained by higher volatility, therefore the excess yield of the first day could have been the result of the underpricing caused by the uniform-price auction format (Kandel et al. [1999]).

II.4.2. Empirical evidence of discriminatory-price auctions

Looking at discriminatory US government bond auction data from the 1973-1984 period, Cammack found that participants at T-bill auctions had heterogeneous expectations concerning the post-auction secondary market prices. The average auction yields were 4 basis points higher than the corresponding secondary market prices in the period examined. The degree of underpricing showed a positive correlation with the expectations concerning the dispersion of bids, that is, if bidders expected a wide range of figures, underpricing tended to be significant. The auction results affected the secondary market: when bids showed a high variation, the disclosure of that fact pushed secondary market prices downwards. When the number of participants at the auction was higher than expected, prices rose on the secondary market (Cammack [1991]).

Hamao and Jegadeesh write that before 1989 the Japanese Treasury agreed on the subscription price of government bonds through negotiations with a syndicate of over 800 members consisting mostly of Japanese-owned banks and insurance companies. Under pressure from the US, between 1989 and 1990 40 percent of the 10-year bonds were sold at discriminatory-price auctions, the remaining 60 percent awarded to the syndicate at the average price in a non-competitive procedure, then in October 1990 the ratio of auctioned securities was increased to 60 percent. In their empirical study the authors analyzed the 1989-1995 period, concluding that the expected profit of auction participants was not significantly different from zero. Market uncertainty and competition had no significant impact on the mark-up of participants. On the other hand, profits were higher when the relative proportion of US actors was greater within the accepted bids and the proportion of Japanese bidders was smaller. Japanese participants tended to purchase large volumes simultaneously while Americans did not exhibit a similar homogeneity (Hamao & Jegadeesh [1998]).

Gordy states that the negative-slope bid curve can be seen as a sign of risk aversion. It indicates that the bidder has an idea about future secondary market prices and the greater the expected profit per bond, the higher the amount he is willing to risk. Even though for a long time it was thought in literature that participants can be considered risk neutral as, being large corporations, they bring only a negligible part of their assets to the auction, Gordy points to the principal-agent problem in that the manager deciding on the bid may be risk averse (for merely psychological reasons or driven by his private interest[18]). He used data from Portugal to empirically examine why participants submit several price-quantity bids. He found that by submitting more than one bid they could approximate their average yield to the average price of the whole auction, thereby reducing the probability of the winner's curse. The empirical evidence showed that the various actors submitted a large number of bids and their submitted bids showed the greatest variance

[18] The latter assumption contravenes the assumption used in more recent research that the portfolio manager may be a risk lover to earn his bonus.

when there was high volatility on the secondary market and the expected number of well-informed bidders was also high (Gordy [1999]).

Hortacsu set up a model in which continuous demand functions are generated. A number of real characteristics have been integrated into the model (private information, reserve requirements, secondary market) while it also has some major flaws. First, the number of auction participants is determined exogenously (whereas it would be reasonable for more participants to bid when the expected profit is higher), and second, the slope of the bid functions of participants is the same, which is contrary to empirical evidence. The article is often quoted as an empirical study, which is because the paper does contain statistical data about the Turkish government bond market. However, the empirical elements were mostly aimed at testing the model. Hortacsu recommends the model for simulation studies (Hortacsu, [2002])[19].

Hortacsu's model was augmented by Kang and Puller; their examination of the Korean discriminatory, then uniform-price auctions between 1999 and 2002 revealed that after filtering for the effect of the auction, the discriminatory-price format is slightly more advantageous both for the expected revenue and for efficiency (Kang & Puller [2008]). These results may not be surprising in light of the assumptions of the Hortacsu model (e.g., exogeneity of the number of participants). Korea switched to a uniform-price auction model in 2000.

Marszalec applied the models of Hortacsu [2002] and Février, Raphaele, & Visser [2004] to data from Polish discriminatory-price T-bill auctions. Both models yielded better outcomes for the discriminatory-price auction than for the uniform-price format (Marszalec [2008]. Nevertheless, the Polish central bank switched to the uniform-price auction format on 1 January 2012, but there is no in-depth analysis of the experiences with that system at the time

[19] There is also a new and upgraded version of that article (Hortacsu-McAdams, [2010]). We reviewed the older version here because that was augmented and applied by other cited authors in our article.

of writing of this dissertation. Based on anecdotal evidence from the Polish Ministry of Finance, the introduction of uniform-price auctions was driven by two expectations. First, they wanted to reduce the fear of the winner's curse and thereby increase demand and second, they expected volatility on the secondary market to decrease (because previously winning bidders with lower prices wanted to realize profits in the secondary market immediately)[20]. The profits of actors in the primary market decreased in excess of preliminary expectations, the average auction yield was lower than the mid prices on the secondary market (the difference reaching 6 basis points at times), and in certain periods it was below secondary market ask yields. Volatility on the secondary market (at the moments after the auctions) did not change significantly as a result of the switch to the uniform-price format. However, due to the low number of observations, we cannot rule out the hypothesis that the variance of yields has decreased.

Nyborg et al. examined data from Swedish discriminatory-price auctions between 1990 and 1994 and found that the volatility of yields significantly contributed to bid shading.[21] This phenomenon is attributable to the fear of the winner's curse (Nyborg et al. [2002]).

Elsinger and Zulehner examined the changes in the bids of various actors at discriminatory-price Austrian government bond auctions between 1991 and 2006. Bidders adapted to market circumstances (such as uncertainty, the number of bidders, the volume offered) in diverse ways: for instance, by the degree of bid shading or by changing the quantity demanded or the variance (steepness) of bids. Among market circumstances, market uncertainty (volatility) has the greatest effect on the following: degree of bid shading, individual variation of bidders, profits as well as the concentration of winning bids by participant; the demanded quantity is the only factor that does not

[20] This expectation contradicts the findings of several studies as literature tends to link higher volatility to uniform-price auctions.

[21] As Krishna puts it: bid shading (or as other authors would say: demand reduction) means that at a given price bids are submitted for smaller quantities than they would be based on the honest valuation (Krishna [2009]).

depend on volatility. According to the authors, these findings confirm the common-valuation condition of theoretical models; however, the fact that the concentration of winning bids increases in a volatile environment suggests that the assumption of the symmetry of bidders is not realistic (Elsinger, Zulehner, & Schmidt-Dengler [2007]). In a more recent study the same authors looked at the effects of Austria's EU accession on the government bond market. Before 1995 only domestic entities participated in issuances while after the EU accession intensifying competition significantly depressed yields and reduced the bidders' profit (Elsinger et al. [2012]).

Rocholl analyzed discriminatory-price German auctions from the 1998-2002 period. Similarly to the results of the Finnish paper (Keloharju et al. [2005]), he also found that the issuer, instead of maximizing its revenues at a single auction, sets the auction price close to the market price. This can be interpreted as the Treasury building up its reputation because it treats the issue as a repeated game. He also looks at the ratio of competitive to non-competitive bids. In Germany 30 percent of all bids are normally non-competitive while 50 percent of the accepted bids fall into this category. According to Rocholl, as volatility increases, more non-competitive bids are submitted while the price and quantity of competitive bids decrease and their dispersion increases. As an important finding, even though the auction is discriminatory, the profit of bidders is not significantly different from zero while literature tends to assume positive profits (Rocholl [2005]).

Discriminatory-price repo auctions in the Euro area were examined by two teams. Bindseil, Nyborg, & Strebuaev [2002] found that, unlike the empirical evidence of government bond auctions, the winner's curse and private information are not the driving forces for the outcome of repo auctions while secondary market yields and interest expectations have a major influence. They also concluded that large bidders achieved better average prices than their smaller counterparts. Bruno, Ordine, & Scalia [2005] found that large actors participate in auctions more regularly and submit less steep bid curves. The volatility of yields has a significant effect on bids: a volatile environment reduces the probability of bid submission and makes bids less dependent on

interbank yields. Linzert, Nautz, & Breitung [2006] examined the repo auctions of the Bundesbank and, similarly to the previous studies, they also found no evidence for the winner's curse but, as opposed to the experience of the ECB, they did not notice any significant effect of interest expectations on bidder behavior.

II.4.3. Empirical comparison of uniform-price and discriminatory-price auctions

The past decades have facilitated numerous empirical observations to compare discriminatory and uniform-price auctions. Experiments fall into two categories. The auction format of identical goods was changed at a certain point in time in Zambia, Germany and Mexico; a similar comparison was also made in the United States and the experiment of the IMF with the sale of gold also fall in this category. There were two experiments in the United States and one in Norway to auction different products in a close-to-identical time interval with different methods. However, experiments in both categories have been plagued by the identification problem, that is, the change caused by the auction method is difficult to tell apart from the effects of other circumstances. In order to avoid this problem, an empirical study was conducted in Switzerland, which we will describe after the aforementioned experiments.

Between 1976 and 1980 the IMF sold one fifth of its gold stock, with the comparison of auction formats among the objectives. This experiment demonstrated a significant advantage of the uniform-price format as the margin was approximately 6 basis points lower relative to the previous day's prices on the international gold market than in the case of discriminatory-price auctions (Feldman & Reinhart [1995]).

According to Tenorio's article, between October 1985 and January 1987 Zambia sold dollars to importers at auctions on a weekly basis on a total of 68 occasions, using a uniform-price format the first 42 times and discriminatory-price auctions from the 43rd auction onwards. In the course of the experiment the volume sold increased and the exchange rate of the kwachas declined.

The participants (particularly bidders submitting high bids) responded to the change of auction format with a delay. According to Tenorio, if we filter out other factors, uniform-price auctions yielded higher revenue due to the higher participation relative to the volume offered. It should be noted that the elimination of other factors relied on a large number of assumptions; furthermore, the Treasury used a minimum price at which bids were received regularly, which could have also had a significant effect (Tenorio [1993]).

Nautz [1995] analyzed the repo transactions of the Bundesbank where the central bank borrowed securities from credit institutions. The repo transactions were sold in uniform-price auctions up to 1988, then the discriminatory-price format was used. While uniform-price auctions brought steep bid curves and higher-than-market prices, which the authors attributed to the format (contrary to most of the literature), discriminatory auctions were afflicted by the winner's curse, therefore price levels were lower in later auctions. The Bundesbank attached great importance to whether the auction yields were close to the market yields and if not, how markets perceived that phenomenon. Empirical evidence showed that market yields responded significantly to auction results when the assumed effect of the auction method fell short of the customary: that is, when the price was lower than usual in uniform-price auctions or higher than usual in discriminatory auctions.

Umlauf examined the auctions of 30-day Mexican T-bills between 1986 and 1991. The discriminatory auction model was replaced by the uniform-price method in July 1990, facilitating the comparison of the auction methods as 181 discriminatory and 26 uniform-price issues occurred in the period examined. At the time of discriminatory-price auctions the 6 largest of the participants (out of the 25 bidders participating on average) submitting competitive bids won 72 per cent of the issued volume. This is because Mexican law did not impose sanctions on collusion at that time. The members of the presumed cartel sold in the secondary market the overwhelming majority of the T-bills purchased in the afternoon of the auction. Looking at the profits thus generated Umlauf found that the average cartel profit of 2.06

basis points measured at discriminatory auctions fell to an average of 0.44 basis points after the introduction of uniform-price auctions. Critics find it rather surprising that the cartel was able to achieve relatively low extra profits even before the rules of the game were changed; others explain this by the fact that the Treasury had considerable discretion in respect of the volume of issue, which made manipulation more difficult. Importantly, Umlauf also found that at times of volatility the margin was greater, which is explained by the fact that bidders with more limited analytical capacities vary their bids more for fear of the winner's curse. In the period examined, Mexico faced major macroeconomic challenges; consequently, the Treasury eventually decided for discriminatory-price auctions with a view to reducing the volatility of yields (Umlauf [1993]).

In the literature reviewed the only government bond market experiment that showed higher expected revenue from discriminatory auctions was conducted in the United States between 1973 and 1976. First, 6 uniform-price auctions were held, followed by 10 discriminatory auctions after August 1974. However, the low number of observations in itself detracts from the reliability of the conclusions, and the experiment did not allow for observing the learning process of bidders. The parameters altered in the course of the auctions included forward market trading (allowed or not), and interest rates were also modified. Simon demonstrated that even though there was little difference in the profit of bidders (0.34 percentage point), other factors must also be taken into account: with discriminatory auctions a 7-8 basis point saving can be achieved relative to the uniform-price format, which may cause a revenue drop of as much as 0.75 per cent for the Treasury (Simon [1994]). However, this is the study that had the most uncertainty in its methodology, which is indicated by the fact that other authors concluded from the same experiment that the greater demand at uniform-price auctions would be reflected in higher revenues for the Treasury in the long term (Tsao & Vignola [1977]) cited by (Mester [1995]).

Berg et al. concluded from data from Norway, Israel and Switzerland that the aggregate bid curve can be described with the same S-shaped function

irrespective of the auction format. Then they looked at data from Norwegian auctions between 1991 and 1996, when discriminatory-price auctions for short-term T-bills and uniform-price auctions for long-term government bonds ran in parallel. They assume that the distributions of the bids for short and long term securities can be described with similar parameters. Applying the empirical function they found that the uniform-price auctions of Norwegian bonds saved 24 basis points of taxpayer money on average and the same savings could have been achieved by the uniform-price auction format of short-term securities as well (Berg et al. [2000]). The latter result is hard to believe as the yields of short-term securities follow the expected curve of the central bank base rate all over the world (with the exception of high-risk countries).

In the second experiment conducted in the United States (1992-1998) two- and five-year bonds were sold at uniform-price auctions and other bonds continued to be offered under the discriminatory format. Nyborg & Sundaresan [1996] examined the profits achieved at auctions in 1992 and 1993 at both uniform-price (two- and five-year) and discriminatory-price auctions. In contrast, Archibald, Flynn, & Malvey [1995] compared the profits on two- and five-year bonds at the discriminatory auctions before the start of the experiment and the uniform-price auctions under the experiment. The main conclusion of the experiment is that uniform-price auctions entailed higher demand and stronger dispersion of bids. These observations are attributable to two reasons: large actors submitted steeper bid curves, and the mitigation of the winner's curse encouraged bidders with smaller analytical capacities to participate. None of the experiments showed major differences in the profit of bidders: the comparison of different asset classes in the same period brought mixed results, with a tendency to prefer uniform-price auctions, while research of the same bonds in different periods clearly showed a slight cost advantage of uniform-price auctions. As a result of the experiment, the Treasury switched to the uniform-price auction format for all of its instruments in 1998.

In order to avoid identification problems, Heller et al. transformed the aggregate demand curves of the Swiss uniform-price bond auctions to discriminatory demand curves, though they used strong assumptions for this purpose. The assumed that the uniform-price bids observed reflect actual demand, that is, no bid shading occurs, which contradicts a number of research results. They also assumed that valuations are independent and each participant is negligibly small. Briefly, under this procedure the bids received in uniform-price auctions were used to estimate the probable distribution of the cut-off price for the uniform-price format, then for the discriminatory format. Then, the estimated distribution of the cut-off price of discriminatory auctions was used to estimate hypothetical discriminatory-price bids, which in turn allowed for projecting the Treasury's revenue. Significantly higher expected revenues were found to apply to the uniform-price scenario (more than half percent funding advantage, which means a smaller spread in case of long-term bonds, naturally) (Heller & Lengwiler [2001]).

As a result of an experiment conducted in 1985, Italy has auctioned its long-term government bonds under a uniform-price format since 1988; Korea (2000) and Poland (2012) have also switched to uniform-price auctions. In contrast, Mongolia has replaced the uniform-price auction method by the discriminatory format, while the United Kingdom, for instance, uses uniform-price auctions only for its variable interest rate bonds (Kaminska [2010]). These scenarios may also allow for interesting research but we have not found any in-depth analysis of them in the literature surveyed.

Among others, Mester collects the empirical conclusions relating to the effect of auction format on expected Treasury revenues in a summary table (Mester [1995]). A more comprehensive set of titles is presented in *Table 2*.

***Table 2*. Studies comparing uniform-price and discriminatory-price auctions**

Academic article	Market	Between	Higher revenue	
			Uniform-price	Discriminatory
(Feldman & Reinhart, 1995)	IMF; gold	1976-80	x	
(Tenorio, 1993)	Zambia; USD	1985-87	x	
(Umlauf, 1993)	Mexico; T-Bill	1986-91	x	
(Simon, 1994)	USA; T-Bill	1973-76		x
(Tsao & Vignola, 1977)	USA; T-Bill	1973-76	x	
(Berg, Boukai, Landsberger, & Lengwiler, 2000)	Norway; T-Bill and T-Bond	1991-96	x	
(K. G. Nyborg & Sundaresan, 1996)	USA; T-Bill and T-Bond	1992-93	Difficult to decide	
(Archibald, Flynn, & Malvey, 1995)	USA; T-Bond	1991-95	x	
(Heller & Lengwiler, 2001)	Switzerland; T-Bond	1993-2000	x	

Source: own table based on (Mester [1995])

We can observe that in most empirical experiments spreads were smaller in uniform-price auctions. This seems to suggest that uniform-price auctions yield higher revenues for the Treasury[22]. It should be emphasized that all the thoroughly planned and controlled experiments (IMF, Norwegian and the later US experiment) lean towards the uniform-price format while the methodology of the (earlier US) experiment that recommended the discriminatory-price format is highly uncertain. Spreads of a few basis points may represent significant differences in Treasury revenues as maturities increase. It should be noted, however, that uniform-price auctions were suspended in Zambia to avoid the excessive devaluation of the kwachas and in Mexico due to the dominance of foreign investors submitting aggressive bids[23] and the volatility of yields (Kondrát [1996]).

However, experiments described in the literature covered have been plagued by the identification problem; in other words, the change caused by the auction method is difficult to tell apart from the effects of other

[22] However, in theory the auction format may also have an impact on the final investor (secondary market or forward) prices used for the comparison.

[23] The lesson that switching to the uniform-price format increased the weight of foreign actors may also be relevant for the Hungarian government bond market. The relationship between the role of foreign investors and the auction format is not discussed in any other study surveyed, though. This finding should be treated with reservation, though, as the auction format favourable for foreign (potentially large) actors may depend on the specific rules of the issuance, such as the right to change the volume.

circumstances. This problem could be resolved only with the use of strong assumptions. It would be a real scientific breakthrough, though, to set up an experiment in which the same product would be sold simultaneously in both uniform-price and discriminatory auctions. Even though fewer conclusions could be drawn than in the previously proposed arrangement (due to the repetition of auctions), it would be instructive to see an experiment where primary market actors have to submit bids for both auction formats, then the real format would be decided by drawing lots. We should note, however, that the experiment may increase the 'fog of war', the strategy space may become even more complicated and the number of possible equilibria may increase to extreme heights.

II.5. International practice

***Table 3*. Treasuries using the various auction methods**

Discriminatory	Uniform price	Both
Bangladesh	Argentina	Brazil
Belgium	Australia	Canada
Cambodia	Columbia	Ghana
Cyprus	Korea	Italy
Ecuador	Norway	Mexico
France	Singapore	New-Zealand
Germany	Switzerland	Sierra-Leon
Greece	Trinidad and Tobago	Slovenia
Hungary	USA	United Kingdom
Israel		
Jamaica		
Latvia		
Lithuania		
Macedonia		
Malta		
Mauritius		
Mongolia		
Panama		
Portugal		
Solomon Islands		
Sweden		
Turkey		
Venezuela		

Sources: National central banks; Morgan Stanley [2012]; Brenner et al. [2009]

Brenner et al. examined the countries using uniform-price government bond auctions and discriminatory-price auctions. They demonstrated in statistical terms that countries with market-oriented economies[24] and those that practice common law tend to use a uniform-price method, whereas those that are less market oriented, perhaps employ more severe restrictions on participation in auctions and practice civil law tend to use discriminatory-price auctions for the sale of government bonds. Countries employing uniform-price auctions are generally less corrupt and have a more simple business environment.

[24] Stock market capitalization as a percentage of GDP was used as a proxy for this.

Furthermore, the authors found that in countries with concentrated banking systems (the value of the assets of the three largest banks as a share of all banking assets is higher than a certain threshold) had a tendency to use discriminatory-price auctions. The authors explain this with the argument that as large primary market actors (mostly large banks) could obtain higher profits at discriminatory auctions, they try to influence auction rule makers in that direction (Brenner et al. [2009]).

The claim that discriminatory-price auctions favor large banks needs to be investigated further. It is indeed advantageous for large actors that bidders with smaller analytical capacities may shade their bids in discriminatory auctions for fear of the winner's curse or they may stay away from the auction altogether. However, collusion and other forms of manipulation (characteristic of large actors) tend to be present in the uniform-price format. Little is known about the resultant of these two effects. If we accept the part of the reasoning of the authors that discriminatory-price auctions favor large actors, we may explain this by the fact that in most countries uniform-price auctions are (also) organized with terms that make manipulation very expensive (e.g., through the ability to change the volume sold). Consequently, the dominant considerations may indeed be the winner's curse and the resulting bid shading, and we can assume that in reality, large banks benefit from discriminatory-price auctions.

II.6. Summary and conclusion

Uniform-price and discriminatory-price auctions cannot be ranked based on theoretical models by the expected revenue of the seller, and the format that is more advantageous in a given situation probably depends on the circumstances (bid-to-cover ratio, number of participants, market uncertainty, etc.).

The amount of evidence from ‘laboratory’ experiments is limited but it does coincide with real life experience. Empirical evidence shows that there are countries employing discriminatory-price auctions where the profit of bidders is not significantly different from 0 basis point (Germany, Japan), but

in most countries uniform-price auction would probably bring higher expected revenue for the issuer than discriminatory-price auctions do.

The data collected shows that globally there are more government bond issuers that employ the discriminatory-price format. The exclusive use of the uniform-price format is rare among countries similar to Hungary. Central bank instruments are also sold mostly under the discriminatory arrangement.

In addition to the aforesaid, the following conclusion drawn from the literature reviewed may be particularly relevant.

- Re-issues after the auction may reduce the success of manipulation strategies based on short squeeze, thus they may reduce the volatility on the secondary market (Department of the Treasury, [1992]; Scalia, [1997]).

- The right to change the volume offered decreases the probability of manipulation (Back & Zender, [2001]; Damianov & Becker, [2010]; Damianov, Oechssler, & Becker, [2010]; Keloharju, Nyborg, & Rydqvist, [2005]; Ilan Kremer & Nyborg, [2004]; Ilian Kremer & Nyborg, [2004]; McAdams, [2007]).

- A distinction can be drawn between pre-trade and post-trade transparency (see Balogh & Kóczán, [2008]). Pre-trade transparency (e.g., the clarity of rules) may be important in avoiding the fog of war (Binmore & Swierzbinski, [2000]). On the other hand, a high degree of post-trade transparency may be conducive to the survival of cartels as it may expose rogue cartel members (Kondrát, [1996]).

- If instead of pursuing short-term profits, the Treasury sets the cut-off price close to the market price, it may promote its reputation, which can be more profitable in the long run (Keloharju et al., [2005]; Rocholl, [2004]).

- An experiment with two types of auctions being held simultaneously for a given instrument could be a scientific breakthrough.

Even though studies of auction formats tend to focus on the effect on expected revenue, the issuer may have a number of other motives and the considerations to be used to optimize the choice are far from clear. **If the objective of the auction of a good is...**

- **... to maximize revenue:** empirical evidence indicates that the *uniform-price* format may be more advantageous in most markets in the long term (see the papers overseen in Table 2).
- **... to issue near the market price**: actually, this is the original question answered in Table 2. These papers are discussing the expected revenue through the differences between primary and secondary market yields. Empirical evidence shows that *uniform-price* auctions may bring lower average margins in the longer term, thus the outcome may be closer to the market price on average (see the papers overseen in Table 2). However, this is not necessarily true for individual auctions due to higher volatility on the primary market.
- **... to assure the continuity of financing and reduce volatility on the primary market**: there is empirical evidence that bids submitted in uniform-price auctions have a higher dispersion (Ausubel & Cramton, [2002]; Back & Zender, [1993]; Biais & Faugeron-Crouzet, [2002]; Engelbrecht-Wiggans & Kahn, [1998]; LiCalzi & Pavan, [2005]; Back & Zender, [1993]; LiCalzi & Pavan, [2005]; Maxwell, [1983]; Noussair, [1994]; Wilson, [1979]), thus prices may show greater variation and the *discriminatory-price* model may be more advantageous.
- **... to find out about honest valuations**: in contrast to earlier misconceptions (Friedman, [1991]; Miller, [1991]; Department of the Treasury, [1992]), the *discriminatory-price* model is likely to be more favorable (because in the uniform-price format bidders may submit steeper bid curves than their valuation would justify (Ausubel & Cramton, [2002]; Back & Zender, [1993]; Biais & Faugeron-Crouzet, [2002]; Engelbrecht-Wiggans & Kahn, [1998]; LiCalzi & Pavan, [2005]; Back & Zender, [1993]; LiCalzi & Pavan, [2005]; Maxwell, [1983]; Noussair, [1994]; Wilson, [1979])).

- ... **to increase the number of bidders and strengthen the role of the primary market**: the *uniform-price* auction is preferred, because of the less significant winner's curse (Ausubel, [1997]; Bolten, [1973]; Friedman, [1959]; Milgrom & Weber, [1982]), as also shown by empirical evidence (Archibald, Flynn, & Malvey, [1995]).
- ... **to increase efficiency**[25]: no ranking is possible on an analytical basis but experiments and the empirical studies based on the Hortacsu model favor the *discriminatory-price* format (Hortacsu, [2002]).
- ... **to prevent collusion**: based on both theory (Bikhchandani & Huang, [1993]; Daripa, [2001]; Nyborg & Strebulaev, [2004]) and laboratory experience (Goswami, Noe, & Rebello, [1996]; Sade, Schnitzlein, & Zender, [2006]), *discriminatory-price* auctions are more favorable, while there is analytical and empirical evidence that the exact rules of the auction (e.g., right to change the volume sold) have the greatest effect on the possibility of collusion (Back & Zender, [2001]; Damianov & Becker, [2010]; Damianov, Oechssler, & Becker, [2010]; Keloharju, Nyborg, & Rydqvist, [2005]; Ilan Kremer & Nyborg, [2004]; Ilian Kremer & Nyborg, [2004]; McAdams, [2007]).
- ... **to orientate the market price** (in the case of central bank instruments): difficult to answer because the reviewed literature has not examined this issue. As there is no empirical study available, we should take a theoretical approach. Market price is probably best oriented if there are more participants or high-volume bids in the auction, in which case the auction price may have a greater impact on the secondary market as well. The problem of bidders may be interpreted as a private-value auction (i.e., not as a common-value auction frequently studied in literature), that is, bidders do not ask the simple question of how to win instruments below the post-auction market price. Instead, banks would like to obtain cheaper funds even if they have to pay the price of reputation risk ('stigma effect' that can be evaluated bank by bank because participation in FX swap and

[25] An auction is efficient if the goods are awarded to those bidders whose honest valuation is the highest.

central bank credit auctions may be seen as a sign of difficulties in raising funds in the money market, which may raise the risk premium of the bank concerned: stigma effect). This problem may turn the entire auction into a private-value auction due to the private valuation of the reputation loss. Assuming risk aversion, a private-value auction may result in bids being submitted at discriminatory-price auctions even at a smaller 'expected financial gain – reputation loss' difference because the price a bank paid for the funds if their bid is accepted will be known. In contrast, in the case of uniform-price auctions the high degree of 'fog of war' means that bidders may be uncertain about the bid price and less clear about the expected financial gain. The above reasoning relies on a large number of assumptions. Consequently, more studies and model experiments would be needed on the subject of the orientation of market prices. In the case of central bank instruments currently sold at auctions (one-week and three-month FX-swaps, six-month variable interest rate collateralized loans, FX-auctions) the orientation of the market price may be important, and several factors may need to be taken into account.

Overall, for the time being there seems to be no strong argument for the adoption of the uniform-price format in the case of central bank auctions, in contravention to the international practice of central banks, thus discriminatory-price auctions may continue to be appropriate allocation mechanisms.

In the case of the auction of government bonds, maximizing the expected revenue of the issuer may also be important. In this respect the overwhelming majority of empirical evidence shows that uniform-price auctions have an advantage of a few basis points or at least the average profit of bidders was lower in uniform-price auctions in most of the cases reviewed. It should be noted, however, that discriminatory auctions may be more advantageous in an uncertain market environment or where the bid-to-cover ratio is low. Consequently, amidst the present uncertainties, switching to the uniform-price format could be hazardous. Changing the auction format (or conducting

an experiment into such a change) would be relevant if volatility remained persistently low with consistently high bid-to-cover ratios. However, the adoption of the uniform-price format may be worth considering under better market conditions in the hope of cheaper funding. In order to suppress the possibility of manipulation, in the uniform-price system it is particularly important for the issuer to be able to change the volume sold, and the success of a switch depends to a large extent on the probability of the market entry of smaller participants, thus also on the characteristics of the primary dealer system. The publication of an in-depth study on the change implemented by the Polish treasury in 2012 could shed light on important considerations for the Hungarian auction system.

III. COUNTRY-SPECIFIC DETERMINANTS OF SOVEREIGN CDS SPREADS: THE ROLE OF FUNDAMENTALS IN EASTERN EUROPE

The financing costs of the government debt are strongly related to the country's credit risk, measured mostly through sovereign CDS spreads. This has two reasons. First, the foreign currency denominated bond yields can be decomposed to a risk-free yield (like the sovereign German Euro-yield or the USA Dollar-yield) and the rest of the bond yield, which is called bond spread. The bond spread is in generally cases near the CDS spread, and CDS spreads tend to lead bond spreads (Alper, Forni, & Gerard [2012]; Varga [2009]). Second, in the case of domestic bonds of riskier countries, the credit risk of the country also has a significant effect on yields on the longer terms. The credit risk premium of the local currency denominated bonds might be somewhat different from CDS spreads, but CDS spreads have a significant co-movement with long term domestic yields (Monostori [2012b]; Monostori [2013e]).

In this part we study the relationship between relative sovereign CDS spreads and a wide array of relative country-specific fundamentals on Eastern European data between July 2008 and March 2012. We find a significant effect of growth expectations, banking system stability, government debt and the institutional-political background in the long-term relationship of relative CDS spreads. Changes of these fundamental variables mainly affect CDS spreads gradually, through an error-correction mechanism. Contrary to other studies we do not find higher fiscal deficit being associated with higher CDS spreads, which may be a result of reverse causality between credit risk and fiscal balance. Our results suggest that some of the fundamental variable's impacts are time-varying and imply relevance of the wake-up call hypothesis.

III.1. Introduction

Sovereign CDS spreads have received increasing attention in the past several years. The financial crisis of 2007-2008 and the ensuing sovereign crisis of the Eurozone periphery have increased activity in sovereign CDS markets and broadened the market's scope from emerging markets with large bond portfolios in the pre-crisis era to the smaller emerging markets and eventually to developed economy sovereigns. Market participants used the instrument to either take a speculative position on the credit risk outlook of sovereigns, or to hedge credit risk exposure through bonds; whereas analysts, central banks and the financial media observed the market to gauge the perceived credit risk of sovereigns.

Like sovereign bond spreads, CDS spreads depend on default risk. In CDS contracts, the buyer of protection pays a regular fee, the CDS spread, for the conditional payment of the cost of default (notional minus the recovered amount on the cheapest-to-deliver bond) in case such event materializes. The increase in the probability of default or the decrease in the recovery rate increase the expected conditional cash flow for the buyer of protection, for which sellers of protection will demand higher CDS spreads.

CDS spreads have several informational advantages over sovereign bond spreads. First, CDS markets are in recent years much better in terms of market liquidity (depth, breadth, resiliency, immediacy and tightness) than foreign currency denominated bond markets in Eastern Europe. What is more, second, several studies have shown that CDS spreads tend to lead bond spreads in price discovery (e.g. Alper et al. [2012]; Varga [2009]). Third, unlike bond spreads, CDS spreads are available for fixed maturities. Fourth, taking a long position in the bond market requires more funding liquidity due to the payment of notional, while taking a short position has been even more difficult, if not impossible, in some markets[26]. Fifth, bond spreads might

[26] This might also have caused bond spreads to behave sticky at low yields, since they are difficult to sell short (Varga [2009]). However, after the 2012 European Union regulation on naked short positions (decided in March 2012 by the European Council, entry into force in November 2012), CDS spreads are influenced in a similar way.

contain not only credit risk premium, but also liquidity risk premium[27]. All in all, especially for our sample between July 2008 and March 2012, these factors may cause larger deviations from the theoretical default risk component in the bond market than in CDS markets.

There are several channels through which fundamental factors (economic, financial, institutional, political circumstances) affect default risk and hence sovereign CDS spreads. On the basis of reasons for default, we can separate a short-term inability to pay (financing) aspect and a longer-term (sustainability or solvency) aspect. In the first case, the government is unable to finance maturing debt and coupon payments on time, which is a consequence of the inability to generate liquid resources via tax revenue, revenue from asset sales, bond market issuances or accessing loan facilities of international organizations. Default risk is lower in this respect if - compared to short-term debt obligations - there is large fiscal revenue and primary sufficit at the sovereign's disposal, if new government debt issuance is running smoothly and if there are international official resources accessible in case of need. The currency denomination of maturing debt and of government resources may also be important in times of financial turbulence, when it is difficult to obtain foreign exchange liquidity, hence the trade and current account and the level of international reserves may be important.

On the other hand the sustainability or solvency aspect of debt repayments constitutes a longer-term viewpoint on credit risk. Sovereign debt is sustainable if its path – as a ratio to resources, in effect to GDP - is non-explosive[28]. In economic (policy) terms we can consider debt sustainable if fiscal policy can stabilize the dynamics of the debt path – as a ratio of GDP - by enacting appropriate measures. Once above a critical threshold of this

[27] However, in the case of CDS spreads there are other factors that might influence yields. 1) Since the „voluntary restrucuring" in Greece (2012), which was not a trigger for CDS's according to the ISDA definition, the credibility of the CDS product declined. Although, the finally introduced collective action clause (CAC) triggered CDS payouts, the loss in the credibility of CDS's was persistent. 2) Another factor is partner risk.

[28] A deep empirical investigation about the sustainability of Hungarian government debt: (Ábel & Kóbor [2011]).

ratio, feedbacks may emerge between the debt ratio and the effective interest rates that the sovereign has to pay on debt, while fiscal tightening may not be effective due to output costs. In this case, default is unavoidable at some point in time in the future unless some exogenous factor breaks the debt ratio's explosive dynamics.

Sustainability also has a political side. Since governments cannot be declared bankrupt by court the way corporations can, they default either if they effectively run out of financial resources to honor oncoming debt obligations (the financing ability aspect) or if there is a political decision not to pay. The willingness to pay is in most cases dependent on the social and economic costs of debt servicing. Large shares of debt servicing relative to national income, reform fatigue from constant fiscal austerity measures and the perception of being in the above mentioned debt trap all increase the chance of such political decisions. On the other side the adverse consequences of default - exclusion from debt markets, and higher long-term interest rates once new issuance is possible[29], the immediate need to balance the budget, risks to the balance sheet of the banking sector, reputational costs - may hold politicians back from making such decisions.

Hence a country's macroeconomic and financial variables, but also political and institutional factors play a role in determining the default risk of the sovereign. A higher growth rate, balanced budget, low interest payments on debt, a lower gross or net debt stock to GDP, developed market infrastructures that are resistant to financial market stress, international aid or loan facilities, government's political background that has both wide legitimacy and the willingness to service debt [30] are some important fundamental factors. Also, the balance sheets of the private sector and the

[29] An interesting approach can be read in (Benczur & Ilut [2009]).

[30] However, the information about the willingness to service debt is asymmetric between governments and investors. An interesting model related to this is presented in Szűcs et al. [2010].

banking system are important due to the conditional liabilities these mean for the government due to the potential need for bailouts.

However, most empirical studies find that sovereign credit spreads (foreign currency bond spreads or CDS spreads) cannot be adequately explained by country-specific fundamental variables. The literature is diverse regarding attempts at describing the remaining part of credit spreads.

While we deal with these in more detail in the next chapter, the main directions have been the following. A large number of papers examine the non-country-specific part of spreads to identify the type of cross-border effects. Several studies deal with the general correlation between spreads, which is described as the spreads' systemic component. This component is mostly interpreted as risk pricing or risk appetite and is usually either identified by using the VIX index as a proxy or extracting the first principal component of sovereign spreads.

The separation of fundamental default risk and risk pricing is however not straightforward as risk pricing may have an impact on default risk itself. If auctioning of new government debt fails due to a shock to general risk appetite, this may lead to an increased default risk by hindering the sovereign's ability to honor maturing debt. It may also lead to sustainability worries due to an increase in interest rates – which increases the debt servicing cost - and due to a depreciation of the exchange rate - which increases the value of foreign currency denominated debt in terms of domestic GDP. This self-fulfilling potential is more relevant in countries where fundamentals are already initially worse, i.e. when there is a large stock of maturing debt that can only be financed from the market and/or if there is a large relative stock of government debt and foreign currency debt in particular.

Besides systemic risk repricing, there are other forms of cross-border shocks to sovereign spreads. These risk transmissions, which can be explained due to similarity of fundamentals (e.g. macroeconomic or financial linkages between countries) are often called *spillover*, while unexplained extreme co-

movements are referred to as *contagion*. The wake-up call hypothesis on the other hand considers the case when shocks to one country's spreads contaminate countries with similar fundamentals owing to market participants realizing the importance of those fundamentals.

A strand of the literature aims at separating and identifying country- or instrument-specific factors in spreads beside the default risk component, such as a liquidity premium, components related to specificities of the instrument (e.g. specific features of bonds), or institutional factors characteristic of the market. These are more relevant in case of sovereign bonds, yet CDS spreads may also be affected. For example, recent Europe-wide restriction on naked short CDS positions (holding CDS spread protection without a long sovereign position) have acted to decrease spreads by structurally restraining one side of the market.

This part's objective is to empirically assess the role of country-specific fundamental determinants [31] in shaping Eastern European. We take the traditional and simple methodological approach of (Edwards [1983]; [1985])[32] and a wealth of publications since to date. In doing so, we do not endeavor to elaborate on the theoretical underpinnings of various factors' impacts nor do we attempt to distinguish between different channels (e.g. default risk or liquidity risk) through which variables affect spreads; we rather keep the focus on variables' reduced-form effects on spreads.

We adhere to the literature in assuming that most of the time series variation in CDS spreads are a result of common shocks to the pricing of risk and we concentrate the analysis on the other, cross-sectional aspect of CDS spreads by assessing which fundamental factors have been empirically important in explaining the relative riskiness of countries as proxied by the relative

[31] The main role of fundamentals might be that we (and the market) are trying to forecast the risks and the price of risks through the fundamentals.

[32] In the traditional work of Edwards, the non-paying event is determined in a logistic way, and with some assumptions (what is concerned exactly by the non-paying event, what is risk neutrality, etc.) the final estimation equation can be derived.

magnitude of these indicators. In terms of estimation methodology we use a time fixed effects panel regression on both the levels and changes of spreads and fundamental variables. We link the short-run dynamics with the relationship between variable levels through an error-correction term.

We lay emphasis on using a dataset that treats some empirical issues that, in previous studies, have often been disregarded. First, where possible we use projections of future variables instead of actual data. CDS spreads (and bond spreads) derive from expected future cash flows during the tenor of the instrument. Therefore it is arguably the expectations of the variables influencing credit spreads (growth, budget balance, etc.) and not the actual data available at the time that matters. Using actual data instead of expectations introduces a source of error, and it will contaminate inference on how the variable affects spreads. This error will be larger for variables whose expectations are in general more volatile. Also, a mistake can be made in assessing the explanatory power of macroeconomic variables when comparing their actual data with financial time series. Though macroeconomic variables change (or are observed) infrequently, while financial indicators fluctuate on high frequency, it may be the case that the expectation of macroeconomic variables is just as volatile as the financial time series and that this explains more of the latter's variation than actual data. Also, using actual data might also have the problem of reliability[33]. However the disadvantage of using expectations might be that analysts' expectations in surveys might not reflect the expected value of macroeconomic data, but some kind of an expected mode for example.

Second, we aim to reduce the adverse effects of variable omissions by including a larger and conceptually wider set of fundamental variables than usual in similar studies. Besides the standard macroeconomic variables, we incorporate data on the banking sector and use a set of political and institutional variables as well. Principal components and factors are extracted from conceptually similar variables' groups and these are then used in CDS

[33] A detailed paper about the reliability of statistical data: (Bauer et al. [2008]).

spreads' regressions to overcome problems of multicollinearity and the curse of dimensionality. To further limit adverse effects of variable omission, we attempt to make use of the extra information contained in credit ratings compared to that in our fundamental variable set.

We must state that the linkage between fundamentals and CDS spreads might be very complicated. We only give a linear approximation (in line with the relevant literature), which might be a strong simplification.

Although we do not explicitly incorporate cross-section and time period heterogeneity of fundamental variables' effects in our baseline model, we do check the robustness of our general results on subsamples. Also, regressions are re-estimated on shorter time windows to gain an intuition on how coefficients have evolved through time.

Our study's main contribution to the literature is in assessing the fundamental factors relevant for Eastern European CDS spreads. Analysis of sovereign bond spreads' determinants do exist for the region but even that is scarce and our study contributes to those in assessing a larger array of relevant factors limiting problems of variable omissions.

The part is structured as follows. The next section reviews the main directions and results of the related literature. Section 3 introduces the data, and describes the methodology. Section 4 presents results for Eastern European countries.

III.2. Literature review

III.2.1. Sovereign spreads and default risk

The financial economics literature expanded significantly on sovereign CDS spread-related subjects complementing the existing literature on sovereign bond spreads. While there are important differences that we briefly summarize below, both CDS and bond spreads contain information on sovereign default risk. In CDS contracts the buyer of protection pays the CDS spread in exchange for the conditional payment of losses in case the sovereign reference entity defaults. In the bond market, spreads over the risk free rate

represent – in part - the premium for the conditional losses of the default event. The increase of both the perceived probability of default and the expected loss conditional on the credit event increases CDS and bond spreads, since the expected payout to the buyer of protection rises in case of CDS spreads and the expected loss on bonds increases for bond investors.

Studies that aim to directly estimate the default risk component of spreads - in order to compare it with other components or to proceed to uncover the default risk component's determinants - have to estimate both the probability of default and the expected loss given default. Both are problematic, but of the two concepts the latter is even harder to grasp. Although arguably also related to both the actual financing ability and a general willingness to repay, papers which use this ratio typically calculate with some sort of historical averages or refer to market conventions (the CDS Standard model on the ISDA website and in Bloomberg applications for example assume a 25 percent recovery for emerging markets and 40 percent for senior obligations of developed sovereigns). A detailed account of sovereign credit event episodes in Sturzenegger and Zettelmeyer [2005] shows however that the recovery rate has been highly variable. Cruces and Trebesch [2013] show that higher haircuts (investor losses) are associated with longer periods of exclusion from capital markets and higher subsequent yield spreads for sovereign bonds.

Approximating the probability of default has proceeded along different paths. One approach follows from structural credit risk modeling along the lines of Merton [1974]. The method calculates a forward-looking expected default frequency using information contained in the balance sheet of the entity. A distance-to-default measure based on the ratio of asset value's volatility to net worth (equity) is calibrated to observed default frequencies. For corporate issuers several papers use the expected default frequencies provided by Moody's KMV (e.g. Amato [2005]; Berndt et al. [2005]; Kim et al. [2009]). In the case of sovereigns, Weigel and Gemmill [2006] estimate a distance-to-default measure as a latent variable influenced by various macroeconomic and financial variables, while (Gapen et al. [2005]) use information of the sovereign's balance sheet to arrive to a distance-to-default

measure. Still another possibility, advocated by Remolona et al. [2008], is to use historical default frequencies for given rating levels, which are published for different time horizons by rating agencies.

Another line of the literature instead tries to estimate the default risk component by aiming to separate it from other components in spreads. These studies usually assume a dynamic process for the arrival rate of credit events (or for the credit spread itself) under a risk-neutral (objective) and an observed (subjective) measure. Then, using the term-structure of the risk free rate and spreads the risk premium and default risk components can be identified. This is the approach taken by Duffie et al. [2003] for Russian government bonds, Pan & Singleton [2008] for CDS spreads in Korea, Mexico and Turkey, and Longstaff et al. [2011] for CDS spreads of 15 emerging market sovereigns.

A more traditional reduced-form method, which this dissertation also belongs to, uses fundamental variables in regressions of spreads as a proxy of the default risk component. Influential early papers in this strand were (Edwards [1983]; [1985]), which were followed by a vast number of publications to date (Cantor & Packer [1996]; Eichengreen & Mody [1998]; Min [1999]; Ades et al. [2000]; Afonso [2003]; Ferrucci [2003]; Bernoth & Erdogan [2010]; Rowland [2004]; Baldacci et al. [2008]; Ebner [2009]; Nickel et al. [2009]; Alexopoulou et al. [2009]; Attinasi et al. [2009]; Mody [2009]; Sgherri & Zoli [2009]; Schuknecht et al. [2010]; Hilscher & Nosbusch [2010]; Bernoth & Erdogan [2010]; D'Agostino & Ehrmann [2013] and many others).

The usually employed macroeconomic fundamental variables can be classified into the following major groups:

- *Fiscal position related variables* (fiscal deficit, government gross or net debt, interest payments on government debt, etc.). A worsening fiscal debt position is expected to increase the perceived risk of default, because it increases the cost of debt servicing relative to the cost of non-payment.

- *External position related variables* (current account and trade balance, terms-of-trade indicators, stock of official reserves, stock of external debt, exports or imports to GDP ratio, exports to debt ratios). A worsening external position is expected to increase the perceived default risk of the issuer, usually argued on the grounds of availability of foreign currency liquidity. Small open economies may also be more vulnerable to international shocks.
- *Real activity and level of development* (real GDP growth and other indicators of real activity, per capita GDP, etc.). GDP growth is important as it decreases the relative cost of debt servicing to income and thus makes a given level of debt more sustainable. Developed countries are on one hand expected to be more prone to financial market shocks and to be politically less volatile and less willing to default[34].
- *Banking sector variables* (usually proxied by financial variables or expected default frequencies of larger banks domiciled in the given country). The financial crisis has highlighted the importance of systemic banking sector risk and its interconnectedness with sovereign risk. A deterioration of the banking sector's risk profile increases the conditional liabilities of the sovereign and thus leads to increased sovereign spreads.

There are two main points to stress regarding the empirical results of the literature. One is the heterogeneity of findings. Depending on the estimation type, variable set, estimation sample (both in cross-section and the time sample) the coefficients of key variables may be largely different, may gain or lose significance or even take the sign opposing that justifiable on theoretical grounds. (See for instance Haugh et al. [2009] Table 1 for a review on differences in fiscal variables' impacts.)

There are several explanations for disparities. Obviously differences in the methodology might explain some of the differences due to differences in

[34] Developed and emerging economies' sovereign yield spreads can be explained with different economic and political determinants (Maltritz & Molchanov [2013]).

assumptions and restrictions on residuals and coefficients. Another, perhaps even more important point, is the use of different variable sets. Due to the high correlation between macroeconomic variables, omission of some of them may bias coefficients of others left in the model. Unfortunately the inclusion of a more complete set of relevant factors leads to large uncertainty of parameter estimates due to multicollinearity.

Effects of variables may be different across countries and in time, so results may differ due to a choice of the estimation sample. This is in line with arguments of several papers in the more recent literature. Changing importance of macroeconomic variables in the crisis are pointed out by a series of empirical papers (Baldacci et al. [2008]; Sgherri & Zoli [2009]; Bernoth & Erdogan [2010]; Schuknecht et al. [2010]; Borgy et al. [2012]; D'Agostino & Ehrmann [2013]). There are studies, which stress an increased interdependence of sovereigns with the banking sector (e.g. Mody [2009]; Attinasi et al. [2009]) and some authors find that the reaction to financial market shocks is dependent on the vulnerability, i.e. the macroeconomic fundamentals of the sovereign (Sgherri & Zoli [2009]; Haugh et al. [2009]), although this form of non-linearity might be treated by using the logarithm of spreads as dependent variables instead of the nominal approach followed by these and some other studies. From the results of papers, which use individual country regressions or SUR (seemingly unrelated regression) techniques instead of panels it seems that there are differences in the effect of macroeconomic variables' impact on sovereign spreads across countries (e.g. Nickel et al. [2009]; Longstaff et al. [2011]; Afonso & Rault [2010]).

A second point to highlight regarding the literature's findings is the recognition of the necessity of using forward-looking variables in the explanation of financial indicators, which are also forward-looking in nature. There is a notable increase in the number of studies using forecasts, surveys rather than actual data (Sgherri & Zoli [2009]; Nickel et al. [2009]; Aizenman et al. [2011]; D'Agostino & Ehrmann [2013]; Alper et al. [2012]).

Besides macroeconomic fundamentals political and institutional factors play a role in determining default risk. As mentioned before sovereign default is either a direct consequence of running out of liquidity or a political decision. Addressing the latter (and often neglecting the former) cause, a strand of the literature, following the seminal paper of Eaton-Gersovitz [1981], approaches the pricing of sovereign debt from the aspect of the willingness to repay debt. In this line of thought the price of debt and hence the sovereign risk spread depends on the costs and benefits of not repaying (repudiating) debt. In cases where the relative benefit of default increases, investors need to be compensated for the increased risk of default by higher credit spreads. There are several costs that can deter governments from repudiating debt, such as the fear of exclusion from debt markets, reputational costs, impediments to foreign trade, loss of financial assets held abroad, or collateral risk of domestic actors (for example instability of the banking system due to their holdings of government securities). Panizza et al. [2009] provide a comprehensive review of the evolution of the related literature.

A few studies show that political risk and institutions have an impact on default risk. Erb et al. [1996] find political risk as measured by Institutional Investor ratings affecting country risk, while Baldacci et al. [2008] find that several measures of political risk are associated with sovereign bond spreads. For Eastern European countries in particular, both Nickel et al. [2009] and Ebner [2009] highlight the importance of political factors, although these studies do not explicitly measure such effects. Regarding institutional factors Ebner [2009] shows a significant effect of EU candidate status for the case of Croatia and Turkey. In a different context and a different sample, Dasgupta et al. [2010] show the effect of similarities in quality of governance in contagion. Several papers, which use domestic inflation in the explanation of foreign currency bond spreads highlight inflation's role also as a proxy for quality of governance and political stability (Cantor & Packer [1996]; Afonso [2003]).

III.2.2. Non-credit risk factors

Both CDS spreads and foreign exchange bond spreads are affected by several factors, which are in various aspects different from credit default risk, but maybe related to each other and default risk as well. A number of studies separate risk appetite or the pricing of risk from the quantity of risk (usually only default risk). A consistent treatment is that of Gai & Vause [2006], who identify risk appetite as the general pricing of risk that is characteristic of investors' attitude toward uncertainty (risk aversion) and the level of uncertainty itself (e.g. due to the general macroeconomic outlook) at a given point in time. This price of risk and the particular riskiness of the entity (quantity of risk) together make up the risk premium embedded in risky assets. Gai & Vause [2006] refer to corporate entities within a country i.e. quantity of risk comprises the fundamentals of the firm and price of risk is mostly due to macroeconomic uncertainty. In terms of sovereigns, however, we could think of the quantity of risk as the country-specific relative credit risk – which partly also represents macroeconomic fundamentals as described before – and the pricing of risk as a more general, global macroeconomic outlook and global liquidity conditions.

Different methods are used in the literature to extract the risk pricing component. Several of the previously mentioned papers, which identify credit risk and perhaps other risk components regard the residual term as one that represents risk appetite or use explicit proxies generally indicators of global financial market relevance (the VIX index, flight-to-quality measures and market liquidity proxies referred to below). There are a large number of papers that empirically arrive to such global price of risk through either taking the principal component (or factors) of financial time series in the first place or using the principal components method on residuals (Collin-Dufresne et al. [2001]; Mcguire & Schrijvers [2003]; Kisgergely [2009]; Barbosa & Costa [2010]; Berndt & Obreja [2010]; Ang & Longstaff [2011]; Broto & Pérez-Quirós [2011]; Kocsis & Nagy [2011]). On the sovereign CDS and bond market this systemic component is usually found to explain more than half of the variation of spreads.

The recent sovereign crisis led to an expansion of the literature on the commonality of sovereign spread (and other financial indicators') movements. Although such definitions are vague (see Pericoli & Sbracia [2001]), a distinction has been made between papers that deal with the fundamental explanation of cross-country correlations, such as financial market or trade linkages, i.e. financial or trade spillovers (Reinhart & Kaminsky [2000]; Kodres & Pritsker [2002]; Forbes & Chinn [2003]; Dungey et al. [2003]; Dungey & Martin [2007]; Vasicek & Claeys [2012]), and the contagion literature or volatility spillovers, which deals with excessive correlation compared to normal periods that cannot be attributed to fundamentals (Forbes & Rigobon [2002]; Bae et al. [2000]; Bekaert et al. [2003]; Dungey & Martin [2007]; Beirne et al. [2009]; Wang & Shih [2010]; Andenmatten & Brill [2011]). The wake-up call hypothesis, a related concept, postulates that contagion tends to hit countries, which have similarities with those hit initially by the crisis, i.e. investors tend to differentiate based on attributes characteristic of crisis countries (see e.g. Van Rijckeghem & Weder [2001]; Dasgupta et al. [2010]).

A large strand of the literature has dealt with liquidity factors. Several papers provide the theoretical reasoning for the existence of liquidity risk in asset prices (Goldfajn & Valdes [1997]; Allen & Gale [2000]; Brunnermeier & Pedersen [2009]). General market liquidity conditions have been shown to have an effect on bond spreads by an abundance of studies (Benczur [2001]; Codogno et al. [2003]; Duffie et al. [2003]; Bernoth & Erdogan [2010]; Manganelli & Wolswijk [2009]; Attinasi et al. [2009]; Sgherri & Zoli [2009]; Favero et al. [2010]; Haugh et al. [2009]; Chudik & Fratzscher [2012] and De Santis [2012], and many others). Liquidity proxies have varied widely across studies, but two different approaches can be identified. Some authors used general market liquidity measures such as core economy short-term interest rates (US Fed or ECB rate), global asset price volatility or flight-to-quality measures. Others, on the other hand, referred to liquidity characteristics of the given bond market, employing bid-ask spreads, trading volume or the bond market size. Market liquidity arguably influences the pricing of sovereign bonds more than that of CDS contracts because a transfer of notional is

needed in the case of bond purchase and maturity, and also because it is relatively easier to take on short positions in the CDS market.

Technical characteristics of the instruments are also relevant in determining spreads. In case of foreign currency bond spreads such details are for example the currency denomination, the remaining time to maturity, if the issuer is a public or private entity, collective action clauses, market of issuance, subordination clauses, inclusion of optional features (e.g. Eichengreen & Mody [1998]; Min [1999]; Kocsis & Mosolygó [2006]). CDS and bond spreads (relative to the risk free rate) should in theory be closely equal, but have empirically been shown to deviate from each other by a number of papers (Varga [2009]; Bai & Collin-Dufresne [2011]; Wu & Game [2011]). The deviation may be explained by limits to arbitrage (the difficulty to short sell bonds), the cheapest-to-deliver option in CDS spreads (when CDS payments are triggered the seller of protection has to pay the price of the cheapest bond of the issuer), and the risks to implementing the basis trade: funding risk, counterparty risk, and sizing the CDS position (see e.g. Bai & Collin-Dufresne [2011] for more details.)

III.3. Data and Methodology

III.3.1. Data

Data on the dependent variable, CDS spreads, were downloaded from Bloomberg and the most liquid 5-year maturity was chosen.

Although the CDS market has been liquid for large emerging market sovereigns since the mid-2000s, some Eastern European sovereigns with small or nearly non-existent public debt markets (e.g. the Baltic States) have been illiquid until the escalation of the crisis in late-2007 to mid-2008 which introduces stale quotes and other data problems. It is also natural to assume a structural break in the data generating process of CDS spreads prior to the escalation of the crisis. We therefore constrained our data set to begin in July 2008. The end of our time sample is March 2012 due to the availability of macroeconomic data.

Our choice of cross-section was determined by the availability of variables. A full set of macroeconomic variable forecasts were available from Consensus Economics for 14 Eastern European countries (Bulgaria, Czech Republic, Croatia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russia, Slovakia, Slovenia, Turkey and Ukraine). Slovenia was however dropped as its CDS spread time series became continuous only in the end of 2009. A large subset of the variables used in the analysis was available for all 13 countries, but still a set of potentially important variables were missing for a few countries. A larger set of variables were able to cover all the economic concepts that the literature and we considered important for a smaller cross-section of 9 countries (with the exclusion of Estonia, Romania, Slovakia and Ukraine; the remaining 9 countries: Bulgaria, Czech Republic, Croatia, Hungary, Latvia, Lithuania, Poland, Russia and Turkey). We use the latter dataset as the benchmark for presenting results although we consider estimation results on the other panel also in the section on robustness checks.

The frequency of the panel was chosen to be monthly. Although financial time series were readily available on daily (or even intraday) frequencies, macroeconomic, institutional, political variables' frequency ran from monthly to annual. Due to the relatively short time sample we opted for using the monthly frequency even if this necessitated interpolation in the case of some quarterly and few annual variables. We expect, however, that this does not result in significant bias since variables available on quarterly and annual frequency were typically those representing slowly changing stock-type variables (e.g. external debt ratios to GDP), where a linear interpolation should not be significantly different from neither the true data generating process nor the informational base on which market participants trade CDS spreads[35]. On the other hand, nearly all variables which are expected to be more volatile, such as the macroeconomic forecasts, were available on a

[35] Another possible method would be using real time (last available) data. However, for example in the case of banking sector stability data, banks might forecast the main developments of the actual period before data publications. The robustness checks in III.4.3. show that the results are robust to the chosen frequency.

monthly basis. Also note that – beside its theoretical relevance – a practical advantage of using survey projections is that we did not need to interpolate important variables, such as the GDP growth rate, the current account balance or the budget balance, whose actual data are usually available on a quarterly basis (and are published with significant time lag). Values of CDS spreads were taken to be the close of the 21st of the given month (or the trading day before) because Consensus Economics Forecast surveys were closed before or on this day of the month. Other variables of daily availability were taken for the 15th of the month, while lower frequency variables were taken at end of the preceding month.

Turning to variables, rating agencies' long-term foreign currency ratings were used as alternative proxies of sovereign credit risk. Ratings of the three major agencies (Standard and Poor's, Moody's and Fitch Ratings) were each transformed to a linear scale similar to that seen in the literature (Cantor & Packer [1996]; Afonso [2003]). In our scaling the best rating (AAA in S&P, Fitch notation, Aaa in Moody's notations) was assigned a value of 1, the next rating level (AA+/Aa1) was assigned a value of 2, and so on.

Macroeconomic explanatory variables used in this dissertation are the following:

- *Fiscal position related variables*.
    - Consensus Economics monthly survey medians for budget deficits. (Available only for the 9-country panel.)
    - Fiscal stock-type variables were on one hand sourced from Bloomberg by downloading all sovereign bond and loan data outstanding between 2007 and 2012. These data were then used to construct time series of aggregate outstanding bond market and loan market sizes at the given monthly time periods by taking into account issuance and maturity dates, currency denomination and issuance amounts. Several series were constructed that comprise different views as to which aspect of government debt is important: total bonds and loan facilities

outstanding, total bonds outstanding, total foreign currency bonds outstanding, total short-term debt outstanding, total short-term foreign currency bonds outstanding. Nominal amounts were converted to Euros at prevailing exchange rates at the middle of the month and were divided by GDP also in Euros (actual 4-quarter GDP value, interpolated to monthly frequency, sourced from the IMF IFS database).

- Quarterly government gross debt to GDP data were taken from IMF IFS and a forward-looking measure was calculated based on Consensus Economics forecasts (real GDP growth, budget balance and inflation, the latter taken as a proxy for the GDP deflator). (The forward-looking measure was available only for the 9-country panel.)

- *External position indicators.*
  - Consensus Economics survey medians for current account to GDP, export and import (billion USD) volumes. The trade balance to GDP was calculated from export and import volumes, the current exchange rate and (actual) GDP.
  - Energy-reliance measures were calculated as a net export of oil, natural gas and refined oil products. These measures were taken from the CIA World Factbook for 2009 for all countries and were calculated in GDP terms. These energy-reliance measures enter regressions in a form of being multiplied by Brent oil price and the Goldman Sachs Commodity Price index since opposing signs of energy-reliance mean different signs of expected reaction of CDS spreads when energy prices are rising. These variables are expected to be an important determinant of relative risk assessment for example in energy-exporting Russia, where an increase of oil price has the potential to significantly raise government resources.
  - Official reserves-to-GDP were sourced from IMF IFS on quarterly frequency.

    - External debt to GDP and short-term external debt-to-GDP were taken from the World Bank Quarterly External Debt Database in quarterly frequency. (Available only for the 9-country panel.)
- *Real growth and development related indicators*.
    - Consensus Economics survey medians for real GDP growth, industrial production growth and investment growth were included. (The latter variable available only in the 9-country panel.)
    - GDP per capita variable was calculated from data available from the IMF IFS database on quarterly frequency.

There is a note in place regarding the use of Consensus Economics data. Consensus Economics supplies forecast for the actual and the next year. This introduces jumps in both time series in the months of January, when the reference year of projections changes. To smooth out forecast series we used the one-year ahead (fixed horizon) calculated projections as done by several papers in the literature using similar data (Nickel et al. [2009]; Dovern et al. [2012]; D'Agostino & Ehrmann [2013]). This measure is calculated as a weighted average of the survey estimates for the actual year and the next year in the following way:

$$X_{12M} = \frac{m*X_t + (12-m)*X_{t+1}}{12} \quad (1)$$

where *m* represents month, X_t and X_{t+1} represent the forecast median for the given year and the next year, respectively.

Studies that dealt with the effect of banking sectors' credit risk spillover to sovereigns in the case of developed European markets were able to either take expected default frequencies, CDS spreads or the sectoral equity index of the major banks domiciled in a given country (e.g. Sgherri & Zoli [2009]; Mody [2009]; Attinasi et al. [2009]; Ejsing & Lemke [2009]). This has not been an option in Eastern Europe due to data availability; therefore explicit variables on the health of the banking sector were included:

- *Banking profitability indicators*. The return on equity and the return on assets, quarterly, sourced from the IMF FSI database.
- *Capital adequacy* as measured by regulatory capital to risk-weighted assets, quarterly, sourced from the IMF FSI database.
- *Portfolio quality*. Non-performing loans to total assets, quarterly, sourced from the IMF FSI database.
- *Funding liquidity*. Loans to deposits quarterly, calculated from data of the IMF IFS database. (Available only for the 9-country panel.)
- *External debt stock*. Total debt and short-term external debt stock of banks calculated into GDP ratios, quarterly, taken from the World Bank Quarterly External Debt Database in quarterly frequency. (Available only for the 9-country panel.)

Institutional and political variables:

- *Dummy variable of EU membership membership*[36]. A value of 1 denotes membership.[37]
- *EIU political risk index*. Composite index compiled by the Economist Intelligence Unit of factors relating to political stability on monthly basis. Values are scaled between 0 and 100, the perceived political risk increasing with score.
- *The Heritage Foundation Index of Economic Freedoms*. The Heritage Foundation compiles indices of business freedom, fiscal freedom, monetary freedom, investment freedom, financial freedom and property rights, and an overall measure. Annual basis, range of values between 0 and 100, with increasing values denoting better institutions.

[36] None of the countries in the 9 country panel was a Eurozone member, therefore a dummy for Eurozone membership was not neccessary.

[37] In a few years' time, taking a part in the first element of the European banking union, Single Supervisory Mechanism (SSM) membership might also become an important dummy. An analysis about the dilemmas of joining SSM: (Darvas & Wolff [2013]).

Finally, several financial time series were downloaded from Bloomberg on monthly frequency (15th of the month to avoid problems of simultaneity) to proxy for the pricing of risk and to use as proxies for energy shocks as referred to above:

- Equity volatility. VIX and VDAX indices (30-day implied ATM volatility of the S&P 500 and the DAX equity indices, respectively.)
- EUR/USD exchange rate.
- US corporate credit risk. Spread of BBB and AAA rated issuers.
- Brent crude oil price, next delivery.
- Goldman Sachs Commodity Index

To sum up, two balanced panels were constructed running on monthly frequency from July 2008 to March 2012. The panel that we focus our analysis on has a larger set of available variables, but contains a cross-section of 9 Eastern European countries. The other panel has a smaller variable set and a larger cross-section of 13 countries.

Overall we have 414 and 598 observations (time period * cross-section) for each variables in the two panels. The 9-country panel includes 44, the 13-country panel 37 explanatory variables, respectively. We compare results on the two panels for robustness checks. We also test for possible bias caused by the linear interpolation by rerunning regressions on quarterly data only.

We employed data reduction techniques to circumvent problems of multicollinearity (and the curse of dimensionality). Variables of similar concepts were grouped together and first principal components were extracted. The time series of these principal components were then used in spreads' (and ratings') regressions. A possible caveat here is that the first principal components of different groups may still be correlated with each other and may therefore obscure partial effects. Another approach that we took therefore was running factor analysis (with varimax rotation) on a larger set of variables and extracting rotated orthogonal components. This method has the advantage over principal components that factor scores will be largely

uncorrelated and the disadvantage of potentially harder interpretation of the factors.

The following principal components were extracted from the variable set:

- PC_GROWTH: aggregating forecasts pertaining to economic activity (real GDP, industrial production and investment growth),
- PC_INST: principal component aggregating institutional and political variables, but also GDP-per-capita was eventually included here due to its high correlation with these variables.
- PC_RATING: the first principal component of Fitch, Moody's and Standard and Poor's ratings.
- PC_STOCK: the first principal component of government debt-to-GDP, outstanding loans and bonds-to-GDP and reserves to GDP in the 13-country panel; and additionally external debt-to-GDP and bank external debt-to-GDP in the 9-country panel.

Initially, we tried to extract first principal components from banking sector variables, variables relating to government debt ratios, and on the external position. However the resulting variables were still highly correlated, so in this case variables were grouped together and three orthogonal factors were extracted.

- F_BANK: factor aggregating banking sector non-performing loans to assets, loan to deposit ratio; and negatives of ROE, ROA and capital adequacy. Bank sector external, short-term external debt, as well as total external debt and short-term debt, which were available only in the 9-country panel, also loaded mostly on this factor.
- F_GDEBT: factor collecting mainly the commonalities of the outstanding stocks to GDP of all government bonds, FX bonds, short-term bonds, short-term FX bonds, bonds and loans; and a forward-looking indicator of gross debt to GDP (available only in the 9-country panel).

- F_EXTERN: factor representing trade balance, current account balance, reserves and the energy trade balance variables multiplied with the price of crude oil and commodity indices.

Appendix 2 Table 6 presents the exact groupings of variables, while *Table 7* and *Table 8* shows loadings of variables on principal components and rotated factors in the 9-country panel. *Appendix 5 Table 11* shows a Johansen-Fisher panel cointegration test.

III.3.2. Methodology

For a risk-neutral investor Pan & Singleton [2008] use the following pricing model for a sovereign CDS contract of M-year maturity:

$$CDS_t(M) = \frac{(1-R)* \int_t^{t+M} E_t\left[\lambda_u e^{-\int_t^u (r_S+\lambda_S)ds}\right]du}{\frac{1}{2}*\sum_{j=1}^{2M} E\left[e^{-\int_t^{t+j/2}(r_S+\lambda_S)ds}\right]} \quad (2)$$

The numerator of the function is the present value of the payment conditional on default. R is the recovery rate (1-R, is the loss), λ is the default intensity (arrival rate of the credit event) and r is the risk free rate. The integral in the numerator expresses the expectation of the arrival function of the credit event throughout the life of the contract, i.e. it quantifies the probability of default and uses a discount factor for the conditional payment at the arrival time of default. Note also that this formulation allows the default intensity, λ, to be time-varying. The denominator is the discount factor for the fixed cash flow of the CDS fee.

While the integrals that express the probability of the credit event and discount factors make the pricing equation seem complex, as Longstaff et al. [2011] note it is well approximated by:

$$CDS_t(M) \approx (1-R) * \lambda_t \quad (3)$$

the product of the risk-neutral arrival rate of default and loss given default for the risk-neutral investor assuming no arbitrage. Limits to arbitrage, the

presence of risk premia may cause the CDS spread to deviate from the risk-neutral value.

In case of a one-period contract Edwards (1983, 1985) shows that if a logistic function is assumed between the probability of default and fundamental variables, then the logarithm of the sovereign spread can be expressed as a linear function of a vector of fundamental variables (X_t) pertaining to issuer and issue (bond or loan-specific) characteristics and the logarithm of a term including the risk free rate:

$$\log(S_t) = \log(1 + r_t) + \boldsymbol{\beta} * X \quad (4)$$

More generally, then, spreads of a given country at a given time period could be described as:

$$\log(S_{it}) = \alpha_i + \gamma_t + \beta * X_{it} + \delta * Z_i + \varphi * W_t + \varepsilon_{it} \quad (5)$$

where γ_t are time fixed effects, to control for shifts in risk appetite and other time-specific premia, Z_i are time-invariant (cross-section specific) variables and W_t are cross-section invariant (time-period specific) variables, such as systemic risk proxies. Note that to be able to estimate parameters either cross-section fixed effects or time-invariant variables and either time fixed effects or cross-section invariant variables have to be dropped from the equation.

Restricted variants of (5) have been used in the literature for estimating variables' effects on spreads in panel datasets. In the original Edwards [1983]; [1985] models α_i, γ_t and ß were estimated and no cross-section or time-invariant variables were included. Time fixed effects therefore proxied for the time-varying risk premium. Most papers in the literature instead used a set of cross-section invariant W_t without time fixed effects as the goal of these papers was to investigate which variables of systemic nature (risk free rate; global risk appetite measure as the VIX index; global liquidity proxies such as the US corporate Baa-Aaa spread) were more or less important in explaining spreads. On the other hand the set of fundamental factors were

also time-varying in nature so that cross-section fixed effects could be included, which could also capture effects of omitted cross-section specific (time-invariant) variables.

The objectives of our analysis necessitate using time fixed effects and (close to) time-invariant variables. Our study concentrates on the question of how (based on which fundamental variables) the market differentiates between countries across the region. Since at this point we are uninterested in disentangling effects of different (global) systemic variables, we simply use time fixed effects, γ_t, to control for shifts in risk appetite and other time-specific premia. (This may be problematic in cases when the elasticity of spreads to risk premia is cross-section specific. However specifying the CDS spread in logarithms instead of nominal units (basis points) should resolve this problem as in this case a unit increase of systemic risk variables causes larger adjustments for countries with worse fundamentals, and thus relative higher spreads.) On the other hand we are interested in effects of close to time-invariant variables to which end we drop the cross-section fixed effects from the model. Our empirical formulation is then:

$$\log(CDS_{it}) = \gamma_t + \beta * X_{it} + \varepsilon_{it} \quad (6)$$

Least-squares estimation of variables' effects (β) is unaffected by variables' cross-sectional (regional) means. In fact, the time fixed effect, γ_t, will absorb the relationship between the regional means of explanatory and dependent variables. A regression on demeaned variables will result in no constant and the same parameter estimates, β.

$$\log(CDS_{it}) - \log(CDS_{mean,t}) = = \gamma_t - \log(CDS_{mean,t}) + \beta * X_{mean,t} + \beta * (X_{it} - X_{mean,t}) + \varepsilon_{it} == \beta * (X_{it} - X_{mean,t}) + \varepsilon_{it} \quad (7)$$

This form makes it more explicit that our empirical model aims to address the question on how *relative* fundamentals of a given country at a given time

period have been empirically important in explaining the *relative* CDS spreads in the region.

We estimate both a levels' equation between spreads and fundamental variables and a short-run equation on their differences, which also includes an error-correction term. The short-run equation allows us to calculate the pace at which changes in relative fundamentals show up in relative CDS pricing. Note that significance of such an error-correction mechanism is inconsistent with the assumptions of efficient markets, rational investors and absence of arbitrage opportunities, which would imply immediate adjustment of spreads to newly available fundamental information[38].

Market structure may provide an intuitive explanation for our specification choice, for both modeling the relationship between relative levels of variables and for a potential error-correction mechanism. A segment of the CDS and sovereign bond markets (fund managers, macro and credit hedge funds) is interested in trading the relative value of sovereign spreads. Fund managers in particular generally have a longer-term investment horizon and usually hold a wider portfolio of bonds. For these participants it is not the absolute level of returns that is important, but the relative returns compared to benchmarks, therefore they will aim to increase the portfolio shares of countries with relative higher spreads given a level of risk. This requires an understanding of the relative riskiness of different sovereigns, on which collecting information may be time-consuming and costly, which may be one reason for gradual adjustments. Also, the large portfolio sizes compared to the daily liquidity of market makers may lead fund managers to only progressively increase holding sizes to targets in order to avoid liquidity costs[39].

In the variable set *X*, besides the fundamental (macroeconomic, financial and political-institutional) variables mentioned before, we also use the

[38] This is in line with the latest findings, that while both country-specific and global developments are important in the long-run, global factors are the main determinants of spreads in the short-run (Csonto & Ivaschenko [2013]).
[39] A comprehensive overview about government bond portfolio optimization: (Puhle [2008]).

information content of credit ratings to control for some of the effects of possible omitted variables[40]. Although rating scales of the three agencies in our dataset (Fitch, Moody's, Standard and Poor's) are consistent with each other, there are often differences in how the agencies rate each sovereign. This might be a consequence of different perception on the outlook of different fundamental factors or on the relative importance of these factors in the probability of default. We therefore use the first principal component of the three agencies' ratings, which we consider a better aggregate alternative proxy for credit risk then each rating alone. Also rating changes are infrequent (and time-invariant for some countries in some agencies' case) but rating's first principal component has a larger time series variance in the differences as individual series, which is more consistent with the higher variance of fundamental factors.

There have been different approaches and techniques in the literature of using ratings' information content in explaining spreads. We follow Eichengreen & Mody [1998] in using ratings' (principal component's) orthogonalized component to fundamentals. Since ratings are correlated with fundamental variables, direct inclusion in spreads' regression impairs inference on fundamental factors' partial effects on spreads. On the other hand, the orthogonalized component (the error term of ratings regressed on the same set of fundamental variables) may contain information of important omitted variables that have an effect on both ratings and spreads through their impact on default risk. The orthogonalized component might however also include other undesirable factors as well; for example measurement error due to linear scaling of ratings, which might call for a non-linear specification of the rating regression. Therefore, while inclusion of such a term might be beneficial in treating endogeneity bias due to omitted variables, it may also lead to problems if the error term is correlated with other fundamentals.

[40] Under strong assumptions, in theory, ratings might provide enough statistics to determine CDS spreads in a way that fundaments would not give us additional explanatory power. Of course in practice this is not the case (one very plausible argument is that ratings are discrete, while upgrades or downgrades need time).

Therefore we will run regressions of spreads both with and without the rating term.

A set of explanatory variables may be not only a cause but also a consequence of increased credit risk. An increased credit risk could force indebted countries' governments, households, banking sectors to deleverage[41] resulting in relative better and improving balances ("flow"-type indicators) in the countries with the worst debt ("stock-type") indicators. Sudden stops of external capital inflows may lead to momentous current account improvements in countries with relative higher credit risk through large FX readjustments. Governments with the largest debt ratios are those generally most impacted by decreased market confidence in times of financial turmoil, which entails soaring interest rates and failure of auctions. Such financial distress then forces these countries' governments to introduce austerity measures to balance budgets. The reverse causality may empirically cause higher CDS spreads to be associated with better balances or at least to reduce worse balances' true, unfavorable, impact on spreads. Still other simultaneity issues arise between spreads and the debt ratios, budget balance and growth variables due to the interest rate channel. Some papers (Sgherri & Zoli [2009]; Baldacci et al. [2008]) use instrumental variables techniques to attempt to control for endogeneity issues of this sort.[42]

In this dissertation explanatory variables precede CDS spreads in time to reduce simultaneity effects. In the section on robustness checks we also run regressions separately on the subsample of countries that have worse "stock-type" indicators and compare coefficients with others with more favorable fundamentals. We find however that there is no systematic change in parameters in the direction expected due to endogeneity effects (although parameters do vary due to cross-section heterogeneity in some variables' effects). We also run our main regression using two-stage least square

[41] A detailed paper about leverage-cycles: (Berlinger et al. [2012]).

[42] Or to handle other similar endogeneity or measurement problems, like (Benczur [2001]) handle the substitutions of expected loss given default and realized loss given default.

estimation with instruments that aim to control for the endogeneity in countries with worse fundamentals.

To gain an intuition on the time-varying heterogeneity of parameters, which many authors found significant (Mody [2009]; Bernoth & Erdogan [2010]; Aizenman et al. [2011]; D'Agostino & Ehrmann [2013]) we investigate the evolution of coefficient impacts through studying regression output on rolling windows. Regarding the possible cross-section dependence of results, we look at differences in parameters by dividing the sample in two based on stock indicators as mentioned above. We however consider our sample too small for consistent estimation of cross-section specific coefficients.

One further note is in place however regarding heterogeneous parameters. Conclusions that parameters are time-varying and cross-section specific may potentially be treated by specifying the dependent variable to be in logarithm instead of nominal units (basis points). This specification may take care of heterogeneity of the sort that variables (either fundamentals or the risk pricing) influence spreads more in countries and time periods of relative higher risk.

III.4. Results

III.4.1. General results

We treat the panel with the larger set of variables (9 countries) as our benchmark since problems of omitted variables may be less relevant in this case. We compare estimates on the other dataset as a robustness check in the last part of this section.

The main regression results are shown in *Table 4* for the long-run (levels') equation that describes the relationship between *relative* CDS spreads and *relative* fundamental variables in a time fixed effects specification as discussed before.

Most variables have the expected sign, are significant at conventional levels, and are able to explain a large part of CDS spreads' relative levels. As expected, inferior outlook for growth, as measured by the first principal

component of real GDP, industrial production and investments projections, leads to higher CDS spreads. Banking system instability (based on the factor assessing bank profitability, portfolio quality, capital adequacy indicators, as well as external debt indicators) is also important, which supports findings of the recent literature (Sgherri & Zoli [2009]; Mody [2009]; Attinasi et al. [2009]; Ejsing & Lemke [2009]). Also confirming expectations, countries with worse external balances, i.e. current account, trade (and energy) balance, and countries with higher government debt as a ratio to GDP, are considered relatively more risky by participants in the CDS market. The variable assessing the level of development, political stability and stronger institutions (PC_INST) also has a significant impact on CDS spreads and, as we will later see, it is one of the key variables.

***Table 4*. Long-run regression results**

Dependent variable	Log CDS spread			Dependent variable	Log CDS spread		
Explanatory variables	coefficient	std.error	sign.	Explanatory variables	coefficient	std.error	sign.
PC_GROWTH*(-1)	0.253	0.015	***	PC_GROWTH*(-1)	0.253	0.016	***
F_BANK	0.310	0.015	***	F_BANK	0.303	0.015	***
F_EXTERN	0.148	0.015	***	F_EXTERN	0.121	0.017	***
F_GDEBT	0.211	0.016	***	F_GDEBT	0.203	0.017	***
PC_INST*(-1)	0.161	0.008	***	PC_INST*(-1)	0.154	0.009	***
FISCBAL*(-1)	-0.024	0.008	***	FISCBAL*(-1)	-0.023	0.013	*
RATING_RESIDUAL	0.068	0.012	***	RATING_RESIDUAL	0.068	0.012	***
Observations	405			Observations	405		
Periods	45			Periods	45		
Cross-sections	9			Cross-sections	9		
R-squared	0.853			R-squared	0.850		
adj. R-squared	0.832			adj. R-squared	0.829		
D-W stat.	0.165			D-W stat.	0.161		

*Note: For convenience, variables, whose increasing values are consistent with CDS spread decreases (higher growth, better institutions, better fiscal balance) are multiplied by -1, so that their coefficients and t-statistics are aligned with other variables and CDS spreads. All equation coefficients are therefore expected to be positive. The right-hand panel uses a dummy variable's interaction with fiscal balance and external position for instruments in TSLS estimation. The dummy variable takes a value of 1 in the case of countries with relative good "stock-type" variables. Throughout the text we use the common notation for significances: * at 10 percent, ** at 5 percent, *** at 1 percent confidence levels.*

However, the coefficient of expected fiscal balance, FISCBAL, is opposite of the expected sign (a better fiscal position is associated with higher CDS spreads), which is probably due to endogeneity between this variable and CDS spreads[43]. There are two possible channels of endogeneity: in times of financial stress, such as the time period under review here, countries with worse fundamental indicators experience a larger deterioration of financial indicators (increase in interest rates, depreciation of the exchange rate, higher CDS spreads) and this drives them to rebalance their budget[44] to counter the higher debt burden that increased interest rates and a depreciating currency cause. Also, effecting spreads in the opposite direction, countries with larger debt stocks will face relative higher interest payments, which worsens their budget balances. (Endogeneity may potentially contaminate the parameter of external position as well, since countries with bad fundamentals will experience higher devaluation leading to better trade balances and their private sectors will be more pressed to decrease leverage.)

To attempt to control for such endogeneity we re-estimate the regression with two-staged-least-squares using instruments for external position and fiscal balance that are constructed as products of these variables and a dummy variable that takes a value of 1 in observations where the given country had better-than-average "stock-type" indicator in the region as measured by the principal component, PC_STOCK. If the endogeneity problem only arises in countries of worse-than-average stock-type indicators than these instruments affect CDS spreads only through the impact on the endogeneous variable. This alternative specification (*Table 4*, right panel) causes fiscal balance to decrease in significance, while other variables' coefficient estimates are affected only to a minor extent. Due to the small

[43] However, this might also be caused by non-linearities that the regression cannot handle. There were also some considerable outliers, like the good fiscal year of 2011 in Hungary, which was caused by extemporaneous measures and did not have a significant positive effect on CDS spreads.

[44] Of course, this will also have an effect on other macroeconomic data, for example economic growth. A paper about fiscal policy's impact on economic growth: (Benczúr et al. [2003]).

impact on estimates and to concerns that may relate to the validity of such an instrument we choose to instead use the OLS estimates.

Finally, the residual of the rating regression - where the first principal component of ratings are regressed on the same set of fundamental variables – does have a significant effect on CDS spreads. We expect this residual to contain some information relevant in terms of default risk that is not captured by our fundamental variable set. For example, ratings could be affected by expectations on the future path of banking variables and stock-type indicators on which we only have actual data. They may also capture significant tail risks to the outlook for growth, fiscal or external balance that do not show up in median projections of Consensus Economics surveys. Rating agencies may also react to problems in government debt auctioning, the existence (or prospect) of international lending facilities, which arguably do have an impact on financing ability of debt, but are hard to proxy. They may also be able to better capture changes in political or institutional circumstances that we only have infrequently and possibly inadequately measured with our proxies. While the rating residual is significant it is reassuring that even leaving out this factor decreases the explanatory power of the model by only 2 percent. (Note that exclusion of this variable from the CDS spread regression results in the same coefficient estimates of fundamental variables, since it is by construction orthogonal to these factors.)

Turning to the short-run equation (*Table 5*), changes in the *relative* growth outlook, external position and gradual relative shifts in the institutional-political proxy leads to the *relative* adjustment of CDS spreads in the Eastern European region. Changes in the proxies for banking system stability, and variables representing outstanding government debt-to-GDP and the fiscal balance outlook are statistically insignificant, while rating changes (above that expected due to fundamental variable changes) are also insignificant at the 5 percent significance level. These variables may however have an indirect impact through the error-correction term, which is significant and of the expected sign. When CDS spreads are relatively lower than expected due to fundamentals (the ECM term is negative), this causes CDS spreads to rise.

The ECM coefficient indicates that 11 percent of the long-run error is corrected in one period, i.e. 1 month, thus ceteris paribus about 6 months are needed for half of such deviation to disappear.

Table 5. Short-run regression results

Dependent variable	Log differences of CDS spread		
Explanatory variables	coefficient	std.error	sign.
d(PC_GROWTH*(-1))	0.084	0.031	***
d(F_BANK)	0.064	0.089	
d(F_EXTERN)	0.203	0.078	**
d(F_GDEBT)	0.078	0.072	
d(PC_INST*(-1))	0.221	0.108	**
d(FISCBAL*(-1))	0.015	0.013	
d(RATING_RESIDUAL)	0.023	0.036	*
ECM(t-1)*-1	0.110	0.020	***
Observations	396		
Periods	44		
Cross-sections	9		
R-squared	0.869		
adj. R-squared	0.850		
D-W stat.	2.003		

Dependent variable	Log differences of CDS spread		
Explanatory variables	coefficient	std.error	sign.
d(PC_GROWTH*(-1))	0.068	0.033	**
d(F_BANK)	0.026	0.093	
d(F_EXTERN)	0.191	0.084	**
d(F_GDEBT)	0.045	0.079	
d(PC_INST*(-1))	0.204	0.116	*
d(FISCBAL*(-1))	0.011	0.014	
d(RATING_RESIDUAL)	0.010	0.037	
log(CDS)(t-1)*(-1)	0.106	0.021	***
PC_GROWTH(t-1)*(-1)	0.034	0.008	***
F_BANK(t-1)	0.027	0.009	***
F_EXTERN(t-1)	0.011	0.007	
F_GDEBT(t-1)	0.026	0.007	***
V_INST(t-1)*(-1)	0.013	0.005	***
FISCBAL(t-1)*(-1)	-0.008	0.003	**
RATING_RESIDUAL(t-1)	0.002	0.005	
Observations	396		
Periods	44		
Cross-sections	9		
R-squared	0.872		
adj. R-squared	0.850		
D-W stat.	1.993		

Dependent variable	Log differences of CDS spread		
Explanatory variables	coefficient	std.error	sign.
d(PC_GROWTH*(-1))	0.080	0.029	***
d(F_BANK)	0.032	0.135	
d(F_EXTERN)	0.156	0.122	
d(F_GDEBT)	-0.189	0.107	*
d(PC_INST*(-1))	0.125	0.165	
d(FISCBAL*(-1))	0.021	0.020	
d(RATING_RESIDUAL)	-0.032	0.058	
ECM(t-1)*(-1)	0.099	0.021	***
d(VIX)	0.012	0.002	***
d(VDAX)	0.003	0.003	
d(US_CREDIT)	0.001	0.000	***
d(USD/EUR)	1.324	0.168	***
Observations	396		
Periods	44		
Cross-sections	9		
R-squared	0.579		
adj. R-squared	0.566		
D-W stat.	2.027		

Note: For convenience, again, variables, whose increasing values are consistent with CDS spread decreases (higher growth, better institutions, better fiscal balance) are multiplied by -1, so a positive coefficient is expected everywhere in the table. The ECM, and lagged CDS spreads are also inverted this way, since originally a negative sign is expected that signals adjustment to the long-run equation. CDS spreads are taken as close values on the 21st of each month (or the nearest trading day before), while Consensus Economics projections are closed before this date in the middle of the month. Other regressors' values are taken at the end of the previous month.

The middle panel of *Table 5* shows an explicit estimation of the lagged levels of variables included in the long-run equation to gain an intuition on which variables cause the error-correction term to be significant. Most variables' lagged levels remain significant at conventional confidence levels and of expected sign, though the rating residual is found to be unimportant and the external position affects spreads only through immediate changes in this specification.

The large explanatory power of such a regression in log CDS spread changes is largely due to the time fixed effects, which includes effects of the significant

risk pricing component of spreads. Without time fixed effects the explained variance of CDS spread changes would drop to around 10 percent. In the right hand panel we show the estimate of the model using common proxies of global risk appetite and global liquidity (VIX, VDAX indices, EU/USD rate and the Baa-Aaa US corporate spread). The results confirm the importance of risk appetite in affecting CDS spread changes, although these proxies cannot fully capture all time-specific effects as shown by the relative lower explanatory power of the regression compared to our benchmark time fixed effects specification in the left panel of *Table 5*.

Fundamental variables affect CDS spreads in this regression mainly through the long-term adjustment term. Of the fundamental variables only expected growth, PC_GROWTH, is significant in differences at the 5 percent level. A regression (not shown here) that includes the growth variable's two components, the regional average growth and the deviation from the regional average (the cross-section specific part), results in only the regional average part remaining significant. This indicates that changes in expected growth are significant in such a short-run equation only due to their ability to proxy the general growth outlook.

Our findings are consistent with the main results of the literature on sovereign spreads. It is predominantly a time-varying common risk factor that explains the changes of CDS spreads. This risk factor does however have a "fundamental" component, the general growth outlook, whose changes are able to explain some of the shocks to time-specific risk pricing. Fundamental country-specific factors enter spreads mainly through an error-correction term suggesting the importance of the long-run relationship between relative spreads and relative fundamentals. Expectations on growth and external positions are significant in such a relationship, but also government debt ratios and a general development factor also related to EU membership, institutional strength and political stability are important determinants[45].

[45] However we think that institutional strength and political stability are not on the same importance in the case of developed and less developed countries. The difference between

III.4.2. Have the aspects of differentiation between countries changed through time?

Several papers in the literature (Mody [2009]; Bernoth & Erdogan [2010]; Aizenman et al. [2011]; D'Agostino & Ehrmann [2013]) emphasized the time-varying nature of the relationship between sovereign spreads and explanatory variables. While a more refined approach would be a direct incorporation of time-variation into the model, here we resort to simple rolling window regressions on one- and two-year fixed-length windows.

Appendix 3 Figure 10 and *Figure 11* plot coefficient point estimates and their 2 standard error bounds on the two window lengths. Although there are notable differences, some general results stand out. On one hand, the coefficient of growth decreases to a fraction of its initial value. In contrast, the coefficients of factors representing the stability of the banking sector, the "flow-type" external position variables and government debt ratios increase. The institutional-political variable's coefficient remains of similar magnitude and of high significance throughout the period, while the fiscal balance variable and the rating residual are insignificant or on the border of insignificance throughout the sample.

Variables' standard deviations are different (relative to each other and through time), thus coefficient estimates' changes does not say anything about how the relative importance of these variables changed in explaining the CDS spread. To gain an intuition on this concept we calculate and plot the following measure. For each time window and each explanatory variable we calculate the difference between the R-squared of the full model and the R-squared of a restricted regression that excludes the given variable. Variables, which are important in explaining the levels of CDS spreads in the region, contribute more to the explanatory power of the model.

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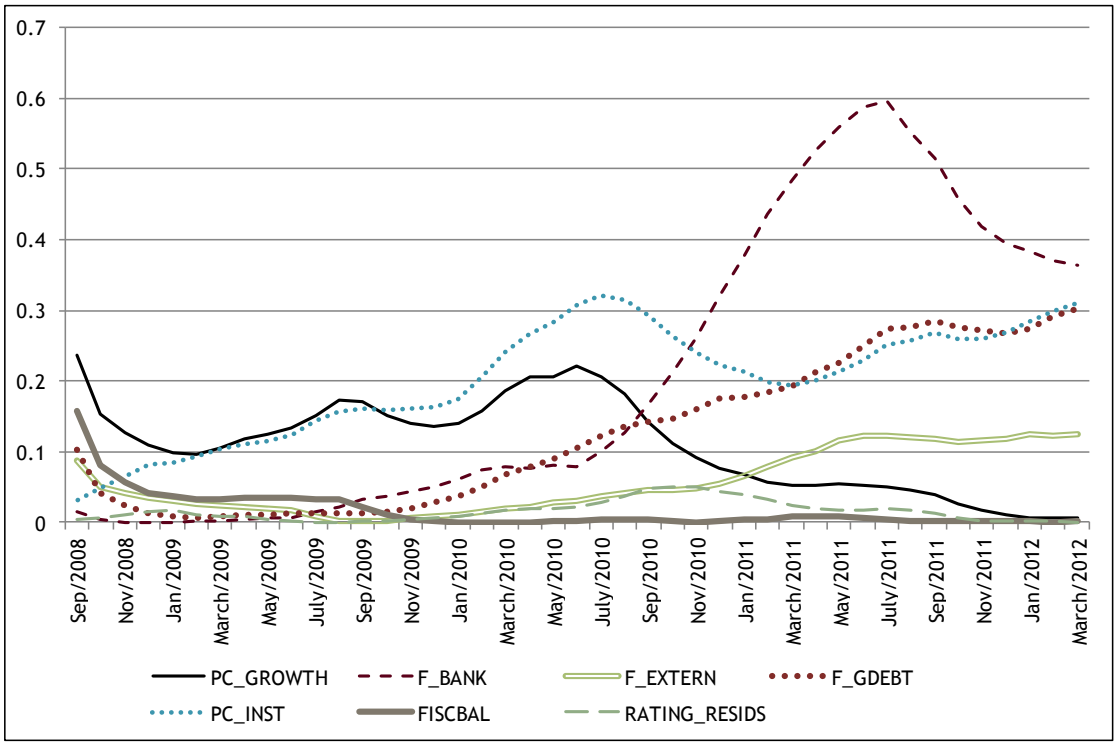
the institutional strength and political stability of two developed countries might cause a less significant difference in CDS spreads, then a difference of two developing countries.

***Figure 3*. Explanatory power differences of restricted and unrestricted long-run regressions**



Note: 1-year rolling windows. Dates indicated are ending dates of the estimation window.

Contributions to the explanatory power of regressions suggest similar processes as coefficients' evolutions (*Figure 3*). We observe a decrease of explanatory power of the growth outlook variable during the period, while government debt, banking system stability, external balance factors have become significantly more important in the CDS spreads regressions over time. The institutional-political variable has been significant throughout the sample, while rating residuals and fiscal balance outlook have not added much explanatory power.

These results imply that time-variation of variables' effects were important in Eastern Europe during the crisis. Moreover, considering that the Eurozone periphery's sovereign crisis brought issues of government debt, banking system stability and external balances into the center of attention, the findings that these factors gained relative importance suggests wake-up call effects.

III.4.3. Robustness checks

We perform several robustness checks to see how sensitive results are. First, regressions are re-estimated on quarterly data to see whether linear interpolation of variables had a significant affect. A priori we would expect the banking stability factor and the component of development-institutions-politics to be possibly affected as these are constructed by the use of (also) linearly interpolated variables. Growth, external position, fiscal balance and ratings are on the other hand dominantly based on either Bloomberg data (available daily), or on projections of Consensus Economics (available on a monthly basis). Since on quarterly frequency we have less observations we expect coefficient uncertainty to be larger.

Appendix 4 Table 9 shows the results of quarterly regressions. The only material difference in the long-run equation compared with the baseline model is the insignificance of the fiscal balance variable (which is available monthly). Otherwise standard errors are systematically higher, as expected. The short-run equation estimates are also similar to those in the monthly case. One key difference, however, is the larger coefficient of the error-correction term. Much of this difference is reasonable: since time intervals are longer between two observations in the quarterly data set, therefore to represent a long-term effect of similar magnitude the coefficient of the ECM term has to increase more than three-fold.

We next turn to the issue of cross-section heterogeneity of results. Since we have a low number of time series observations even on the monthly frequency and as suggested before coefficients are also varying over time, it is not possible to estimate regressions separately for each country. We therefore restrict ourselves to estimating the model on two subsamples, and then we turn to comparing results of the panel data set of 13-countries to gain an intuition on how stable results are to cross-section selection.

Appendix 4 Table 9 shows coefficient estimates on the two subsamples. We chose to split the sample based on the relative value of stock variables, with regressions estimated for a subsample of countries of worse initial

fundamentals (Bulgaria, Latvia, Hungary, Turkey) and another subsample of the remaining five countries, where stock-type variables were relatively better (Croatia, Czech Republic, Lithuania, Poland, Russia).

Although most coefficients remain significant and of expected sign in the long run regression, there are some differences in coefficients worth mentioning. Compared to the baseline model the bank variable has a significantly larger parameter in the countries with better stocks, whereas the government debt variable loses significance. In the subsample of countries with worse fundamentals external position, government debt and ratings have greater parameters than in the benchmark estimation. In the short-run equation the relative CDS spreads of countries with better fundamentals are found to be more affected by changes of fundamentals and less so by the error-correction term compared with the other subsample's estimates.

The data set of the larger cross-section also results in somewhat different coefficient estimates for some variables. Notably, in the long-run equation government debt becomes insignificant, while the coefficients of growth and ratings are significantly larger. This may either result from the difference of the cross-section or from the smaller variable set in this panel. To find out, we estimate the model using the smaller variable set on the cross-section of 9 countries. In the case of the growth variable, this estimation results in a similarly large parameter as in the 13-country panel, which implies that the smaller variable set seems to be the reason of the deviation from the benchmark model. In the case of government debt, however, the coefficient is similar to the benchmark case, suggesting that in this case the addition of the four new countries caused the difference between the two panels. Ratings' parameter differs due to a blend of the two reasons. The rating regression residuals seem to take up larger coefficients to explain spreads when government debt loses significance due to the cross-section differences, but they are also larger owing to the difference in the variable set. The lower coefficients of rating residuals in the benchmark regression also suggests that the used 9-country panel's variable set has a significant informational advantage relative to the variable set of larger cross-section.

To sum up experiences of cross-section heterogeneity, some parameters, such as institutions in the long-run equation and changes in the prospects for growth and the external position, as well as the ECM term seem to be stable explanatory variables in the model with coefficients largely similar across different estimation samples. However changes to the sample leads to significant impacts of parameters in some cases for growth, bank stability and the debt variable in the levels equation.

Finally, and in view of the cross-section heterogeneity that we find for some variables, we compare regressions estimated on samples including and excluding Hungary. The reason for such an exercise is to assess how relevant results are in an out-of-sample context: namely if the relationship between relative CDS spreads and fundamentals estimated for other Eastern European countries provides a good estimate for such a relationship in the Hungarian case. Results presented in *Appnedix 4 Table 10* are reassuring in this respect. Both long-run and short-run equations have similar estimates with and without Hungary for the full time sample and the subsample estimated on 2010-2012 data, although government debt's coefficient increases even more in the latter sample when Hungary is not in the sample.

III.5. Conclusions

We study the relationship between relative sovereign CDS spreads and relative country-specific fundamentals. Principal components and factors are extracted from a wide array of fundamental variables encompassing expectations of growth, fiscal and external balances and actual data on the banking sector, government debt position, as well as indicators assessing the institutional strength and political stability of countries. The sample of the data is the Eastern European region in the period between July 2008 and March 2012. Time fixed effect panel regressions of both levels and first differences are estimated between CDS spreads and fundamental variables, with an error-correction mechanism linking levels to the short-run equation.

In agreement with previous studies, we find that lower expected growth, weaker external balances, higher government debt ratios are associated with higher sovereign CDS spreads. Consistent with the recent literature, the indicators of banking sector stability are found to be important in explaining spreads. We show that explicit proxies of institutional and political factors, which are rarely used in related studies, also have a significant impact. In contrast with much of the literature, however, we do not find a positive relationship between the level of fiscal deficit and CDS spreads, which may be a result of the sample and of reverse causality between credit risk and fiscal balance.

According to the regression of variable changes, relative fundamentals affect CDS spreads mainly through an error-correction term contradicting standard theory, which predicts immediate reaction of markets to new information. The significance of the error-correction term may be due to the activity of fund managers, who, owing to the time cost of information collection and market liquidity reasons, adjust portfolios only gradually.

Some coefficients seem to be sensitive to selection of the country sample. Time-variation of parameters is supported by simple rolling regressions, pointing to an increase of government debt, banking stability and external balance in the assessment of relative riskiness of countries. This may be a result of a wake-up call effect from the sovereign crisis of the Eurozone periphery.

IV. APPLICATION TO THE HUNGARIAN CDS SPREAD

This part is a case study about the change in the Hungarian relative CDS spread. As far as we know, this part provides the most in-depth analysis of the country-specific fundamental determinants of the Hungarian CDS spread so far.

The model discussed in the previous part attributes the Hungarian CDS spread's relative increase to both a worsening of fundamentals (growth prospects and banking stability) and to a changing in investor preferences: government debt, one of the country's key weaknesses, has become more important in relative sovereign risk assessment.

The estimations were also carried out for three other regional countries (Poland, Russia, and Turkey). The results are presented in Appendices 6-8: Figures 12-26.

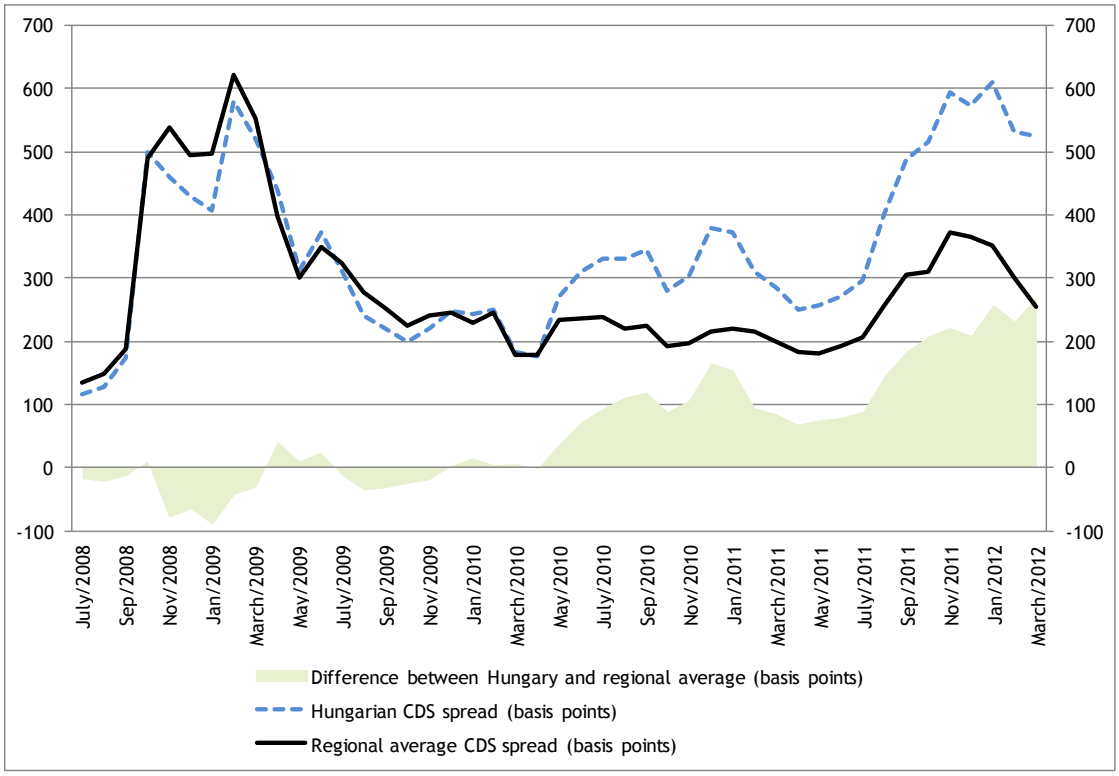
IV.1. Introduction, stylized facts

Since the beginning of our sample in July 2008, Hungarian 5-year CDS spreads have increased from near 100 basis points to over 500 basis points in March 2012, when our sample ends. Spreads first shot above 500 basis points after the bankruptcy of Lehman Brothers, when the crisis spread to emerging markets. The whole region was affected by that risk premium shock, and the Hungarian CDS spread rose roughly together with the regional average. Eastern European indicators experienced another peak in early 2009, but then a region-wide decline followed in most of 2009. In spring and summer 2010, Hungarian CDS spreads increased again, however, this time it was an increase of mostly country-specific origins: the average of Eastern European CDS spreads remained largely stagnant until 2011 summer.

In mid-2011 fears of the euro area sovereign crisis spreading to Italy and the euro area banking sector, as well as concerns related to a Greek default, in the autumn, led to a new round of CDS spread increases in the region. The Hungarian indicator was proportionately more affected and its difference

compared to the regional average has increased to 300 basis points by which time it was around double the Eastern European average (*Figure 4*). Expectations of a Greek-IMF-EU agreement and the bond swap acted to reduce Hungarian and other Eastern European spreads in the last months of the sample period.

***Figure 4*. Hungarian 5-year CDS spreads and the Eastern European average (July 2008 – March 2012)**



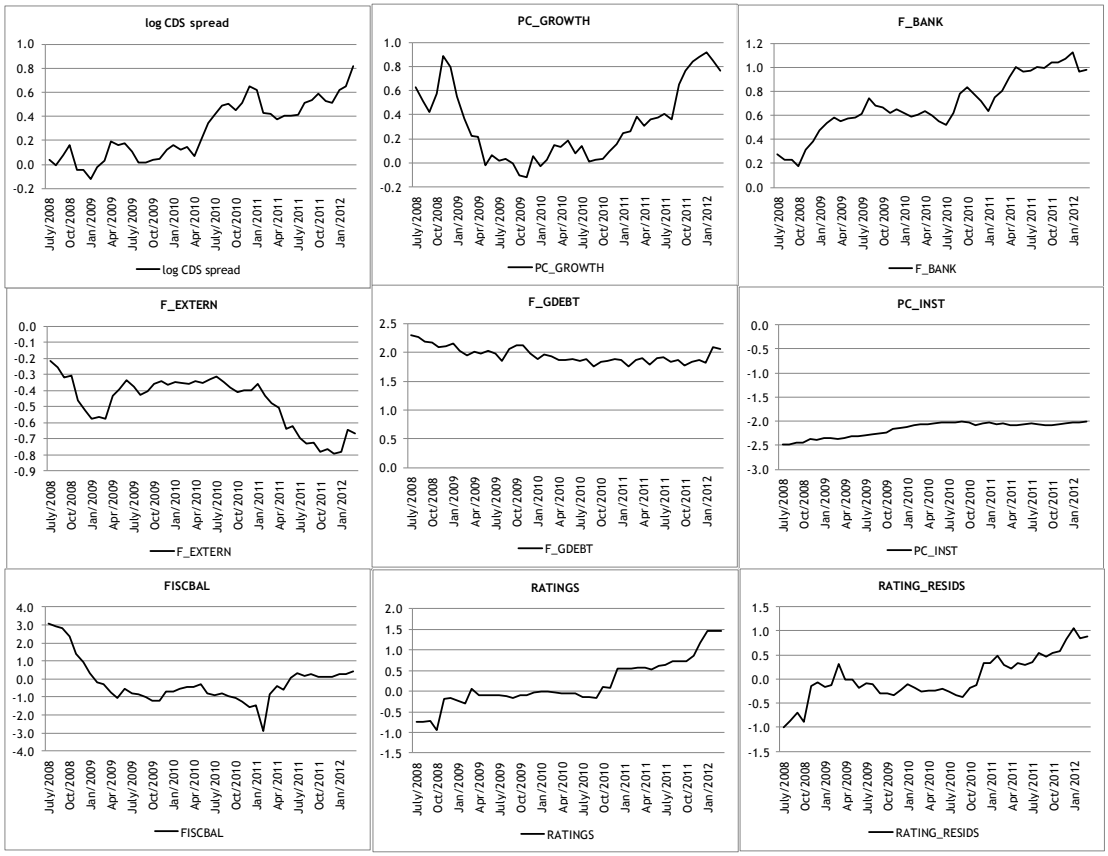
In terms of variables incorporated in our model, the logarithm of Hungarian CDS spread compared to the mean of Eastern European logarithmic CDS spreads began to deviate from near 0 levels in end-2009, early-2010 and increased to a value of 0.8 by the end of the sample.

Based on fundamental variables (*Figure 5*) Hungary had a relative worse growth outlook, banking stability and a significantly worse government debt position than the regional average in the whole period. Moreover the growth variable and the factor representing banking sector vulnerability deteriorated during the period, which are thus candidates for explaining the worsening of the relative spread. On the other hand Hungary has been significantly better

than regional peers on the grounds of the institutional-political-development component proxied by the variable, PC_INST. Also, the prospects of external balance were better and has improved compared to the region in the period.

In terms of credit ratings, Hungary was initially better than the regional average but this has changed during the sample. Fundamentals partly explained the deterioration since the rating residual rose by a smaller extent than relative ratings themselves. Yet there has been a notable rise in this factor as well, which indicates the importance of factors which our rating regressions were not able to capture.

***Figure 5*. Hungarian indicators compared to regional averages**

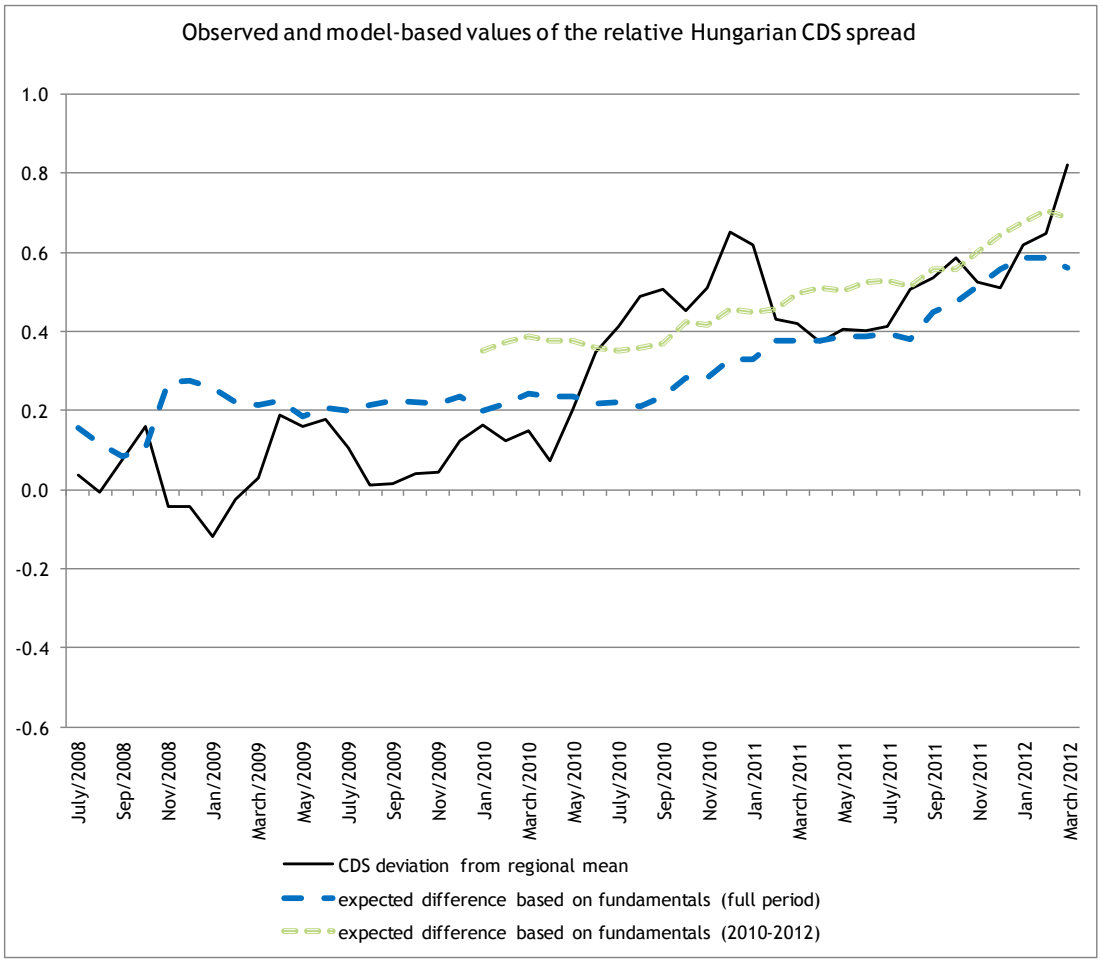


Note: Variables are scaled so that increases are consistent with a deterioration of credit risk. Similar figures for the other countries in the sample are shown in *Appendix 9 Figures 27-35*.

IV.2. Model explanations for the deterioration

To apply results of the model we turn to the long-run equation to assess how relative fundamentals have explained relative Hungarian CDS spreads. *Figure 6* plots the observed and model-based estimates for the relative CDS spread throughout the sample. Since results have suggested a time-varying property of coefficients we also calculated and plotted the expected value of the Hungarian relative CDS spread based on estimates of the 2010-2012 subsample.

***Figure 6*. Relative CDS spreads**

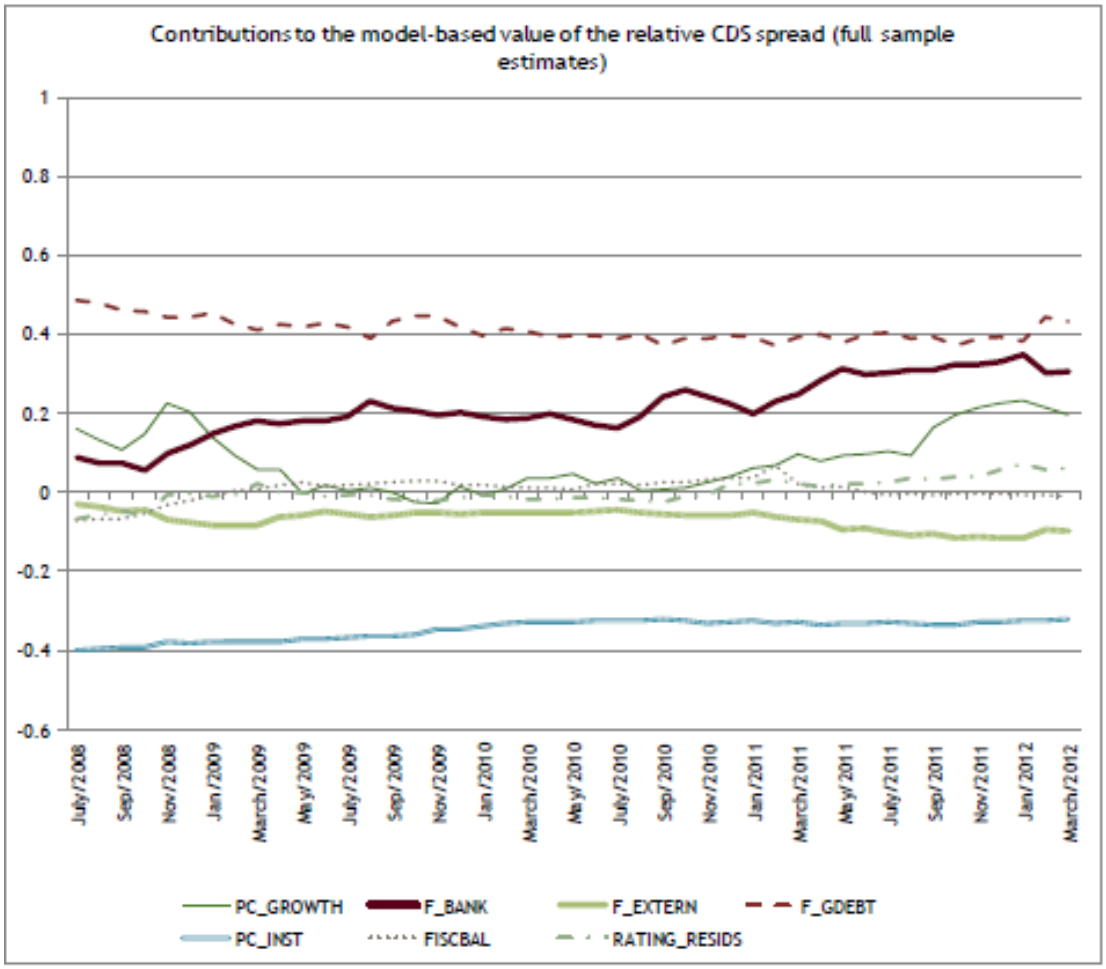


The figure shows that, on the whole, the observed Hungarian CDS spread was relatively close to the values implied by fundamentals and the model. A large part of the spread's deterioration was also consistent with a worsening of fundamental variables. Based on full sample estimates, CDS spreads were

somewhat lower before 2010 than expected based on the model, and were higher than model estimates after this period.

Figure 7 shows the contributions of various fundamentals variables to the model-based value of the dependent variable (full sample estimates). Relative high government debt stands out as the primary factor worsening the Hungarian CDS spread compared to the region, while the main factor reducing the CDS spread is the effect of better institutions. Banking stability and to a lesser extent the periodically inferior growth prospects contributed to explaining Hungary's higher CDS spread, while the better external balance moderated the indicator. The effect of fiscal balance and rating residuals on the level of relative CDS spreads seems unimportant compared to other factors. It is also clear that increases of values (denoting a relative deterioration) of the growth and bank variables have been the main culprits in worsening CDS spreads. A relative improvement of external balances could only lessen the CDS increase.

***Figure 7*. Contributions to the model-based value of the relative CDS spread**



As shown earlier in *Figure 6*, Hungarian relative CDS spreads were higher than model-based values after mid-2010 if we calculate with the full sample's coefficients, but were largely in-line with the model-implied values if we look at 2010-2012 estimates. This points to another key factor in the increase of relative CDS spreads, that of shifts in variables' coefficient estimates, i.e. changes in CDS spreads' sensitivity to variables over time. As we have seen in the previous section, mainly those variables' coefficients have increased, which were relevant in terms of the crisis of the Eurozone periphery, i.e. government debt and banking stability variables, suggesting a wake-up call effect. Unfortunately, exactly these variables happened to be relative weaknesses of Hungary compared to Eastern European peers.

To quantify the two distinct effects on the relative Hungarian CDS spread, i.e. the worsening of fundamentals and the shift in investor preferences (the wake-up call effect), we use the Oaxaca-Blinder decomposition (Blinder [1973]; Oaxaca [1973]). In particular we decompose the difference between the model-implied value for March 2012 due to the 2010-2012 period estimates (CDS_{p2} = 0.69) and the model-implied value for January 2010 due to the full sample estimates (CDS_{full} = 0.2).

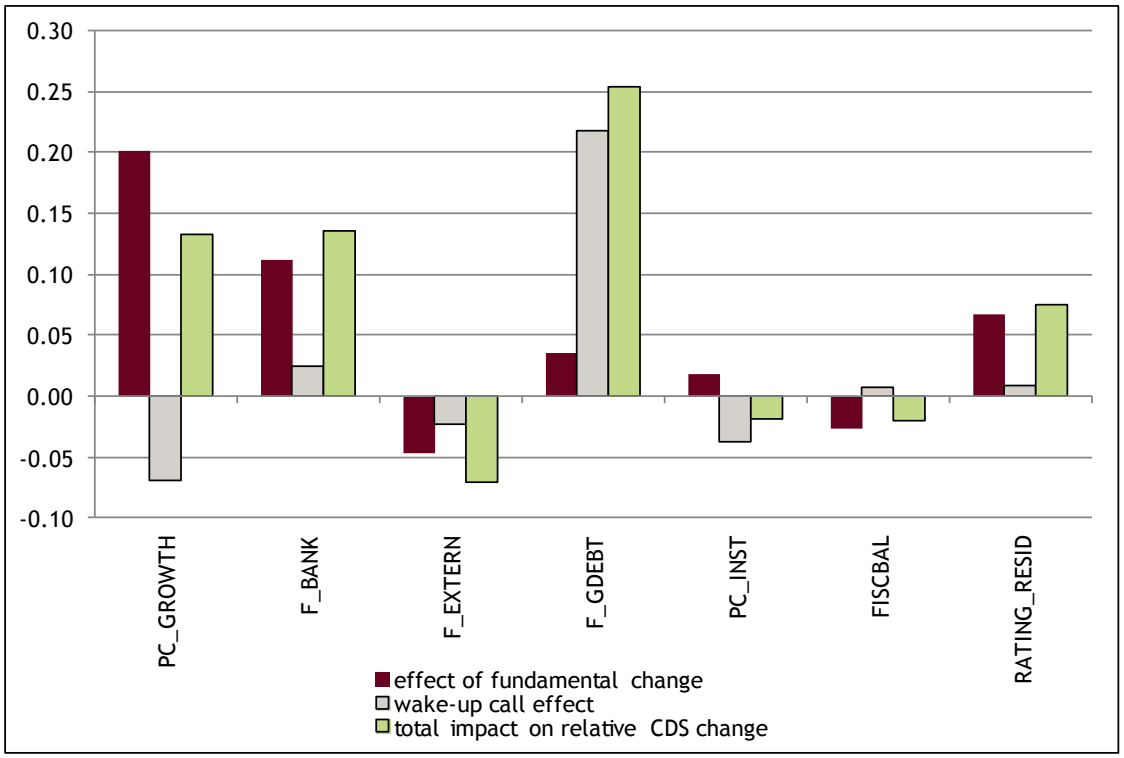
Applied to our context the Blinder-Oaxaca decomposition separates the effect of changing parameters, $\beta_{p2} - \beta_{full}$, and changing variables, $X_2 - X_1$, so that:

$$CDS_{p2} - CDS_{full} = \beta_{p2} * X_2 - \beta_{full} * X_1 == \beta_{p2} * X_2 - \beta_{full} * X_1 - \beta_{full} * X_2 + \beta_{full} * X_2 == \left(\beta_{p2} - \beta_{full}\right) * X_2 + (X_2 - X_1) * \beta_{full} \quad (8)$$

where β_{full} and β_{p2} denote the full sample and the second period (2010-2012) estimates, X_1 and X_2 stand for fundamental variable values in March 2012 and January 2010, respectively.

Figure 8 presents the result of such decomposition. The approximate increase of 0.5 in the model-implied values of the relative Hungarian CDS spread due to the different estimates and time periods is mainly the result of worsening relative growth outlook and banking stability on the one hand, and a large increase in government debt's parameter, i.e. a wake-up call effect, on the other.

***Figure 8*. Fundamental and wake-up call effects in changes of Hungarian spreads**



In the above reasoning we referred to implications of the long-run equation and have neglected model dynamics. We end this subsection with a brief account of how the above mentioned effects translate into (model-implied) changes of the Hungarian spread. The worsening of fundamentals has two effects. On one hand it can immediately impact Hungarian CDS spreads through the coefficients of fundamental variables' changes. We have seen however that these effects are relatively small. The other channel is the increase of the model-implied CDS spread level, which causes the error-correction term to affect CDS spread changes gradually over time.

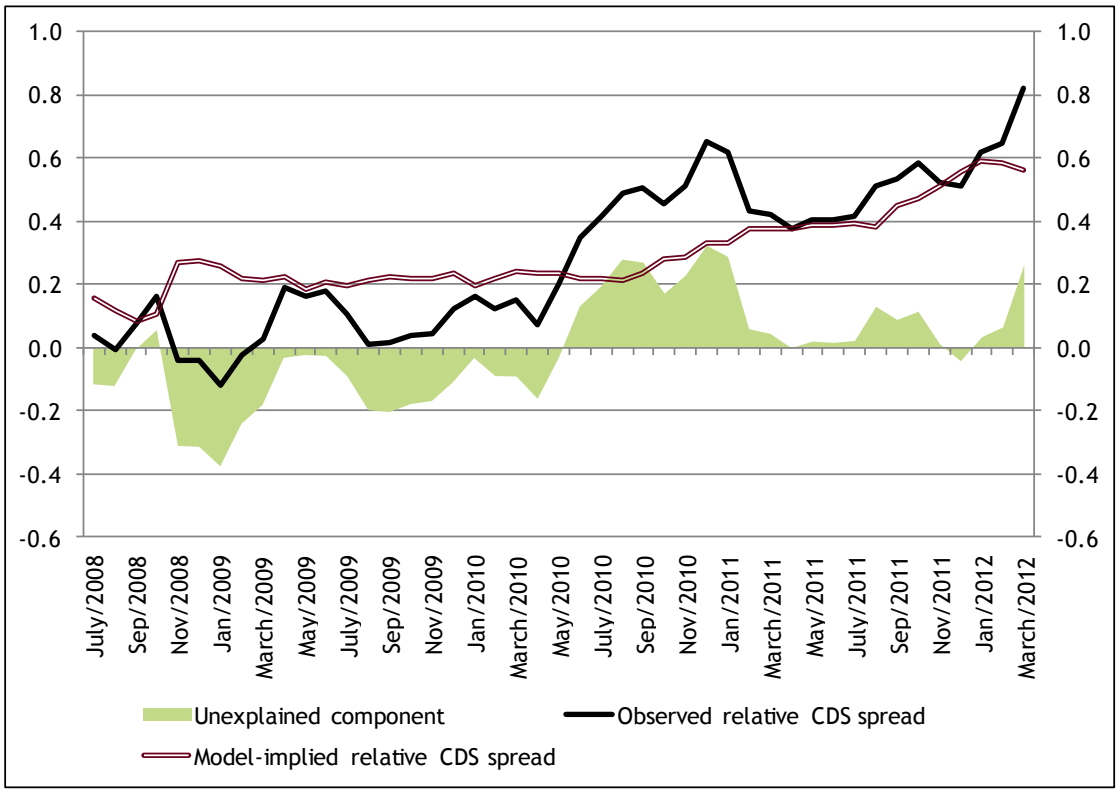
Similarly, the wake-up call affects spreads mainly by increasing the model-implied CDS spread level. In the Hungarian case and after 2010 the long-run equation estimates of the full sample implied a lower CDS spread than which has been observed in the market. This would have caused the error-correction mechanism to exert a downward pressure on Hungarian CDS spreads in the short-run equation. However due to changes in investor preferences the

model-implied long-run CDS spread increased to near the observed levels, which therefore hampered such an error-correction effect.

IV.3. Explanations for the residuals of the model

Finally we turn to factors that are left unexplained by our model. Although the (long-run) model explains the general level and main tendencies of the relative value of the Hungarian CDS spread it is worth highlighting some factors, which may explain the residual, which has been sizable at times. In order to identify these factors we resort to a narrative approach turning to market analysts' and the financial media's commentaries of key Hungarian country-specific news events.

***Figure 9*. The Hungarian relative CDS spread and its unexplained component**



These commentaries helped identify the following factors in larger changes of the CDS spread's unexplained component:

- *Non-linearities in the impact of the Hungarian forint fluctuations.* Due to an excessive stock of FX-denominated loans (mostly CHF-based

mortgage loans) in Hungary[46], the weakening of the currency has the potential to hit the Hungarian economy and the banking sector disproportionally more than other countries in the region. Especially as the exchange rate of the forint approaches levels that market participants identify as a danger zone, non-linear effects between the exchange rate and the CDS spread arise. While the model is able to explain spread movements due to a deterioration of the growth outlook, which regularly has taken place in these periods of financial instability (early 2009, mid-end-2011) and the logarithmic specification of the spread in the model helps to account for some of the non-linearities, clearly the model lacks in explaining the full sovereign credit risk impact of exchange rate deterioration. Two main reasons may be tail risks to the growth and fiscal outlook that are not captured by the base case projections of economists surveyed by Consensus Economics, and the impact of forward-looking expectations of banking sector stability for which the actual data we have could be a poor proxy. Non-linearities have in the past worked the other way around as well. Once improving international and domestic conditions caused the forint to move away from the perceived danger zone, Hungary's spreads improved relatively more than the model's prediction (e.g. in the summer of 2009).

- *Sudden shift in households' exchange rate expectations.* Related to the previous point, households have added to some of the non-linearities due to a change in their behavior regarding FX market activity. In general, households have historically had a stabilizing impact on the exchange rate of the Hungarian forint as in periods of exchange rate depreciations they tended to increase their foreign currency holdings, whereas they sold FX holdings when the forint strengthened. However, unusually rapid episodes of HUF weakening seemed to alter this

[46] A detailed paper about credit expansion and external financing needs in Hungary: (Király et al. [2008]). Another paper about the banking sector's external financing costs: (Páles & Homolya [2011]).

sector's behavior adding to the pace of forint depreciations (such as in early 2009 and in January 2012).

- *News, statements about the IMF and other international agreements (i.e. the ECB EUR/HUF FX swap line).* According to market analysts' opinions, in the period following the collapse of Lehman Brothers, a key determinant of relative improvement of Hungary's risk assessment has been related to Hungary's IMF program that ensured the financing ability of the sovereign. This has been arguably important in a time when even domestic auctions have failed. As we have observed in the past years not only the changes to having such an international financial safety net but also expectations of the possibility or of the timing of such agreements have been important in influencing spreads (breakup of agreement in July 2010 and December 2011; and hopes of an agreement in November 2011 and in early-2012). Although these factors are not explicitly built into our model, so normally we cannot assess their quantitative impact, they may however enter though the rating residual, if credit rating agencies downgrade/upgrade the country due to this factor.
- *Impact of political statements.* Market participants have occasionally reacted significantly to politician's statements. In recent years several episodes could be identified including both positive (e.g. announcement of the Orbán-Barosso agreement, April 2012) and negative (e.g. statements about a potential default of Hungary, June 2010) effects. Although we do have variables grasping domestic politics incorporated in our variable PC_INST, this measure is unable to pick-up such high-frequency market movements for most of these variables are available on annual frequency and also since they rather refer to general political stability.
- *Market assessment of government fiscal measures.* Even though our model incorporates the impact of government fiscal measures' announcements through impacting the growth and fiscal outlook projections, these variables may not be able to capture the indirect

effects that measures have on market confidence toward the government. Both negative and positive events can be mentioned in the last years: the Hungarian CDS spread significantly declined around the time of the announcement of the Széll Kálmán Plan (February-March 2011), which, judging from market commentaries, was seen as an important step not only from the perspective of balancing the budget, but also in the aspect of the government taking a market-friendly path. On the negative side government announcements such as the introduction and the augmentation of the bank levy (June 2010), the regulatory changes regarding the private pension funds, the sectoral taxes and the early mortgage repayment scheme (October 2010) negatively impacted Hungarian risk assessment.

IV.4. Conclusion

In the case of Hungary our model is able to reasonably explain both the level and the general trends of the CDS spread compared to the Eastern European region. Regarding the Hungarian relative CDS spread levels, the high government debt ratio and, increasingly, the poor banking sector stability, stand out as main factors of a higher spread, while based on relative development-institutions-political stability and the external balance the country would have a lower than average CDS spread.

The deterioration of the Hungarian indicator compared to the region observed since end-2009 and early-2010 is the consequence of two reasons. On one hand it is due to the worsening of relative fundamentals, in particular the growth outlook and banking stability. On the other hand, however, it seems to be a result of bad luck: investors have in the past years given a larger weight to government debt ratios in their relative risk assessment, which turns out to be Hungary's key weakness compared to regional peers.

V. SUMMARY

The goal of Part II was to compare the two most commonly used auction techniques (discriminatory and uniform price auctions) through the summary of the relevant literature. Among several other countries, Poland has changed its auction method on the T-bond and T-bill markets from the previously used discriminatory format to the uniform price formula (the change was implemented on January 1, 2012). In Hungary, both the ÁKK (in the case of T-Bonds and T-bills) and the MNB (in the case of FX, FX-swaps, and Credit auctions) still use the discriminatory format. The most important goal of the analysis was to review the arguments for and against the different formulas.

The literature about the allocation of the issued bonds analyses the different formulas (uniform and the discriminatory auctions) mostly from the perspective of the expected revenue of the issuer. While in the case of single-unit auctions (for example art masterpiece), the second price and the first price auctions result in the same expected revenue, this theorem cannot be universalized for the (in the case of securities) relevant multi-unit (uniform price and discriminatory) auctions.

In the simplest multi-unit model the aggregate demand curve is higher in the case of uniform price auctions; while in the case of the discriminatory method, the average price of the accepted bids is increased by the presence of price discrimination. The main results of further models are that on the one hand, the uniform price auction is able to stimulate the participation of the bidders with smaller analyzing capacity; but on the other hand it gives more opportunity for the manipulation of prices and cartels. Therefore, the two formulas cannot be ranked on the basis of theoretical models.

The theoretical results about the bidding behavior in the case of the two methods are confirmed by both laboratory and real-life empirical evidence. Those observations where the different auction formulas could be compared in real-life auctions (because the auction format of a security was changed

from a given date, or two similar securities were auctioned in the same time but with different methods) showed almost in every case that the use of the uniform price formula results in a lower cost of several basis points.

However, all real-life experiments have been plagued by the identification problem, that is, the change caused by the auction method is difficult to tell apart from the effects of other circumstances. It would be a real scientific breakthrough, though, to set up a real-life experiment in which the same product would be sold simultaneously on both uniform-price and discriminatory auctions. Even though fewer conclusions could be drawn than in the previously proposed arrangement (due to the repetition of auctions), it would be instructive to see an experiment where primary market actors have to submit bids for both auction formats, then the real format would be decided by drawing lots. We should note, however, that the experiment may increase the 'fog of war', i.e. the strategy space may become even more complicated and the number of possible equilibria may increase to extreme heights. Such an experiment could be a very important step in future work; however, it has to be supported by a bond issuer.

Despite the empirical evidence of a lower expected revenue in the discriminatory auction case, the majority of national treasuries are using the discriminatory formula, and the central bank instruments are also typically issued by using this method. This can be explained by the fact that issuers might not only consider the expected revenue, but also other factors as well (for example the lower expected volatility in the case of discriminatory auctions).

The main advantages of the uniform price auction method might be: higher expected revenue, low markup between the market price and the auction price (in the long-term average), and increased participation in the auctions.

The discriminatory auctions are able to reduce volatility, reveal better the true valuations, and hinder price-manipulations.

In the case of central bank instruments, the orientation of the market price might be an important goal. Whether the discriminatory or the uniform price auction is the better method in this aspect is still a question. This is difficult to answer because the reviewed literature has not examined this issue. As there is no empirical study available, we should take a theoretical approach to resolve this problem. Market price is probably best oriented if there are more participants or high-volume bids in the auction, in which case the auction price may have a greater impact on the secondary market as well. The problem of bidders may be interpreted as a private-value auction (i.e., not as a common-value auction frequently studied in literature), that is, bidders do not ask the simple question of how to win instruments below the post-auction market price. Instead, banks would like to obtain cheaper funds even if they have to pay the price of reputation risk ('stigma effect' that can be evaluated bank by bank because participation in FX swap and central bank credit auctions may be seen as a sign of difficulties in raising funds in the money market, which may raise the risk premium of the bank concerned). This problem may turn the entire auction into a private-value auction due to the private valuation of the reputation loss. Assuming risk aversion, a private-value auction may result in bids being submitted at discriminatory-price auctions even at a smaller 'expected financial gain – reputation loss' difference because the price a bank paid for the funds if their bid is accepted will be known. In contrast, in the case of uniform-price auctions, the high degree of 'fog of war' means that bidders may be uncertain about the bid price and less clear about the expected financial gain. The above reasoning relies on a large number of assumptions. Consequently, more studies and model experiments would be needed on the subject of the orientation of market prices.

In the case of central bank instruments currently sold at auctions (one-week and three-month FX-swaps, six-month variable interest rate collateralized loans, FX-auctions) the orientation of the market price may be important, and several factors may need to be taken into account. Overall, for the time being there seems to be no strong argument for the adoption of

the uniform-price format, so in line with the international practice of central banks, discriminatory-price auctions may continue to be appropriate allocation mechanisms.

In the case of the auction of Hungarian government bonds, maximizing the expected revenue of the issuer may also be important. In this respect the overwhelming majority of empirical evidence shows that uniform-price auctions have an advantage of a few basis points or at least the average profit of bidders was lower in uniform-price auctions in most of the cases reviewed. It should be noted, however, that discriminatory auctions may be more advantageous in an uncertain market environment or where the bid-to-cover ratio is low. Consequently, amidst the present uncertainties, switching to the uniform-price format could be hazardous. Changing the auction format (or conducting an experiment into such a change) would be relevant if volatility remained persistently low with consistently high bid-to-cover ratios. However, the adoption of the uniform-price format may be worth considering under better market conditions in the hope of cheaper funding. In order to suppress the possibility of manipulation, in the uniform-price system it is particularly important for the issuer to be able to change the volume sold, and the success of a switch depends to a large extent on the probability of the market entry of smaller participants, thus also on the characteristics of the primary dealer system. The publication of an in-depth study on the change implemented by the Polish treasury in 2012 could shed light on important considerations for the Hungarian auction system.

In Part III we study the relationship between relative sovereign CDS spreads and relative country-specific fundamentals.

We adhere to the literature in assuming that most of the time series variation in CDS spreads are a result of common shocks to the pricing of risk and we concentrate the analysis on the other, cross-sectional aspect of CDS spreads by assessing which fundamental factors have been empirically important in explaining the relative riskiness of countries as proxied by the relative magnitude of these indicators.

We lay emphasis on using a dataset that treats some empirical issues that, in previous studies, have often been disregarded. First, where possible we use projections of future variables instead of actual data (in line with D'Agostino & Ehrmann [2013]). Second, we aim to reduce the adverse effects of variable omissions by including a larger and a conceptually wider set of fundamental variables than usual in similar studies. Besides the standard macroeconomic variables, we incorporate data on the banking sector and use a set of political and institutional variables as well. Principal components and factors are extracted from conceptually similar variables' groups and these are then used in CDS spreads' regressions to overcome problems of multicollinearity and the curse of dimensionality. To further limit adverse effects of variable omission, we attempt to make use of the extra information contained in credit ratings compared to that in our fundamental variable set. A further output of this research could be a methodological paper, in which the main question would be, if our model can beat the mainstream models in this topic.

Principal components and factors are extracted from a wide array of fundamental variables encompassing expectations of growth, fiscal and external balances and actual data on the banking sector, government debt position, as well as indicators assessing the institutional strength and political stability of countries. The sample of the data is the Eastern European region in the period between July 2008 and March 2012. Time fixed effect panel regressions of both levels and first differences are estimated between CDS spreads and fundamental variables, with an error-correction mechanism linking levels to the short-run equation.

In line with previous studies, we find that lower expected growth, weaker external balances and higher government debt ratios are associated with higher sovereign CDS spreads. Consistent with the recent literature, the indicators of banking sector stability are found to be important in explaining spreads. We show that explicit proxies of institutional and political factors, which are rarely used in related studies, also have a significant impact. In contrast to much of the literature, however, we do not find a positive relationship between the level of fiscal deficit and CDS spreads, which may be

a result of the sample and of reverse causality between credit risk and fiscal balance.

According to the regression of variable changes, relative fundamentals affect CDS spreads mainly through an error-correction term contradicting standard theory, which predicts immediate reaction of markets to new information. The significance of the error-correction term may be due to the activity of fund managers, who, owing to the time cost of information collection and market liquidity reasons, adjust portfolios only gradually.

Some coefficients seem to be sensitive to selection of the country sample. Time-variation of parameters is supported by simple rolling regressions, pointing to an increase of government debt, banking stability and external balance in the assessment of relative riskiness of countries. This may be a result of a wake-up call effect from the sovereign crisis of the Eurozone periphery.

This part's main contribution to the literature is in assessing the fundamental factors relevant for Eastern European CDS spreads. Analysis of sovereign bond spreads' determinants do exist for the region but even that is scarce and our study contributes to those in assessing a larger array of relevant factors limiting problems of variable omissions.

In Part IV our model is able to reasonably explain both the level and the general trends of the relative spread compared to the region. The high government debt ratio and, increasingly, the poor banking sector stability, stand out as main factors of a higher relative spread, while based on relative development-institutions-political stability and the external balance the country would have a lower than average spread.

Since the end of 2009 and early-2010 the observed worsening of the Hungarian indicator compared to the region is the consequence of two reasons. On the one hand it is due to the worsening of relative fundamentals, in particular to the growth outlook and banking stability. On the other hand, however, it seems to be a result of bad luck: investors have in the past years

given a larger weight to government debt ratios in their relative risk assessment, which turns out to be Hungary's key weakness compared to regional peers.

In the upcoming weeks, a paper will be submitted to Economics of Transition. This paper will be similar to Part IV, but the case studies will investigate three big Eastern European economies, Poland, Russia and Turkey.

VI. APPENDICES

VI.1. Appendix 1: The Revenue Equivalence Theory

From: (Krishna, 2009, p. 28)

"**Proposition.** Suppose that values are independently and identically distributed and all bidders are risk neutral. Then any symmetric and increasing equilibrium of any standard auction, such that the expected payment of a bidder with value zero is zero, yields the same expected revenue to the seller.

Proof. Consider a standard auction form, A, and fix a symmetric equilibrium β of A. Let $m^A(x)$ be the equilibrium expected payment in auction A by a bidder with value x. Suppose that β is such that $m^A(0)=0$.
Consider a particular bidder—say, 1—and suppose other bidders are following the equilibrium strategy β. It is useful to abstract away from the details of the auction and consider the expected payoff of bidder 1 with value x and when he bids β (z) instead of the equilibrium bid β (x). Bidder 1 wins when his bid β (z) exceeds the highest competing bid β (Y_1), or equivalently, when $z>Y_1$. His expected payoff is:

$$\pi^A(z,x) = G(z)x - m^A(z)$$

where as before $G(z) \equiv F(z)^{N-1}$ is the distribution of Y_1. The key point is that $m^A(z)$ depends on the other players' strategy β and z but is independent of the true value, x. Maximization results in the first-order condition

$$\frac{\partial}{\partial z}\pi^A(z,x) = g(z)x - \frac{d}{dz}m^A(z) = 0$$

At an equilibrium it is optimal to report z=x, so we obtain that for all y

$$\frac{d}{dy}m^A(y) = g(y)y$$

Thus,

$$m^A(x) = m^A(0) + \int_0^x yg(y)dy = \int_0^x yg(y)dy = G(x) \times E(Y_1|Y_1 < x)$$

since, by assumption, $m^A(0)=0$. Since the right-hand side does not depend on the particular auction form A, this completes the proof" (Krishna, 2009, p. 28).

VI.2. Appendix 2: The Database

Table 6. Data

Code	Variable	Data source	9-country panel	13-country panel	Original frequency
CDSL	logarithm of 5-year CDS spread	Bloomberg	not grouped	not grouped	daily
RATM	Moody's credit rating, linear scale	Bloomberg	PC_RATING	PC_RATING	daily
RATS	S&P credit rating, linear scale	Bloomberg	PC_RATING	PC_RATING	daily
RATF	Fitch credit rating, linear scale	Bloomberg	PC_RATING	PC_RATING	daily
dGDP	real GDP growth projection	Consensus Economics	PC_GROWTH	PC_GROWTH	monthly
dINV	investment growth projection	Consensus Economics	PC_GROWTH	PC_GROWTH	monthly
dIND	industrial production projection	Consensus Economics	PC_GROWTH	PC_GROWTH	monthly
GDPCAPL	GDP per capita, logarithm	IMF IFS	PC_INST	PC_INST	quarterly
FISCBAL	fiscal balance (/GDP*) projection	Consensus Economics	not grouped	n/a	monthly
GGDBOND	gov't bonds outstanding (/GDP*)	Bloomberg	F_GDEBT	F_GDEBT	daily
GGDFX	gov't FX bonds outstanding (/GDP*)	Bloomberg	F_GDEBT	F_GDEBT	daily
GGSD	gov't short-term bonds outstanding (/GDP*)	Bloomberg	F_GDEBT	F_GDEBT	daily
GGSDFX	gov't short-term FX bonds outstanding (/GDP*)	Bloomberg	F_GDEBT	F_GDEBT	daily
GLOANFAC	gov't loan facilities (/GDP*)	Bloomberg	F_GDEBT	F_GDEBT	daily
GGDBL	gov't bonds and loans outstanding (/GDP*)	Bloomberg	F_GDEBT	F_GDEBT	daily
GGDBL2	forward-looking gov't gross debt to GDP**	IMF IFS	F_GDEBT	n/a	quarterly
TRBAL	trade balance projection (/GDP*)	Consensus Economics	F_EXTERN	F_EXTERN	monthly
CA	current account balance projection (/GDP*)	Consensus Economics	F_EXTERN	F_EXTERN	monthly
TRBAL_ROG	2009 trade balance of oil + refined oil products + gas	CIA WF	F_EXTERN	F_EXTERN	annual
EDGDP	external debt (/GDP*)	World Bank QEDS	F_BANK	n/a	quarterly
SEDGDP	short-term external debt (/GDP*)	World Bank QEDS	F_BANK	n/a	quarterly
RES	official reserves (/GDP*)	IMF IFS	F_EXTERN	F_EXTERN	quarterly
BEDGDP	bank sector external debt (/GDP*)	World Bank QEDS	F_BANK	n/a	quarterly
BSEDGDP	bank sector short-term external debt (/GDP*)	World Bank QEDS	F_BANK	n/a	quarterly
ROE	return on equity	IMF FSI, MNB ST	F_BANK	F_BANK	quarterly/annual***
ROA	return on assets	IMF FSI, MNB ST	F_BANK	F_BANK	quarterly/annual***
LOAN_DEP	loan-to-deposit ratio	IMF IFS	F_BANK	n/a	quarterly
CAP_ADEQ	regulatory capital to risk-weighted assets	IMF FSI	F_BANK	F_BANK	quarterly
NPL	non-performing loans to assets	IMF FSI	F_BANK	F_BANK	annual
EU	dummy variable of EU membership		PC_INST	PC_INST	monthly
EZ	dummy variable of EZ membership		PC_INST	PC_INST	monthly
BRENT	Brent oil price per barrel, next delivery	Bloomberg	F_EXTERN	F_EXTERN	daily
GSCOM	Goldman Sachs Commodity Index	Bloomberg	F_EXTERN	F_EXTERN	daily
USD	EUR/USD rate	Bloomberg	not grouped	not grouped	daily
US_CSPR	US corporate Baa-Aaa issuer yield spread	Bloomberg	not grouped	not grouped	daily
VIX	ATM 3-month implied volatility of the S&P-500 index	Bloomberg	not grouped	not grouped	daily
VDAX	ATM 3-month implied volatility of the DAX index	Bloomberg	not grouped	not grouped	daily
P_EUI	Economist Intelligence Unit measure of Political Risk.	Bloomberg	PC_INST	PC_INST	monthly
P_HOV	Heritage Foundation Index of Economic Freedom, overall score	Heritage Foundation	PC_INST	PC_INST	annual
P_HBI	Heritage Foundation Index of Economic Freedom, business freedom	Heritage Foundation	PC_INST	PC_INST	annual
P_HFS	Heritage Foundation Index of Economic Freedom, fiscal freedom	Heritage Foundation	PC_INST	PC_INST	annual
P_HMO	Heritage Foundation Index of Economic Freedom, monetary freedom	Heritage Foundation	PC_INST	PC_INST	annual
P_HIN	Heritage Foundation Index of Economic Freedom, investment freedo	Heritage Foundation	PC_INST	PC_INST	annual
P_HFN	Heritage Foundation Index of Economic Freedom, financial freedom	Heritage Foundation	PC_INST	PC_INST	annual
P_HPR	Heritage Foundation Index of Economic Freedom, property rights	Heritage Foundation	PC_INST	PC_INST	annual

*Notes: IFS: International Financial Statistics; FSI: the Financial Stability Indicators; QEDS: Quarterly External Debt Statistics; WF: World Factbook; * GDP is a 4-quarter calculated nominal GDP measure ending at the given quarter. **The forward-looking debt ratio is calculated by taking t-1 year's debt-ratio and calculating the t-year and t+1 year ratios using CE projections of actual and next years' fiscal balance, CPI (as a proxy of GDP deflator) and*

*GDP real growth. From the t and t+1 year-end projections the 12-month projection is calculated as in the case of other CE projections (see main text). *** Annual available only for: BG, EE, RU, SK.*

Table 7. Principal components

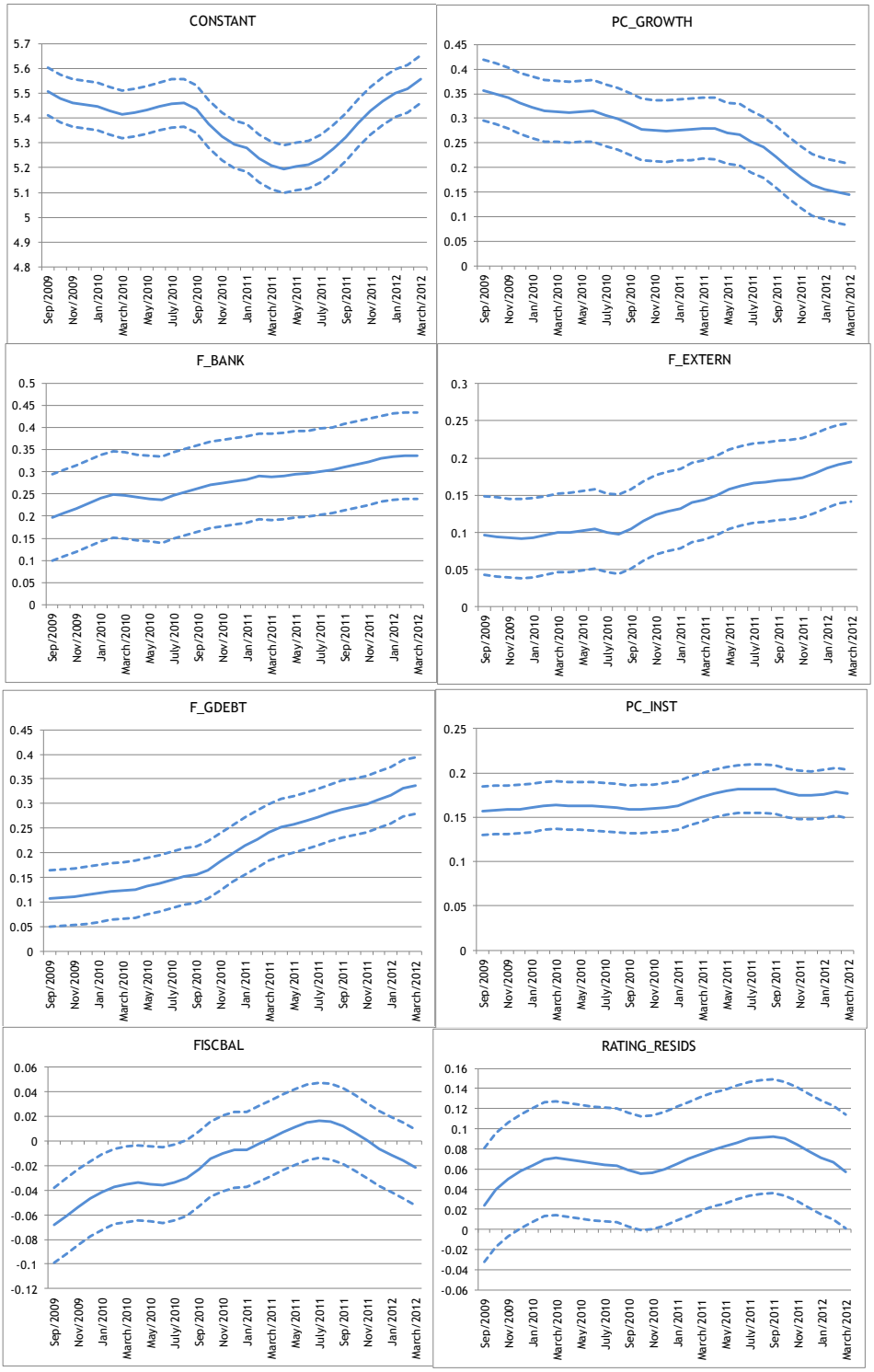
Principal component	Explained variance share of group	Variables and their loadings									
		dGDP	dINV	dIND							
PC_GROWTH	94%	0.586	0.579	0.566							
		gdpcapl	EU	P_EUI	P_HOV	P_HBI	P_HFS	P_HMO	P_HIN	P_HFN	P_HPR
PC_INST	61%	0.246	0.290	-0.339	0.389	0.298	-0.011	0.317	0.381	0.362	0.351868
		RATF	RATM	RATS							
PC_RATING	96%	0.581	0.574	0.577							
		RES	GGDBL	EDGDP	BEDGDP						
PC_STOCKS	55%	0.386	0.353	0.663	0.535						

Table 8. Factors

	Communalities: explained variable variances	Factor loadings after varimax rotation		
		F_BANK	F_GDEBT	F_EXTERN
BEDGDP	81%	***0.896***	-0.071	0.067
BSEDGDP	87%	***0.883***	-0.242	0.179
EDGDP	83%	***0.839***	0.332	0.141
SEDGDP	88%	***0.875***	-0.186	0.285
-ROE	55%	***0.736***	0.092	-0.028
-ROA	64%	***0.784***	0.155	0.037
-CAP_ADEQ	17%	0.380	0.146	0.088
NPL	37%	***0.555***	0.175	-0.186
GGDBOND	90%	-0.127	***0.930***	0.134
GGDFX	38%	0.183	0.440	0.391
GGSD	79%	-0.196	***0.859***	0.099
GGSDFX	17%	-0.047	0.286	0.300
GLOANFAC	80%	***0.809***	0.350	-0.136
GGDBL	93%	0.218	***0.937***	0.059
GGDBL2	87%	0.135	***0.841***	-0.378
-CA	79%	-0.157	-0.154	***0.863***
-TRBAL	80%	0.143	-0.243	***0.847***
-RES	30%	-0.435	0.026	0.332
-BRENT*TRBAL_ROG	88%	0.347	0.463	***0.740***
-GSCOM*TRBAL_ROG	90%	0.324	0.437	***0.775***

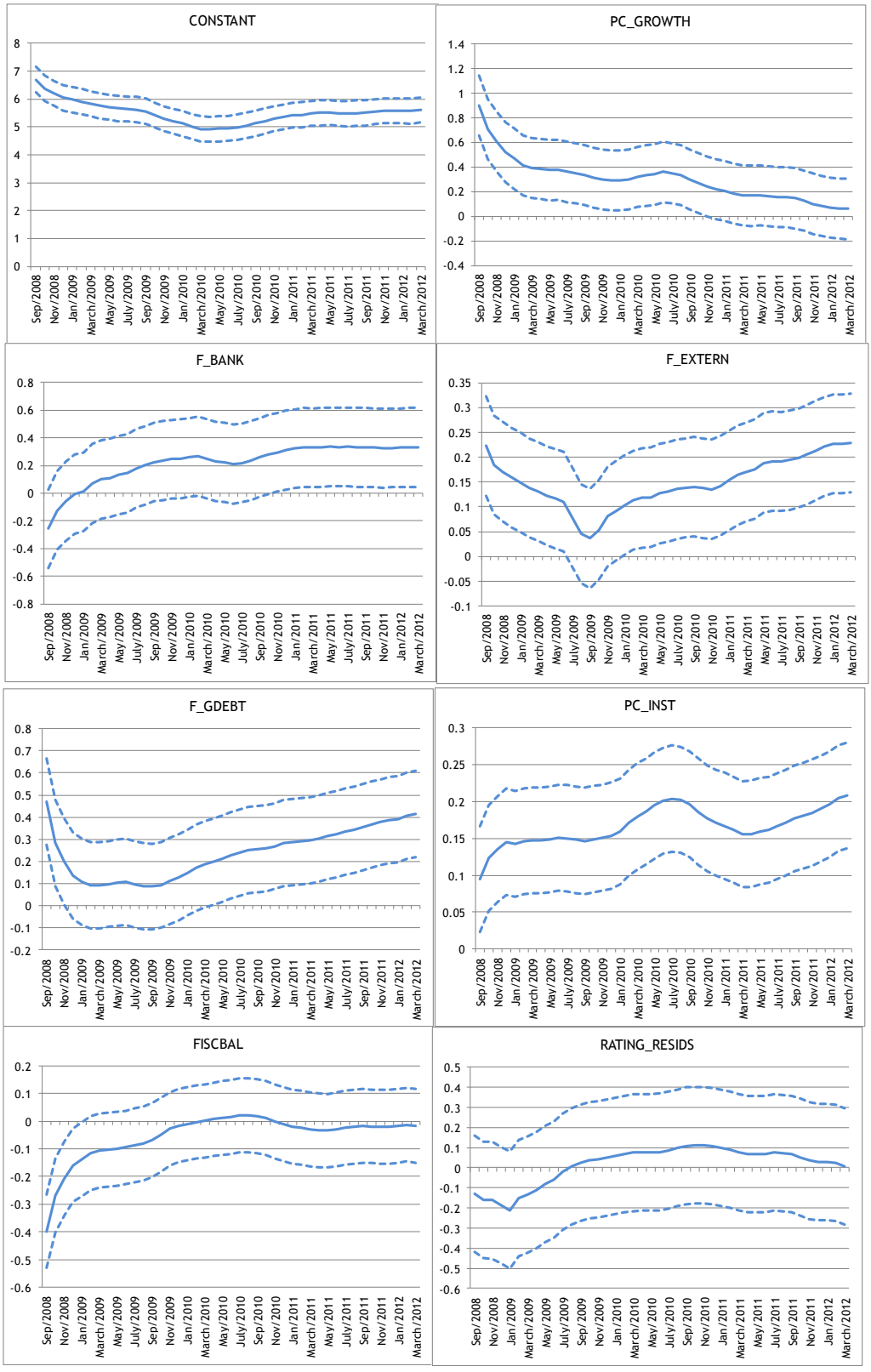
VI.3. Appendix 3: Coefficient estimates of rolling window regressions

Figure 10. **Coefficient estimates of the long-run panel regressions on two-year rolling windows**



Note: dates indicated are ending dates of the estimation period

***Figure 11*. Coefficient estimates of the long-run panel regressions on one-year rolling windows**



Note: dates indicated are ending dates of the estimation period

VI.4. Appendix 4: Robustness checks

Table 9. Robustness checks: estimation on quarterly data and cross-section subsamples

Dependent variable	Log CDS spread			Log CDS spread			Log CDS spread			Log CDS spread			Log CDS spread			Log CDS spread		
	monthly data			quarterly data			relative better stock-type variables			relative worse stock-type variables			13-country panel			13-country panel's variables on the 9-country panel		
Explanatory variables	coefficient	std.error	sign.	coefficient	std.error	sign.	coefficient	std.error	sign.	coefficient	std.error	sign.	coefficient	std.error	sign.	coefficient	std.error	sign.
PC_GROWTH*(-1)	0.253	0.015	***	0.230	0.022	***	0.167	0.027	***	0.268	0.022	***	0.398	0.016	***	0.359	0.018	***
F_BANK	0.310	0.015	***	0.315	0.023	***	0.844	0.054	***	0.409	0.087	***	0.239	0.013	***	0.285	0.016	***
F_EXTERN	0.148	0.015	***	0.190	0.022	***	0.144	0.028	***	0.359	0.146	**	0.138	0.012	***	0.155	0.015	***
F_GDEBT	0.211	0.016	***	0.269	0.044	***	-0.051	0.058		0.353	0.094	***	0.010	0.012		0.211	0.017	***
PC_INST*(-1)	0.161	0.008	***	0.172	0.014	***	0.137	0.009	***	0.233	0.049	***	0.142	0.005	***	0.166	0.009	***
FISCBAL*(-1)	-0.024	0.008	***	0.023	0.012	*	-0.042	0.016	**	0.003	0.019							
RATING_RESIDUAL	0.068	0.012	***	0.078	0.033	**	0.091	0.032	***	0.162	0.033	***	0.191	0.013	***	0.103	0.011	***
Observations	405			135			225			180			585			405		
Periods	45			15			45			45			45			45		
Cross-sections	9			9			5			4			13			9		
R-squared	0.853			0.942			0.892			0.892			0.883			0.836		
adj. R-squared	0.832			0.907			0.860			0.849			0.872			0.813		
D-W stat.	0.165			0.140			0.173			0.335			0.163			0.168		

Dependent variable	Log differences of CDS spread			Log differences of CDS spread			Log differences of CDS spread			Log differences of CDS spread			Log differences of CDS spread			Log differences of CDS spread		
	monthly data			quarterly data			relative better stock-type variables			relative worse stock-type variables			13-country panel			13-country panel's variables on the 9-country panel		
Explanatory variables	coefficient	std.error	sign.	coefficient	std.error	sign.	coefficient	std.error	sign.	coefficient	std.error	sign.	coefficient	std.error	sign.	coefficient	std.error	sign.
PC_GROWTH*(-1)	0.084	0.031	***	0.134	0.043	***	0.129	0.042	**	0.052	0.046		0.144	0.032	***	0.110	0.039	***
F_BANK	0.064	0.089		0.099	0.129		0.469	0.201	**	-0.130	0.153		0.010	0.036		0.026	0.047	
F_EXTERN	0.203	0.078	**	0.202	0.147		0.320	0.111	***	-0.152	0.178		0.176	0.053	***	0.219	0.072	***
F_GDEBT	0.078	0.072		0.162	0.114		0.165	0.100		-0.068	0.139		-0.052	0.040		0.102	0.053	*
PC_INST*(-1)	0.221	0.108	**	0.394	0.162	**	0.271	0.140	*	0.061	0.190		0.093	0.103		0.248	0.110	**
FISCBAL*(-1)	0.015	0.013		0.025	0.018		-0.035	0.023		0.032	0.027							
RATING_RESIDUAL	0.023	0.036	*	0.078	0.065		0.109	0.072		0.025	0.046		0.063	0.042		0.032	0.037	
ECM (t-1)*(-1)	0.110	0.020	***	0.499	0.087	***	0.144	0.031	***	0.128	0.046	***	0.074	0.016	***	0.096	0.020	***
Observations	396			126			220			176			572			396		
Periods	44			14			44			44			44			44		
Cross-sections	9			9			5			4			13			9		
R-squared	0.869			0.950			0.912			0.875			0.854			0.867		
adj. R-squared	0.850			0.918			0.885			0.824			0.839			0.848		
D-W stat.	2.003			1.949			2.237			1.921			1.974			1.971		

Table 10. Robustness checks: estimations including and excluding Hungary from the sample

Dependent variable	Log CDS spread			Log CDS spread			Log CDS spread 2010-2012 including Hungary			Log CDS spread 2010-2012 excluding Hungary		
	full sample including Hungary			full sample excluding Hungary								
Explanatory variables	coefficient	std.error	sign.	coefficient	std.error	sign.	coefficient	std.error	sign.	coefficient	std.error	sign.
PC_GROWTH*(-1)	0.253	0.015	***	0.255	0.018	***	0.162	0.016	***	0.199	0.016	***
F_BANK	0.310	0.015	***	0.309	0.019	***	0.334	0.012	***	0.415	0.018	***
F_EXTERN	0.148	0.015	***	0.145	0.019	***	0.182	0.014	***	0.094	0.020	***
F_GDEBT	0.211	0.016	***	0.222	0.036	***	0.317	0.015	***	0.574	0.047	***
PC_INST*(-1)	0.161	0.008	***	0.161	0.008	***	0.179	0.008	***	0.184	0.008	***
FISCBAL*(-1)	-0.024	0.008	***	-0.024	0.013	*	-0.006	0.009		-0.100	0.018	***
RATING_RESIDUAL	0.068	0.012	***	0.065	0.012	**	0.077	0.012	***	0.110	0.012	***
Observations	405			360			243			216		
Periods	45			45			27			45		
Cross-sections	9			8			9			8		
R-squared	0.853			0.852			0.893			0.906		
adj. R-squared	0.832			0.827			0.877			0.889		
D-W stat.	0.165			0.155			0.225			0.155		

Dependent variable	Log differences of CDS spread			Log differences of CDS spread			Log differences of CDS spread 2010-2012 including Hungary			Log differences of CDS spread 2010-2012 excluding Hungary		
	full sample including Hungary			full sample excluding Hungary								
Explanatory variables	coefficient	std.error	sign.	coefficient	std.error	sign.	coefficient	std.error	sign.	coefficient	std.error	sign.
PC_GROWTH*(-1)	0.084	0.031	***	0.097	0.032	***	0.007	0.043		0.024	0.047	
PC_BANK/F_BANK	0.064	0.089		0.145	0.097		0.064	0.111		0.078	0.117	
PC_EXTERN*(-1)/F_EXTERN	0.203	0.078	**	0.235	0.084	***	0.047	0.119		0.040	0.134	
PC_GDEBT/F_GDEBT	0.078	0.072		0.132	0.079	*	0.150	0.092		0.164	0.090	*
PC_INST*(-1)	0.221	0.108	**	0.249	0.113	**	0.201	0.135		0.206	0.139	
FISCBAL*(-1)	0.015	0.013		0.011	0.015		0.022	0.016		0.038	0.021	*
RATING_RESIDUAL	0.023	0.036	*	0.049	0.041		0.095	0.056	*	0.081	0.068	
ECM (t-1)*(-1)	0.110	0.020	***	0.114	0.021	***	0.115	0.031	***	0.124	0.036	***
Observations	396			352			234			216		
Periods	44			44			44			27		
Cross-sections	9			8			9			8		
R-squared	0.869			0.871			0.810			0.824		
adj. R-squared	0.850			0.849			0.779			0.791		
D-W stat.	2.003			2.002			2.088			2.237		

VI.5. Appendix 5: Panel Cointegration Test

Table 11. Panel Cointegration Test

Johansen Fisher Panel Cointegration Test
Series: CDSL -V_NOV F_BANK F_EXTERN F_GDEBT -V_INST -FISCBAL RES_EQFIN_RAT_TSLS
Date: 01/28/14 Time: 16:38
Sample: 2008M07 2012M03
Included observations: 405
Trend assumption: Linear deterministic trend
Lags interval (in first differences): 1 1

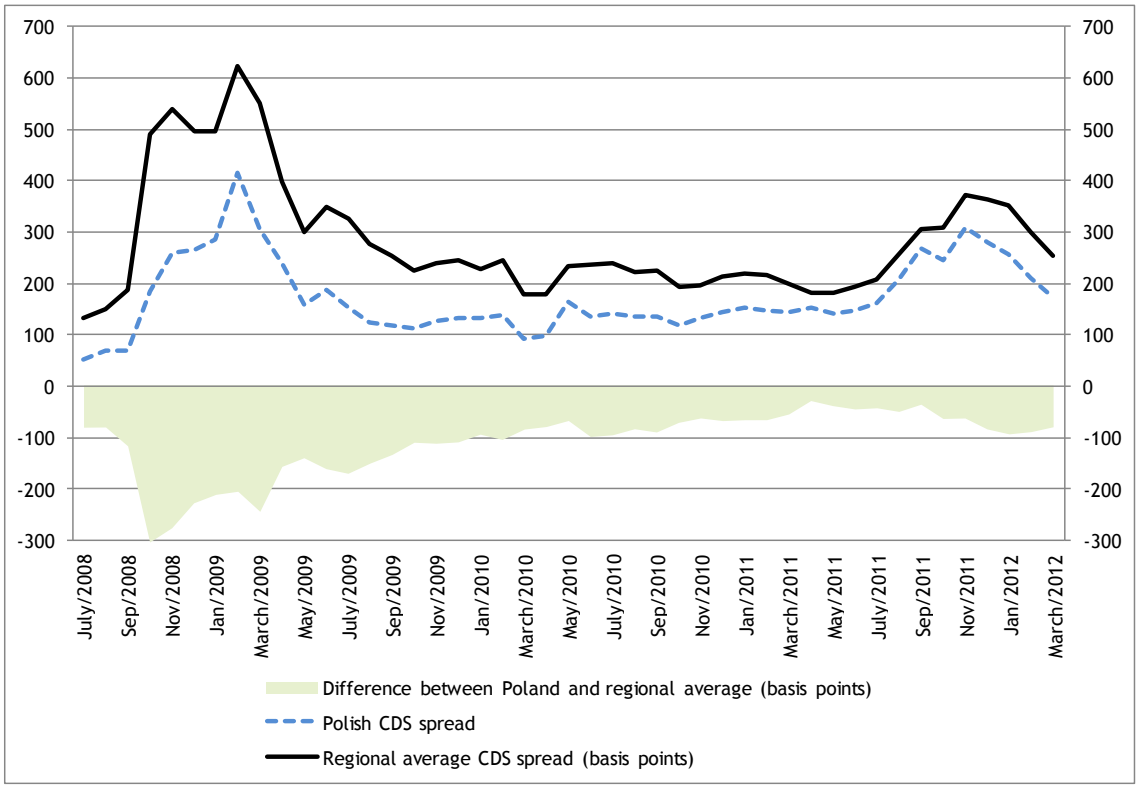
Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)

Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.
None	440.5	0.0000	142.4	0.0000
At most 1	278.0	0.0000	102.1	0.0000
At most 2	189.1	0.0000	76.11	0.0000
At most 3	121.9	0.0000	41.43	0.0013
At most 4	89.41	0.0000	37.19	0.0050
At most 5	64.38	0.0000	34.66	0.0104
At most 6	46.85	0.0002	42.44	0.0010
At most 7	27.57	0.0688	27.57	0.0688

* Probabilities are computed using asymptotic Chi-square distribution.

VI.6. Appendix 6: Application to the Polish CDS spread

***Figure 12*. Polish 5-year CDS spreads and the Eastern European average (July 2008 – March 2012)**



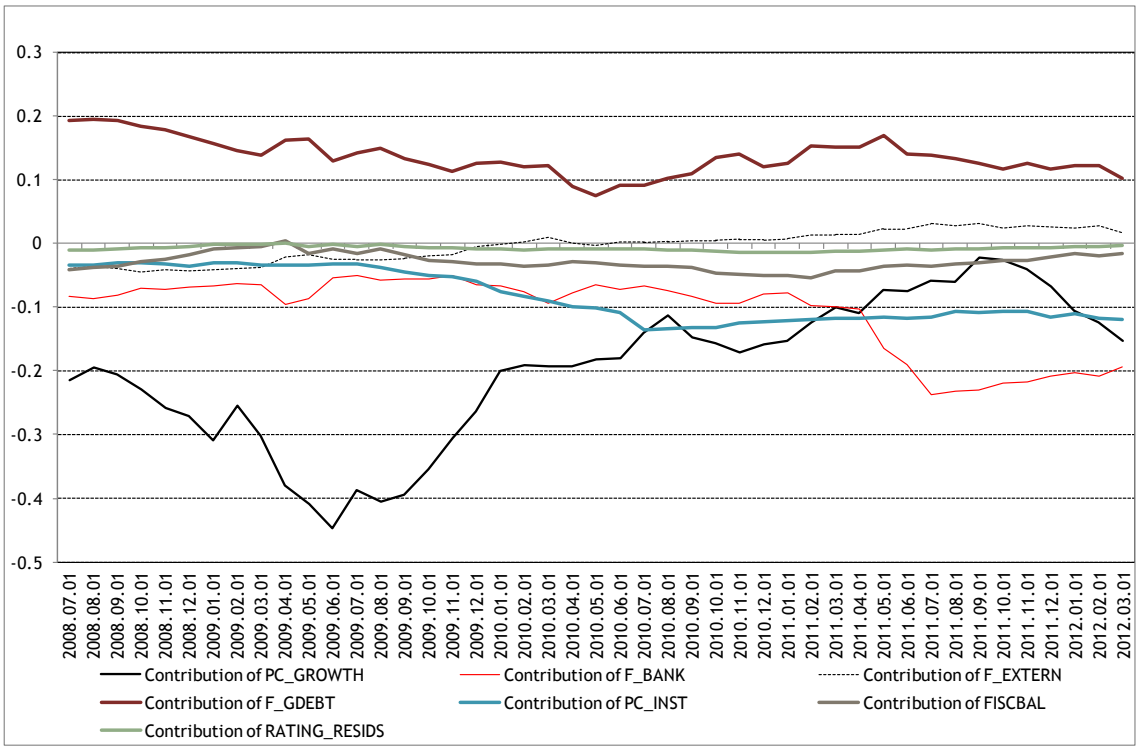
The Polish CDS spread was below the regional average during the whole sample. The international shock caused by the Lehmann default hit the Polish CDS spreads less powerfully than those of the regional peers; however a big part of the relative advantage disappeared between February and October of 2009.

The estimated relative CDS spread was negatively affected by the relatively bad government debt factor during the whole sample. During the examined period, Poland produced one of the worst government debts in the region behind Hungary, being similar to Turkey's government debt levels till the end of 2010 and to Lithuania's levels afterwards. Poland had the second highest outstanding bonds / GDP ratio and debt / GDP ratios behind Hungary, and the Polish outstanding amount of short debt was also higher than average.

The estimated relative CDS spread was positively influenced by the growth outlooks, especially at the beginning of the sample. This principal component was typically the best in the region in 2009, and the second best (behind Russia) till the end of 2010. Two Baltic countries – that were hit strongly at the beginning of the crisis –also had better growth outlooks from the beginning of 2011. The outstanding relative outlooks in 2009 were mostly influenced by the GDP expectations, and to a smaller extent by the investment or industrial output expectations.

The model-based relative CDS spread was also improved by two relatively fast developments. The factor of banking stability developed quickly between April and July 2011 due to better returns. The factor of institutional and political development improved between 2009 and 2010 because of the better EUI political risk index, and the Heritage Foundation overall economic index (mostly driven by the business freedom and the property rights subindices).

***Figure 13*. Poland: Contributions to the model-based value of the relative CDS spread**

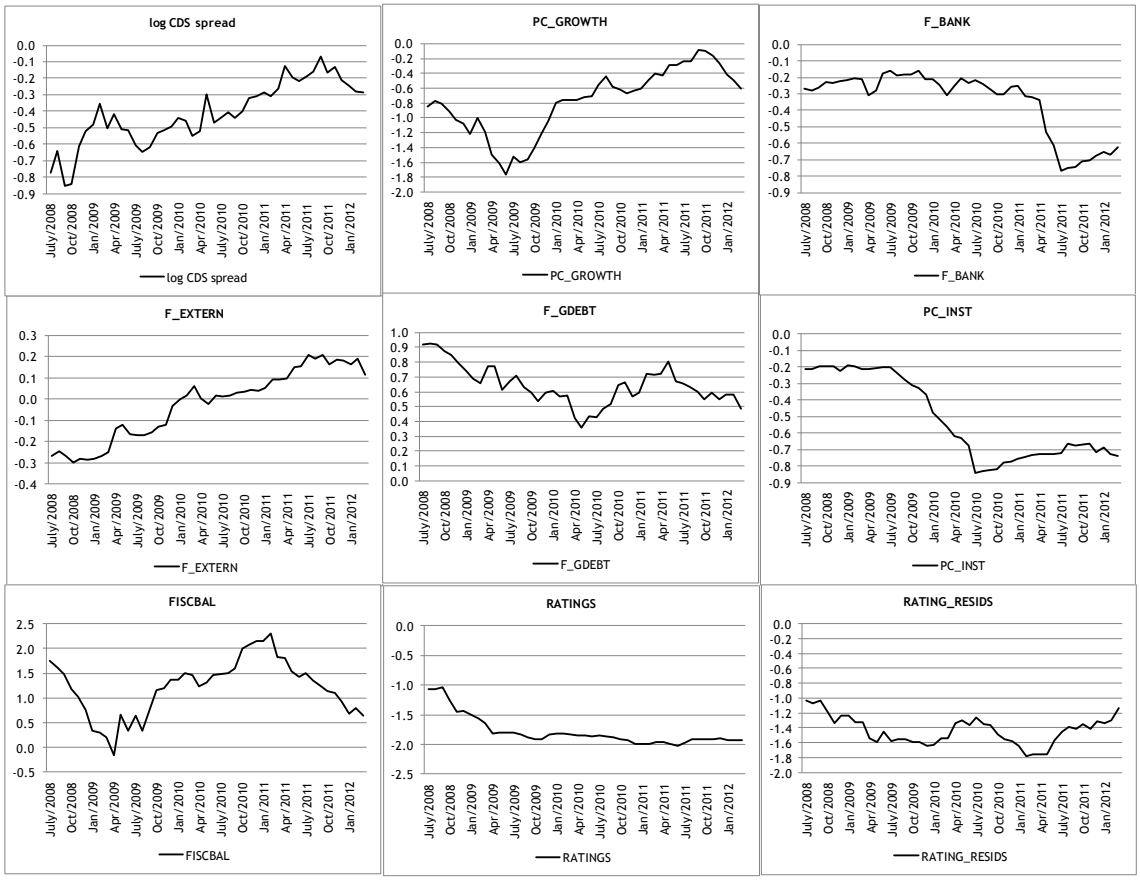


Poland's credit rating was considerably above the regional average during the whole sample (almost through the whole interval it was the second best

behind the Czech Republic, only Lithuania was better at the beginning of the period). There was only one change in the credit rating of Poland; S&P upgraded the rating at the end of 2008. The credit ratings were significantly better than the model-based ratings in the whole sample, so credit ratings might have included additional positive information compared to the model.

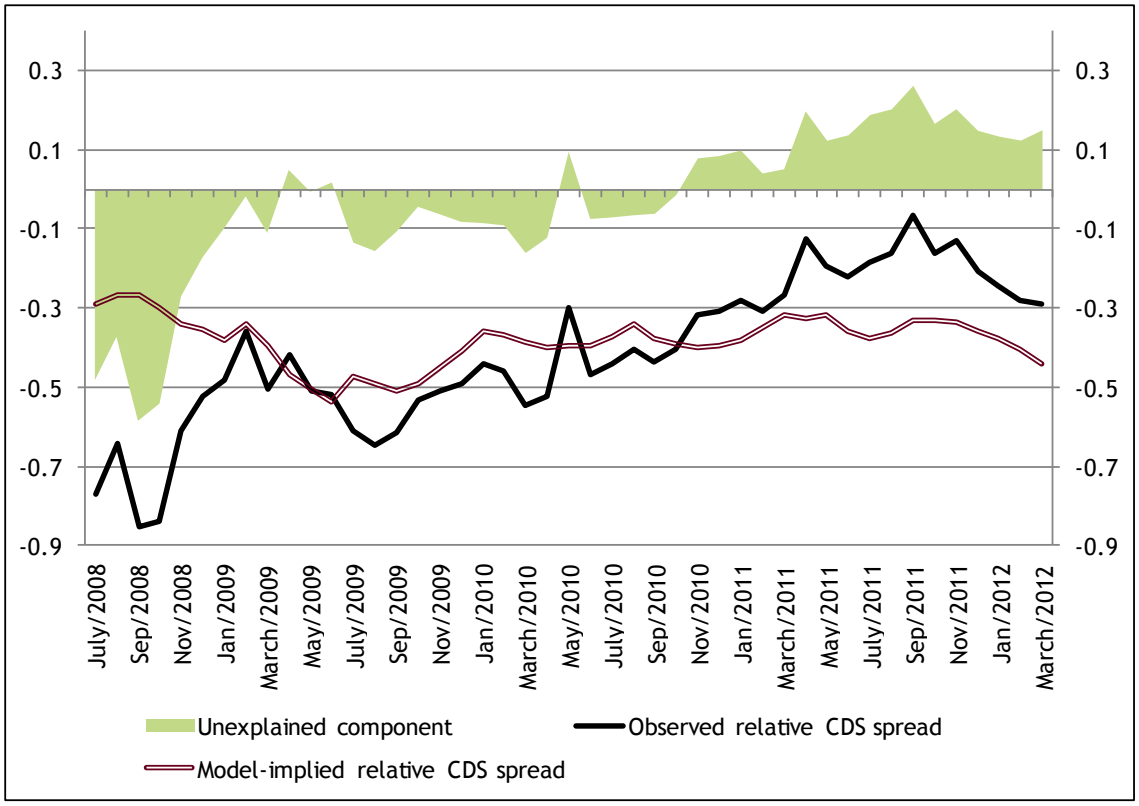
The relative external balance deteriorated significantly till the spring of 2011 because the Polish current account and trade balance was almost unchanged whereas the regional peers' values improved. However, this only had minor effects on our model estimation.

***Figure 14*. Polish indicators compared to regional averages**



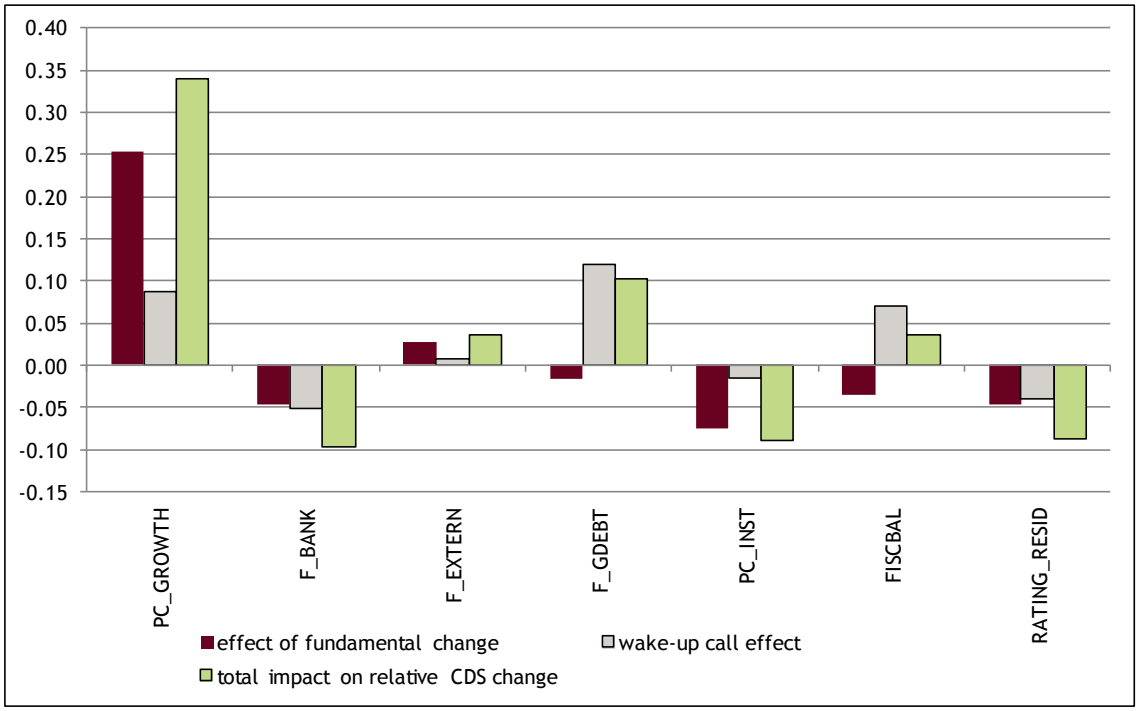
At the end of 2008, the CDS spreads were significantly lower than the model-based values. Later, until the spring of 2011 the fit was good, after that the model-based CDS got lower than the real value.

***Figure 15*. The Polish relative CDS spread and its unexplained component**



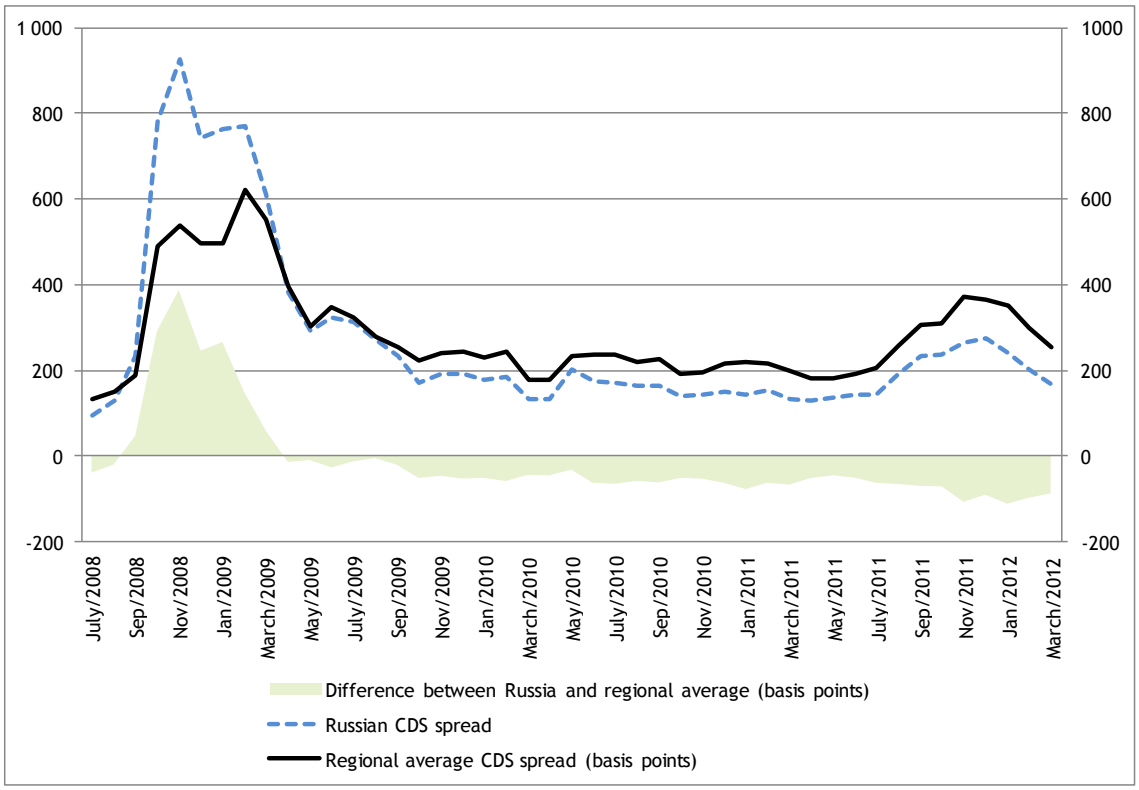
The deterioration of the principal component for growth (and the wake-up call effect which might have influenced its significance) worsened the estimated CDS spread. Also the increase in the government debt's (and fiscal balance's) importance had a negative effect. The higher importance of rating residuals and the banking factor had positive effects and some fundamentals also improved (banking sector stability, institutional and political environment, fiscal balance, rating residual).

Figure 16. **Fundamental and wake-up call effects in changes of Polish spreads**



VI.7. Appendix 7: Application to the Russian CDS spread

Figure 17. **Russian 5-year CDS spreads and the Eastern European average (July 2008 – March 2012)**



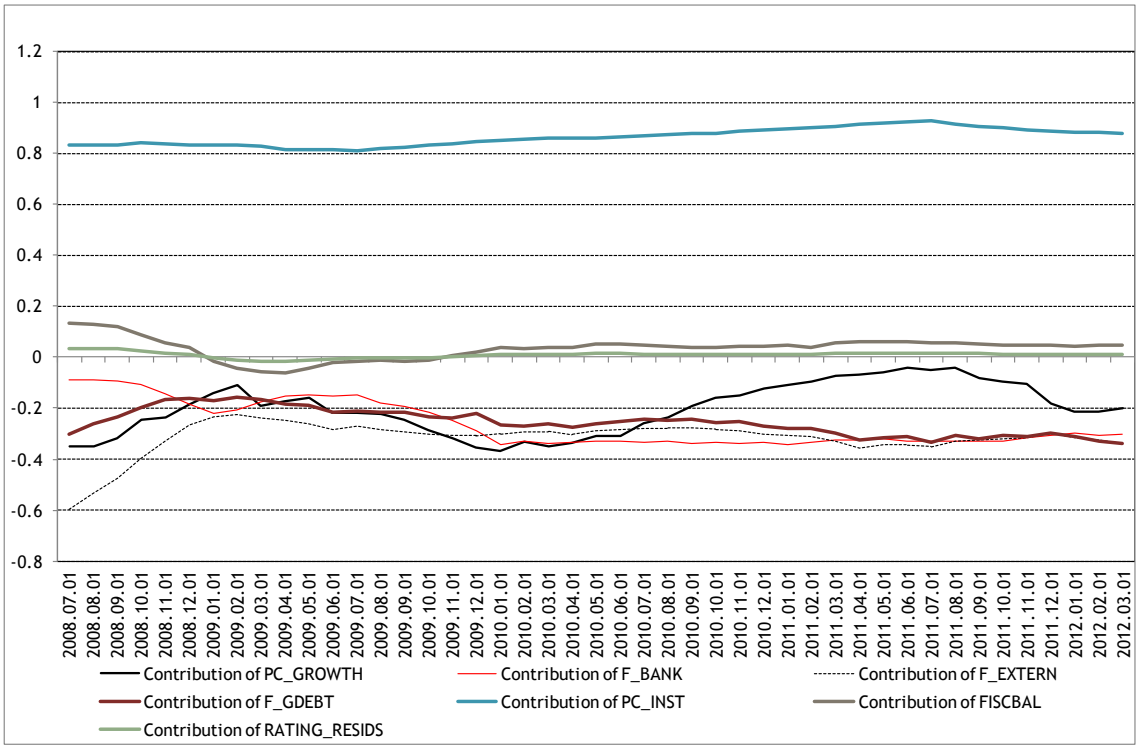
The increase in the Russian CDS spread after the Lehman default was extremely high, only Latvia experienced a similar rise. However, the recovery in the spring of 2009 was faster than in the peer countries that had significant problems with their real economies. During these months, the Russian CDS spread declined to the regional average, and since then, it is even lower: probably one of the reasons for this is Russia's smaller vulnerability to the debt crisis in some Eurozone member countries.

The estimated relative CDS was worsened in an extreme amount by the institutional-political factor during the whole period (as Russia is not a EU member, the EIU political risk index was high and was even increasing since the end of 2010 and low values of the Heritage Foundation Index of Economic Freedom also contributed to the unfavorable CDS levels).

However, external balance, growth, government debt and banking stability had a positive effect on the estimated relative CDS during the whole sample. There were multiple developments that had significant effects on the external balance factor. At the beginning of the crisis, the lower energy prices deteriorated the factor, later their increase coincided with the relative worsening of trade balance and current account compared to the peer countries. However, Russia had the best values in the region both in current account and trade balance during the sample period (although Latvia had a more positive current account / GDP rate for a short period in 2010). The principal component for growth was hit earlier than in other countries, but the recovery was also faster. Since 2009, the growth component is less volatile for Russia than for other countries.

The movements in the estimated relative CDS spread were mostly caused by changes in external balance (fast deterioration in the end of 2008) and growth outlooks (deterioration in the end of 2008, recovery in 2009, then a relative fall from the beginning of 2010 until mid-2011 followed by relatively better developments compared to peer countries). Positive banking sector developments also had an effect on Russian CDS spread: in the end of 2009 returns developed significantly, later negative events in the comparison countries had a positive effect on the Russian relative position.

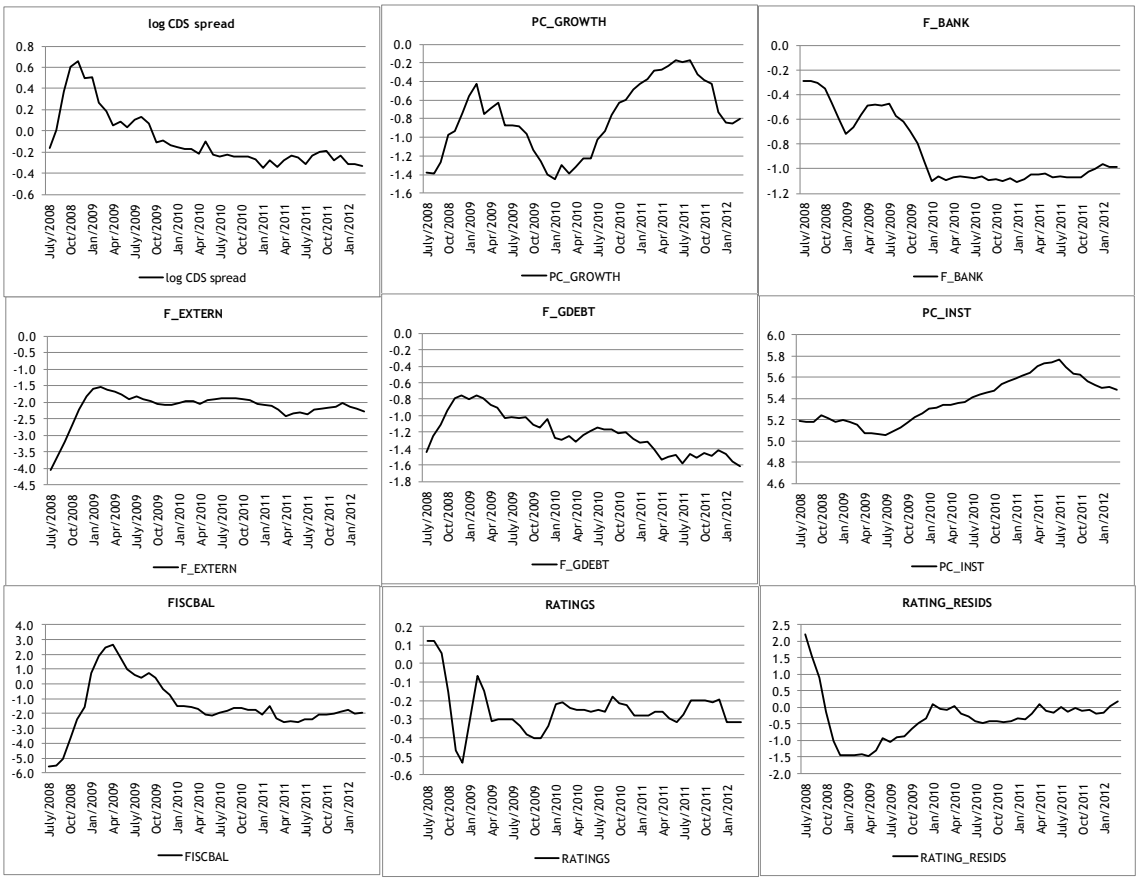
***Figure 18*. Russia: Contributions to the model-based value of the relative CDS spread**



The fast worsening of external balance at the beginning of the crisis and the fluctuation in relative growth outlooks are also obvious to detect in Figure 19.

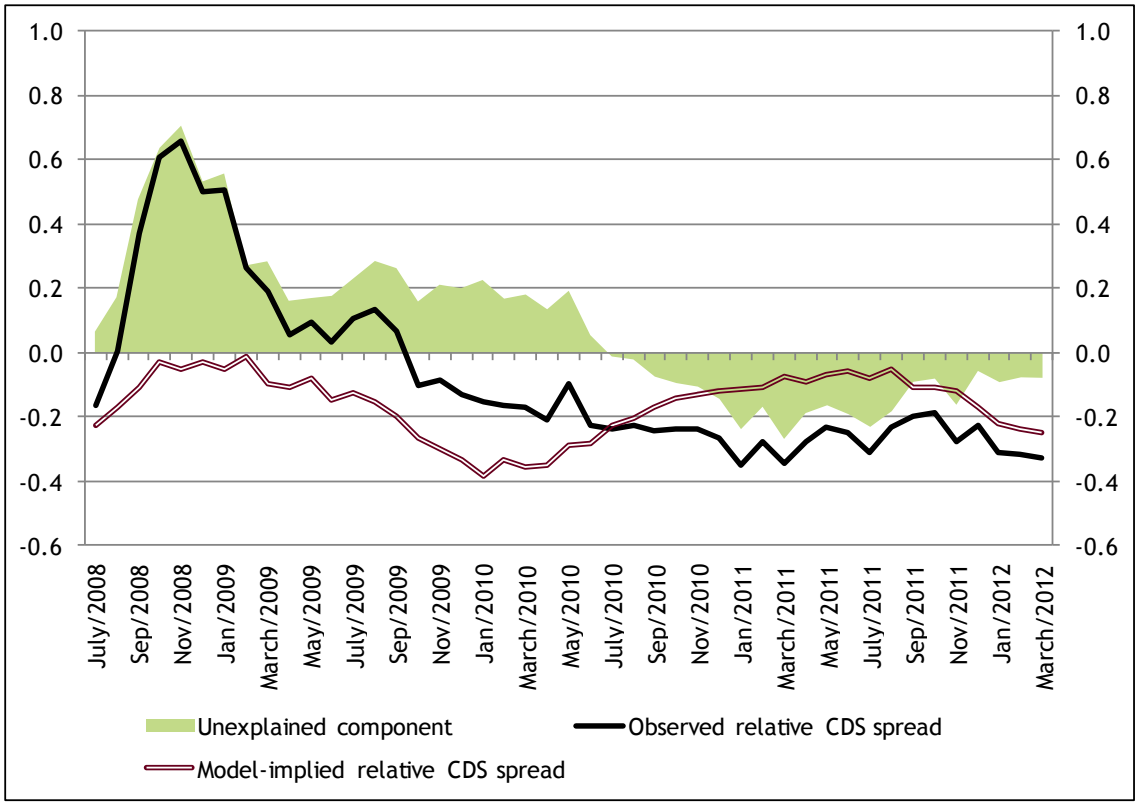
Actual credit ratings were better than model-based ones before the crisis, but turned worse after the autumn of 2008. Since 2010, our model estimates the credit ratings accurately. Since the Lehman default, Russia has better than average ratings, only the Czech Republic and Poland could permanently outperform Russia in this aspect. From the three big credit rating agencies, only Fitch introduced modifications in Russia's credit rating: it downgraded twice (late 2009/ early 2010 and in the second half of 2010) and upgraded once (late 2011 / early of 2012).

***Figure 19*. Russian indicators compared to regional averages**



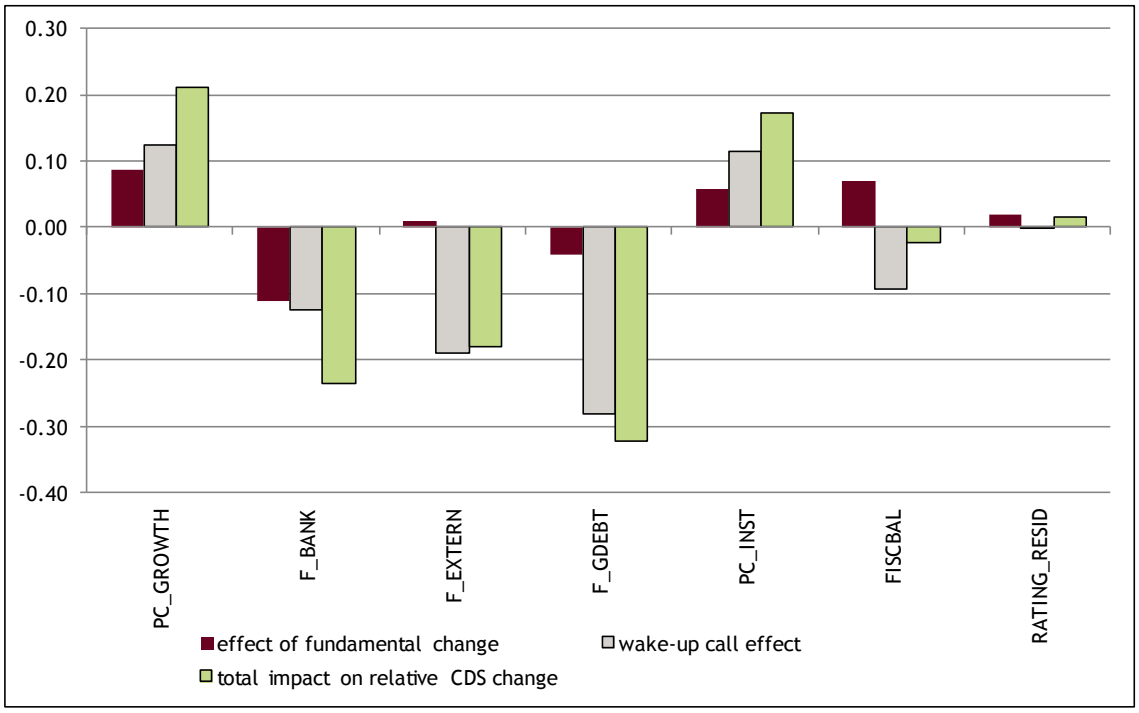
The unexpected component of the relative CDS increased through November 2008, and decreased in two waves: between November 2008 and April 2009, then from May 2010 through January 2011.

Figure 20. **The Russian relative CDS spread and its unexplained component**



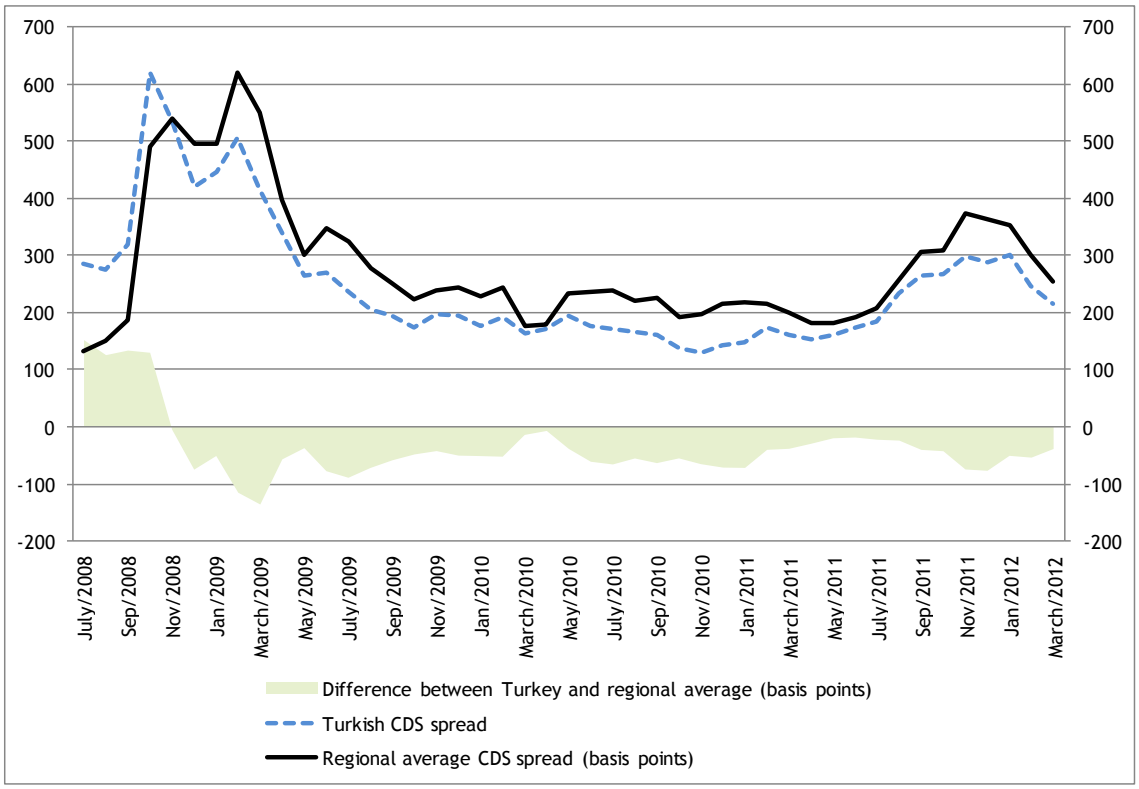
The positive developments from 2010 were probably caused mostly by the wake-up call effects. Banking sector, government debt, fiscal balance and external balance gained significance, and these positive effects were only partly balanced out by the increasing importance of the institutional-political factor and the decreasing significance of growth expectations.

***Figure 21*. Fundamental and wake-up call effects in changes of Russian spreads**



VI.8. Appendix 8: Application to the Turkish CDS spread

Figure 22. **Turkish 5-year CDS spreads and the Eastern European average (July 2008 – March 2012)**



The Turkish CDS spread is below the regional average starting from the end of 2008. Turkey was hit by the crisis earlier then the regional average, and the recovery was also a bit faster. The recovery in 2009 (similarly to the regional peers) was mostly caused by better growth aspects, banking stability and partially by the better institutional and political factor, whereas the worsening of the external balance had a reverse effect. In the beginning of 2010, several developments turned around: government debt got better, while banking stability and growth got worse.

External balance (more exactly: current account and trade balance) deteriorated between mid-2009 and mid-2011, while the regional trend improved until early 2010. The most important weakness was the political-institutional background, which was the second worse in the region. However this improved in an absolute sense during the whole period, having an effect

on the relative institutional development in the following way: since most countries experienced decline until mid-2010, followed by improvement, the relative institutional-political development of Turkey got better until mid-2010 and remained mostly unchanged since. This weakness is caused by several components: Turkey is not an EU member, it has a low GDP / capital ratio (currently only Bulgaria has a lower ratio, but until the end of 2008, Russia also underperformed Turkey in this sense). Only Russia is worse than Turkey in terms of EIU political risk index: the index got better in the winter of 2008/2009 and deteriorated in the first half of 2010. There were positive developments before mid-2010 in the Heritage Foundation overall index, mostly caused by the sharp increase in the investment subindex between 2009 and 2010. The changes in the relative growth outlooks were caused by the different business cycle patterns compared to the regional peers (faster recovery in early 2009, fewer positive changes between early 2010 and mid-2011, larger than average slowdown from the middle of 2011). Overall, Turkey's principal component for growth was the regional best in 2010. Relative banking sector stability also differed from peers: while neighbor countries got better in this sense in 2009, Turkish banking stability (returns and short external banking sector debt) deteriorated in the second half of 2010. However, in terms of banking sector stability, Turkey was the regional leader until mid-2011 when Russia outperformed Turkey in this sense.

The factor for government debt got significantly better in 2010. In this year, Turkey's position changed from worst to a regional average position in terms of outstanding short term bonds, while other indicators also improved.

Overall, growth and banking sector stability was strong in Turkey; while institutional-political development and rating residuals were poor (the latter means that credit ratings included further unfavorable information about Turkey not included in our model). Government debt was also a relatively weak point before 2010 and after that, external balance deteriorated the estimated CDS spread significantly.

Turkey's credit ratings were the regional worst throughout the sample; however all three major rating agencies upgraded the country in the end of 2009.

***Figure 23*. Turkey: Contributions to the model-based value of the relative CDS spread**

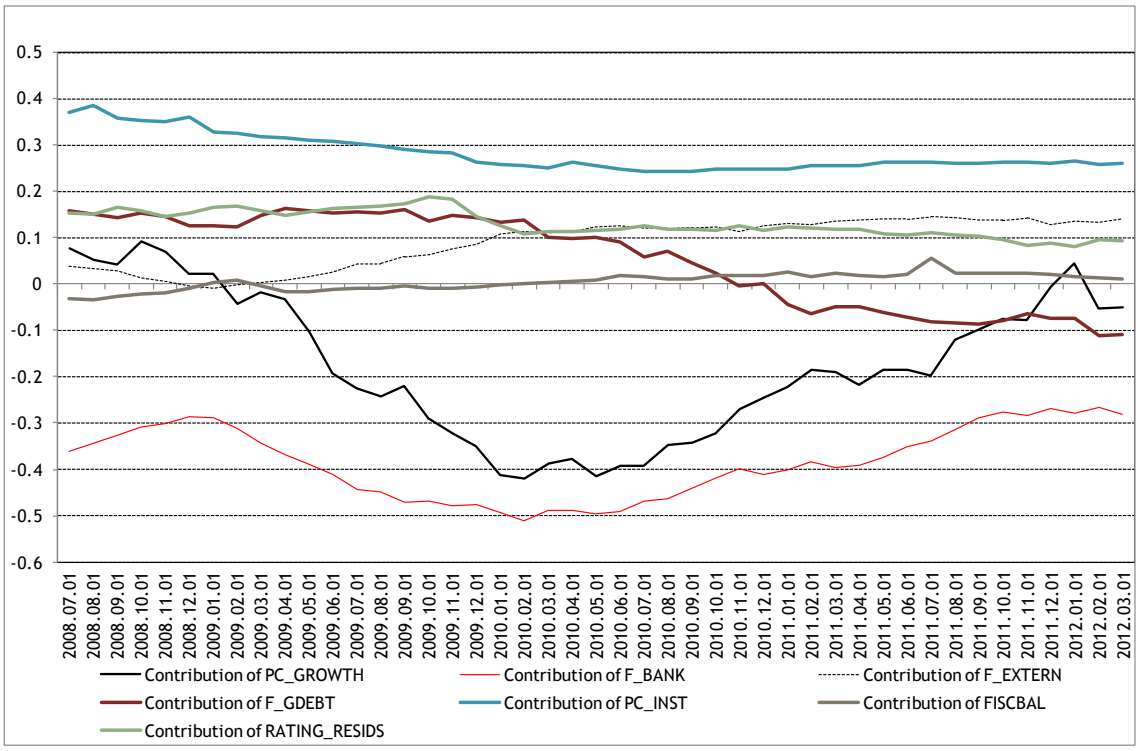
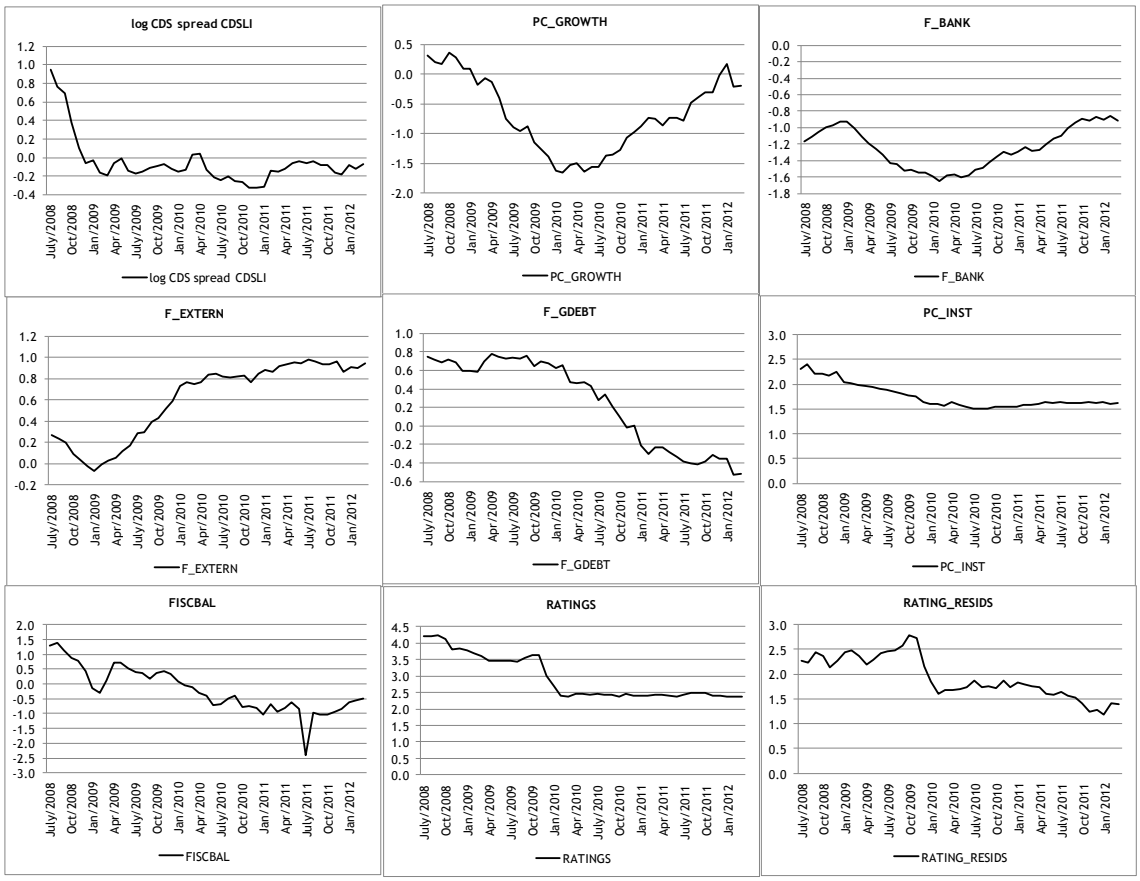
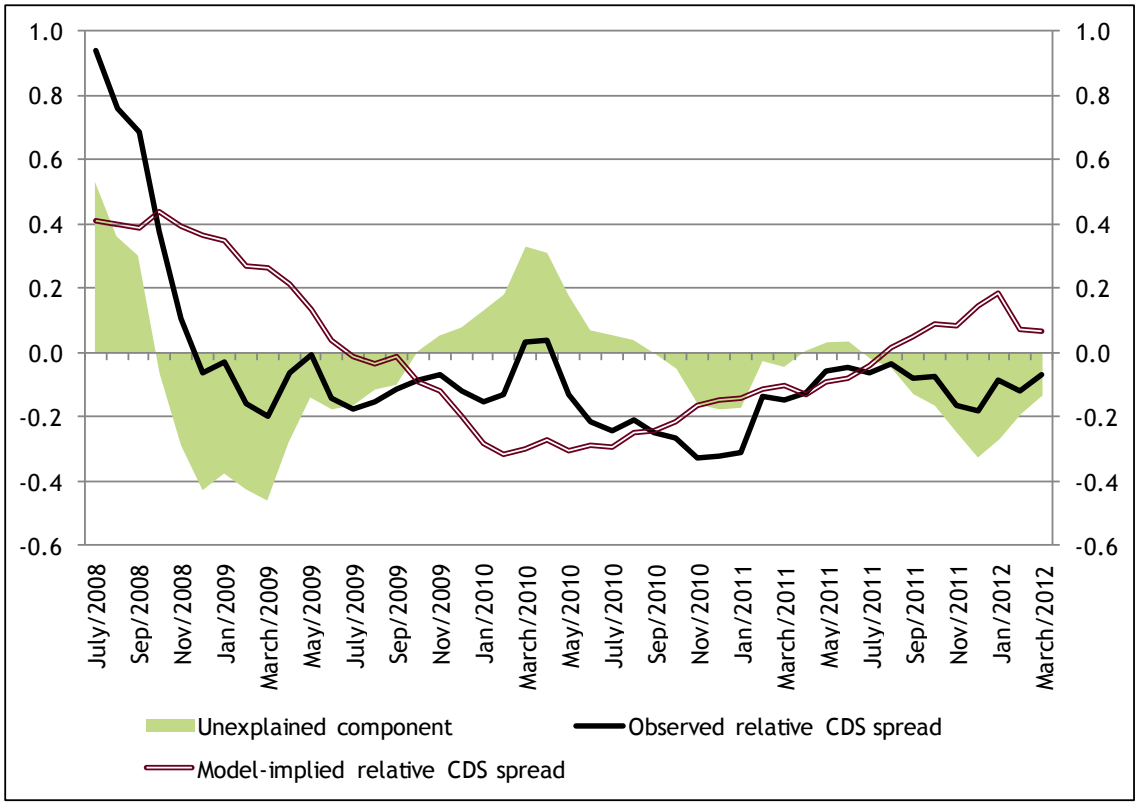


***Figure 24*. Turkish indicators compared to regional averages**



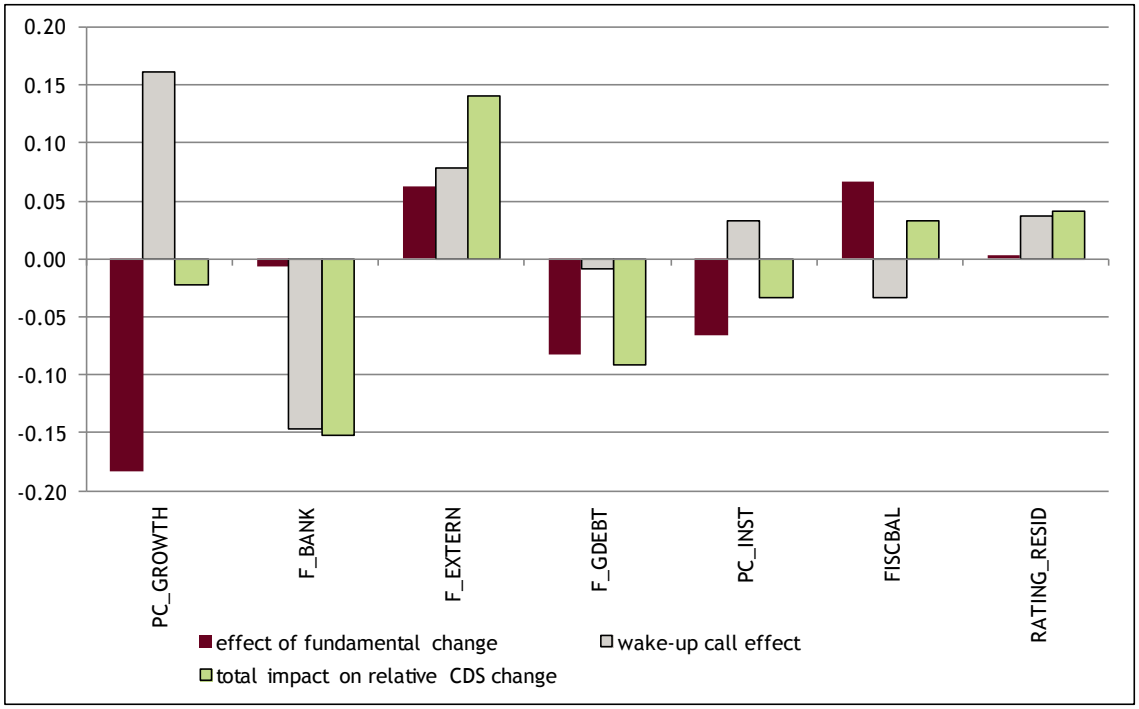
Our model's fit is relatively good since the spring of 2009. Actual CDS was worse than estimated before the Lehman default and in the first half of 2010; while it outperformed the estimated values in the winter of 2008/2009 and since mid-2011.

***Figure 25*. The Turkish relative CDS spread and its unexplained component**



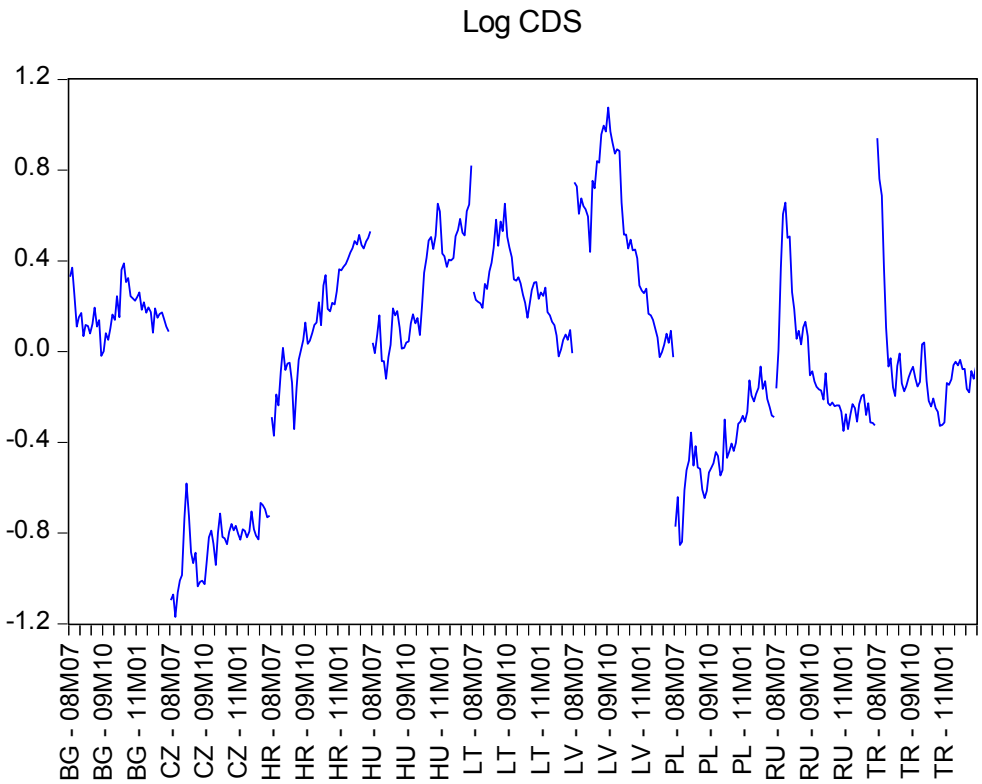
The effect of the fundaments was mixed in the second half of the sample. The estimated CDS spread improved due to the developments in government debt, growth and institutional-political factors; while it deteriorated because of the external and fiscal balance. Banking sector stability becoming more important had positive, while growth aspects becoming more important and external balance becoming less important had negative wake-up call effects.

***Figure 26*. Fundamental and wake-up call effects in changes of Turkish spreads**



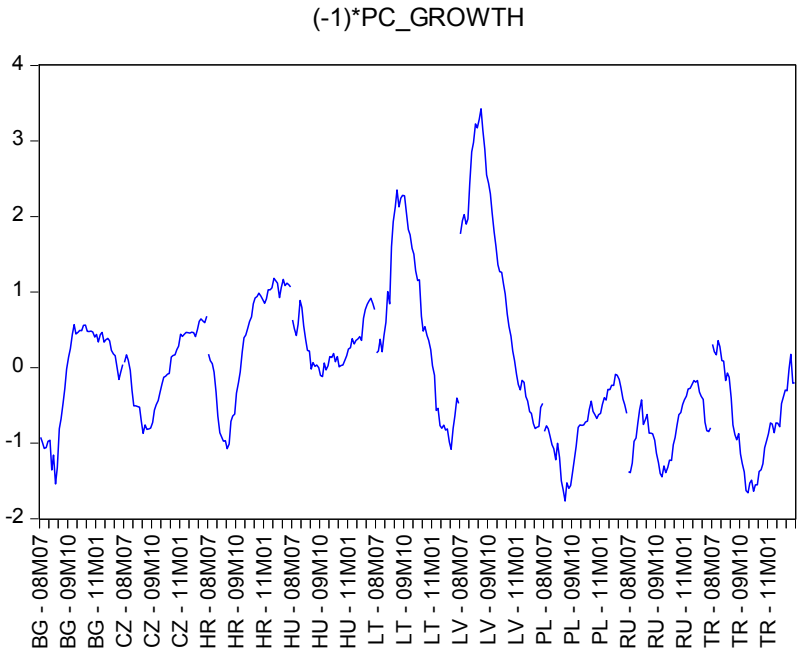
VI.9. Appendix 9: Graphs about relative fundamentals

Figure 27. **Log CDS spread compared to regional averages**



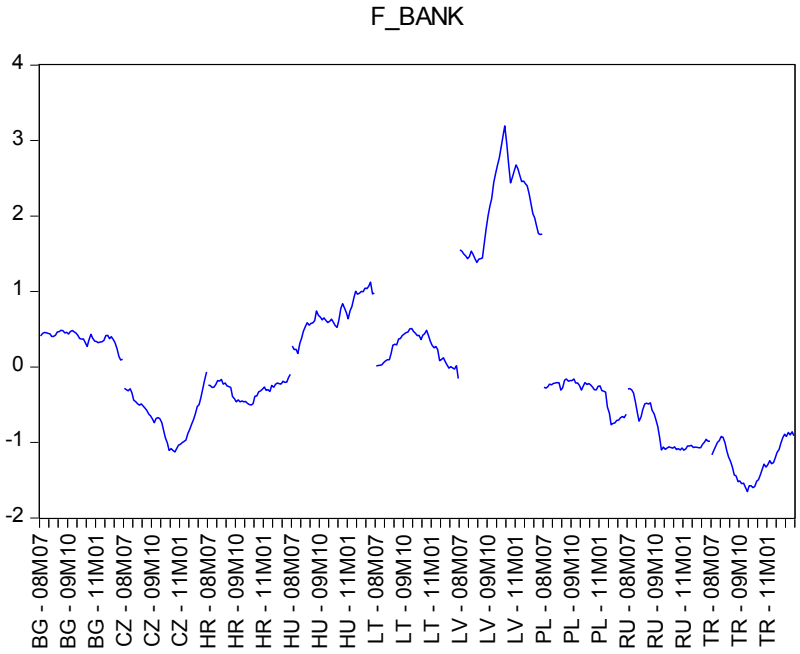
Note: Variables are scaled so that increases are consistent with a deterioration of credit risk.

***Figure 28*. PC_GROWTH compared to regional averages**



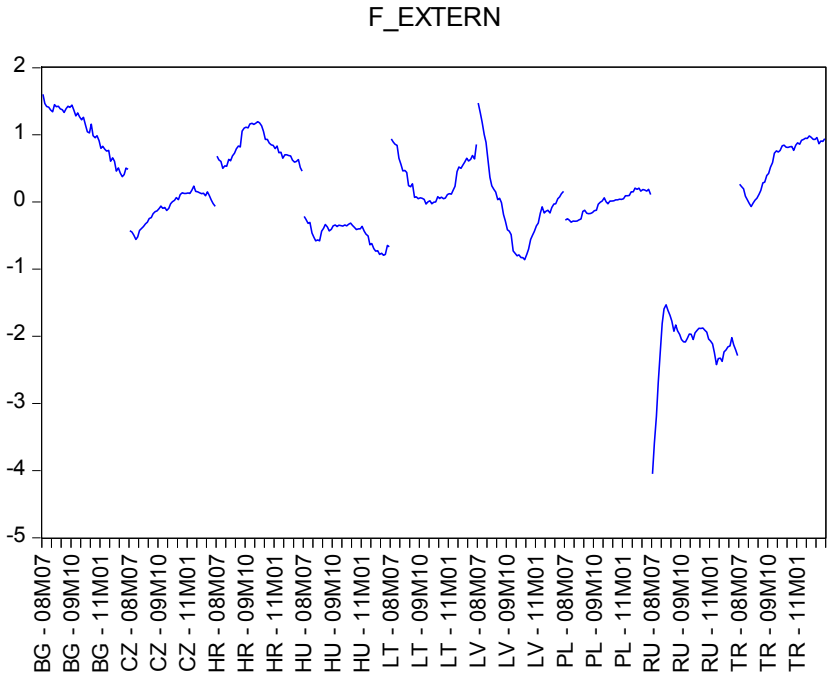
Note: Variables are scaled so that increases are consistent with a deterioration of credit risk.

***Figure 29*. F_BANK compared to regional averages**



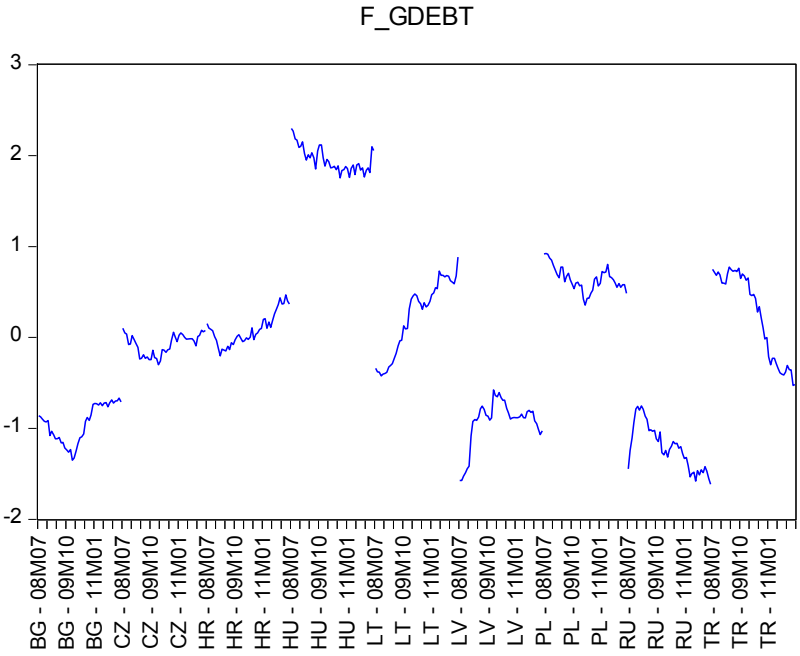
Note: Variables are scaled so that increases are consistent with a deterioration of credit risk.

***Figure 30*. F_EXTERN compared to regional averages**



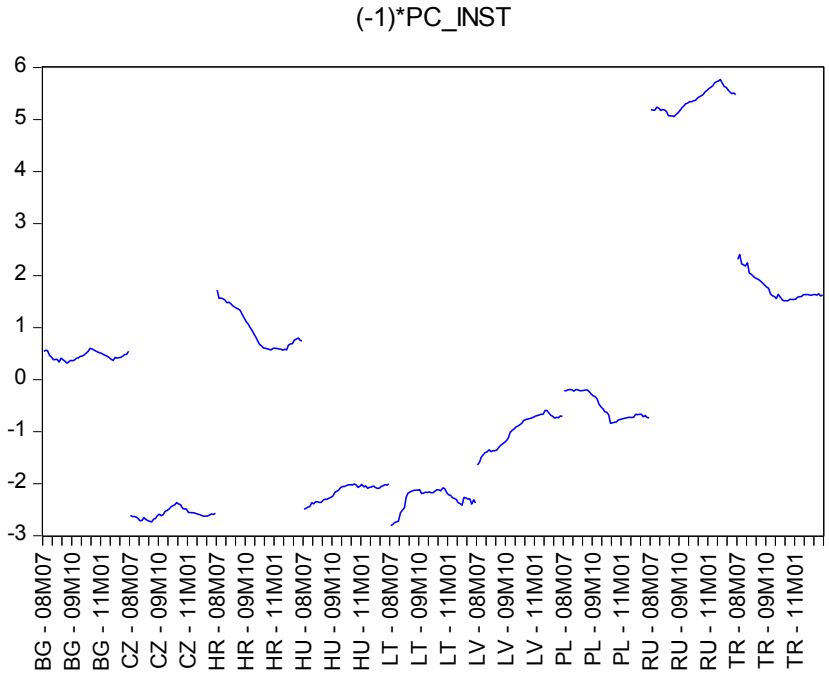
Note: Variables are scaled so that increases are consistent with a deterioration of credit risk.

***Figure 31*. F_GDEBT compared to regional averages**



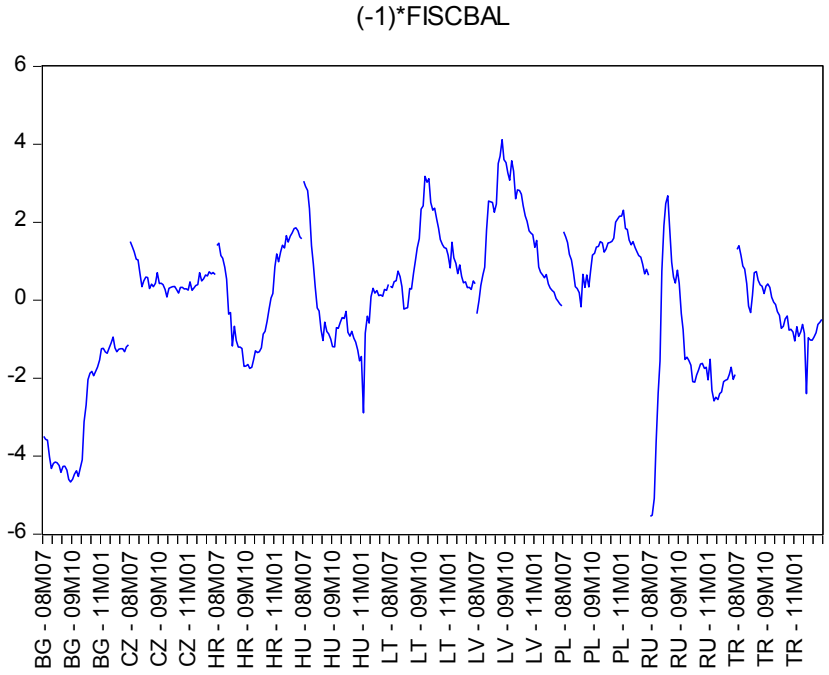
Note: Variables are scaled so that increases are consistent with a deterioration of credit risk.

***Figure 32*. PC_INST compared to regional averages**



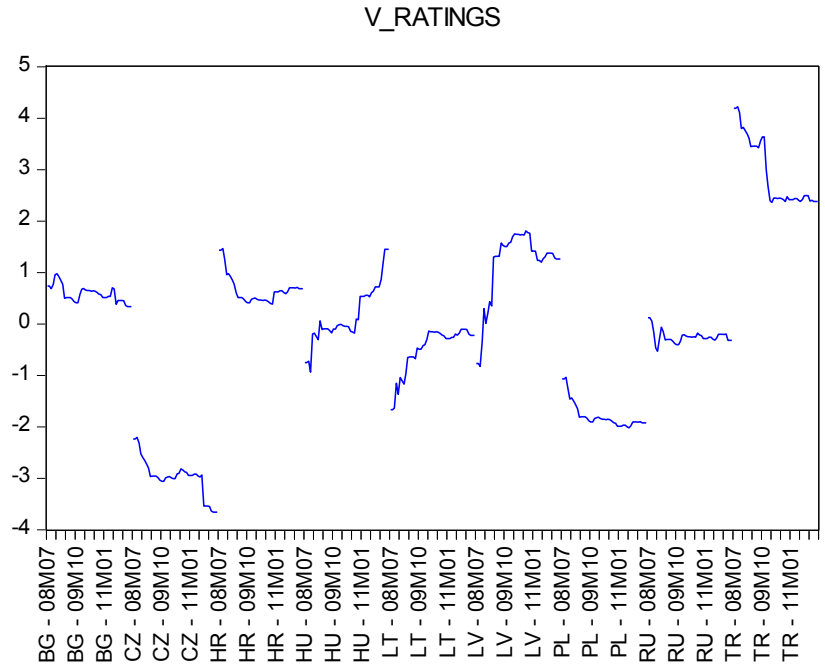
Note: Variables are scaled so that increases are consistent with a deterioration of credit risk.

***Figure 33*. FISCBAL compared to regional averages**



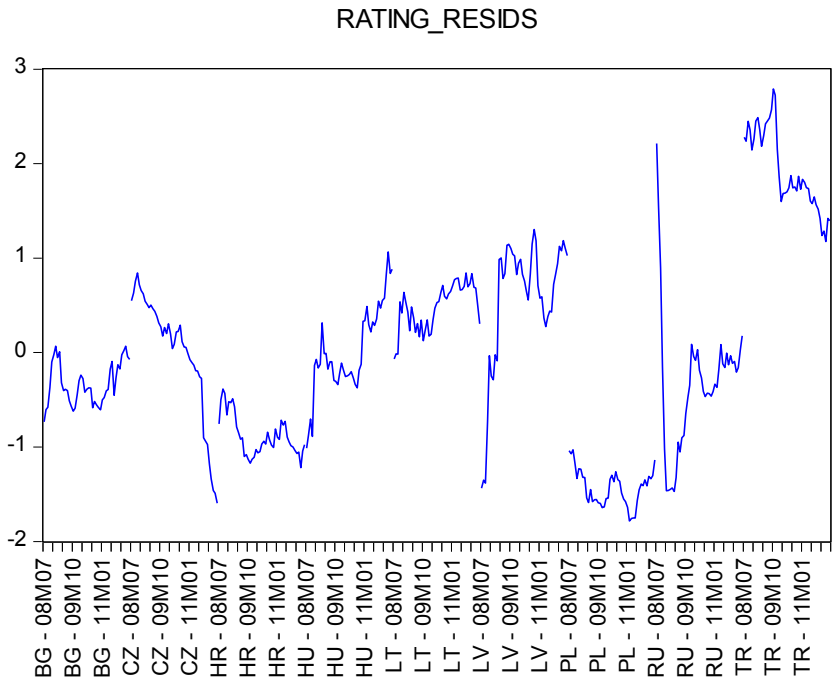
Note: Variables are scaled so that increases are consistent with a deterioration of credit risk.

***Figure 34*. RATINGS compared to regional averages**



Note: Variables are scaled so that increases are consistent with a deterioration of credit risk.

***Figure 35*. RATING_RESIDS compared to regional averages**



Note: Variables are scaled so that increases are consistent with a deterioration of credit risk.

VII. REFERENCES

Ábel, I. & Kóbor, Á. [2011]: Növekedés, deficit és adósság – fenntartható keretben. *Közgazdasági szemle*, LVIII.(2011. június), pp.511–528.

Ades, A. et al. [2000]: Introducing GS-ESS: A New Framework for Assessing Fair Value in Emerging Markets Hard-Currency Debt. *Global Economics Paper* No. 45, Goldman Sachs, New York.

Afonso, A. [2003]: Understanding the Determinants of Sovereign Debt Ratings: Evidence for the Two Leading Agencies. *Journal of Economics and Finance*, 27(1), pp.56–74. Available at: http://link.springer.com/10.1007/BF02751590. DOI: http://dx.doi.org/10.1007/bf02751590

Afonso, A. & Rault, C. [2010]: Long-run Determinants of Sovereign Yields., *CESifo Working Paper Series 3155.*, CESifo Group, Munich.

Aizenman, J., Hutchison, M.M. & Jinjarak, Y. [2011]: What is the Risk of European Sovereign Debt Defaults? Fiscal Space. CDS Spreads and Market Pricing of Risk. *NBER Working Paper No.17407*.

Alexopoulou, I., Bunda, I. & Ferrando, A. [2009]: Determinants of Government Bond Spreads in the New EU Countries. *ECB Working Papers No. 1093*.

Allen, F. & Gale, D. [2000]: Financial Contagion. *The Journal of Political Economy*, 108(1), pp.1–33. DOI: http://dx.doi.org/10.1086/262109

Alper, C.E., Forni, L. & Gerard, M. [2012]: Pricing of Sovereign Credit Risk: Evidence from Advanced Economies During the Financial Crisis. *IMF Working Paper*, WP/12/24.

Amato, J.D. [2005]: Risk Aversion and Risk Premia in the CDS Market. *BIS Quarterly Review*, (December), pp.55–68.

Andenmatten, S. & Brill, F. [2011]: Measuring Co-Movements of CDS Premia during the Greek Debt Crisis. , *Discussion Paper Uni Bern* No. 1104. Uni Bern DP.

Ang, A. & Longstaff, F.A. [2011]: Systemic Sovereign Credit Risk: Lessons from the U.S. and Europe. *NBER Working Papers No. 16982*.

Archibald, C.M., Flynn, S.T. & Malvey, P.F. [1995]: Uniform-Price Auctions : Evaluation of the Treasury Experience. *Office of Market Finance, U.S. Treasury Manuscript*. Available at: http://www.treasury.gov/resource-center/fin-mkts/Documents/final.pdf.

Attinasi, M.-G., Checherita, C. & Nickel, C. [2009]: What Explains the Surge in Euro Area Sovereign Spreads During the Financial Crisis of 2007-09?. *Public Finance and Management* 10, 595-645. p.

Aussenegg, W., Pichler, P. & Stomper, A. [2006]: IPO Pricing with Bookbuilding and a When-Issued Market. *The Journal of Financial and Quantitative Analysis*, 41(4), pp.829–862. Available at: http://www.jstor.org/stable/27647276.

Ausubel, L.M. [1997]: An Efficient Ascending-Bid Auction for Multiple Objects. *University of Maryland Department of Economics Working Papers No. 97-06*. Available at: http://www.market-design.com/files/ausubel-an-efficient-ascending-bid-auction-for-multiple-objects.pdf.

Ausubel, L.M. & Cramton, P. [2002]: Demand Reduction and Inefficiency in Multi-Unit Auctions. *University of Maryland, Department of Economics Working Papers No. 98 wpdr*. Available at: http://drum.lib.umd.edu/bitstream/1903/7062/1/98wp-demand-reduction.pdf.

Back, K. & Zender, J.F. [1993]: Auctions of Divisible Goods : On the Rationale for the Treasury Experiment. *Review of Financial Studies*, 6(4), pp.733–764. DOI: http://dx.doi.org/10.1093/rfs/6.4.733

Back, K. & Zender, J.F. [2001]: Auctions of divisible goods with endogenous supply. *Economics Letters*, 73(1), pp.29–34. Available at: www.nccr-finrisk.uzh.ch/media/pdf/BackZender.pdf.

Bae, K.-H., Karolyi, G.A. & Stulz, R.M. [2000]: A New Approach to Measuring Financial Contagion. , *NBER Working Papers No. 7913*.

Bai, J. & Collin-Dufresne, P. [2011]: The CDS-Bond Basis During the Financial Crisis of 2007-2009. Available at: http://www.ckgsb.edu.cn/Userfiles/doc/JennieBai_28Feb2012.pdf.

Baldacci, E., Gupta, S. & Mati, A. [2008]: Is it (Still) Mostly Fiscal? Determinants of Sovereign Spreads in Emerging Markets. *IMF Working Paper*. WP/08/259.

Balogh, C. & Kóczán, G. [2008]: Állampapírok másodpiaci kereskedési infrastruktúrája. *MNB-tanulmányok 74.* Available at: http://www.mnb.hu/Root/Dokumentumtar/MNB/Kiadvanyok/mnbhu_mnbtanulmanyok/MT_74.pdf.

Barbosa, L. & Costa, S. [2010]: Determinants of Sovereign Bond Yield Spreads in the Euro Arae in the Context of the Economic and Financial Crisis., Banco de Portugal Economic Bulletin. (Autumn 2010), pp.131–150.

Bartolini, L. & Cottarelli, C. [1997]: Designing Effective Auctions for Treasury Securities. *Current Issues in Economics and Finance, Federal Reserve Bank of New York*, 3(9), pp.1–6. Available at: http://app.ny.frb.org/research/current_issues/ci3-9.pdf.

Bauer, P. et al. [2008]: Makrogazdasági statisztikák elemzői szemmel. *Statisztikai Szemle*, 86.(7-8), pp.666–694.

Beirne, J. et al. [2009]: Global and Regional Spillovers in Emerging Stock Markets: A Multivariate GARCH-in-mean Analysis. *CESifo Working Paper Series*, 2794.

Bekaert, G., Harvey, C.R. & Ng, A. [2003]: Market Integration and Contagion. *NBER Working Papers*, 9510.

Benczur, P. [2001]: Identifying Sovereign Bond Risks. *CEU-Economics Working Paper*, No. 9.

Benczur, P. & Ilut, C.L. [2009]: Evidence for Relational Contracts in Sovereign Bank. *Society for Economic Dynamics Meeting Papers No. 91.* Available at: http://public.econ.duke.edu/~brossi/NBERNSF/Ilut.pdf.

Benczúr, P., Simon, A. & Várpalotai, V. [2003]: Fiskális makropolitika és a növekedés elemzése kalibrált modellel. *MNB Füzetek 2003/13.*, Available at: http://english.mnb.hu/Root/Dokumentumtar/MNB/Kiadvanyok/mnbhu_mnbfuzetek/mnbhu_mf200313/mf2003_13.pdf

Berg, S.A. et al. [2000]: Market Demand for Treasury Securities. *Norges Bank Manuscript*. Available at:

http://wwz.unibas.ch/fileadmin/wwz/redaktion/finance/personen/yvan/papers/logistic.pdf.

Berlinger, E., Horváth, F. & Vidovics-Dancs, Á. [2012]: Tőkeáttétel-ciklusok. *Hitelintézeti Szemle*, 14(1), pp.1–23.

Berndt, A. et al. [2005]: Measuring Default Risk Premia from Default Swap Rates and EDFs., *BIS Working Papers No. 173*.

Berndt, A. & Obreja, I. [2010]: Decomposing European CDS Returns. *Review of Finance*, 14(March 2010), pp.189–233. Available at: http://rof.oxfordjournals.org/cgi/doi/10.1093/rof/rfq004 [Accessed August 29, 2013].

Bernoth, K. & Erdogan, B. [2010]: Sovereign Bond Yield Spreads: A Time-varying Coefficient Approach. *DIW Discussion Papers No. 1078.*, DIW, Berlin.

Biais, B. & Faugeron-Crouzet, A.M. [2002]: IPO Auctions: English, Dutch, … French, and Internet. *Journal of Financial Intermediation*, 11(1), pp.9–36. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1042957301903195 [Accessed August 12, 2012].

Bikhchandani, S. & Huang, C. [1993]: The Economics of Treasury Securities Markets. *The Journal of Economic Perspectives*, 7(3), pp.117–134. Available at: http://www.jstor.org/stable/2138446.

Bindseil, U., Nyborg, K.G. & Strebuaev, I.A. [2002]: Bidding and Performance in Repo Auctions: Evidence from ECB Open Market Orations. *ECB Working Papers No. 157*. Available at: http://www.ecb.int/pub/pdf/scpwps/ecbwp157.pdf.

Binmore, K. & Swierzbinski, J. [2000]: Treasury auctions: Uniform or discriminatory? *Review of Economic Design*, 5(4), pp.387–410. Available at: http://www.springerlink.com/openurl.asp?genre=article&id=doi:10.1007/s100580000026.

Bjonnes, G. [2001]: Bidder behavior in uniform price auctions: Evidence from Norwegian Treasury Bond auctions. Discussion Paper September 2001., Norwegian Business School, Oslo.

Blinder, A.S. [1973]: Wage Discrimination: Reduced Form and Structural Variables. *Journal of Human Resources*, 8, pp.436–455.

Bolten, S. [1973]: Treasury bill auction procedures: an empirical investigation. *The Journal of Finance*, 28(3), pp.577–585. Available at: http://onlinelibrary.wiley.com/doi/10.1111/j.1540-6261.1982.tb03586.x/abstract [Accessed August 7, 2012].

Borgy, V. et al. [2012]: Fiscal Sustainability, Default Risk and Euro Area Sovereign Bond Spreads. *Banque de France Working Paper No. 350.*

Brenner, M., Galai, D. & Sade, O. [2009]: Sovereign debt auctions: Uniform or discriminatory? *Journal of Monetary Economics*, 56(2), pp.267–274. Available at: http://linkinghub.elsevier.com/retrieve/pii/S030439320900004X [Accessed August 7, 2012].

Broto, C. & Pérez-Quirós, G. [2011]: Sovereign CDS Premia During the Crisis and their Interpretation as a Measure of Risk. *Banco de Espana Economic Bulletin April*, pp.134–142.

Brunnermeier, M.K. & Pedersen, L.H. [2009]: Market Liquidity and Funding Liquidity. *Review of Financial Studies*, 22(6), pp.2201–2238. Available at: http://rfs.oxfordjournals.org/cgi/doi/10.1093/rfs/hhn098 [Accessed August 13, 2013].

Bruno, G., Ordine, M. & Scalia, A. [2005]: Banks' participation in the Eurosystem auctions and money market integration. *Temi di discussione No. 562.* Available at: http://www.bancaditalia.it/pubblicazioni/econo/temidi/td05/td562_05/td562en/en_tema_562.pdf.

Cammack, E.B. [1991]: Evidence on Bidding Strategies and the Information in Treasury Bill Auctions. *Journal of Political Economy*, 99(1), pp.100–130. Available at: http://www.jstor.org/stable/2937714.

Cantor, R. & Packer, F. [1996]: Determinants and Impact of Sovereign Credit Ratings. *Federal Reserve Bank of New York Economic Policy Review*, (1996 October), pp.37–53. Available at: http://www.iijournals.com/doi/abs/10.3905/jfi.1996.408185.

Chudik, A. & Fratzscher, M. [2012]: Liquidity , Risk and the Global Transmission of the 2007-08 Financial Crises and the 2010-11 Sovereign Debt Crisis. ECB Working Papers, 1416.

Codogno, L., Favero, C. & Missale, A. [2003]: Yield Spreads on EMU Government Bonds. *Economic Policy*, 18(37), pp.503–532. Available at: http://doi.wiley.com/10.1111/1468-0327.00114_1.

Collin-Dufresne, P., Goldstein, R.S. & Martin, J.S. [2001]: The Determinants of Credit Spread Changes. *The Journal of Finance*, 56(6), pp.2177–2207.

Cox, J.C., Smith, V.L. & Walker, J.M. [1984]: Theory and Behavior of Multiple Unit Discriminative Auctions. *The Journal of Finance*, 39(4), pp.983–1010. Available at: http://www.jstor.org/stable/2327608.

Cruces, J. J. & Trebesch, C. [2013]: Sovereign Defaults: The Price of Haircuts. *American Economic Journal: Macroeconomics*, 5(3), pp. 85-117.

Csonto, B. & Ivaschenko, I. [2013]: Determinants of Sovereign Bond Spreads in Emerging Markets: Local Fundamentals and Global Factors vs. Ever-Changing Misalignments. *IMF Working Paper 13/164.* Available at: http://www.imf.org/external/pubs/ft/wp/2013/wp13164.pdf

D'Agostino, A. & Ehrmann, M. [2013]: The Pricing of G7 Sovereign Bond Spreads: The Times, they are A-changin. *MPRA Paper No. 40604.*

Damianov, D.S. & Becker, J.G. [2010]: Auctions with variable supply: Uniform price versus discriminatory. *European Economic Review*, 54(4), pp.571–593. Available at: http://linkinghub.elsevier.com/retrieve/pii/S001429210900107X [Accessed August 12, 2012].

Damianov, D.S., Oechssler, J. & Becker, J.G. [2010]: Uniform vs. discriminatory auctions with variable supply – experimental evidence. *Games and Economic Behavior*, 68(1), pp.60–76. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0899825609001559 [Accessed August 7, 2012].

Daripa, A. [2001]: A theory of treasury auctions. *Journal of International Money and Finance*, 44(0), pp.7–15. Available at: http://www.sciencedirect.com/science/article/pii/S0261560601000225 [Accessed August 7, 2012].

Darvas, Z. & Wolff, G.B. [2013]: Should Non-Euro Area Countries Join the Single Supervisory Mechanism? *Danube: Law and Economics Review*, 4(2), pp.141–163. Available at: http://www.degruyter.com/view/j/danb.2013.4.issue-2/danb-2013-0007/danb-2013-0007.xml [Accessed August 28, 2013].

Das, S.R. & Sundaram, R.K. [1997]: Auction Theory: a Summary with Applications to Treasury Markets. *NBER Working Paper Series No. 5873*.

Dasgupta, A., Leon-Gonzales, R. & Shortland, A. [2010]: Regionality Revisited: An Examination of the Direction of Spread of Currency Crises. *DIW Discussion Papers No. 1023*. DIW Berlin.

Department of the Treasury [1992]: *Joint Report on the Government Securities Market*. Available at: http://archive.org/stream/jointreportongov00unit/jointreportongov00unit_djvu.txt.

Dovern, J., Fritsche, U. & Slacalek, J. [2012]: Disagreement among Forecasters in G7 Countries. *The Review of Economics and Statistics*, 94(4), pp.1081–1096. Available at: http://www.mitpressjournals.org/doi/pdf/10.1162/REST_a_00207.

Duffie, D., Pedersen, L.H. & Singleton, K.J. [2003]: Modeling Sovereign Yield Spreads: A Case Study of Russian Debt. *The Journal of Finance*, LVIII(1), pp.119–160.

Dungey, M. et al. [2003]: Characterizing Global Investors' Risk Appetite for Emerging Market Debt During Financial Crises. , *IMF Working Papers No. 03/251*.

Dungey, M. & Martin, V.L. [2007]: Unravelling Financial Market Linkages During Crises. *Journal of Applied Econometrics*, 22(1), pp.89–119.

Eaton, J. & Gersovitz, M. [1981]: Debt with Potential Repudiation: Theoretical and Empirical Analysis. *Review of Economic Studies*, 48, 289-309.

Ebner, A. [2009]: An Empirical Analysis on the Determinants of CEE Government Bond Spreads. *Emerging Markets Review*, 10(2), pp.97–121. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1566014109000119 [Accessed August 28, 2013].

Edwards, S. [1983]: LDC's Foreign Borrowing and Default Risk: An Empirical Investigation 1976-1980. *American Economic Review,* vol. 74 (4) September, AEA, 726–734. p.

Edwards, S. [1985]: The Pricing of Bonds and Bank Loans in International Markets: An Empirical Analysis of Developing Countries' Foreign Borrowing. *European Economic Review*. Volume 30, Issue 3, June 1986, 565–589. p.

Eichengreen, B. & Mody, A. [1998]: What Explains Changing Spreads on Emerging-Market Debt: Fundamentals or Market Sentiment? *NBER Working Papers No. 6408*. NBER.

Ejsing, J.W. & Lemke, W. [2009]: The Janus-Headed Salvation Sovereign and Bank Credit Risk Premia During 2008-09. *ECB Working Papers No. 1127.*, ECB.

Elsinger, H., Schmidt-Dengler, P. & Zulehner, C. [2012]: Competition in Austrian Treasury Auctions. Oesterreichische Nationalbank Working Papers Forthcoming. Available at: http://www.wcas.northwestern.edu/csio/Conferences/SchmidtDenglerPaper.pdf.

Elsinger, H., Zulehner, C. & Schmidt-Dengler, P. [2007]: Bidding Behaviour in Austrian Treasury Bond Auctions. *Monetary Policy and the Economy*, (2 (August 2007)), pp.109–125. Available at: http://ideas.repec.org/a/onb/oenbmp/y2007i2b6.html.

Engelbrecht-Wiggans, R. & Kahn, C.M. [1998]: Economic Theory. *Economic Theory*, 12(2), pp.227–258. Available at: http://www.jstor.org/stable/25055122.

Engelmann, D. & Grimm, V. [2009]: Bidding Behavior in Multi – Unit Auctions — An Experimental Investigation. *The Economic Journal*, 119(537), pp.855–882. Available at: http://onlinelibrary.wiley.com/doi/10.1111/j.1468-0297.2009.02249.x/abstract.

Erb, C.B., Harvey, C.R. & Viskanta, T.E. [1996]: Political Risk, Economic Risk and Financial Risk. *Financial Analysts Journal*, 52(6), pp.29–46. Available at: http://www.cfapubs.org/doi/abs/10.2469/faj.v52.n6.2038.

Erhart, S. et al. [2013]: Mindenki másképp csinálja avagy A jegybankmérlegek és a jegybanki eszköztár átalakulása néhány feltörekvő országban. *MNB*

Szemle, 2013. Október. Különszám, pp.48–62. http://www.mnb.hu/Root/Dokumentumtar/MNB/Kiadvanyok/mnbhu_mnbszemle/mnbhu_msz_20131030/erhart.pdf

Eső, P. [1997]: Árverés és verseny a közbeszerzésben. *Közgazdasági szemle*, XLIV.(July - August), pp.597–611. Available at: http://epa.oszk.hu/00000/00017/00029/pdf/eso.pdf.

Fabra, N. [2003]: Tacit Collusion in Repeated Auctions : Uniform versus Discriminatory. *The Journal of Industrial Economics*, 51(3), pp.271–293. Available at: http://www.jstor.org/stable/3569711.

Favero, C., Pagano, M. & von Thadden, E.-L. [2010]: How Does Liquidity Affect Government Bond Yields? *Journal of Financial and Quantitative Analysis*, 45(01), pp.107–134.

Feldman, R.A. & Reinhart, V. [1995]: Auction Format Matters: Evidence on Bidding Behavior and Selling Revenue. *IMF Working Paper No. 95/47*. Available at: http://adlib.imf.org/digital_assets/wwwopac.ashx?command=getcontent&server=webdocs&value=EB/1995/WP/13935.PDF.

Ferrucci, G. [2003]: Empirical Determinants of Emerging Market Economies' Sovereign Bond Spreads. *BoE Working Papers No. 205.*, BoE.

Février, P., Raphaele, P. & Visser, M. [2004]: Econometrics of Share Auctions. Department of Economics, University of Chicago Manuscript. Available at: http://www.econ.yale.edu/seminars/apmicro/am04/fevrier-040401.pdf.

Forbes, K.J. & Chinn, M.D. [2003]: A Decomposition of Global Linkages in Financial Markets Over Time. , pp.1–51.

Forbes, K.J. & Rigobon, R. [2002]: No Contagion, Only Interdependence: Measuring Stock Market Comovements. *Journal of Finance*, LVII(5), pp.2223–2261.

Friedman, M. [1991]: How to Sell Government Securities Wall Street Journal, 28 August 1991. *Wall Street Journal*, (August), p.A8. Available at: http://0055d26.netsolhost.com/friedman/pdfs/wsj/WSJ.08.28.1991.pdf.

Friedman, M. [1959]: Testimony in Employment, Growth, and Price Levels. Joint Economic Committee, 86th Congress, 1st Session, October 30. Available at: http://papers.nber.org/books/fabr61-1

Gai, P. & Vause, N. [2006]: Measuring Investors' Risk Appetite. *International Journal of Central Banking*, 1, pp.167–188.

Gapen, M.T. et al. [2005]: Measuring and Analyzing Sovereign Risk with Contingent Claims. *IMF Staff Papers*, 55(1), pp.1–49. Available at: http://www.palgrave-journals.com/doifinder/10.1057/palgrave.imfsp.9450026.

Goldfajn, I. & Valdes, R.O. [1997]: Capital Flows and the Twin Crises: The Role of Liquidity. *IMF Working Papers, 97/87*. IMF.

Gordy, M.B. [1999]: Hedging Winer's Curse with Multiple Bids: Evidence from the Portuguese Treasury Bill Auction. *The Review of Economics and Statistics*, 81(3), pp.448–465. Available at: http://www.jstor.org/stable/2646768.

Goswami, G., Noe, T.H. & Rebello, M.J. [1996]: Collusion in Uniform-Price Auctions : Experimental Evidence and Implications for Treasury Auctions. *The Review of Financial Studies*, 9(3), pp.757–785. Available at: http://www.jstor.org/stable/2962310.

Hamao, Y. & Jegadeesh, N. [1998]: An Analysis of Blidding in the Japanese Government Bond Auctions. *The Journal of Finance*, 53(2), pp.755–772. Available at: http://www.jstor.org/stable/117369.

Harris, M. & Raviv, A. [1981]: Allocation Mechanisms and the Design of Auctions. *Econometrica*, 49(6), pp.1477–1499. Available at: http://www.jstor.org/stable/1911413.

Haugh, D., Ollivaud, P. & Turner, D. [2009]: What Drives Sovereign Risk Premiums?: An Analaysis of Recent Evidence from the Euro Area. *OECD Economics Department Working Papers, No. 718.*, OECD.

Heller, D. & Lengwiler, Y. [2001]: Should the Treasury Price-Discriminate ? A Procedure for Computing Hypothetical Bid Functions. *Journal of Institutional and Theoretical Economics*, 157, pp.413–429. Available at: http://wwz.unibas.ch/fileadmin/wwz/redaktion/finance/personen/yvan/papers/heller-lengwiler-01.pdf.

Hilscher, J. & Nosbusch, Y. [2010]: Determinants of Sovereign Risk: Macroeconomic Fundamentals and the Pricing of Sovereign Debt. *Review of Finance*, 14(2), pp.235–262. Available at:

http://rof.oxfordjournals.org/cgi/doi/10.1093/rof/rfq005 [Accessed August 19, 2013].

Horatcsu, A. [2002]: Bidding Behavior in Divisible Good Auctions : Theory and Evidence from the Turkish Treasury Auction Market. Available at: http://home.uchicago.edu/~hortacsu/paper2_aug2.pdf.

Horatcsu, A. - McAdams, D. [2010]: Mechanism Choice and Strategic Bidding in Divisible Good Auctions: An Empirical Analysis of the Turkish Treasury Auction Market. Journal of Political Economy, 2010, 118(5), pp. 833-865. http://www.jstor.org/stable/10.1086/657948

Hudson, R. [2000]: Analysis of uniform and discriminatory price auctions in restructured electricity markets. *Relatório Técnico, Oak Ridge National Laboratory, Oak …*, pp.1–7. Available at: http://www.ornl.gov/sci/ees/etsd/pes/pubs/pricing.pdf [Accessed August 7, 2012].

Kaminska, I. [2010]: A loser's nightmare in Europe's debt auctions? *Financial Times Alphaville*. Available at: http://ftalphaville.ft.com/blog/2010/09/24/351991/a-losers-nightmare-in-europes-debt-auctions/.

Kandel, S., Sarig, O. & Wohl, A. [1999]: The demand for stocks: an analysis of IPO auctions. *Review of Financial Studies*, 12(2), pp.227–247. Available at: ftp://www1.idc.ac.il/Faculty/sarig/sarigo/demand.pdf.

Kang, B. & Puller, S.L. [2008]: The Effect of Auction Format on Efficiency and Revenue in Divisible Goods Auctions: a Test. *The Journal of Industrial Economics*, LVI(2), pp.290–332. Available at: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.75.5985.

Keloharju, M., Nyborg, K.G. & Rydqvist, K. [2005]: Treasury Auctions Strategic Behavior and Underpricing in Uniform Price Auctions : Evidence from Finnish Treasury Auctions. *The Journal of Finance*, 60(4), pp.1865–1902. Available at: http://www.jstor.org/stable/pdfplus/3694856.pdf.

Kim, D.H., Loretan, M. & Remolona, E.M. [2009]: Contagion and Risk Premia in the Amplification of Crisis: Evidence from Asian Names in the Global CDS Market. *Journal of Asian Economics*, 21(3), pp.314–326. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1049007809000669 [Accessed August 28, 2013].

Király, J. et al. [2008]: Retail Credit Expansion and External Finance in Hungary: Lessons from the Recent Past (1998 – 2007). *BIS Papers chapters, Financial globalisation and emerging market capital flows*, (44), pp.221–233.

Kisgergely, K. [2009]: What Moved Sovereign CDS Spreads in the Period of Financial Turbulence? *Report on Financial Stability, MNB, November 2009.*

Klemperer, P. [2004]: *Auctions: Theory and Practice*. Princetone: Princeton University Press. Available at: http://www.nuff.ox.ac.uk/users/klemperer/VirtualBook/VirtualBookCoverSheet.asp.

Klemperer, P. [2002]: What Really Matters in Auction Design. *The Journal of Economic Perspectives*, 16(1), pp.169–189. Available at: http://www.jstor.org/stable/2696581.

Kocsis, Z. - Monostori, Z. [2013a]: Country-Specific Determinants of Sovereign CDS Spreads: the Role of Fundamentals in Eastern Europe. *Magyar Közgazdaságtudományi Egyesület (MKE) konferencia*. Budapest.

Kocsis, Z. - Monostori, Z. [2013b]: Country-Specific Determinants of Sovereign CDS Spreads: the Role of Fundamentals in Eastern Europe. In *Annual Financial Market Liquidity Conference*. Budapest.

Kocsis, Z. & Mosolygó, Z. [2006]: A devizakötvény-felárak és a hitelminõsítések összefüggése – keresztmetszeti elemzés. *Közgazdasági szemle*, LIII(2006. szeptember), pp.769–798.

Kocsis, Z. & Nagy, D. [2011]: Variance Decomposition of Sovereign CDS Spreads. *MNB Bulletin*, (October 2011), pp.36–50.

Kodres, L.E. & Pritsker, M. [2002]: A Rational Expectations Model of Financial Contagion. *The Journal of Finance*, LVII(2), pp.769–799.

Koesrindartoto, D. [2004]: Treasury Auction, Uniform or Discriminatory?: An Agent-Based Approach. *Iowa State Uniiversity, Department of Economics Working Paper No. 04013*. Available at: http://www2.econ.iastate.edu/research/webpapers/paper_11988_04013.pdf [Accessed August 7, 2012].

Kondrát, Z. [1996]: Az aukcios modszer hatása a kincstár bevételére. *Közgazdasági szemle*, XLIII. (Ju, pp.506–524. Available at: http://epa.oszk.hu/00000/00017/00017/pdf/kondrat.pdf

Kremer, Ilan & Nyborg, K.G. [2004]: Divisible-good auctions: the role of allocation rules. *The RAND Journal of Economics*, 35(1), pp.147–159. Available at: http://www.jstor.org/stable/1593734.

Kremer, Ilian & Nyborg, K.G. [2004]: Underpricing and market power in uniform price auctions. *Review of Financial Studies*, 17(3), pp. 849-877. Available at: http://rfs.oxfordjournals.org/content/17/3/849.short [Accessed August 7, 2012].

Krishna, V. [2009]: *Auction theory* Second ed. San Diego: Academic Press. Available at: http://books.google.com/books?hl=en&lr=&id=qW1128ktG1gC&oi=fnd&pg=PP1&dq=Auction+Theory&ots=SS4i8Q6MIj&sig=f984hoRGpa41qGLKfPd90Hedolw [Accessed August 7, 2012].

LiCalzi, M. & Pavan, A. [2005]: Tilting the supply schedule to enhance competition in uniform-price auctions. *European Economic Review*, 49(1), pp.227–250. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0014292102003240 [Accessed August 7, 2012].

Linzert, T., Nautz, D. & Breitung, J. [2006]: Bidder behavior in central bank repo auctions: Evidence from the Bundesbank. *Journal of International Financial Markets, Institutions and Money*, 16(3), pp.215–230. Available at: http://ac.els-cdn.com/S1042443105000478/1-s2.0-S1042443105000478-main.pdf?_tid=43a5e2c6-1dbc-11e2-b678-00000aacb35d&acdnat=1351070700_6e7e2967497292366fd06d0d9ae0c96e [Accessed October 25, 2012].

List, J.A. & Lucking-Reiley, D. [2000]: Demand reduction in multiunit auctions: Evidence from a sportscard field experiment. *The American Economic Review*, 90(4), pp.961–972. Available at: http://www.jstor.org/stable/10.2307/117317 [Accessed August 7, 2012].

Longstaff, F.A. et al. [2011]: How Sovereign is Sovereign Credit Risk? *American Economic Journal: Macroeconomics*, 3(2), pp.75–103. Available at: http://www.nber.org/papers/w13658.pdf.

Maltritz, D. & Molchanov, A. [2013]: Country Credit Risk Determinants with Model Uncertainty. *International Review of Economics and Finance*, Accepted Manuscript. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1059056013000531 [Accessed August 29, 2013].

Manganelli, S. & Wolswijk, G. [2009]: What Drives Spreads in the Euro Area Government Bond Market? *Economic Policy*, 24(58), pp.191–240.

Marszalec, D. [2008]: A Structural Econometric Analysis of Polish Treasury Bill Auctions. *Department of Economics and Nuffield College, University of Oxford Manuscript*. Available at: http://www.webmeets.com/files/papers/EARIE/2009/214/DMarszalec_TBillAuctions_Feb09.pdf.

Maxwell, C.C. [1983]: *Auctioning divisible commodities: A study of price determination*. Doctoral Dissertation. Harward University.

McAdams, D. [2007]: Adjustable supply in uniform price auctions: Non-commitment as a strategic tool. *Economics Letters*, 95(1), pp.48–53. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0165176506003156 [Accessed August 12, 2012].

Mccabe, K.A., Rassenti, S.J. & Smith, V.L. [1990]: Auction Institutional Design : Theory and Behavior of Simultaneous Multiple-Unit Generalizations of the Dutch and English Auctions. *The American Economic Review,*, 80(5), p.The American Economic Review. Available at: http://www.jstor.org/stable/2006779.

Mcguire, P. & Schrijvers, M.A. [2003]: Common Factors in Emerging Market Spreads. *BIS Quarterly Review*, (December 2003), pp.65–78.

Merton, R.C. [1974]: On the Pricing of Corporate Debt: The Risk Structure of Interest Rates. *Journal of Finance*, 29(2), pp.449–470.

Mester, L.J. [1995]: There's more than one way to sell a security: The Treasury's Auction Experiment. *Federal Reserve Bank of Philadelphia Business Review*. Available at: http://www.philadelphiafed.org/research-and-data/publications/business-review/1995/brja95lm.pdf.

Milgrom, P.R. & Weber, R.J. [1982]: A Theory of Auctions and Competitive Bidding. *Econometrica*, 50(5), pp.1089–1122. Available at: http://www.jstor.org/stable/1911865.

Miller, M. [1991]: Interview with Merton Miller. *The New York Times*, 15th September, p.3:13. Available at: http://www.nytimes.com/1991/09/15/business/wall-street-diana-b-henriques-treasury-s-troubled-auctions.html.

Min, H.G. [1999]: Determinants of Emerging Market Bond Spread: Do Economic Fundamentals Matter? *Policy Research Working Paper No. WPS 1899*, The World Bank, Washington D.C.

Mody, A. [2009]: From Bear Stearns to Anglo Irish: How Eurozone Sovereign Spreads Related to Financial Sector Vulnerability. *IMF Working Paper, No. 108.*

Monostori, Z. [2014]: Discriminatory versus Uniform-price Auctions. *MNB Occasional Papers No. 111.* http://www.mnb.hu/Root/Dokumentumtar/MNB/Kiadvanyok/mnbhu_mnbtanulmanyok/OP111_final.pdf.

Monostori, Z. [2013a]: Diszkriminatív áras és egyenáras aukciók I. rész: elméleti eredmények. In *Doctoral Student Conference*. Budapesti Corvinus Egyetem.

Monostori, Z. [2013b]: Diszkriminatív áras és egyenáras aukciók II. rész: empirikus eredmények. In *Doctoral Student Conference*. Budapesti Corvinus Egyetem.

Monostori, Z. [2013c]: Diszkriminatív áras és egyenáras aukciók. *Közgazdasági Szemle, LX., pp. 1048-1074.*. http://www.kszemle.hu/tartalom/letoltes.php?id=1415

Monostori, Z. [2013d]: Why did the Polish treasury change the auction format? In *Workshop on Impact of global crisis on EU and CEECs governance and financial markets*. Corvinus University of Budapest.

Monostori, Z. [2013e]: Crisis on the Hungarian Government Bond Markets in the Winter of 2011-2012: Was that a Liquidity Problem? *Society and Economy*. 35 (4), pp. 539-550. DOI: http://dx.doi.org/10.1556/socec.2013.0009

Monostori, Z. [2012a]: Szuverén forintkötvények hozamainak dekompozíciója. In *Vállalkozói- és Gazdasági Trendek a Kárpát-medencében Konferencia*. Miercurea Ciuc.

Monostori, Z. [2012b]: Magyar szuverén fix kamatozású forintkötvények hozamdekompozíciója. *Hitelintézeti Szemle*, 11(5), pp.462–475. http://www.bankszovetseg.hu/wp-content/uploads/2012/10/462-475-monostori.pdf

Monostori, Z. [2012c]: Crisis on the Hungarian Government Bond Markets: Is that a Liquidity Problem? In *7th South East European Doctoral Student Conference*. Thessaloniki.

Monostori, Z. [2012d]: Is there a Liquidity Problem on the Hungarian Sovereign Bond Makets? In *Spring Wind Conference*. Győr.

Monostori, Z. [2011a]: Az ötéves magyar szuverén fix kamatozású forintkötvények hozamainak dekompozíciója. In *OTDK dolgozat*. Gödöllő.

Monostori, Z. [2011b]: Liquidity of Hungarian sovereign bond markets during the crisis. In *Annual Financial Market Liquidity Conference*. Budapest.

Monostori, Z. [2010]: Az ötéves, magyar, szuverén, fix kamatozású forintkötvények hozamainak dekompozíciója. In *TDK dolgozat*. Budapesti Corvinus Egyetem.

Morgan Stanley [2012]: *Emerging Markets - Local Markets Guidebook*. Available at: http://www.docstoc.com/docs/118900740/Morgan-Stanley---Local-Markets-Guidebook.

Nautz, D. [1995]: Zur Fernsteuerung des Geldmarktes durch die Wertpapierpenisongeschäfte der Bundesbank. *Zeitschrift für Wirtschafts- und Sozialwissenschaten*, 115(4), pp.623–644.

Nickel, C., Rother, P.C. & Rülke, J.C. [2009]: Fiscal Variables and Bond Spreads – Evidence from Eastern European Countries. *ECB Working Papers, 1101*. ECB.

Noussair, C. [1994]: Equilibria in a multi-object uniform price sealed bid auction with multi-unit demands. *Economic Theory*, 5, pp.337–351. DOI: http://dx.doi.org/10.1007/bf01215207

Nyborg, K.B. & Strebulaev, I.A. [2004]: Multiple unit auctions and short squeezes. *Review of Financial Studies*, 17(2), pp.545–580. DOI: http://dx.doi.org/10.1093/rfs/hhg038

Nyborg, K.G., Rydqvist, K. & Sundaresan, S.M. [2002]: Bidder Behavior in Multi-Unit Auctions - Evidence from Swedish Treasury Auctions. *Journal of Political Economy*, 110(2), pp.394–424. Available at: http://www0.gsb.columbia.edu/faculty/ssundaresan/PDFpapers/bidding_multiunit_auctions.pdf.

Nyborg, K.G. & Sundaresan, S. [1996]: Discriminatory versus uniform Treasury auctions : Evidence from when-issued transactions. *Journal of Financial Economics*, 42, pp.63–104. DOI: http://dx.doi.org/10.1016/0304-405x(95)00871-b

Oaxaca, R. [1973]: Male-Female Wage Differentials in Urban Labor Markets. *International Economic Review*, 14(October), pp.693–709.

Páles, J. & Homolya, D. [2011]: A hazai bankrendszer külföldi forrásköltségeinek alakulása. *MNB-szemle*, (2011 október), pp.61–69.

Pan, J. & Singleton, K.J. [2008]: Default and Recovery Implicit in the Term Structure of Sovereign CDS Spreads. *The Journal of Finance*, LXIII(5), pp.2345–2384.

Panizza, U., Sturzenegger, F. & Zettelmeyer, J. [2009]: The Economics and Law of Sovereign Debt and Default. *Journal of Economic Literature*, 47(3), pp.653–700. DOI: http://dx.doi.org/10.1257/jel.47.3.651

Pericoli, M. & Sbracia, M. [2001]: A Primer on Financial Contagion. *Journal of Economic Surveys*, vol. 17, pp. 571-608.

Puhle, M. [2008]: *Bond Portfolio Optimization*. Verlag Berlin Heidelberg: Springer.

Reinhart, C.M. & Kaminsky, G.L. [2000]: On Crises, Contagion and Confusion. *Journal of International Economics*, 51(1), pp.145–168.

Remolona, E.M., Scatigna, M. & Wu, E. [2008]: A Ratings Based Approach to Measuring Expected Losses from Sovereign Defaults. *International Journal of Finance & Economics*, 13(1), pp.26–39.

Van Rijckeghem, C. & Weder, B. [2001]: Sources of contagion: is it finance or trade? *Journal of International Economics*, 54(2), pp.293–308. DOI: http://dx.doi.org/10.1016/s0022-1996(00)00095-7

Rocholl, J. [2005]: Discriminatory auctions with seller discretion : evidence from German treasury auctions. *Deutsche Bundesbank. Discussion Paper Series*, (15). Available at: http://www.bundesbank.de/Redaktion/EN/Downloads/Publications/Discussion_Paper_1/2005/2005_05_06_dkp_15.pdf? blob=publicationFile.

Rowland, P. [2004]: Determinants of Spread , Credit Ratings and Creditworthiness for Emerging Market Sovereign Debt: A Follow-Up Study Using Pooled Data Analysis. *Borradores de Economia Nu. 296*, Banco de la Republica de Colombia.

Sade, O., Schnitzlein, C. & Zender, J.F. [2006]: Competition and Cooperation in Divisible Good Auctions: An Experimental Examination. *Review of Financial Studies*, 19(1), pp.195–235. Available at: http://leeds-faculty.colorado.edu/zender/papers/SSZ1.pdf [Accessed August 12, 2012].

De Santis, R.A. [2012]: The Euro Area Sovereign Debt Crisis: Safe Haven, Credit Rating and the Spread of the Fever from Greece, Ireland and Porugal. *ECB Working Papers, No. 1419*. ECB.

Sareen, S. [2004]: Cross-Country Comparison of Models for Issuance of Government Securities. *Duke University Department of Economics Manuscript*. Available at: http://www.geocities.ws/samitasareen/ctry_summ_boc_mod0603.pdf.

Scalia, A. [1997]: Bidder Profitability under Uniform Price Auctions and Systematic Reopenings: the Case of Italian Treasury Bonds. *Bank of Italy Working Paper No. 303*. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1804020.

Schuknecht, L., von Hagen, J. & Wolswijk, G. [2010]: Government Bond Risk Premiums in the EU Revisited - The Impact of the Financial Crisis. *ECB Working Papers, 1152. ECB*.

Sgherri, S. & Zoli, E. [2009]: Euro Area Sovereign Risk During the Crisis. *IMF Working Papers, WP/09/222*. IMF.

Simon, D.P. [1994]: The Treasury's Experiment with Single-Price Auctions in the Mid-1970s: Winner's or Taxpayer's Curse? *The Review of Economics and Statistics*, 76(4), pp.754–760. Available at: http://www.jstor.org/stable/pdfplus/2109776.pdf.

Smith, V.L. [1967]: Experimental Studies of Discrimination Versus Competition in Sealed-Bid Auction Markets. *The Journal of Business*, 40(1), pp.56–84. Available at: http://www.jstor.org/stable/2351305.

Sturzenegger, F. & Zettelmeyer, J. [2005]: Haircuts: Estimating Investor Losses in Sovereign Debt Restructurings, 1998–2005. *Journal of International Money and Finance*, 27(5), pp.1–67. DOI: http://dx.doi.org/10.1016/j.jimonfin.2007.04.014

Sundaresan, S. [1994]: An Empirical Analysis of U.S. Treasury Auctions Implications for Auction and Term Structure Theories. *The Journal of Fixed Income*, 4(2), pp.35–50. Available at: http://www.iijournals.com/doi/abs/10.3905/jfi.1994.408109.

Szatmári, A. [1996a]: Aukciók, avagy a képbe kerül, ha a Louvre a képbe kerül? *Közgazdasági szemle*, XLIII.(April), pp.303–314.

Szatmári, A. [1996b]: DKJ. In *TDK dolgozat*. Budapesti Corvinus Egyetem.

Szűcs, N., Havran, D. & Csóka, P. [2010]: Információs paradoxon a vállalkozások hitelezésében nem fizető vevő esetén. *Közgazdasági szemle*, LVII(2010 április), pp.318–336.

Tenorio, R. [1993]: Revenue Equivalence and Bidding Behavior in a Multi-Unit Auction Market: An Empirical Analysis. *The Review of Economics and Statistics*, 75(2), pp.302–314. Available at: http://www.jstor.org/stable/2109436.

Tsao, C.S. & Vignola, A.J. [1977]: Price Discrimination and the Demand for Treasury's Long Term Securities. *U.S. Department of Treasury Manuscript*.

Umlauf, S.R. [1993]: An empirical study of the Mexican Treasury bill auction. *Journal of Financial Economics*, 33(3), pp.313–340. Available at: http://www.sciencedirect.com/science/article/pii/0304405X93900109.

Varga, L. [2009]: The Information Content of Hungarian Sovereign CDS Spreads. *MNB Occassional Papers No. 78.*. Available at:

http://english.mnb.hu/Root/Dokumentumtar/ENMNB/Kiadvanyok/mnben_muhelytanulmanyok/mnben_op_78/op_78.pdf

Vasicek, B. & Claeys, P. [2012]: Measuring Sovereign Bond Spillover in Europeand the Impact of Rating News. *ECB Working Paper*, forthcoming. ECB.. Available at: http://www.cnb.cz/miranda2/export/sites/www.cnb.cz/en/research/research_publications/cnb_wp/download/cnbwp_2012_07.pdf.

Vickrey, W. [1961]: Counterspeculation, Auctions, and Competitive Sealed Tenders. *The Journal of Finance*, 16(1), pp.8–37. Available at: http://www.jstor.org/stable/2977633.

Viswanathan, S. & Wang, J.J.D. [2000]: Auctions with when-issued trading: a model of the US Treasury markets. *Manuscript*, 2. Available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Auctions+with+When-Issued+Trading:+a+Model+of+the+U.S.+Treasury+Markets#0 [Accessed August 7, 2012].

Wang, J.J.D. & Zender, J.F. [2002]: Auctioning divisible goods. *Economic Theory*, 19(4), pp.673–705. DOI: http://dx.doi.org/10.1007/s001990100191

Wang, M.-C. & Shih, F.-M. [2010]: Volatility Spillover: Dynamic Regional and World Effects. *European Journal of Scientific Research*, 41(4), pp.582–589.

Weigel, D. & Gemmill, G. [2006]: What Drives Credit Risk in Emerging Markets? The Roles of Country Fundamentals and Market Co-movements. *Journal of International Money and Finance*, 25(3), pp.476–502. DOI: http://dx.doi.org/10.1016/j.jimonfin.2006.01.006

Wilson, R. [1979]: Auctions of Shares Author. *The Quarterly Journal of Economics*, 93(4), pp.675–689. Available at: http://www.jstor.org/stable/1884475.

Wu, J.J. & Game, A.L. [2011]: Cointegration Test with Stationary Covariates and the CDS-Bond Basis during the Financial Crisis. *Divisions of Research & Statistics and Monetary Affairs*, pp.1–29.

VIII. PUBLICATIONS OF THE AUTHOR IN THIS TOPIC

VIII.1. Publications in Hungarian

Books, book chapters, conference proceedings:

Monostori, Z. [2013a]: Diszkriminatív áras és egyenáras aukciók I. rész: elméleti eredmények. In *Doctoral Student Conference*. Budapesti Corvinus Egyetem.

Monostori, Z. [2013b]: Diszkriminatív áras és egyenáras aukciók II. rész: empirikus eredmények. In *Doctoral Student Conference*. Budapesti Corvinus Egyetem.

Monostori, Z. [2012a]: Szuverén forintkötvények hozamainak dekompozíciója. In *Vállalkozói- és Gazdasági Trendek a Kárpát-medencében Konferencia*. Miercurea Ciuc.

Monostori, Z. [2011a]: Az ötéves magyar szuverén fix kamatozású forintkötvények hozamainak dekompozíciója. In *OTDK dolgozat*. Gödöllő.

Monostori, Z. [2010]: Az ötéves, magyar, szuverén, fix kamatozású forintkötvények hozamainak dekompozíciója. In *TDK dolgozat*. Budapesti Corvinus Egyetem.

Journal articles:

Erhart Szilárd - Kicsák Gergely - Kuti Zsolt - Molnár Zoltán - Monostori Zoltán [2013]: Mindenki másképp csinálja avagy A jegybankmérlegek és a jegybanki eszköztár átalakulása néhány feltörekvő országban. *MNB Szemle,* 2013. Október. Különszám, pp.48–62. http://www.mnb.hu/Root/Dokumentumtar/MNB/Kiadvanyok/mnbhu_mnbszemle/mnbhu_msz_20131030/erhart.pdf

Monostori, Z. [2013c]: Diszkriminatív áras és egyenáras aukciók. *Közgazdasági Szemle, LX., pp. 1048-1074.*. http://www.kszemle.hu/tartalom/letoltes.php?id=1415

Monostori, Z. [2012b]: Magyar szuverén fix kamatozású forintkötvények hozamdekompozíciója. *Hitelintézeti Szemle*, 11(5), pp.462–475. http://www.bankszovetseg.hu/wp-content/uploads/2012/10/462-475-monostori.pdf

VIII.2. Publications in English

Books, book chapters, conference proceedings:

Kocsis, Z. - Monostori, Z. [2013a]: Country-Specific Determinants of Sovereign CDS Spreads: the Role of Fundamentals in Eastern Europe. Magyar Közgazdaságtudományi Egyesület (MKE) konferencia. Budapest.

Monostori, Z. [2013d]: Why did the Polish treasury change the auction format? In *Workshop on Impact of global crisis on EU and CEECs governance and financial markets*. Corvinus University of Budapest.

Monostori, Z. [2012c]: Crisis on the Hungarian Government Bond Markets: Is that a Liquidity Problem? In *7th South East European Doctoral Student Conference*. Thessaloniki.

Monostori, Z. [2012d]: Is there a Liquidity Problem on the Hungarian Sovereign Bond Makets? In *Spring Wind Conference*. Győr.

Journal articles:

Monostori, Z. [2014]: Discriminatory versus Uniform-price Auctions. *MNB Occasional Papers No. 111.* http://www.mnb.hu/Root/Dokumentumtar/MNB/Kiadvanyok/mnbhu_mnbtanulmanyok/OP111_final.pdf.

Monostori, Z. [2013e]: Crisis on the Hungarian Government Bond Markets in the Winter of 2011-2012: Was that a Liquidity Problem? *Society and Economy*. 35 (4), pp. 539-550. http://www.akademiai.com/content/0661306013T326P0

Conferenece presentations:

Kocsis, Z. - Monostori, Z. [2013b]: Country-Specific Determinants of Sovereign CDS Spreads: the Role of Fundamentals in Eastern Europe. In *Annual Financial Market Liquidity Conference*. Budapest.

Monostori, Z. [2011b]: Liquidity of Hungarian sovereign bond markets during the crisis. In *Annual Financial Market Liquidity Conference*. Budapest.