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Eglė ALEKNEVIČIŪTĖ

ASSESSMENT OF THE FACTORS INFLUENCING GOVERNMENT BOND MARKET COMOVEMENTS IN THE GLOBAL ENVIRONMENT

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Eglė ALEKNEVIČIŪTĖ

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Key Terms

Arbitrage Pricing Theory – a well-known pricing theory for estimating the price of an asset, assuming that asset's return is dependent on various macroeconomic, market and security-specific factors (Ross, 1976).

Agglomerative hierarchical clustering – clustering method where each vertex starts in its cluster, and cluster pairs are merged as one moves up the hierarchy, so it can be interpreted as a bottom-up clustering process (Panton et al., 1976):

Bartlett's sphericity test – PCA quality characteristic, indicating to what extent the data deviates from the reference situation.

Bilateral factors – in this dissertation, country-specific factors, represented by a mutual characteristic between two countries (e.g. export from one country to the other, distance between two countries).

Between-group linkage – clustering scheme based on the average distance of all the objects in one cluster with all the objects in another. Proximity of two clusters is the average pairwise proximity between all the pairs in different clusters (Tan, Steinbach and Kumar, 2006).

Bootstrapping – method to derive properties (standard errors, confidence intervals and critical values) of the sampling distribution of estimators (Schmidheiny, 2016).

Complete linkage (furthest neighbour) – clustering scheme that reflects the distance between two clusters, basing it on the distance of two most dissimilar members of the cluster (Murtagh and Contreras, 2011).

Divisive hierarchical clustering – a clustering method where all observations start in one cluster, and splits are performed recursively as one moves down the hierarchy (a top down approach) (Fraley and Raftery, 1998).

Euclidean distance – distance between clusters emphasizing the outliers to generate distance patterns (Wolfson et al., 2004).

Lance-Williams equation – equation that describes the proximity between clusters $i \cup j$ and k, where $i \cup j$, is formed by merging clusters i and j.

Cointegration – existence of a stationary linear combination of non-stationary time series (Jones and Nesmith, 2007).

Comovements – a mutual dependence between two government bond markets.

Contagion – an occurrence of excess comovements between normally uncorrelated assets that cannot be explained by economic fundamentals.

Credit risk – a potential that a borrower will fail to meet its obligations in accordance with agreed terms (BCBS, 2000) or investor's required compensation for a non-zero country's probability of default (Manganelli and Wolswijk, 2009; Kilponen, Laakkonen and Vilmunen, 2012).

Differentiation – in this dissertation, existence of the groups of government bond markets, commoving more strongly in between. Markets with high positive comovements are grouped together and segregated from those with oppositely commoving markets.

Diversification – in this dissertation, investment portfolio formation strategy, combining different securities to reduce unsystematic risk, specific to a particular security. Diversification lowers the portfolio risk (volatility) because not all the securities move together and can nearly be eliminated by holding a variety of non-commoving securities (adapted by the author, based on Markowitz, 1968).

Financial globalization – an aggregate concept, referring to increasing global linkages through cross-border financial flows (Prasad et al., 2003).

Financial integration – an individual country's linkages to international capital markets, affecting the structure of financial system, which in turn may have implications for financial stability (defined by the author, based on Prasad et al. (2003) and Tayebi and Fakhr (2009).

Excess comovements – correlation between two asset prices beyond what could be explained by the key economic fundamentals (Ocran and Mlambo, 2009).

Financial crisis – sharp, brief, ultra-cyclical deterioration of all or most of a group of financial indicators: short term interest rates, asset prices, (stock, real estate, land) prices, commercial insolvencies and failures of financial institutions (Minsky, 1982).

Flight-to-quality – the actions of investors, moving their capital away from riskier investments to the safest possible, usually caused by uncertainty in financial markets (Baur and Lucey (2006).

Fundamental factors – in this dissertation, country-specific factors related to the country's internal performance and characteristics of its financial market (e.g. macroeconomic factors, market liquidity).

Global factors – in this dissertation, factors that affect all the economies.

Global environment – *in this dissertation*, a large set of countries (75) with their own financial markets.

GARCH models – some of the most popular methods, used for the estimation of volatility between financial markets (Loh, 2013).

Home bias – the tendency for investors to invest in a large amount of domestic securities, despite of the benefits of international diversification (Foad, 2002).

Identity matrix – theoretical matrix with orthogonal variables.

Joliffe criteria – criteria for stopping the PCA when the percentage of explained variance reaches a certain threshold (Coudert and Gex, 2006; ECB, 2007).

Kaiser criteria – criteria for choosing the number of factors for the PCA, keeping only the eigenvalues greater than 1 (Coudert and Gex, 2006; ECB, 2007).

Kaiser-Mayer-Olkin (KMO) measure – a measure of PCA sampling adequacy, providing an index ([0; 1]) of the proportion of variance that might be common among the variables.

Market comovements – mutual dependence between two government bond markets

Market fragmentation – concept that all markets are diverse and composed of different segments, reflecting different needs, wants, responses to marketing messages, and behaviour. These many segments that characterize all markets are indicative of the fragmentation of these markets (Wharton, 2011).

Market transparency – the ability of market participants to obtain information about the trading process (i.e. price, order size, trading volume, risk and trader identity) (Madhavan, 2000).

Metric space – a set for which distances between all the members of the set are defined.

Multicollinearity – a high degree of correlation (linear dependency) among several independent variables, commonly occurring when a large number of independent variables are incorporated in a regression model (Jeeshim, 2002).

No-bail-out clause – an article that ensures that the responsibility for repaying public debt remains national and prevents risk premiums caused by unsound fiscal policies from spilling over to partner countries, encouraging prudent fiscal policies at the national level (Article 125 in Treaty on the Functioning of the European Union/ Economic and Monetary Policy, 2007)

Partitioning (non-hierarchical) clustering – a method to cluster data units into a set number of clusters, specified in advance, aiming to initial partitions of data units and alter cluster memberships to obtain better partition (Fraley and Raftery, 1998).

Real effective exchange rate – unadjusted weighted average rate at which one country's currency exchanges for a basket of multiple foreign currencies, indicating country's international competitiveness in foreign exchange market (Catao, 2007).

Risk aversion – unwillingness of investors to implement a riskier transaction with questionable pay-off and the choice of a less risky transaction even if the latter will bring the smaller pay-off. It is one of the main assumptions of Utility Theory (Rabin, 2000).

Pull factors – country-specific factors, "pulling" international capital flows into a country (Fratzscher, 2012).

Push factors – common global factors, "pushing" international capital flows into a country (Fratzscher, 2012).

Primary market – market where government bonds are issued (Smith, 2010).

Quantitative easing – unconventional monetary policy, implemented by a central bank when purchasing large quantities of long-term securities with the stated objective to reduce long-term interest rates and increase the money supply in order to spur economic activity (Krishnamurthy and Vissing-Jorgensen, 2011).

Scree plot – a figure in PCA that displays eigenvalues associated with a component in descending order versus the number of the component.

Secondary market – market where government bonds are traded after their initial emission, providing cost-efficient and secure platform for market participants to buy and sell the bonds fairly and transparently (Smith, 2010).

Single linkage – clustering scheme defining the distance between two clusters based on the distance of two most similar members of clusters (one from each cluster) (Murtagh and Contreras, 2011).

Sovereign debt crisis – deterioration of the capacity of multiple governments to pay their debt, most commonly referred to the crisis in Europe in 2009-2014.

Sovereign default – an event when debt service is not paid by the government on the due date (or within a specified period) or payments are not made within the time frame specified under a guarantee (Beers and Mavalwalla, 2016).

Spillover effects – externalities of economic activity or processes that affect those who are not directly involved, exploring and exhibiting the linkages between two or more economic variables (Polyzoidou, 2014).

Variance Inflation Factor – a measure of how much the variance of an estimated regression coefficient is inflated by the existence of a correlation among the predictor variables in the model.

Vector Autoregression – an econometric model used to capture the linear interdependencies among multiple time series (Kunst, 2007).

Ward's (minimum variance) method – clustering scheme that finds clusters with tight minimum variance. Distance is determined by how much the error sum of squares increases when merging the clusters (Johnson, 1967).

Abbreviations

AHC – agglomerative hierarchical clustering.

APT – Arbitrage Pricing Theory.

BCBS – Basel Committee on Banking Supervision.

BIS – Bank for International Settlements.

BRICS – five major emerging national economies: Brazil, Russia, India, China and South Africa.

CDS – credit default swaps, the most widely used type of credit derivatives.

EU – European Union.

EMU – European Monetary Union (Eurozone).

FED – Federal Reserve System, central banking system in the US.

IMF – International Monetary Fund.

NYSE – New York stock exchange.

OECD – Organization for Economic Development.

OPEC – Organization of Petroleum Exporting Countries.

PCA – Principal Component Analysis.

SPX – Standard and Poors 500 stock market index.

VAR – Vector Autoregression.

VIF – Variance Inflation Factor.

VIX – Chicago Board Options Exchange Volatility Index.

WB – World Bank.

INTRODUCTION

Relevance of the topic. Strengthening relationship between financial markets is one of the outcomes of financial integration. Consequently, it triggers a faster transmission of information as well as problems from some markets to the others and is gaining increasingly more attention from researchers in the field. Some researchers argue that increased integration affects the dynamics of the relationship between financial markets by changing the nature and frequency of economic shocks (e.g. Aruoba et al., 2010). In addition, the phenomenon also causes scientific and practical discussions on whether different financial markets are on the way to a merger into a single market, or each market can still be seen as independent.

Economists proved that the elimination of capital movement barriers significantly increases integration of financial markets (Ciner, 2007). Some scientists hypothesize that global financial integration depends on economic integration of the countries involved (e.g. Bracker and Koch, 1999), while the others argue that it takes substantial amounts of time for policy changes to influence financial integration (e.g. Bekaert, Harvey and Lumsdaine, 2002). Financial integration is also closely related to investment diversification issues. Researchers investigating the influence of the relationship between financial markets on investment diversification effect (e.g. Meric et al., 2012) showed that strengthening stock market dependence reduce the benefits of diversification. Contrarily, others show that financial markets are only partially integrated with feasible benefits from portfolio diversification (e.g. Abad, Chuliá and Gómez-Puig, 2009).

Even though the relationship between financial markets have been widely covered by the research literature, as a follow up of the last financial crisis, researchers started to analyse the common movements of the market pairs and groups of pairs, aiming to draw a map of markets dependant on each other. Consequently, a concept of market comovements has been used more often. In that context, the term of comovements is identified as one type of relationship between financial markets, showing that these markets move together: their returns as well as the volatility patterns are consistent with each other. Applying this new approach and assessing the comovements between the groups of financial markets allows to further search what influences these comovements and fills the gap in scientific literature.

Financial theory holds stocks to be riskier than bonds. Historically, investment portfolios were formed from securities, representing different risk-return characteristics with investments in government bonds chosen by risk averse investors (e.g. mutual funds) as (almost) riskless. Consequently, by choosing government bonds from different countries risk averse investors were able to minimize investment risks and earn lower returns. Traditionally, researchers and practitioners pay more attention to the relationship between stock markets rather than bond markets. Nevertheless, with investment flows being transferred from stock to government bond

markets during financial crises and investors accepting lower returns to reduce investment risks, researchers draw their attention to bond markets. It has been determined that this process is related to general panic in the markets and negative future expectations, and, as it progresses, strengthened dependence between government bond markets is exposed.

The severe global economic impacts of recent financial crises made it more important for investors to understand how country (market) patterns are transmitted to other countries (markets), intensifying the need to determine linkages between government bond markets. It has also received attention from multiple researchers in the field arguing that financial integration and financial crises change government bond market characteristics and strengthen their comovements as well as reduce the diversification effect (Kim, 2006; Abad, Chulia and Gomez-Puig, 2009; Brennan, Kobor and Rustaman, 2011; von Hagen, Schuknecht, and Wolswijk, 2011). Consequently, investors need to determine the strength of government bond market comovements as well as to identify the factors influencing them.

Modern scientific literature draws attention to important issues in financial markets, including the following: how to characterize financial markets in separate regions and how financial integration changes these characteristics; how different financial markets interact and which methods can be used to determine that interaction; how do financial market comovements vary depending on a country's/ a region's macroeconomic/fiscal situation; what structural changes are revealed in financial markets during the crises; how do financial markets of different securities influence each other; what factors influence the financial market comovements; do and, if so, how portfolio selection decisions influence financial integration; etc. Most of these questions and the researches implemented to answer them are discussed in more details hereinafter.

There exist various methods to assess government bond market comovements and the factors influencing them, but the attitudes of researchers in the field are ambiguous. Moreover, comovements have been proven to be unstable, with the variations being most vividly seen during the crises, requiring researchers' attention. Due to the reasons mentioned here, the investigation of government bond market comovements and the factors influencing them is relevant in both theoretical and empirical aspects. This doctoral dissertation focuses on these aspects.

Research problematic and the level of its investigation.

The investigation of the relationship between financial markets has been primarily based on classic financial models, such as the Capital Asset Pricing Model, allowing to determine the dependence between risk and return of financial asset, or the Arbitrage Pricing Theory, enabling to assess the influence of a set of factors on financial asset's returns. Development of the models enabled to empirically calculate and forecast the expected returns of financial assets as well as to use these forecasts in investment portfolio formation. Initially tested in domestic financial

markets, these models were quickly employed in international financial markets, triggering the discussion about different factors that determine the returns internationally.

Relationship between financial markets has been investigated in a number of earlier studies, starting from Longin and Solnik (1995), Karolyi and Stulz (1996), followed by Ehrmann et al. (2005), and Li, Zhang and Willett (2011). Connolly et al. (2005), Kim et al. (2006) argued that understanding the time-varying nature of the relationship between financial markets was crucial for asset allocation and risk management, while Maslov and Roehner (2003) emphasised that the relationship was not completely deterministic.

Researchers used different methods to determine relationship between financial markets: Granger's Causality (Kose, Doganay and Karabacak, 2010; Kalbaska and Gatkowski, 2012; and others), cointegration and VAR models (Clare et al., 1995; Yang, 2005a; Poghosyan, 2012; among others), correlation analysis (Longin and Solnik, 1995; Quinn and Voth, 2008), GARCH models (Ang and Bekaert, 2002; Inoguchi, 2007; Piljak, 2013; among others).

Mantegna (1999), Onnela et al. (2005), Adamic et al. (2017) analysed financial markets and their comovements as structured networks. Onnela et al. (2005), Tumminello et al. (2007) analysed financial networks of stocks, while clusters of financial institutions, were analysed by Amini, Cont and Minca (2011) Battiston et al. (2012). On a similar scale Coudert and Gex (2006), Bunda, Hamann and Lall (2009) used principal component analysis (PCA) to determine the relationship between financial markets and to show clusters forming among them.

A significant part of previous studies assessed the degree of dependence between financial markets, ignoring the channels through which financial markets are connected. Harvey et al. (1994) were some of the firsts arguing that the same factors drive stock and bond returns. Afterwards, researchers discovered that government bond yields and yield spreads might have been influenced not only by quantifiable/economically substantiated factors (Codogno, Favero, and Missale, 2003; Perego and Wermeulen, 2013; among others), but by global tendencies as well (Barrios et al., 2009; Caceres, Guzzo, and Segoviano, 2010; Fang, 2012, and others).

Multiple scientists investigated the risks that bond markets undertook to determine what influenced their comovements (Manganelli and Wolswijk, 2007; Fang, 2012; Paniagua, Sapena and Tamarit, 2015). Researchers excluded credit and liquidity risks (country-specific) and global risk as influencing government bond markets with remaining discussions on the importance of each risk. Gómez-Puig (2009), Favero and Missale (2012) revealed that country-specific risk components in government bond yield spreads became stronger than the global ones after 2008; Manganelli and Wolswijk (2009) related government bond yield spreads with credit and liquidity risks, determined by the global risk, while Codogno, Favero, and Missale (2003), Bernoth et al.

(2006), Niehof (2014) stated that the main factors influencing government bond yields and their spreads were global risk, liquidity, and fiscal factors.

The importance of global factors on financial market returns has been investigated by Forbes and Chinn (2003), Barrios et al. (2009), Manganelli and Wolswijk (2009), Favero et al. (2010), Paniagua, Sapena and Tamarit (2015). Bekaert and Harvey (2000) proved that liberalized markets showed higher degree of comovements with global factors, and Caceres, Guzzo and Segoviano (2010) revealed that increased global risk aversion widenned government bond yield spreads. Even though Bunda, Hamann and Lall (2009), Miyajima, Mohanty and Chan (2012), Piljak (2013) divided factors influencing government bond markets into global and country-specific, they concluded that the latter have stronger influence on government bond returns. In addition, some researchers included certain market characteristics and showed that government debt market returns and yields depend on them (Inoue, 1999; Gómez-Puig, 2009; Attinasi et al., 2009; Bernoth and Erdogan, 2012).

What if fundamentals in two countries do not present strong comovements in between but these countries are strongly connected through trade or financial linkages? For example, most of fundamentals in Germany will probably be different from fundamentals in Lithuania, but a big part of Lithuanian export is orientated to Germany. Should it influence comovements between government bond markets in these countries? Moreover, what if fundamentals in the countries are absolutely different but these countries speak the same language or are close to each other? Do these connections influence comovements between their government bond markets? Some researchers argued that financial market comovements depended on bilateral linkages among the countries (Pretorius, 2002; Didier, Love and Martinez Peria, 2012; Shinagawa, 2014), since they represented economic dependence. Most research on bilateral factors has been focused on stock markets, by employing Multivariate Factor Models (Malhotra et al., 2010; Kalotychou, Remolona and Wu, 2014; among others). Similarly, other authors used multiple regression (Pretorius, 2002; Marcišauskienė and Cibulskienė, 2013) or state-space models (Paniagua, Sapena and Tamarit, 2015) for this assessment.

The financial crisis that started in 2008 as well as its propagation has generated a lot of empirical literature analysing changes in bond yield spreads (Fang, 2012; Manasse and Zavalloni, 2012; and others) or risk spillovers across the markets (Bekaert and Harvey, 2000; Caceres, Guzzo and Segoviano, 2010). Researchers tended to investigate either emerging or developed financial markets, assuming the latter to be more integrated. Most studies concentrated on major financial markets, such as the ones of biggest economies (Sutton, 2000; Ciner, 2007; Boffelli and Urga, 2013) or uniquely the US (Onnela et al., 2005; Weigel and Gemmill, 2006; Tumminello et al., 2007). Other authors showed that emerging markets accepted the shocks originating in developed

ones (Bunda, Hamann and Lall, 2009; Pretorius, 2002). Moreover, multiple papers assessed the EU or the EMU financial market integration and dependence (Christiansen, 2003; Fang, 2012; Paniagua, Sapena and Tamarit, 2015) proving that the introduction of euro was a significant determinant of financial market comovements. Government bond markets in other regions have been analysed far less, but there exist studies, designated for that purpose in Asia (Battern et al., 2004; Meric et al., 2012), South America (Weigel and Gemmill, 2006), Africa (Ebeke and Kyobe, 2015), the Baltics (Paškevičius and Norkaitytė, 2011; Gudonytė and Tvaronavičienė, 2012; Rupeika-Apoga, 2013), BRICS countries (Mensi et al., 2014) or the peripheral EMU countries (Kalbaska and Gatkowski, 2012; Gómez-Puig and Sosvilla-Rivero, 2013). Finally, some researchers assessed the comovements of a wide range of financial markets (e.g. Forbes and Chinn (2003), Didier, Love and Martinez Peria (2012)) but the results obtained were diverse.

Deficiency of researches on government bond market comovements, disagreements on the methods used, analyses of different regions motivate further investigation. Researchers analysing the influence of various factors on these comovements concentrated on different aspects. They assessed the strength and stability of the dependence but only few analysed the common features among groups of government bond markets. It left a gap for the assessment of comovements between government bond markets and identification of the groups of markets, most closely commoving in between. In addition, there is still a lack of complex methodology for the assessment of all types of factors – global and country-specific – influencing government bond market comovements and tests of such a methodology in the global environment.

Research problem – what factors influence government bond market comovements and how to assess this influence in the global environment.

Research object – factors influencing government bond market comovements.

Research aim – after disclosing the characteristics of government bond market comovements, to prepare the methodology for identification and assessment of the factors influencing these comovements and to test this methodology in the global environment.

Research aim is supported by the following objectives:

1. To disclose the characteristics of government bond markets comovements and the methods for their evaluation.
2. To distinguish the methods for assessing the factors influencing government bond market comovements.
3. To identify the factors influencing government bond market comovements.
4. To propose a conceptual model and to prepare a research methodology for the assessment of government bond market comovements and the factors influencing them.

5. To conduct an empirical research and to assess government bond market comovements and the factors influencing them in the global environment.

6. To discuss the results of empirical research and to suggest recommendations for their application.

Research methods. Analysis, synthesis and comparison of scientific literature is used to characterize comovements between government bond markets and to identify the factors influencing them. Assessment of government bond market comovements is implemented by employing correlation analysis and evaluating its statistical significance with Fisher's null hypothesis test. Identification of different levels of government bond market comovements is carried out by Agglomerative Hierarchical Clustering (AHC) and Principal Component Analysis (PCA). Assessment of the factors influencing government bond market comovements in the global environment is implemented with Correlation of the Residuals, Pooled and Multiple Regression Analysis. Descriptive statistical methods (average, standard deviation, dispersion) are also used in this research. Data processing is implemented with *MS Excel* and IBM *SPSS 24* statistical programs. These programs, together with *MS Visio Professional*, are used for graphical imaging as well.

Data and its sources. Research is based on historical data of government bond market indices, global and country-specific factors from 2008 to 2016 (8 years). Data is obtained from *Thomson Reuters DataStream* and *Bloomberg* databases, accessed via computers with special software at *HEC Paris* and *Université Catholique de Louvain*. Valuable information sources were the International Monetary Fund, World Bank, Organization for Economic Development and Bank for International Settlements. Finally, some data is obtained from national statistical offices.

Dissertation volume and structure. Dissertation consists of introduction, three parts, conclusions and recommendations, references and appendices. The volume of the dissertation is 186 pages. It contains 29 figures, 17 tables, 317 references and 14 appendices. Dissertation's logical structure is introduced in Figure 1.

In the first part of this dissertation the characteristics of government bond market comovements are defined and the factors influencing the comovements are identified. In addition, conceptual framework for assessing the factors influencing government bond market comovements is prepared and presented. First, second and third research objectives, supporting the research aim, are achieved. In the end of the first part, the main research findings are generalized.

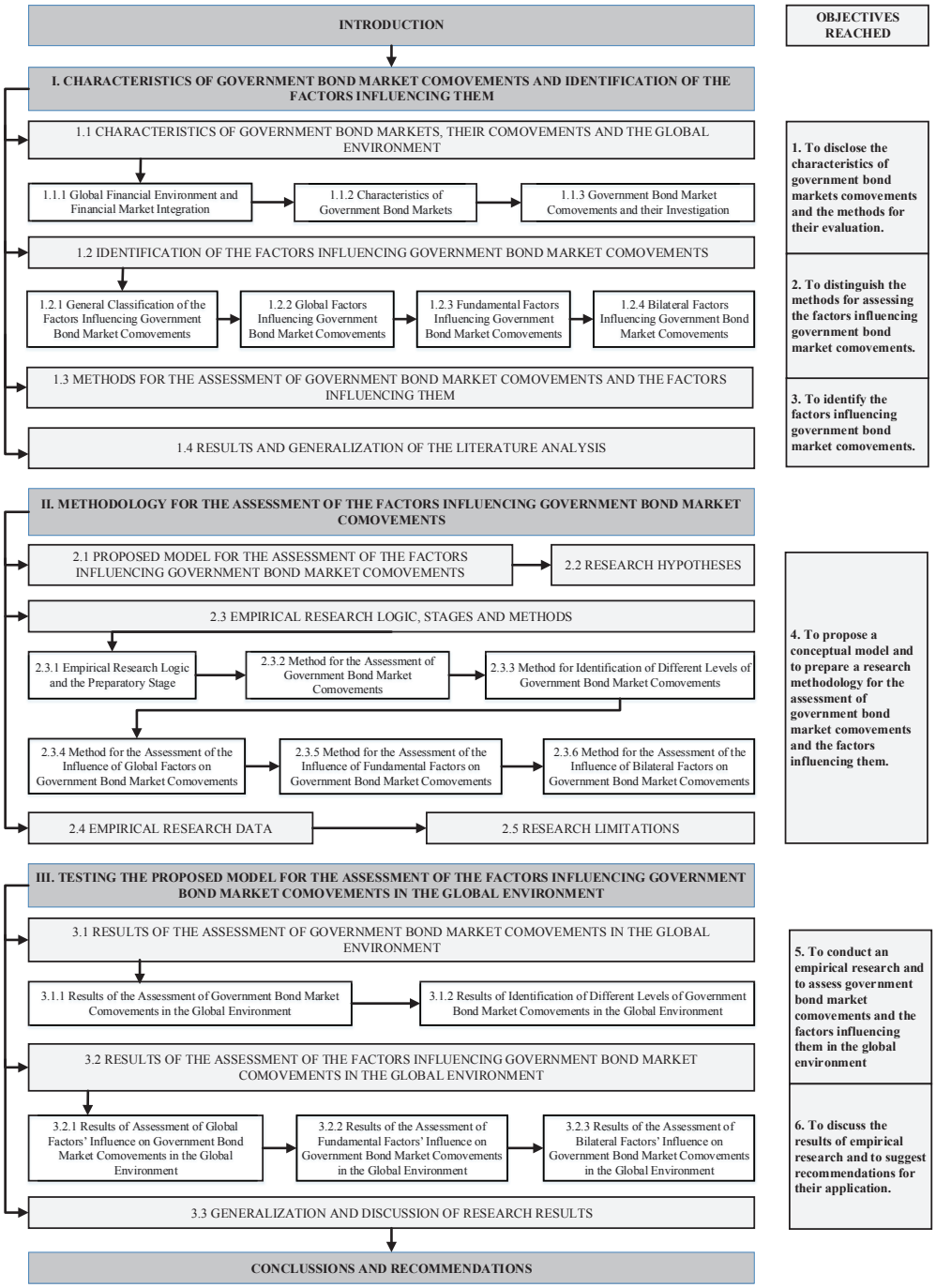

Figure 1 Logical Structure of the Dissertation

In the second part of the dissertation, the methodology for the assessment of the factors influencing government bond market comovements in the global environment is presented. Fourth research objective, raised to support the research aim, is achieved. Presentation of the methodology begins with the introduction of a model for assessing the factors influencing government bond market comovements. This model is supported by five research hypotheses. Further, empirical research logic, stages and methods are presented, followed by empirical research data and research limitations. In the end, the main research findings from the second part are generalized.

In the third part of dissertation, the prepared research methodology is used to empirically assess government bond market comovements and the factors influencing them in the global environment. Fifth and sixth research objectives, raised to support the research aim, are reached in this part. The results of assessing government bond market comovements are presented first, followed by the results of assessing the influence of global, fundamental and bilateral factors on these comovements in the global environment. Finally, the main research findings from the third part are generalized, and the scientific discussion on the results obtained is initiated.

In the end of the dissertation, the conclusions and recommendations are presented, as well as directions for further research.

Research limitations. Not all the possible factors are included in the proposed model. Analysis of government bond market comovements is only one of the potential ways to assess the relationship between government bond markets. Assessment of the factors influencing government bond market comovements in separate clusters is not implemented. 75 analysed government bond markets are assumed to represent global government bond market environment. The empirical research time horizon is 8 years. Regression equations are not constructed for global factors, only for fundamental and bilateral ones. Multiple regressions for all the groups of factors are not carried out at once. Data of fundamental and bilateral factors were not available for some, especially emerging, countries.

Scientific novelty and practical significance of the research results. Several research limitations show that the results of employing the research methodology to assess government bond market comovements and the factors influencing them in the global environment depend on the period and the markets analysed as well as the assumptions undertaken. Nevertheless, it does not diminish the importance of the results in both theoretical and practical levels. On a theoretical level, this research methodology, prepared on the basis of an identified research gap, is one of the first attempts to comprehensively assess not only government bond market comovements but different groups of factors influencing them. On an empirical level, this research covers the majority of global government bond markets, showing the map of different levels of their

comovements, as well as assesses the influence of different groups of factors on these comovements. The novelty of this research is demonstrated by the following features:

1. This research is designed to investigate the theoretical and empirical aspects of government bond market comovements, and not the relationship between them. Consequently, a novel approach is applied, concentrating on the how government bond markets commove and what are the characteristics of these comovements. Analysis of the previous studies shows that the majority of them concentrate on comovements between stock markets, financial institutions and the factors influencing them with a lack of research investigating government bond markets.

2. Assessment of the influence of different factors on government bond market comovements and not the markets themselves is carried out in this research. To the best knowledge of the author, it is one of the first attempts of such research and makes the prepared methodology complex. The idea that government bond markets follow similar patterns as stock markets enabled defining and characterizing different groups of factors influencing their comovements – global, fundamental and bilateral. Nevertheless, strong government bond market comovements in the analysed period would not necessarily mean that the situation in the markets depended on the same external (global) factors – it may be the case that countries' fundamentals have also changed according to similar patterns.

3. A model for the assessment of government bond market comovements and the factors influencing them has been proposed. On the basis of the model, a complex research methodology has been prepared. The aim of this research requires combining different statistical and econometric methods, some of which have been seldom used in financial researches.

4. This research is one of the few that employ hierarchical clustering and principal component analysis to differentiate government bond markets based on their comovements and to exclude government bond market clusters.

5. Pooled and multiple regression analyses have been employed to investigate what influences government bond market comovements with an exhaustive set of global, fundamental and bilateral factors. In order to assess the influence of different groups of factors on government bond market comovements, the differences in fundamental and bilateral factors have been determined for hundreds of country pairs.

6. This research covers 75 government bond markets from different geographic and economic regions. A wide range of government bond markets chosen to test the model enable seeing a general picture of market comovements. Each separate stage of empirical research is structured in a way that allows not only to assess government bond market comovements and the influence of different groups of factors on them but also determines the stability of this influence

during the period of this empirical research. In addition, this research also builds a new big dataset of country-specific (fundamental and bilateral) factors for 75 countries.

7. Results of this research confirmed expectations about government bond market comovements – more than half of the market pairs exhibit significant relatively stable comovements in between, showing how interconnected the global markets truly are. Existence of different levels of government bond market comovements has been confirmed by excluding six government bond market clusters based on their comovements. The excluded market clusters commove independently from the changes in the global environment.

8. Results show that global factors have been less important for government bond market comovements that expected. Consequently, there is still a chance for government bond investment portfolio to hedge against the losses under extreme volatilities in financial markets. Nevertheless, further estimation of the influence of these factors on individual government bond market returns revealed them to be highly dependent on changes in commodity and stock markets. Differences in fundamental factors strongly influence government bond market comovements, indicating that government's ability to borrow still depends on its policy and country's fundamentals. The fact that out of all bilateral factors only foreign direct investment influences government bond market comovements may allow governments to strengthen this financial linkage with the countries they want their government bond markets to be associated with. Research results should benefit the fellow researchers analysing the dependence structure of financial markets in the global environment.

Dissemination of scientific research results. Research results have been disseminated in papers, published in national and international scientific journals, acknowledged by the Research Council of Lithuania, as well as presented in national and international scientific conferences.

Publications:

1. Aleknevičiūtė, E. (2016). Global Factors Influencing Government Bond Market Comovements// Science and Studies of Accounting and Finance: Problems And Perspectives//eISSN 2351-5597, 2016, Vol. 10, No 1: 1-7
2. Levišauskaitė, K., Aleknevičienė, V., and Aleknevičiūtė, E. (2015). Hierarchical Structures of the Relationship between Government Bond Markets in the EU Countries// Transformations in Business and Economics, Vol 14, No. 1 (34). Internet access: http://www.transformations.khf.vu.lt/34
3. Aleknevičiūtė, E. (2014). Recent Tendencies and Determinants Influencing Government Bond Markets in EU Countries: Research Overview// The Papers of the Young Researchers in Economics and Management in Lithuanian Higher Education Institutions, 2014/ 7
4. Levišauskaitė, K., Aleknevičienė, V., and Aleknevičiūtė, E. (2014). Relationship between Government Bond Markets in EU Countries// Theoretical and Applied Economics, International Finance and Banking Conference - FIBA 2014 (XII Edition), ISSN 1844-0029, p. 40-56 Internet access: http://www.ectap.ro/supliment/international-finance-and-banking-conference-fi-ba-2014-xii-edition/20/
5. Levišauskaitė, K., Aleknevičienė, V. and Aleknevičiūtė, E. (2014). Comovements of Financial Markets in EU countries // Engineering Economics 2014 No. 3 (25), p. 261-272. Internet access: http://www.inzeko.ktu.lt/index.php/EE/article/view/5079

Presentations:

1. Aleknevičiūtė, E. (2016). Assessment of the Factors Influencing Government Bond Market Comovements in the Global Environment// Baltic University Programme, 4th PhD Students Training, Rogow, Poland, November 2016.
2. Aleknevičiūtė, E. (2015). The Phenomenon of Negative German Government Bond Yields and their Dependence on Economic Sentiment Indicators// 19th National doctoral and master students' scientific conference "The Processes and the Tendencies of the EU Economics", Vytautas Magnus University, Kaunas, May 2015.
3. Aleknevičiūtė, E. (2014). Hierarchical Structures of the Relationships between Government Bond Markets in EU Countries// 2014 Annual Summer Meeting of Economists in Vilnius, Lithuanian Conference on Economic Research at Vilnius University, Lithuania, July 2014.
4. Aleknevičiūtė, E. (2014). Recent Tendencies and Determinants Influencing Government Bond Markets in the EU Countries: Research Overview// 18th National doctoral and master students' scientific conference "The Processes and the Tendencies of the EU Economics", Vytautas Magnus University, Kaunas, May 2014.
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I. CHARACTERISTICS OF GOVERNMENT BOND MARKET COMOVEMENTS AND IDENTIFICATION OF THE FACTORS INFLUENCING THEM

One of the key aspects of existing global financial environment is interconnection of different markets. It is nearly impossible to investigate financial markets as separate units in the global environment. Some researchers argue that the degree of integration across financial markets in the global environment depends upon the degree of economic integration across the countries involved. Contrarily, others show that an increase in market integration takes a substantial amount of time after official policy changes, with different financial series implying different transition speeds. Either way, financial integration is one of the key characteristics of global financial environment, a part of which are government bond markets.

1.1. Characteristics of Government Bond Markets, their Comovements and the Global Environment

Financial markets are highly competitive, rarely allowing to precisely predict investors' returns. Nevertheless, it is not surprising that the returns promised in different markets vary significantly, with the variations related to the actual or presumptive risks that financial markets or assets are bearing. Some researchers argue that due to elimination of barriers in capital movements, transmission of information in global financial markets has increased significantly. A wider range of investment choices benefit the investors, creating no need to limit themselves to specific markets and leading to increased importance of globalization. Strengthened integration could affect the dynamics of financial market comovements by changing the nature and frequency of shocks in the economy. As financial linkages strengthen, increasing the correlations between shocks associated with nation-specific fiscal and monetary policies, there appears a need for stronger policy coordination.

1.1.1. Financial Integration and the Global Environment

The neoclassical model has been exhaustively used to measure the benefits from international financial integration, development and convergence (see, for example, Hall and Jones (1999); Gourinchas and Jeanne (2003)). This model is suitable to assess the integration benefits from the efficiency of financial asset allocation, but does not capture the benefits obtained through the integration of more indirect channels. As Prasad et al. (2003) noticed, in the neoclassical framework, international financial integration accelerates the growth and convergence of capital-scarce countries by allowing foreign capital flows into them. Therefore,

the extent to which countries benefit from international integration depends on how much capital they need.

There would be no incentives to analyse government bond market comovements if these markets were not integrated. In that case, investors would see the markets as independent and would not consider investments in them as substitutes. To clarify, if there existed strong barriers to and costs of investing abroad, and investors strictly preferred domestic investments, financial market comovements wouldn't be their interest – they would only choose domestic investments. Consequently, to be compared on the same scale, markets should be at least partially integrated.

On the other hand, the concept of fully integrated financial markets is not that feasible as well. As Guiso et al. (2004) noticed, full market integration would be a situation where availability of funds for any user located within the geographical boundaries of the region would possibly be constrained only by the overall supply of funds within the region, but not by the size of the (national or regional) financial market. As a consequence, in a fully financially integrated region, the only measure of financial development that matters would be the one of the most developed area. If this condition existed, investment in government bond markets situated in the other side of the world would be no less attractive than investment in the domestic market.

Even from the first look, this seems to be unrealistic, and markets situated closer to domestic are still somehow assumed to be more attractive than the distant markets, both politically and cost-efficiently (this assumption might not hold when analysing the strongest economies situated further from the domestic market). In addition, as argued by Ekholm (2013), with fully integrated capital markets, capital-rich high-income countries would tend to have a current account surplus and low-income countries with a shortage of capital would always have a current account deficit. According to Mendoza, Quadrini and Rios-Rull (2007), financial heterogeneity affects international portfolio composition: countries with deeper financial markets borrow heavily abroad and invest in high-return foreign risky assets. Consequently, the market integration is expected to be somewhere in between full segmentation and full integration.

According to Prasad et al. (2003), it's important to differentiate financial integration from financial globalization. The authors treat financial globalization as an aggregate concept, referring to increasing global linkages through cross-border financial flows. Financial integration, meanwhile, is identified as an individual country's linkages to international capital markets. Nevertheless, increasing financial globalization is inevitably related to increasing financial integration, and can even be used as interchangeable (Prasad et al., 2003).

The concept of market integration has widely been discussed in academic literature. Ayuso and Blanco (1999) defined market integration as removal of any barriers to cross-border financial transactions, while Fratzscher (2012) stressed the ambiguity in defining financial integration. In

money markets, it is generally defined by holding the law of one price, implying both the absence of barriers for capital flows and the need for investors to undertake capital transactions to eliminate arbitrage opportunities. In stock markets, the elimination of formal barriers, such as capital controls and transaction costs, is not sufficient to induce cross-border capital flows. Consequently, Fratzscher (2012) argued that stronger market integration is observed when the domestic returns are stronger related with world market shocks. This definition is stricter because it covers the openness of financial markets and directly measures the extent of shock transmission across markets, requiring market openness, absence of barriers to capital flows, and the capital to actually flow across markets to take advantage of market opportunities (Fratzscher, 2012).

Yu et al. (2007) notice that deeper and more integrated bond market facilitates risk management, enhances risk profiles and provides efficiency gains. The lack of progress in bond market integration might be caused by different country-specific factors, related to credit or liquidity in some economies, as well as under-development of multiple local bond markets in the region. Jung et al. (2004) states that theoretically, financial integration provides better chances for reducing macroeconomic volatilities. Since countries with less diversified risks experience higher volatility than more advanced countries, the benefits are presumably larger to the former ones.

Fratzscher (2012) argued that identification of financial integration level has important implications both for portfolio allocation and policy-making decisions. The latter are expected to face the global integration challenges and to form policy responses for more integrated and interdependent global financial markets. Even back in 2003 Prasad et al. (2003) showed that the volume of cross-border capital flows has substantially increased with not only a much greater volume of flows among developed economies but from developed to developing as well. Mendoza, Quadrini and Rios-Rull (2007) argued that there would be no imbalances without the risk, even if financial markets were heterogeneous. Consequently, financial integration could lead to large and persistent global imbalances when countries differ in the degree of domestic financial development.

Intuitively, integration of global financial markets is expected to reduce the divergence of domestic and foreign interest rates, and increase the strength of the market comovements, restricting the central banks' ability to influence national interest rates. Despite the high degree of international capital mobility, the biggest central banks can still influence their domestic interest rates abroad.

Mendoza, Quadrini and Rios-Rull (2007) stated that development of domestic financial markets is the source of cross-country heterogeneity. Moreover, financial integration between the countries with heterogeneous domestic financial markets explains large external imbalances in the global environment. Contrarily, Ayuso and Blanco (1999) argued that the main driving force

behind the strengthening relationship between financial markets could be the globalisation of news that affects financial prices instead of a higher degree of market integration. Fratzscher (2012) showed that even if high degree of integration made the EMU financial markets more attractive to investors, it also created less opportunities to diversify portfolios within the area. For policy-makers, the process of European financial integration increased competition, market efficiency and, simultaneously, has made individual EMU markets increasingly interdependent.

According to Ayuso and Blanco (1999), due to the elimination of obstacles for free trade, greater financial integration means higher efficiency and improvement of risk-return combinations available to investors. On the other hand, it reduces the ability of domestic policies to deal with problems arising in global financial markets. It can even be argued that the closer we are to a single world market, the greater is the need for world-wide supervision.

The benefits of financial integration are commonly assessed per country regression analysis. For example, Bekaert, Harvey, and Lumsdale (2002), Henry (2003) found large gains to the country from opening its stock market to foreign investors. The main benefit of international financial integration is the higher economic growth. Prasad et al. (2003) identify the main channels through which international financial integration benefits the country, especially through supporting its economic growth. These channels can be seen in Figure 2.

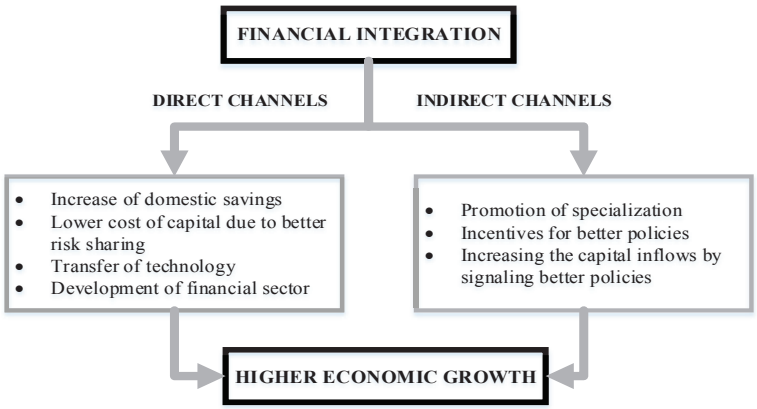


Figure 2 Channels through which Financial Integration Induces Economic Growth
Source: compiled by the author, based on Prasad et al. (2003).

As Prasad et al. (2003) noticed, the direct channels through which international financial integration induce higher economic growth include the increase in domestic savings, reduction in cost of capital because the risk is allocated better, transfer of technologies, and the development of financial sector. On the other hand, the indirect channels include promotion of specialization,

incentives for better macroeconomic and other policies, increasing the capital inflows by signalling better policies. However, as the authors notice, it is difficult to empirically identify strong and robust causal relationship between stronger financial integration and higher growth rates. Consequently, financial integration is not a necessary nor a sufficient condition to promote a high and fast economic growth in the country.

According to Barr and Priestley (2004), it is reasonable to expect bond markets to be more integrated than stock markets because bonds in general are of similar natures, compared to stocks that can be so different. Stultz (1999) argued that the economic costs and benefits of bond market integration are significant because the ability and willingness of investors to diversify internationally should lead to reduction of fiscal deficit funding costs worldwide.

The risk of a portfolio depends not only on the risk of the securities composing it, but on the linkages between securities as well (Esch et al., 2005; d'Addona and Kind, 2006). It has been proven by various authors that international portfolio diversification is a good investment strategy (Solnik, 2000; Reilly and Brown, 2011; Kim, Moshirian and Wu, 2006) that has become the head stone in modern finance. The main arguments for international diversification are that foreign investments offer additional profit potentials while reducing the total portfolio risk, and helping to improve the risk-adjusted domestic portfolio performance (Cappiello et al., 2008). Solnik (2000) added that domestic securities tend to move together due to the same domestic conditions, creating strong positive correlation between national securities. According to Kambadza, and Chinzara (2012), successful international portfolio diversification requires weak or negative financial market comovements so that a poor performance in national market would be hedged by international market.

On the contrary, the criticism of international diversification includes the fact that international securities are riskier than domestic ones. Various authors also agreed that the extent to which gains of international diversification offset higher risks have implications for market efficiency (Gulko, 2002; Ilmanen, 2003; Connolly et al., 2005; Baele et al., 2009). Contrarily, Solnik (2000) argued that in fully efficient, integrated international capital market buying the world market portfolio is a natural strategy. With globalization and free flow of capital, developed markets became highly integrated into global market and correlations across financial assets based in different countries have increased (Brennan, Kobor and Rustaman, 2011). According to Gallali and Kilani (2010), these correlations determine international diversification strategy.

Finally, Maslov and Roehner (2003) emphasized the lack of completely deterministic relationship between financial markets: it is virtually impossible to control for all the variables that influence the market comovements. Understanding the nature of the time variation of these

comovements has also very important implications for asset allocation and risk management (Connolly et al., 2005; Kim et al., 2006).

Generalizing the arguments on financial integration, it can be stated that the integration is still an ongoing process that involves different countries and different paces. Even though financial integration is difficult to measure, it directly and indirectly influences the growth of the economies. There exist no incentives to analyse the financial market comovements if the markets are not at least partially integrated, since otherwise every financial market would by default be independent of the other financial markets, and could not be considered as competing one. On the other hand, the existence of full market integration has not yet been proven, since it would mean that there are no transaction costs and no barriers for entering the markets. In this case, the investigation of financial market comovements would not be relevant as well, with all the markets only depending on global tendencies. Since neither of the extremes have been proven yet, there exists an incentive to investigate government bond markets and their comovements. The characteristics of government bond markets are discussed in the following section.

1.1.2. Characteristics of Government Bond Markets

It should be noted that government bonds are the instrument for governments to finance their short- and long-term debt. The country's monetary policy is in a sense inseparable from its public debt management since both involve sales of official debt to private sector in different forms. The importance of government debt and its management has been investigated by multiple researchers. Clare and Lekkos (2000), Fawley and Neely (2013) and other authors found that in government bond markets, monetary policy actions affect the term structure of interest rates: covariance between government bond yields in different countries reduces the authorities' ability to influence the term structure of interest rates, motivating investors to choose different countries to invest due to several reasons.

According to Brennan, Kobor and Rustaman (2011), the first and most classic reason would be to achieve portfolio volatility reduction. If there exist lags between economic and business cycles in different countries, they lead to less-than-perfect correlations between market indices. Beyond volatility reduction, investing in multiple countries could also be driven by the return enhancement: investor may find an attractive credit spread from a country with lower credit quality within the same currency zone, or he may expect positive return from relative yield curve differences across the countries. Contrarily, Ciner (2007) found cointegration evidence between major bond markets and concluded that benefits of international bond diversification may not be as significant as suggested in prior studies.

There exists an important distinction between corporate and government bonds. The latter ones, backed by the full faith and credit of governments, used to lead market participants to view them as having no credit risk (Fabozzi, 2000). The issuer of the government bond is considered to be the central government and government bond is a debt security issued by central government to support its spending. The author emphasizes that further in this thesis, central government debt securities are referred to as government bonds. Government bonds can reduce the risk of excessive reliance on central bank funding and improve government's transparency and credibility. Herzog and Müller (2014) stated that government debt emission should adjust to public preferences for different maturities. The ability to investigate the patterns of government bond market comovements at different time horizons provides rich information to both policymakers and investors with different investment horizons. According to Yang (2005a), for national policymakers, an independent monetary policy with respect to long-term interest rates is possible only in the long-term, while in the short-term the effectiveness of country's monetary policy is influenced by other countries' policies. Moreover, investors with long investment horizons and passive portfolio management strategies should consider government bond market comovements in portfolio diversification.

Blommestein and Turner (2012) highlighted the importance of long-term government bond interest rate for a country's financial stability. According to them, interest rate structure creates incentives for maturity exposure. The mismatch appears because investors want their assets to be liquid while productive investment is usually longer-term and not liquid. Similarly, Tirole (2008) argues that during macroeconomic shocks, government bonds are an external risk-free store of long-term value needed for financial stability, since risk-free securities are liquid in the macroeconomic sense.

A well-developed government bond market is the basis for developing common bond market and other financial markets. Researches, analysing developed government bond markets, reveal the essential components of them being: regular, systematic emissions; effective system for primary dealers; effective means for risk insurance and liquidity increase. Braun and Briones (2006) added: big market segments, relatively stable proportion between private and public participants and increasing importance of financial institutions. According to Glaessner and Ladekarl (2001), well-developed government bond markets are characterized by a competitive market structure, low transaction costs, small fragmentation, stable market infrastructure and high heterogeneity between the market participants. Having a regular, systemic program for the emission allows market participants to plan their investment and trading strategies. Regular different term-structure government bond emissions allow forming the country's yield curve and use it to price private emissions. Finally, regular emissions form constant market supply and

increase its liquidity. According to Amyx (2000) and Hirose et al. (2004), even the governments that created large net asset positions continue to issue bonds to develop well-functioning government bond market with reliable benchmarks and effective risk management.

Development of domestic government bond market is beneficial for the country on either specific grounds (fulfilment of specific borrowing needs), or general grounds (improvement of financial markets' functioning) (Turner, 2011). *In microeconomic level,* development of government bond market increases financial stability and improves financial intermediation through increased competition (Turner, 2011). Moreover, it allows to create extensive informational, legal and institutional infrastructure (Glaessner and Ladekarl, 2001).

In macroeconomic level, government bonds are used to finance a country's budget deficit and help avoiding government debt accumulation. According to Turner (2011), in this way, government bond markets are used to finance budget deficits in non-inflationary way, increasing monetary policy effectiveness. Without well-developed government bond market, central bank could only dispose short-term securities in market operations, raising the interest rates. Moreover, existence of domestic government bond market and efficient debt management, allows governments to reduce interest rate, exchange rate and other financial risks. Finally, changing to market-oriented government budget deficit funding reduces debt servicing costs in medium-long term (Glaessner and Ladekarl, 2001).

Caceres, Guzzo and Segoviano (2010) indicated that movements in government bond yields can have significant macroeconomic consequences: rising government bond yields tend to move with an increase in long-term interest rates, affecting both investment and consumption decisions. Moreover, on the fiscal side, it increases debt-servicing costs and costs of funding, consequently creating difficulties to refinance the old debt.

Government bond market structure has a decisive impact on other bond market segments, such as corporate bonds (Reserve Bank of Australia, 2003). Existence of government bond yield curve is necessary to efficiently price non-government instruments. In addition, the central government's financing needs determine the scope of emission for corporate bonds, especially in smaller markets where government competes with private entities for limited long-term funding.

Existing differences between government bond markets induce the need to assess their comovements. For example, as Loh (2013) noticed, after the Asian crisis the governments developed their local currency bond markets as an alternative source of funding for the region, not relying only on short-term foreign financing. Moreover, a developed local-currency bond market reduces the crisis effect, since local bond markets can act as the source of funds when the other sources are unavailable. However, strong comovements between financial markets would reduce the benefits of this strategy.

Herzog and Müller (2014) highlighted the importance of institutional issues, leading to differences between the EMU markets. Since the EMU countries have fiscal authority without monetary authority, they are unable to assure the payment for bondholders in all cases and have less incentives to maintain sustainable finance despite the existence of no-bail-out clause. Consequently, there is a disconnection between bond market fundamentals and bond yields. De Grauwe (2012) noticed that the EMU governments have also no direct control on their own currency, enhancing their vulnerability, so they can be similar to developing countries.

It should be noted that for the last few years, the term *government debt* was interchangeably used with sovereign debt in academic literature. Nelson (2013) suggested that government debt, public debt, and sovereign debt should be used interchangeably. Contrarily, other authors argued that even though sovereign debt is the value of bonds issued by the country's government, big difference between government and sovereign debt is that the first one is issued in domestic currency, while the latter – in foreign currency. Addis (2011) argued that sovereign or public debt describes the money owed not by a nation but by a nation's government. Pasquali (2015) also added that public debt, government debt and national debt are interchangeable concepts to describe the amount of money owed by the government to creditors within the country (domestic, internal debt) as well as to international creditors (foreign, external debt).

The author of this dissertation argues that sovereign bond market should not be interpreted as a perfect substitution for government bond market since sovereign bond is considered to be a debt security issued by a national government within a given country and denominated in a foreign currency. Furthermore, the government of a country with unstable economy will tend to denominate its bonds in the currency of a country with a stable economy. Since this research is intended to be implemented in various government bond markets, not all of them being parts of volatile economies, the concept of government bond market is used in this research. The exception is made when talking about debt crisis in Europe, unanimously identified as sovereign debt crisis.

As it has already been noted, governments can finance themselves both domestically and internationally, with government bonds denominated in both domestic and foreign currencies, usually depending on the investors targeted. International government bond issues became possible when governments started searching for financing sources to reduce their external vulnerability, especially after biggest crises (Tovar, 2005; Eichengreen et al., 2003), as well as Paniagua, Sapena and Tamarit (2015), argued that government default in a developed country should be less likely due to the difference between advanced and emerging economy's government debt structure: emerging government bond markets are rarely able to issue debt in their domestic currency, and, as a result, are more likely to default.

According to Benzie (1992), international government bond market is the market for bonds, issued in foreign currency and traded outside the national market. Even though emission of international bonds is promoted by the governments, it is also influenced by regulatory restrictions with central banks limiting the emissions of international bonds, denominated in local currency. If new governments join the global bond market, their bonds usually have shorter maturity when compared to the old-timers. According to the IMF (2003), this results from markets prioritizing shorter maturities due to insufficient knowledge about the issuer. In addition, governments expect their costs of borrowing to decrease before refinancing due to improved economic situation or after extending the country's credit history. Some of the main advantages of international bonds are shown in Figure 3.

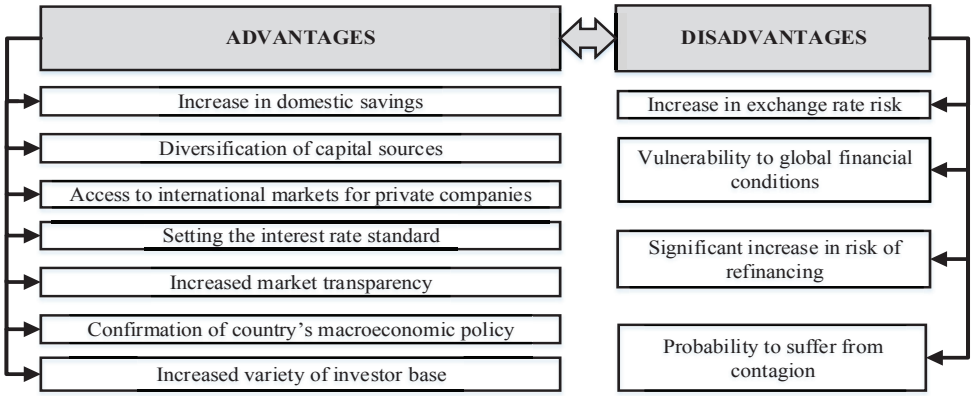


Figure 3 Advantages and Disadvantages of International Bond Emissions

Source: compiled by the author, based on Das, Papaioannou and Polan (2008)

The advantages of international bond emissions outnumber the disadvantages. Das, Papaioannou and Polan (2008) excluded the increase in domestic savings as the main advantage of international emissions since emissions under sustainable debt management can significantly increase country's access to financial resources and its potential for sustainable growth. Governments, by funding in international markets, also diversify their capital sources and reduce their dependence on bank financing. External emission of government bonds also improves the risk profile of country's debt portfolio and provides the access to international capital markets for private companies. By issuing bonds in a foreign currency, government sets the interest rate standard for corporate bonds to be priced. An important, but more difficult to measure, benefit from international bond emission is an increase in transparency and intensified market monitoring – government bond emission prospect requires the disclosure of substantial data, thus enabling

investors to identify a country's financial situation and to assess its default probability. Furthermore, the emission of international bonds allows to confirm a country's macroeconomic policy and increases investor base variety (Das, Papaioannou and Polan, 2008).

Four main disadvantages of international bond emissions were also identified by Das, Papaioannou and Polan (2008). The authors firstly associate these disadvantages with an increase in exchange rate risk, since external debt emission can worsen the proportion between a country's income and liabilities, and increase currency depreciation risk and debt servicing costs. In addition, government becomes more vulnerable to unexpected changes in international global conditions. Negative or imprecise perception of the issuer can evolve from lack of timely information or instability fear, originating from unfavourable interpretation of economic and political changes. It can also harm a country's assurance of stable access to international financial markets and significantly increase the risk of refinancing. Finally, the issuer might suffer from contagion and panic in financial markets, even if the panic is not related to the country's macroeconomic situation (Das, Papaioannou and Polan, 2008).

Summing up the characteristics of government bond markets, discussed above, it can be stated that these markets differ from the stock markets, mainly because they are not only the place for the distribution of financial funds, but an instrument for government policy implementation as well. As some authors notice, for national policymakers, an independent monetary policy is only possible in the long-run, while in the short term its effectiveness is influenced by the other countries' policies. A well-developed government bond market is the basis for the development of common bond market, identified by the regular issues, variety of investor base, low transaction costs, competitive market structure and other features. These markets also participate in an international financial environment, enabling governments to borrow abroad but being the subject of contagions and exposed to changes of international financial conditions as well. In this dissertation, international bonds are investigated, which justifies the necessity to determine their comovements. This phenomenon and the methods to assess it are further discussed.

1.1.3. Government Bond Market Comovements and their Investigation

Relationship between financial markets is a common research topic, gaining increasingly more attention (Georgoutsos ir Migiakis, 2013). The studies of the relationship between financial markets are important in both theoretical and empirical aspects, with the literature surveyed by various authors, including, but not limited to Ehrmann et al. (2005), Li, Zhang and Willett (2011) among others. Prior to discussing these studies in more details, the types of relationship between the markets need to be identified. Some of the most commonly analysed types of relationship are presented in Table 1.

Table 1 Types of the Relationship between Financial Markets

Type of relationship	Definition	Authors
Comovements	Fixed effect of one market on another, without excluding the direction of the impact.	Wang, Elston and Zhu (2010)
	A pattern of positive correlations.	Barberis et al. (2002)
	Something close to a notion of correlation.	Croux, Fourni and Reichlin (2001)
	Common movement of returns that is shared by all returns at time *t*.	Baur and Lucey (2006)
(Inter)dependence	A state of being determined or significantly affected by external forces. Interdependence is mutual dependence.	Keohane and Nye (1977)
	A situation where all the actors are dependent upon one another.	Rana (2015)
	Continued high level of market correlation suggesting strong linkages between two economies existing in all states.	Forbes and Rigobon (2002)
Market interaction	How the effect on the response of one explanatory variable depends on the level of one or more other explanatory variables.	Fitzmaurice (2000)
	Relationship between different markets as well as inside each singular market, at national and international levels.	Nicolau (2010)
Correlation	Natural dependence measure for multivariate normally distributed variables.	Embrechts, McNeil and Straumann (1999)
	Statistical method used to assess a possible linear association between two continuous variables.	Mukaka (2012)
Contagion	A situation when cross-market comovements significantly increase after the shock.	Forbes and Rigobon (2002)
	Occurrence of excess comovements between normally uncorrelated assets that cannot be explained by economic fundamentals.	Brannstrom (2005)
	Significant increase in time-varying comovements in stock markets.	Mobarek, Muradoglu and Mollah (2014)

It can be seen from Table 1 that the concepts tend to intertwine with each other. Since financial markets are commonly assumed to be dependent on each other, Keohane and Nye (1977) described dependence as the state of being determined or significantly affected by external forces, and interdependence as a mutual dependenceOne of the most classical definitions of dependence is introduced by Forbes and Rigobon (2002), who defined it as continued high level of market correlation suggesting strong linkages between two economies in all states. Finally, Rana (2015) simplified the description by identifying dependence as a situation where all the actors are dependent upon one another. Market interaction is assumed to be a more complex term than the dependence of markets. Nicolau (2010) described market interaction as the relationship between different markets (commodities-stocks-bonds-currency) as well as those existing inside of each singular market, at national and international level, while Fitzmaurice (2000) showed a more

quantifiable aspect of it. According to him, the term "interaction" has a precise statistical meaning and refers to how the effect on the response of one explanatory variable depends on the level of one or more other explanatory variables. Consequently, interaction arises when the effect of one explanatory variable depends on the particular level or value of another explanatory variable.

It should be noted that most of the terms described can somehow be connected to correlation between the markets, so it is only fair that the concept of it is described as well. Mukaka (2012) described correlation as a statistical method to assess possible linear association between two continuous variables, while Embrechts, McNeil and Straumann (1999) defined it as a natural dependence measure for multivariate normally distributed variables.

Definition of market comovements is not unilateral as well. Some researchers consider the phenomenon to be the influence of one market on another, or a mutual dependence between two markets (adapted by the author, based on Forbes and Rigobon (2001)). Another definition, introduced by Barberis et al. (2002), describes the comovements between financial markets as a pattern of positive market correlations, and Croux, Fourni and Reichlin (2001) based their description on correlations as well. Baur (2009) argued that, unfortunately, (positive) correlation can describe many types of relationship, not only a particular class of relationship, that is, linear comovements. Finally, Wang, Elston and Zhu (2010) stated that the comovements between financial markets is a fixed effect of one market on another, without excluding the direction of the impact. Comovements between financial markets are assumed to be: 1) more stable dependence between the markets; 2) explainable by certain economic fundamentals.

In the situations when comovements significantly increase, the notion of contagion can be identified (Mobarek, Muradoglu and Mollah, 2014). Forbes and Rigobon (2002) described contagion as a situation when cross-market comovements significantly increase after the shock. Similarly, Brannstrom (2005) defined it as an occurrence of excess comovements between normally uncorrelated assets that cannot be explained by economic fundamentals.

Nevertheless, given the aim of this research and as a result of the analysis and synthesis of scientific literature, in this doctoral dissertation government bond market comovements are identified as a mutual dependence between two government bond markets.

Even though market capitalisation of international bond markets is much larger than the one of stock markets, comovements between international bond markets are far less investigated compared to a large body of literature on stock markets (Abad, Chuliá and Gómez-Puig, 2009). Ciner (2007) and other authors also agreed that while there exist numerous studies analysing the relationship between international financial markets, most of them concentrate on stock markets and only very few empirical works examine comovements between international bond markets. Charoenwongse and Piesse (2006) highlighted that the assessment of the relationship between

bond markets is significant to the development of economic and financial systems: bond markets are the instruments for facilitating the monetary policies as well as the suppliers of information for macroeconomic analysis and pricing strategies in financial markets.

Government bond market comovements are commonly assessed by concentrating on market integration. For example, Barr and Priestley (2004) evaluated international bond market integration by investigating the extent to which bond returns are determined by world risk factors rather than by domestic risk factors, while others have found significant variations in international bond market return comovements. Assessing comovements is important for policy-makers, since they need to be assured that their bond markets are not equally vulnerable to spillovers from the other bond markets, and they can calculate and predict with which countries their bond markets are more interdependent. The proportion of bond market interdependence that is due to *contagion* has been proved to be smaller than is widely perceived. Furthermore, empirical findings are inconclusive and represent a number of different perspectives. Ciner (2007) highlighted two main reasons to investigate bond markets:

- Bond markets represent a huge segment of international asset markets. Understanding comovements between them is important in when designing portfolio diversification strategies. With strong bond market comovements, the benefits of diversification can be lost in the long run.
- Government bonds can be indicators of monetary policy actions: when shocks are transmitted to markets, the conduct of monetary policy will be sensitive to international developments not less than to domestic concerns.

Investigation of bond markets mainly started with Reilly, Kao and Wright in 1992 and became more popular later on. The authors were some of the firsts to discover that government bond market indices had the lowest average returns compared to all the other US indices – their correlation was 90%-99% and only valid in the long run. In later research, Yang (2005b) found no long-term relationship among major bond markets and claims that global government bond markets were partially segmented in short-term with no leadership role. Moreover, independent long-term monetary policy with respect to long-term interest rates is possible while in short-term the effectiveness of country's monetary policy is affected by policies of other countries. Yang (2005b) argued that in substantially deregulated international financial markets with large capital flows across the countries bond yields would be expected to move together to a certain extent, depending on the seriousness of remaining barriers to enter the market. Moreover, the market-driven bond yield comovements would be overshadowed by monetary policy independence sought by national authorities, making the extent of international bond market linkages a matter of empirical testing.

Brennan, Kobor and Rustaman (2011) argued that government bond market comovements could appear through different channels, such as: (1) holding internationally diversified portfolios; (2) if real rates are determined by global factors; (3) if there is a flight-to-quality in times of financial stress (Clare and Lekkos, 2000), while other authors exclude different tendencies. The results of some studies, implemented in government bond markets, are presented in Table 2.

Table 2 Previous Research Implemented in Government Bond Markets

Author	Countries, Period	Data	Findings
Reilly, Kao and Wright (1992)	The US; 1976-1990	Corporate and government bond indices.	Government bond indices were the least profitable in a long-run
Clare and Lekkos (2000)	The US, the UK and Germany; 1990-1999	1 year and 10-year US, German and UK interest rates	At times of global financial stress the slopes of yield curves react mainly to international factors
Sutton (2000)	The US, Japan, Germany, the UK and Canada; 1960-1992	10-year government bond yields	Bond yields represent excess comovements and a positive correlation between the markets
Christiansen (2003)	The EMU countries, Denmark, Sweden, the UK and the US; 1988-2002	J. P. Morgan Total return government bond market indices	Euro is an important factor for volatility spillovers. It accounts for substantial differences between the nature of the volatility in the EMU and other bond markets
Battern et al. (2004)	The US, Malaysia, China, Philippines, South Korea, Thailand; 1999-2002	Credit spreads, interest rates and stock market index	Credit spreads of Asian sovereign bonds are negatively related to the changes in the US interest rates.
Mehl (2006)	14 emerging countries; 1995-2005	CPI, IPI and the yield curve slope from BIS, Bloomberg and global financial data	Changes in the US government bond yield curve are used to understand the ongoing process of international financial integration. It has a higher influence on the EMU‘s economies than their domestic yield curves.
Ciner (2007)	The US, Japan, Germany, UK; 1988-2005	JP Morgan government bond indices.	Significant direct and indirect lead-lag comovements between the markets.
Manganelli and Wolswijk (2007)	The EMU countries; 1999-2006	Monthly 10-year government bond yield spreads	There is a dependence between government bond yield spreads, short term interest rates and credit ratings. The factor of government bond yield spreads is short-term interest rates.
Abad, Chuliá and Gómez-Puig (2009)	The EMU except Luxembourg and Greece; 1999-2008	DataStream 10-year government bond benchmark yields	Integration of the EMU government bond markets is incomplete. The EMU and the US markets are also not highly integrated.
Caceres, Guzzo and Segoviano (2010)	The EMU countries; 2007-2010	The EMU 10-year government bond yields and euro swaps	Global risk aversion widens government bond yield spreads, while contagion has a negative effect on government bonds. Fundamentals are also important.
Brennan, Kobor and Rustaman (2011)	G7 countries; 1999-2010	Bank of America/ Merrill Lynch/ MSCI government bond indices	Strong connections between different government bond markets, represented by the comovements of the indices.
Boffelli and Urga (2013)	Belgium, France, Italy, Netherlands, Spain and Germany 2007-2012	10-year benchmark government bond spreads, ultra-high frequency data	Strong links between volatility spreads and worsening fundamentals. Strengthening correlation between the spreads during the sovereign debt crisis not explained by macroeconomic factors.

Battern et al. (2004) analysed government bond yield spreads between benchmark US Treasury bonds and government bonds, issued in South-East Asian markets. He showed that credit spreads of Asian sovereign bonds were negatively related to changes in the US interest rates, and that asset and exchange rate variables were not equally important for separate countries.

Christiansen (2003) studied comovements between international bond markets by excluding domestic and international effects. The author investigates volatility spillover effects from the US and aggregate European bond markets to individual European markets. For the EMU countries and Denmark, bond market volatility was best explained by European (regional) and country (local) effects, while for non-EMU countries local and global effects were more significant, and regional volatilities had smaller effect. Consequently, the results show that common currency is an important factor, determining whether European and the US volatility spillovers strengthen or weaken. Similarly, Sutton (2000) investigated historical trends of 10-year government bond yields in biggest economies and shows bond yields in these markets have excess volatility and comovements relatively to the base model.

Ciner (2007) found evidence of cointegration between major government bond markets and concluded that benefits from international diversification in these markets are not as significant as suggested in prior studies.

It is also proved that the US government bond market is more influential in the information transmission process than the other markets.The same tendency is noticed when comparing the EMU markets with the US. Furthermore, the EMU countries are only partially integrated with German bond market, suggesting the benefits from portfolio diversification to be possible within the Union.

Similarly, the results of Caceres, Guzzo and Segoviano (2010) revealed that global risk aversion is a positive factor for the EMU government bonds – increased risk aversion widens government bond yield spreads. Even though existence of flight-to-quality moves capital from riskier assets to government bonds, a tendency has not been confirmed for high-debt, A-rated issuers – they do not benefit from a flight-to-quality effect. As a consequence, the spreads between AAA-rated and lower-rated markets become wider. Another result obtained by Caceres, Guzzo and Segoviano (2010), was that contagion is always negative for government bonds.

Fang (2012) also showed that government bond yield spreads in the EU have significantly increased from September 2008 and that variations in these spreads are more sensitive to factor changes during the sovereign debt crisis. Gomez-Puig, Sosvilla-Rivero and Ramos-Herrera (2014) determined that the marginal effects of sovereign spreads' drivers increase in the crisis period. Also, as D'Agostino and Ehrmann (2013) noticed, changes in risk aversion have influenced the under-pricing of risk before the crisis, and over-pricing of risk during the crisis.

Finally, Conefrey and Cronin (2013) concluded that while Greece had a strong influence on euro area bond markets around the time of its first bailout, this influence had diminished by the time of its second bailout, making it relatively detached from the other markets.

Manganelli and Wolswijk (2007) showed mutual connection between market discipline and fiscal rules in government bond markets. Negative evaluation from financial markets is reflected in higher interest rates, that might increase the country‘s budget deficit. Simultaneously, fiscal rules improve awareness and increase transparency of fiscal accounts. Researchers also prove that government bond yield spreads in the EMU are determined by countries' credit ratings. In addition, these differences are proportional to the level of short-term interest rates. In order to increase expected returns in a low-interest-rate environment, investors undertake higher risks, causing a positive correlation between interest rates and government bond yield spreads.

Even though researchers pay a lot of attention to different types of relationship between government bond markets, another common branch of research is concentrated on investigation of the factors influencing this relationship. Researches implemented in the field are discussed in the next section, and different types of factors are analysed further.

1.2. Identification of the Factors Influencing Government Bond Market Comovements

It can be often argued that liberalized markets show higher degree of comovements with global factors. Moreover, in an increasingly connected world, real variables can start commoving due to greater trade, coordinated policies, and other common factors. Consequently, the discussions on which specific factors or groups of factors are the most important in determining the relationship between financial markets are a common topic in financial research. This chapter presents the main groups of most commonly identified factors as well as discusses the results of other researches, supporting the influence of specific factors on the relationship between financial markets.

1.2.1. General Classification of the Factors Influencing Government Bond Market Comovements

Analyses in the field tend to assess the influence of different factors on government bond yields or yield spreads in a particular country rather than comovements between certain government bond markets. Factors influencing government bond markets gained researchers' attention since the awareness of these factors would enable forecasting government bond market yields and/or avoiding extreme market volatilities. Hawkesby, Marsh and Stevens (2004) noticed that the analysis of comovements in market prices (and/or returns) captures both market perceptions of direct exposures and exposures themselves to similar external factors. Knowledge

of these common factors could help identify potential channels for financial stability threats, such as through interlinkages or common vulnerabilities between the markets. It has already been noticed that comovements between financial markets tend to change over time (Bekaert and Harvey, 2000; Goetzmann et al., 2005; among others). Variety of interpretations for this pattern have been suggested, from increased trade linkages to contagion in financial markets, driven by changes in investor composition (Quinn and Voth, 2008).

Researchers have identified a lot of factors influencing government bond markets. These factors differ depending on the markets investigated, research periods, data frequency and the methods used for the assessment, but the common tendencies can still be excluded. Since there is still a lack of studies analysing the factors that influence government bond market comovements, this exclusion is further based on several assumptions. Firstly, it is assumed that factors influencing financial markets commonly coincide, that is, the same or similar factors influence stock and bond markets. Harvey et al. (1994) were some of the first authors arguing that factors driving bond returns are the same as factors driving stock returns. Secondly, factors influencing government bond markets also influence comovements between them. These assumptions are further tested in the empirical research.

A common way to identify factors influencing government bond markets is to assess the risks that these markets undertake. This approach has been taken by Gapen et al. (2005), Manganelli and Wolswijk (2007), Fang (2012), Paniagua, Sapena and Tamarit (2015) and other authors, excluding credit risk, liquidity risk and global risk as influencing government bond yields. Gapen et al. (2005) found strong evidence that credit risk is the main risk influencing government bond market yields, but the effects of liquidity risk and global risk can also be observed. Similarly, Manganelli and Wolswijk (2009) related government bond yield spreads with credit and liquidity risks, determined by global risk. Codogno, Favero, and Missale (2003), Geyer, Kossmeier, and Pichler (2004), and Niehof (2014) stated that the main factors influencing government bond yields and their spreads are general risk, liquidity and fiscal factors.

Both credit and liquidity risks were identified as country-specific. Paniagua, Sapena and Tamarit (2015) asserted that due to a high degree of financial integration at the beginning of the EMU, government bond market yields shared a large systemic component. Contrarily, other authors (Gómez-Puig, 2009; Favero and Missale, 2012; among others) reveal that the country-specific risk component in government bond yield spreads became stronger than the systemic component after 2008.

Nevertheless, since this research is concentrated on the factors influencing government bond market comovements and not their yields or volatility, another common approach within recent researches is the exclusion of global and domestic (country-specific) factors influencing

government bond markets (Bunda, Hamann and Lall, 2009; Hilscher and Nosbusch, 2012; Miyajima, Mohanty and Chan, 2012; Conefrey and Cronin, 2013; Piljak, 2013). Paniagua, Sapena and Tamarit (2015) showed that the explanatory power of domestic factors increased during the sovereign debt crisis, when international investors discriminated more between the countries. Similarly, Alexopoulou, Bunda and Ferrando (2009) divided the factors influencing government bond markets into fundamentals[1] and common factors, attaching the changes in government bond market yields to fundamentals.

Bunda, Hamann and Lall (2009), Miyajima, Mohanty and Chan (2012) and Piljak (2013) concluded that country-specific[2] factors have a higher influence on government bond returns than global factors. The author of this dissertation finds it essential to highlight the division between these factors: country-specific factors could be associated with the first two risks (credit and liquidity), and alternatively are named as country's fundamentals, while global factors could be associated with global economic environment and seen as systemic. In order to assess the influence of these factors on government bond market comovements, it is firstly important to separately describe each group of factors influencing these comovements. This is done in the next three sections, starting with global factors.

1.2.2. Global Factors Influencing Government Bond Market Comovements

The first group of factors identified as influencing financial market comovements, are the factors representing global financial situation. The importance of these factors has already been proven by multiple researchers (Weigel and Gemmill, 2006; Bunda, Hamann and Lall, 2009; Miyajima, Mohanty and Chan, 2012; Paniagua, Sapena and Tamarit, 2015; among others). For example, Weigel and Gemmill (2006) proved that global financial conditions, related mainly to the US stock market, explain a big share of variance of financial market comovements. The importance of global factors has also been stressed by Codogno et al. (2003), proving them to be very important in determining government bond yield spreads during the sovereign debt crisis. Gonzalez-Hermosillo (2008) showed that if global financial factors are taken into account, contagion from emerging markets is small or does not exist, and conclude that creditworthiness of the investigated markets is mainly driven by a common set of global factors.

As it was already discussed in the previous section, financial markets and their returns/yields have been found to be influenced by global risk factors (Arghyrou and Kontonikas, 2011; Barrios et al., 2009; Favero et al., 2010; Manganelli and Wolswijk, 2009; Pozzi and Wolswijk, 2008;

[1] In the context of this research, fundamentals are understood as the main macroeconomic characteristics of a certain country as well as the liquidity characteristics of that country's government bond market.
[2] In this dissertation, the concepts of *country-specific* and *domestic* factors are used interchangeably.

Sgrerri and Zoli, 2009). Factors can also be a group of factors jointly representing global financial situation. According to ECB (2007), estimating the degree of global risk aversion at any point of time is important from a financial stability perspective because past episodes of sudden rises in risk premiums, sharp declines in market liquidity and asset prices have often been associated with the loss of risk appetite from investors' side.

Even though various authors used the concepts of global risk sentiment (Miyajima, Mohanty and Chan, 2012), global risk appetite (Gai and Vause, 2004; Illing and Meyer, 2007), global risk variable (Fang, 2012) or global market uncertainty/volatility (Rey, 2000; Perego and Wermeulen, 2013), the author of this dissertation agrees with the researchers identifying the component as global risk aversion (Manganelli and Wolswijk, 2009; Codogno et al., 2003; Schuknecht et al., 2010; Paniagua, Sapena and Tamarit, 2015; among others). Coudert and Gex (2006) defined it as the price of risk – a global decisive factor forming asset prices and making it possible to reflect investor sentiment with regard to risk in constantly changing environment. Figure 4 shows how global risk aversion depends not only on the degree to which investors dislike uncertainty, but on overall level of uncertainty as well.

The author stresses the difference between investors' risk aversion and global risk aversion. According to ECB (2007), the degree of investors' risk aversion is commonly assumed to be fairly stable, while global risk aversion is considered to increase under market uncertainty. Finally, risk premium for different asset prices is influenced by the degree of global risk aversion, as a combination of investors' attitudes and uncertainty in the global environment.

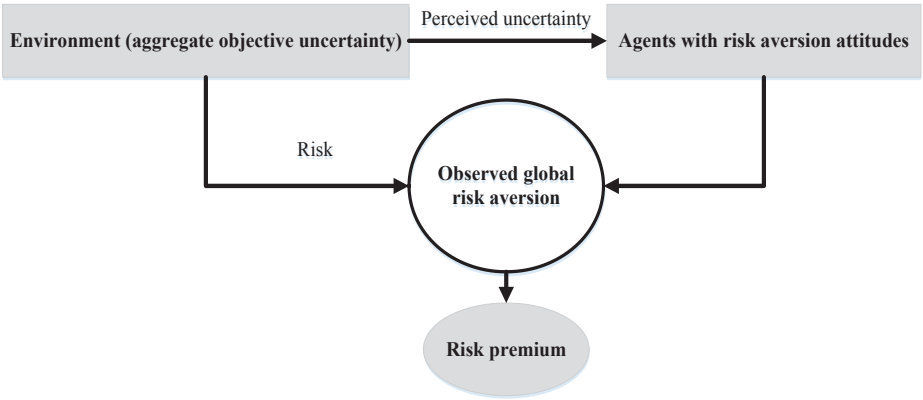


Figure 4 Uncertainty and Global Risk Aversion

Source: adapted by the author, based on ECB (2007)

Barrios et al. (2009) showed a strong positive relationship between global risk aversion and government bond risk premium. Fang (2012), Paniagua, Sapena and Tamarit (2015) revealed that

global risk aversion plays an essential role in explaining government bond yield spreads. Gonzalez-Hermosillo (2008) proved that shocks in a particular market may impact the investors' risk aversion through rebalancing of their portfolios: investors would first abandon the most liquid markets, where exiting is less costly.

Global risk aversion is commonly measured as volatility, common to all economies. Illing and Meyer (2005) argued that risk aversion incorporates both investors' attitude towards risk and their perceptions of risk, while Paniagua, Sapena and Tamarit (2015) stated that changes in investors' risk aversion could not be observed directly. Manganelli and Wolswijk (2009) calculated the spread between the US corporate and government bond yields as a proxy for global risk aversion, while Herrera and Perry (2002), Calvo (2003), Garcia-Herrero and Ortiz (2005) used the US high-yield corporate bond yields for the same purpose. Another common way to measure global risk aversion is to use the indices that, as Illing and Meyer (2005) noticed, assess risk aversion either by looking at specific market aspect or by combining information from various markets into a composite measure. Baur and Lucey (2006) highlight that an increase in aggregate separate investors' risk aversion enhances volatility and global risk aversion. If enhanced volatility in global financial markets is directly related to global risk aversion, the latter may be measured by the volatility index.

One of the most commonly used volatility indices is Chicago Board Options Exchange Volatility Index (VIX) (Kalotychou, Remolona and Wu, 2014), representing implied volatility of S&P 500 index options (Caceres, Guzzo and Segoviano, 2010). According to Mensi et al. (2014), VIX drives stock returns only in bear markets. Coudert and Gex (2006) identified VIX as a direct measure of fear. One of the VIX's drawbacks is the fact that on average, it is based on few observations rather than all possible volatility-price combinations (Gonzalez-Hermosillo, 2008). Nevertheless, its simplicity does not significantly reduce its power compared to other indices.

Since global financial market conditions are not only reflected by the market volatility, the global market situation can be represented by other factors as well, with the choice of the factors constrained by the need to have a small set of sound variables.

The second global factor worth mentioning is money market liquidity, sometimes further divided into funding liquidity and market liquidity. Funding liquidity is a proxy for credit available in a global financial system. Kashiwase and Kodres (2005) used a 3-month-ahead federal fund futures' rate to measure money market liquidity and monetary conditions, affecting monetary conditions in two channels. Firstly, a decline in federal fund rate indicates lower borrowing costs and increasing liquidity in the economy. Secondly, it reduces the returns of government bonds.

Gonzalez-Hermosillo (2008) stated that, ceteris paribus, increased money market liquidity should promote investments in riskier assets by international investors. Contrarily, higher interest

rates should increase the costs of borrowing and the probability of default for creditors. Forbes and Chinn (2003) used short-term interest rates as a proxy for money market liquidity, while Gonzalez-Hermosillo (2008) used the difference between 20-year and 10-year US government bond yields, rationalizing that since these government bonds are risk-free, the spread should only reflect liquidity premium. Gonzalez-Hermosillo (2008) argued that the expected US government bond yields for different maturities should roughly be equal in reality, so the movements in spreads should be strongly influenced by the movements in global liquidity premiums.

When analysing global financial conditions, a proxy for changes in global market portfolio returns is also commonly investigated by researchers (Solnik, 1974; Lessard, 1974; , 1996; Karolyi and Stulz, 2003; among others). The most common way to represent global market portfolio is to use the changes in Standard and Poors 500 stock index value, commonly used as a proxy for world market portfolio for the mature markets (Bunda, Hamann and Lall, 2010; Mensi et al., 2014). Some researchers emphasize that changes in global market portfolio values/returns should influence all the other financial markets. Since stocks can still be identified as the alternative investments to bonds, the structure and index changes should reflect competitive market environment. Karolyi and Stulz (2003) argued that a country's risk premium depends on its covariance with global market portfolio. Moreover, as Bunda, Hamann and Lall (2010) noticed, the sensitivity of government bond market returns to changes in stock market returns might reflect global portfolio reallocations between bonds and stocks. Investors' attitude towards stock markets partly depends on expected growth of the home country. As a result, investors might prefer their domestic stocks when the earnings' growth is high and may switch to riskless assets when the risk aversion increases.

In the factor model developed by Forbes and Chinn (2003), financial market returns in different countries are also a function of commodity market uncertainty (expressed in oil and gold price changes). Mensi et al. (2014) also proved that oil prices display symmetric tail independence with all the BRICS markets, even though the dependence between oil and BRICS markets significantly increased with the onset of financial crisis. Gold price changes commove with those of BRICS stock markets and the degree of comovements decreases after crises.

Mensi et al. (2014), used the West Texas Intermediate (WTI) crude oil price expressed in US dollars per barrel as a global benchmark to determine the prices of other light crudes in the US. In addition, Mensi et al. (2014) included gold price expressed in US dollars per ounce to reflect the changes in commodity prices and its influence on stock markets in other countries. Ziaei (2012) found that gold market uncertainty influences bond and stock markets, while Simakova (2015) argued that even if oil was initially traded for its fundamental purposes, with time it gained a permanent place in investment portfolio – oil and its derivatives are specific with

high liquidity, volatility and high profit opportunities. Moreover, oil market is strongly influenced by political factors and internal situations in major producing/consuming countries, as well as international conflicts and tensions.

According to Simakova (2015), even though a significant component of gold demand results from the characteristics of its rareness, in practice it is used as an essential component of an investment portfolio. Moreover, in many terms, gold price is influenced by governments and central banks: monetary policy performed by governments, changes in interest rates, and inflationary policy effects. Consequently, changes in gold price should influence government bond market comovements. In their research of the government bond market comovements, Forbes and Chinn (2003) assumed that country return factors are a function of global, sectorial and country-specific factors, excluding prices of gold and oil as global factors. The authors used gold prices to capture the changes in global risk aversion, while Simakova (2015) found that interest rates are positively related to oil prices and negatively to gold prices.

The last global factor, commonly excluded as influencing financial markets, is global economic policy uncertainty (EPU). Moore (2016) showed that EPU was higher around recessions, elections, monetary policy surprises as well as was increasing faster than decreasing. According to Mensi et al. (2014), economic policy uncertainty had no impact on BRICS stock markets both before and after the financial crisis. Baker, Bloom and Davis (2012) found evidence that increases in EPU foreshadow the declines in output, employment and investment. Even though it cannot be firmly claimed that economic policy causes negative developments mentioned, with many factors moving together in the economy, high levels of policy uncertainty are associated with weaker growth prospects.

The second group of factors, identified as influencing financial markets and their comovements, are defined as country-specific factors, commonly divided into fundamental and bilateral factors, with both groups of factors being further separately discussed. The next section of the thesis designated to analyse country-specific fundamental factors influencing financial markets and their comovements.

1.2.3. Fundamental Factors Influencing Government Bond Market Comovements

The second group of factors influencing financial markets and their comovements are fundamental factors. According to Pretorius (2002), stock market correlation is expected to increase with fundamentals, influencing stock markets, converging, while Ebeke and Kyobe (2015) associated stronger fundamentals with lower government bond yields as well as lower yield volatility. Similarly, Ang and Piazzesi (2003) were some of the firsts to analyse the sensitivity of government bond yield term structure to the country's fundamentals and to prove

that these factors explain around 85% of government bond yield variance. Contrarily, Quinn and Voth (2008) showed greater synchronization of fundamentals not being the main cause of increasing correlations between financial markets. In general, researchers found that countries' fundamentals only partly explain asset price variance and leave significant residual variance unexplained.

According to Caramazza, Ricci and Salgado (2000), testing whether comovements between countries' fundamentals could explain comovements between their asset prices is one of the ways to empirically explore contagion, since failing to validate this statement has been interpreted as existence of contagion (Kaminsky and Schmukler, 1999; among others). Rigobon (1998) and Forbes and Rigobon (1999) stressed on the ambiguity of evidence that propagation mechanisms between financial markets differ in tranquil and crisis periods: since correlation of fundamentals increases during crises, an increase in asset price correlation provides insufficient evidence of contagion. Manasse and Zavalloni (2012), Caceres, Guzzo and Segoviano (2010) proved that the influence of country-specific fundamentals on sovereign bond spreads strengthens in crises. Brennan, Kobor and Rustaman (2011) showed that even if global government bond markets became largely integrated with time, fundamental factors still significantly impact bond returns.

Boffelli and Urga (2013) evaluated high- and low-frequency components for volatilities and correlations of European government bond spreads and proved the existence of strong linkages between increasing volatility and deteriorating macroeconomic fundamentals. The researchers also analyse time-varying degree of European countries' integration and show that increasing integration in financial markets is not supported by similar increasing integration of fundamentals.

The author of the dissertation stresses that in this classification, the group of fundamental factors is seen in a broader way, including not only the main macroeconomic aggregates but government and market-characterising factors as well. Consequently, in this context, fundamental factors are interpreted as country-specific factors with their values depending on a country's situation rather than on its linkages with other countries. In this section, analysed fundamental factors are further divided into government, macroeconomic and market-characterizing.

GOVERNMENT FACTORS. As Caceres, Guzzo and Segoviano (2010) argued, government bond yields highly depend on government financial situation, most commonly expressed in government debt and government fiscal balance. Government debt represents longer-term government's financial situation while fiscal deficit reveals shorter-term tendencies.

Government debt has been identified as an important factor influencing government bond market yields (Hallerberg and Wolff, 2008; Caceres, Guzzo and Segoviano, 2010; De Grauwe and Ji, 2012; d'Agostino and Ehrmann, 2013; Gibson, Hall and Tavlas, 2014; Ebeke and Kyobe, 2015). Caramazza, Ricci and Salgado (2000) argued that domestic imbalances cause pressure on

financial markets. Moreover, after assessing the influence of government debt on government bond yields, Barrios et al. (2009) proved that foreign debt is more important than public debt. Contrarily, the results of Perego and Wermeulen (2013) showed that the correlation between the EU government bond yields is not affected by differences in government debt levels, while Kalotychou, Remolona and Wu (2014) found that an increase in government debt levels enlarges a country's sensitivity to global risks.

Some empirical studies note a significant influence of fiscal balance on long-term government bond yields (Arghyrou and Kontonikas, 2011; Attinasi et al. 2009; Sgherri and Zoli, 2009; Barbosa and Costa, 2010; Caceres, Guzzo and Segoviano, 2010; Gerlach et al., 2010; Miyajima, Mohanty and Chan, 2012). Caceres, Guzzo and Segoviano (2010) argued that government bond yields increase with worsening fiscal balance, while Perego and Wermeulen (2013) suggested that a country's debt sustainability first depends on its expected fiscal balance, determined by the future economic activity. Some researchers also found better credit ratings being related to lower government bond yield spreads (Cantor and Packer, 1996; Kaminsky and Schmukler, 2002; Hartelius et al., 2008). Manganelli and Wolswijk (2009) showed that lower credit ratings increase the cost of debt while Jaramillo and Tejada (2011) highlighted credit rating as a significant factor of government bond yield spreads even after controlling for other fundamental factors. Brennan, Kobor and Rustaman (2011) proved that lower credit rating makes diversification more valuable by mitigating potential losses due to financial distress. The author of this dissertation draws attention to the fact that credit ratings can be both factors influencing government bond markets, as well as indirect measure of yields. The distinction depends on the assumptions made.

Finally, Bekaert, Harvey and Lumsdale (2002) showed that around one-third of government bond yield spreads reflect country's political risk. Martinez and Santiso (2003) noticed that political instability further aggravates financial vulnerability, especially for countries with weak economic fundamentals. This is particularly relevant in emerging economies with higher political-institutional instability. Herzog and Müller (2014) argued that the quality of bonds is determined by asymmetric information and political reputation, and calculate Political Risk Index (PRI) to measure it. According to the authors, a country has high levels of asymmetric information and weak reputation if its political system is less stable (large number of political parties, more frequent elections, and high corruption), all reflected in PRI.

MACROECONOMIC FACTORS. According to Dornbusch and Claessens (2000), most empirical papers found a country's macroeconomic weaknesses to be an important cause of contagion or comovements between financial markets, as they make a country more vulnerable to crises. Nevertheless, similarities in macroeconomic weaknesses can also lead to shifts in

investors' expectations as investors consider it to be signals and thereby causes for crises. Moreover, multiple researchers have identified the influence of macroeconomic factors on both stock (Didier, Love and Martinez – Peria, 2012; Marcišauskienė and Cibulskienė, 2013) and bond markets (Hilscher and Nosbusch, 2012; Boffelli and Urga, 2013)

One of the most important factors commonly identified as influencing government bond yields is a country's output growth (Longin and Solnik, 1995; Caramazza, Ricci and Salgado, 2000; Miyajima, Mohanty and Chan, 2012; d'Agostino and Ehrmann, 2013; Perego and Wermeulen, 2013; Ebeke and Kyobe, 2015). Ebeke and Kyobe (2015) argued that a higher volatility of GDP growth increases government bond yields by enhancing uncertainty in real economy. Moreover, a higher real GDP growth reduces the level and volatility of bond yields, since better growth prospects encourage more capital inflows and a country's debt becomes easier to service. Perego and Wermeulen (2013) found that correlation between the EU government bond market yields is determined by GDP growth, while Pretorius (2002) argued that the difference between industrial output growth in two countries should be negatively correlated with their financial market comovements. According to Caramazza, Ricci and Salgado (2000), low output growth might indicate external or domestic imbalances becoming increasingly unfounded. Finally, Morgado and Tavares (2007) showed that output growth asymmetry negatively affects comovements between stock markets.

Many authors in the field agreed (expected) price level to be positively associated with government bond yields (Clare and Lekkos, 2000; Andersson et al., 2004; Miyajima, Mohanty and Chan, 2012; d'Agostino and Ehrmann, 2013; Perego and Wermeulen, 2013; Fawley and Neely, 2013; Ebeke and Kyobe, 2015). Pretorius (2002) showed that with inflation influencing security prices, the difference between inflation in two countries is expected to negatively affect the extent of comovements between their financial markets. Moreover, the convergence of inflation rates should affect financial markets in the same direction with the absolute value of inflation differential being a factor, negatively influencing stock market correlations. D'Addonna and Kind (2006) argued that inflation shocks are very important for changes in government bond yields, while Perego and Wermeulen (2013) stated that inflation is important when regional prices are widely diverging. They also found correlation between the EU government bond market yields to be determined by inflation.

A less frequently analysed but still common macroeconomic factor influencing government bond markets is unemployment. D'Agostino and Ehrmann (2013), Paniagua, Sapena and Tamarit (2015), among others, found unemployment to have strong positive influence on government bond yields in different countries. According to Caramazza, Ricci and Salgado (2000), evidence

of pre-crisis domestic macroeconomic imbalances that may have made a country vulnerable to financial market contagion includes high unemployment rate.

Different authors have also identified the country's money market liquidity being an important determinant of government bond yields. Caramazza, Ricci and Salgado (2000) argued that the ratio of broad money to international reserves is a measure of a banking system's ability to withstand currency pressures. Moreover, according to the authors, substantial monetary expansions proxied by the growth of broad money to GDP, fuel inflation expectations and lead to currency pressures. Clare and Lekkos (2000), Fawley and Neely (2013) agreed that return on long-term government bonds is determined by the expectations about future market's liquidity, expressed in short-term interest rates. Walti (2005) chose real interest rates as proxies for a country's money market liquidity, influencing government bond yields.

When assessing the factors influencing government bond yields in emerging markets, Miyajima, Mohanty and Chan (2012) showed the importance of a country's currency price in terms of another currency, expressed in exchange rate and reflecting country's macroeconomic volatility. The results proved international role of domestic emerging government bond markets depending on their exchange rate flexibility with higher flexibility to be essential for volatility reduction and maintenance of their role in international financial system. After analysing government bond yields in emerging markets, Ebeke and Kyobe (2015) showed that exchange rate volatility is one of the factors influencing government bond market yields. Bailey and Chung (1995) analysed the impact of exchange rate fluctuations on risk premium reflected in cross-sections of individual stock returns and find evidence on stock market premiums for risk exposures. Caramazza, Ricci and Salgado (2000) also assumed real exchange rate to be one of the determinants of currency crises, while Morgado and Tavares (2007) found that real exchange rate volatility negatively affects stock return correlations.

Country's current account balance has been identified as one of the most important factors influencing government bond market yields (Barrios et al., 2009; Miyajima, Mohanty and Chan; 2012; d'Agostino and Ehrmann, 2013; Perego and Vermeulen, 2013; Ebeke and Kyobe, 2015). Perego and Wermeulen (2013) found that current account balance is a good indicator of the overall country's asset position, while Teiletche and Xu (2008) suggested using countries' import levels as the determinants of government bond market comovements. Perego and Wermeulen (2013) found that correlation between the EU government bond market yields is determined by country's current account balance, while, contrarily, De Grauwe and Ji (2012) found no significant effect of current account balance on government bond yield spreads.

Finally, another macroeconomic factor, excluded as influencing financial markets, is country's international reserves. According to Summers (2000), many authors emphasized

country‘s vulnerability measures rather than the measures of foreign reserves to short-term liabilities. Caramazza, Ricci and Salgado (2000) argued that the risk of a crisis is likely to be greater in countries with larger short-term obligations and low levels of international reserves. Moreover, these researchers state that the indicators of financial weaknesses or fragility include the ratio of short-term debt to reserves, a proxy for international reserves' inadequacy to cover speculative attacks. Summers (2000) argued that a country's international reserves represent its ability to mobilize resources, as well its economic strength. Similarly, Manasse and Roubini (2005), Ciarlone, Piselli and Trebeschi (2007) excluded international reserves as economic indicators traditionally associated with financial crises.

MARKET CHARACTERISTICS. The final set of factors excluded by researchers represent market characteristics, especially market's liquidity measures. When assessing these factors, researchers analyse bid-ask spreads with small bid-ask spreads indicating higher market liquidity (Inoue, 1999; Aßmann and Boysen-Hogrefe, 2011; Fontana and Scheicher, 2010; Gómez-Puig, 2009). According to Fleming (2001), bid-ask spread directly measures the cost of executing a trade, calculated as the distance between the bid price and the bid-ask midpoint.

Another liquidity measure commonly used in research on government bond markets is the yield spread between more and less liquid securities. Kamara (1994) and Fleming (2001) argued that more liquid securities tend to have higher prices (lower yields) than less liquid securities. This spread is calculated as the difference between the most liquid, benchmark government security and another government security with similar cash flow characteristics. As Fleming (2001) noticed, the drawback of this measure is that it reflects both liquidity price and differences in liquidity between securities. Moreover, the choice of benchmark security can cause a significant estimation error. Nevertheless, this spread gives insights about liquidity that are not provided by other measures and can be calculated without high-frequency data.

Other researchers state that government bond market size represents the market (Flavin, Hurley and Rousseau, 2001; Gomez-Puig, 2009; Haugh et al., 2009; Attinasi et al., 2009; Bernoth and Erdogan, 2012). McCauley (2003) noticed that the relationship between government bond market size and liquidity is complicated because size can be measured in different dimensions. According to Pretorius (2002), the difference in size between two financial markets should have a negative relationship with market comovements.

Market depth, expressed in trade size, also reflects market liquidity. According to Fleming (2001), trade size is an ex-post measure of quantity of securities that could be traded at bid or ask price. Beber, Brandt and Kavajecz (2006) calculated this measure as the average of depth posted at best bid and ask prices. Nevertheless, it underestimates market depth: the quantity traded is often smaller than the quantity that could be traded at a given price. In addition, any quantity

measure of securities that can be traded doesn't consider the cost of executing large trades. Trading frequency can also represent market liquidity, defined as the number of trades executed within a specified interval. Similarly as trading volume, high trading frequency reflects more liquid market and can be associated with volatility and lower liquidity (Fleming, 2001). Trading volume, commonly expressed as the market capitalization to GDP, is based on the assumption that more active markets are more liquid (Fleming, 2001). Even though the measure is relatively simple and available, its drawback is that it is also associated with the volatility (Karpoff, 1987), considered to restrict market liquidity.

The influence on financial markets and their comovements of other factors that are not assigned to the groups of excluded factors has also been shown by researchers. Flavin, Hurley and Rousseau (2001) proved that informational asymmetries influence comovements between financial markets. Herzog and Müller (2014) argued that government bond markets are strongly influenced by informational asymmetries and reputation, suggesting that investors buy bonds without knowing whether the country is sufficiently sustainable to repay its debt obligations and its real political commitment to structural reforms or future budget consolidation. As a result, the bond quality highly depends on beliefs. However, countries with good reputation are unwilling to accept the same risk premium as non-reform-oriented countries, reducing the supply of good-quality bonds. Eventually, these governments might even leave the market, consolidating their budgets autonomously with less external finance. On the other hand, policymakers with less commitments to reform remain in the market with a strong need to finance public expenditures at relatively low rates.

Finally, Quinn and Voth (2008) determined that liberalization of capital accounts is a major determinant of financial market comovements. Bekaert and Harvey (2000) also showed that market correlations increase after liberalization of capital markets.

After excluding and classifying fundamental factors influencing financial markets and their comovements, the objective of the following stage of this chapter is to identify the last group of factors influencing the markets. These factors represent bilateral linkages between the countries and are defined as country-specific bilateral factors.

1.2.4. Bilateral Factors Influencing Government Bond Market Comovements

As it has already been mentioned, analysis and synthesis of previous research reveal that most of the studies are designated to assess the factors influencing government bond markets rather than comovements between the markets. This observation is not surprising, since estimation of factors influencing the comovements can only be implemented by observing the mutual dependence between the factors. It is more complicated to exclude and assess bilateral factors

influencing the comovements but a few researchers have done a great job in this identification. This third group of factors is far less investigated and consists of factors representing bilateral dependence between the markets.

A relatively novel approach to assessing the factors influencing financial market comovements, was developed by Pretorius (2002), Didier, Love and Martinez Peria (2012), Shinagawa (2014) and other authors. They investigated the influence of bilateral linkages between the countries on financial market comovements and claimed that these linkages were the most important determinants of financial market comovements, since they represent the dependence of the economies per se. For example, Forbes and Chinn (2003) developed a factor model of market returns assuming separate country's security market returns to be a function of global, sectorial, cross-country (bilateral) and country-specific factors, and Shinagawa (2014) even described bilateral financial market spillovers as bond yield comovements between (the) countries.

As with the previous groups of factors, most research have been carried out on stock markets, leaving a gap in investigation for the same tendencies in bond markets. In line with the aim of this research dissertation and the fact that comovements between government bond markets are expected to be influenced by similar or even the same factors, the studies of bilateral factors that are identified as influencing stock market comovements are also included in the analysis.

Forbes and Chinn (2003) highlighted the importance of bilateral factors, when compared to global and sectorial factors, in explaining comovements between large financial markets. The authors, as well as Didier, Love and Martinez Peria (2012), classified bilateral factors influencing stock market comovements into real linkages, financial linkages, and other effects. Similarly, Caramazza, Ricci and Salgado (2000) analysed the role of various factors, including trade and financial linkages, to determine how countries that have experienced currency pressures soon after the outbreak of crises differ from the countries that did not. Forbes and Chinn (2003) found that real and financial linkages become increasingly more important for how shocks are transmitted from large economies to other markets with bilateral trade flows being significant determinant of cross-country linkages in bond markets.

Even though Forbes and Chinn (2003) divided real linkages into direct trade flows and competition in third markets, other authors (Walti, 2005; Didier, Love and Martinez Peria, 2012) commonly referred to this factor as bilateral trade. Most of the studies proved the major importance of bilateral trade linkages on the comovements between financial markets (Eichengreen and Rose, 1998; Walti, 2005; Shinagawa, 2014; among others). Eichengreen, Rose and Wyplosz (1996) and Kaminsky and Reinhart (1998) showed that trade linkages explain contagion patterns. Glick and Rose (1999) supported the notion of trade linkages affecting the patterns of contagion in currency crises. Similarly, Eichengreen and Rose (1998) and Rose and

Spiegel (2009) found that trade linkages dominate macroeconomic channels in conveying shocks internationally, while Ma and Cheng (2003) argued that financial crises may be transmitted through trade linkages despite good fundamentals of the countries. Morgado and Tavares (2007) found that bilateral trade positively affects correlation between stock markets. Moreover, they stress that trade is the most obvious economic linkage between the countries.

Forbes and Chinn (2003) identified the channels, through which bigger countries *c* could affect shocks to smaller countries *i* through bilateral real linkages: 1) country's *c* demand for imports from country *i*; 2) relative price of country's *c* and country's *i* exports through trade competition. The authors show that the second bilateral trade factor, trade competition, can also be significant, although its importance fluctuates across the markets and model specifications. The authors obtained import demand (a proxy for trade) being the most important bilateral factor determining how shocks to large economies are transmitted to other markets.

According to Shinagawa (2014), if two countries have stronger bilateral trade linkages, their financial linkages should also be stronger. Researcher uses correlations between stock and bond markets to determine the volume of bilateral trade dependence and proves that bilateral trade can only indirectly influence government bond market spillovers. Moreover, greater bilateral trade linkage leads to bond market comovements. Despite large contradiction of trading flows during crises, Didier, Love and Martinez Peria (2012) did not support significant real/trade linkages' effects on the comovements between the US and other stock markets.

Intensity of trade linkages between two countries can be measured as a share of bilateral trade between two countries in total trade (Eichengreen, Rose, and Wyplosz, 1996; among others). Pretorius (2002) argued that the more important is the trade linkage between two countries, the more correlated their financial markets should be. Similarly, Rose and Spiegel (2009) stated that countries, linked through international bilateral trade, may experience contagion if their trading partner devalue their currencies, so strong trade linkages may encourage devaluation as a response to foreign shocks because countries seek maintaining external competitiveness.

The second group of country-specific bilateral factors identified by other researchers as influencing financial markets are financial linkages. According to Caramazza, Ricci and Salgado (2000), financial linkages could be a channel for spillover and contagion effects with crises potentially inducing investors to rebalance their portfolios for risk management, liquidity or other reasons. Investors with positions in crisis-hit country would want to reduce their risk exposure and sell the assets, positively correlated with the assets in crisis country. On the other hand, investors might sell the assets, highly represented in their portfolios only due to their greater availability. Consequently, strong financial linkages with major lender increase country's financial vulnerability (Caramazza, Ricci and Salgado, 2000). Therefore, some countries experience capital

outflows independently of their macroeconomic fundamentals. Forbes and Chinn (2003) stated that bigger countries could affect the shocks to smaller countries through bank lending or through foreign investment flows.

The results of the research of Didier, Love and Martinez Peria (2012) revealed financial linkages being the dominant determinant of stock market comovements. The markets where the US investors have high stock holdings exhibit greater comovements with the US stock market. Moreover, countries with high portfolio inflows, more liquid and developed stock markets are stronger correlated with the US stock market and have more vulnerable banking and corporate. Caramazza, Ricci and Salgado (2000) revealed that financial linkages are significant in explaining the spreads of financial crises even when fundamentals and trade spillovers are controlled for.

According to Forbes and Chinn (2003), in general bilateral foreign investment is not significantly influencing cross-country linkages, while bilateral bank lending can be significant determinant, although its importance fluctuates across the markets and model specifications. Contrarily, Rose and Spiegel (2009) argued that bilateral foreign investment increased significantly after financial crisis, and Allen and Gale (2008) noticed that foreign investment is demanded in relatively calm periods: shocks then correlate less across the countries and enable international risk-sharing. For measuring financial exposure Forbes and Chinn (2003) used total bank lending and foreign direct investment as a share of GDP, while Ehrmann and Franzcher (2009) assessed all bilateral assets and liabilities for foreign direct investment, portfolio investment, debt and loans, as a share of GDP.

Shinagawa (2014) stated that if country has a large amount of bilateral foreign investment or bank lending in another country, correlation between two financial markets should be larger as well. Consequently, countries with extensive bilateral portfolio exposure are likely to have larger spillovers between their bond markets. Similarly, the IMF (2013) showed that aggregation of assets and liabilities between two countries affects their business cycle comovements. Broner, Gelos and Reinhart (2005) assessed financial interdependence between the countries based on whether they share overexposed investors and show that the index of financial interdependence enables explaining cross-country comovement patterns.

There exists a group of bilateral factors, proven to influence financial market comovements, but not assigned to a separate group by other researchers. The author of the dissertation combines these factors into a separate group, and identifies it as geographical characteristics.

Rose and Spiegel (2009) showed that geographical distance worsens information symmetries between international financial markets. The authors analysed whether the countries that are closer to major financial centers are more financially integrated, and if this integration reduces macroeconomic volatility, and reveal statistically significant positive relationship

between financial remoteness and volatility. Similarly, when assessing extreme dependencies between financial markets, Teiletche and Xu (2008) used measures, reflecting geographical distance and cultural differences between the countries. Flavin, Hurley and Rousseau (2001) showed that distance between the countries and common border influence financial market comovements. Regions' importance is argued to be strongly influencing correlation between two countries' financial markets (Pretorius, 2002) as these markets can be treated similarly by investors or coordinate their policies. Forbes and Chinn (2003) confirmed the influence of cross-country factors, such as cultural similarities or colonial origin, on financial market comovements. Finally, Wälti (2005) revealed that common language positively contributes to stock market synchronization.

Analysis and synthesis of researches, designated to assess bilateral factors influencing comovements between financial markets reveal that they are not equally important. Most of the authors agree portfolio exposure, as well as bilateral trade, being the most significant factors, leading to strengthened comovements between the markets. The results of Forbes and Chinn (2003), indicated that despite the growth in capital flows across the countries, direct trade flows continue being more important factor influencing cross-country comovements than financial linkages in both stock and bond markets.

One of the reasons, explaining the variety of results, obtained by different researchers in financial markets, could be the fact that the influence of different factors on government bond yields/markets is unstable over time. This attitude was supported by Aßmann and Boysen-Hogrefe (2011), Arghyrou and Kontonikas (2011), Barrios et al. (2009), Oliveira et al. (2012) and other authors, who separately assessed the factors before and after financial crises. Researchers proved that during financial crises markets tend to punish certain governments for their weak fundamentals (Arghyrou and Kontonikas, 2011; Bernoth and Erdogan, 2012) and that liquidity risk premium, required by investors, increases (Aßmann and Boysen-Hogrefe, 2011). In addition, increased investor's risk aversion during financial crisis (Arghyrou and Kontonikas, 2011; Barrios et al., 2009; Bernoth and Erdogan, 2012; Haugh et al., 2009; Sgherri and Zoli, 2009) leads to additional pricing of comovements between risk aversion and credit/liquidity risks (Manganelli and Wolswijk, 2009; von Hagen, Schuknecht, and Wolswijk, 2011).

Explanatory power of different factors highly depends on the period analysed. For instance, as Paniagua, Sapena and Tamarit (2015) revealed, fiscal debt and other worsening fundamentals, together with a shift in global risk aversion, explain long-term government bond yield spreads in the peripheral EMU countries. Despite of that, even though lowering global risk aversion has been found to be important in explaining government bond yield spreads before financial crisis, some authors show that country-specific factors became more important afterwards. Forbes and Chinn

(2003) found that in certain periods bilateral trade and financial linkages became more important determinants of shock transmission from the largest economies to the other global markets. In addition to that, it is important emphasizing that the factors influencing separate government bond markets can differ from the factors influencing market comovements. The main difference of the latter ones is the fact that they reflect the comovements between two markets analysed rather than the situation of a particular government bond market.

1.3. Methods for the Assessment of Government Bond Market Comovements and the Factors Influencing Them

The objective of this stage is to discuss the methods used to assess financial market comovements and the results of multiple studies in the field are presented in Table 3. The systemization and discussion includes methods used by researchers to assess the relationship between different types of financial markets, and not only between government bond markets. Having in mind that majority of researches in the field concentrate on stock rather than bond markets, the variety and robustness of methods used is higher. Nevertheless, it is expected for the both types of markets to have similar ways of commoving, the methods used in the latter markets are also suitable for government bond markets.

Moreover, using the methods discussed below is a common practice, implemented by researchers in government bond markets. It can be seen in Table 3 that methods to assess the relationship between financial markets are not unanimous. Nevertheless, it is still possible to divide them into groups with similar characteristics and to exclude their features. Inoguchi (2007), Arouri, Bellalah and Nguyen (2008), Piljak (2013), Perego and Vermeulen (2013) and other authors used Generalized Autoregressive Conditional Heteroskedasticity (GARCH) Models and their specifications to assess volatility or comovements between financial markets. These models are characterized by their ability to capture volatility clustering and widely used to account for non-uniform time-series variance. According to Loh (2013), GARCH is one of the most popular methods used for estimation of financial market volatility. Inoguchi (2007) used it to determine whether Asian government bond markets are correlated with the US market; Perego and Vermeulen (2013) – to assess cross-market dynamic correlations in the EMU and explain them by macroeconomic fundamentals; Piljak (2013) – to assess the factors influencing government bond market comovements. In addition to that, GARCH has also been used by the authors to estimate the cross-market correlations (Arouri, Bellalah and Nguyen, 2008).

Table 3 Most Commonly Used Methods for the Assessment of Financial Market Comovements

METHOD	AUTHORS	ESSENCE
Generalized Autoregressive Conditional Heteroskedasticity Models (GARCH)	Kirchgassner and Wolters (1987), Hamao et al. (1990), Karolyi (1995), Ang and Bekaert (2002), Brooks and Ragunathan (2003), Inoguchi, 2007; Piljak (2013); among others.	Model the volatility (variance) time series, often used in short periods of increased variation (e.g. financial shocks), also estimate cross market correlations. Used by financial professionals in several arenas including trading, investing, hedging and dealing. Implemented in 3 steps: 1) to estimate a best-fitting autoregressive model; 2) to compute autocorrelations of the error term; 3) test for significance.
Cointegration and Vector Auto regression (VAR) models	Engle and Granger, 1987; Clare et al. (1995), Barassi et al. (2001), Smith (2002), Yang (2005a), Poghosyan (2012), among others.	Cointegrated variables are generally unstable, exhibit mean-reverting spreads (cointegration), move around common stochastic trends. Mean-reverting cointegrated financial series' spreads can be modelled for arbitrage opportunities. Law of One Price suggests price cointegration between assets with identical cash flows; spot, future, and forward prices; bid and ask prices. VAR multivariate time series models, based on linear auto regression, enable detecting cointegration.
Granger's Causality	Granger (1969); Kirchgassner and Wolters (1987), Forbes and Rigobon (2002), Kose, Doganay and Karabacak (2010); Kalbaska and Gatkowski (2012), Gómez-Puig and Sosvilla-Rivero (2013).	If changes in market X Granger-cause changes in market Y, then past values of the changes in market X should contain information that helps to predict the changes in market Y beyond the information contained in past values changes in market Y alone.
Principal Component Analysis	Lee and Kim (1993), Meric and Meric (1997), Sløk and Kennedy (2004), Volosovych (2005), Coudert and Gex (2006), Bunda, Hamann and Lall (2009), Meric et al. (2012), Kalotychou, Remolona and Wu (2014), among others.	Multivariate statistical technique, based on APT, by which the common variation asset returns can be expressed as a linear function of a set of variables. It is used to analyse the simultaneous comovements between financial markets, by combining the markets into distinct principal component clusters by their similarities.
Cluster Analysis	Hawkesby, Marsh and Stevens (2004); Bunda, Hamann and Lall (2009); Gilmore, Lucey and Boscia (2010), Amini, Cont and Minca (2011), Battiston et al. (2012), Kocheturov, Batsyn and Pardalos (2014); among others.	Set of objects is grouped in a way that objects in the same group are more similar to each other than those in other groups. Cluster analysis places securities into groups based on the correlation between their returns: the ones with high positive correlations are grouped together and segregated from the negatively correlated. Small interactions are expected to exist between each cluster, providing the possibility for diversification.
Correlation Analysis	Bracker and Koch (1999), Forbes and Rigobon (1999), Rigobon (2000), Dornbusch and Claessens (2000), Pretorius (2002), Ang and Bekaert (2002), Quinn and Voth (2008), Shinagawa (2014) among others.	Commonly used to represent the common movements between financial markets. Financial markets correlate and represent both short and long-term dependence in between. Even if the correlation patterns shift, diversification benefits are still substantial.
Multivariate Factor Models	Berry, Burmeister and McElroy (1988), Stephan, Maurer and Durr (2000), Malhotra et al. (2010), Kalotychou, Remolona and Wu (2014); among others.	Employ multiple factors for explaining market phenomenon equilibrium asset prices. Compares factors to analyse the relationship between variables and security's performance. Multifactor models can be divided into macroeconomic, fundamental and statistical. Macroeconomic models compare security's return to macroeconomic factors. Fundamental models analyse the relationship between a security's return and its financials. Statistical models compare the different securities' returns based on their statistical performance.

Various researchers analysed the volatility transmission in international financial markets and used univariate and multivariate GARCH models for this estimation (Stivers and Sun, 2002; Bala and Premaratne, 2004; among others). They revealed the existence of transmission from developed to emerging markets and that developed markets are more integrated, causing the strengthening of volatility transmission within the same region. For example, when assessing the influence of different factors on government bond yield spreads, Caceres, Guzzo and Segoviano (2010) used dependence between government bond markets as an explanatory variable of yield spreads.

Empirical success of GARCH models in evaluation of univariate time series has motivated researchers to adapt the models to multivariate context. Multivariate (mostly bivariate) GARCH models were used to assess comovements between financial markets by Hamao et al. (1990), Karolyi (1995), Ang and Bekaert (2002), Brooks and Ragunathan (2003), and other authors. Charoenwongse and Piesse (2006) stated that GARCH models are commonly used for the assessment of unexpected bond market returns (also see Christiansen, 2003). The fact that financial volatility is time-, asset class- and market-varying has already been proven. According to Bekaert and Harvey (1995), multivariate GARCH enables modelling conditional correlations and covariances, analysing multinational feedbacks and investigating dynamic linkages between information and volatility inside the markets.

Multivariate GARCH models are motivated by the fact that prices of international securities are at least reacting to the same information and consequently demonstrating non-zero covariance, depending on the set of information available. Since GARCH models and their variations are mostly used to evaluate the volatility of financial time series, and the aim of this research is to assess government bond market comovements, these models will not be used in this research.

Cointegration is another commonly used method for the assessment of comovements between financial markets (Engle and Granger, 1987; among others). The results of empirical research show that financial markets are following the same long-term stochastic tendencies with any benefits from diversification being possible to obtain only in short-term, when the markets are temporarily deviating from long-term tendencies. This kind of studies have been implemented by Taylor and Tonks (1989), Becker et al. (1995), Masih and Masih (1997), Roca (1999), Sharma and Wongbangpo (2002).

Poghosyan (2012) and Costantini used cointegration to assess long-term real government bond yields and the factors influencing them, since the method allows for structural breaks in factor analysis. Conefrey and Cronin (2013) use the spillover index methodology, developed by Diebold and Yilmaz (2012), to evaluate spillover effects between the EMU government bond markets. DeGennaro et al. (1994), Clare et al. (1995) and Yang (2005b) use cointegration to

analyse relationship in the long run between government bond markets in major countries and did not find long-term cointegration among them. Contrarily, Barassi et al. (2001) and Smith (2002) proved the existence of cointegration in these markets.

It is also common for researchers to use Vector Autoregression Framework (VAR) to assess cointegration. Charoenwongse and Piesse (2006) evaluated the relationship between current volatility and past volatility patterns in financial markets, basing it on VAR framework and estimating bond yield series vector (*also see* Yang, 2005b; Piesse and Hearn, 2005; among others), while Yang (2005) employed structural VAR to investigate dynamic linkage patterns between government bond markets.

According to the efficient market hypothesis, prices of securities should reflect all available and relevant information about the issuer. As a result, only news about the issuer could change securities' price. If cointegration enables investigating market indices rather than individual securities' prices, cointegration between indices should be generally justified in the countries with similar industrial structure. Knowing that government bond markets essentially represent similar structures, this logic could be adapted to evaluate comovements between the markets as well. Nevertheless, it should be noted that, according to Bekaert and Harvey (1995), this cointegration analysis provides only binary results: markets are either integrated, or segmented. The authors also notice that market integration is a complex dynamic process, and this property cannot be strictly determined.

Another method, Granger (1969) causality, is a statistical hypothesis test used to determine whether one time series is useful in forecasting the other and whether one phenomenon is causing the other. As Granger (1969) indicated, variable X Granger-causes variable Y if past values of X enable predicting the current level of Y better than past values of Y alone. Consequently, it is argued that past values of X have some informational content that is not present in past values of Y. This definition is based on causal ordering: variables X and Y may be simultaneously correlated by accident, but it is unlikely that past values of X will be useful in predicting Y, giving all the past values of Y (Gómez-Puig and Sosvilla-Rivero, 2013).

Kalbaska and Gatkowski (2012) use Granger causality to analyse the CDS market dynamics in peripheral EMU countries. Gómez-Puig and Sosvilla-Rivero (2013) search for Granger-causal relationship between government bond yields, define contagion and examine public debt behaviour in peripheral EMU countries. Kose, Doganay and Karabacak (2010) use Granger causality to investigate the existence and the direction of the relationship between stock prices and exchange rates and have proven that contagion is a consequence of sovereign debt crisis. Kirchgassner and Wolters (1987) reveal Granger causal linkages between the US and two European government bond markets, while Sutton (2000) shows that bond yields excessively

commove in major government bond markets, capturing comovements with simultaneous correlations between bond yield innovations.

Reisen and Maltzan (1998) presented econometric evidence on comovements between sovereign credit ratings and government bond yield spreads in developed and emerging markets. The authors perform Granger causality tests to examine whether chosen rating agencies lead/lag financial markets. They argue that Granger causality test cautions against overestimating long-term impact sovereign credit ratings have on financial-market assessment of sovereign risk. Moreover, according to the authors, dollar bond spreads and a set of default factors explain the level of credit ratings better than the other way around. Reisen and Maltzan (1998) also proved that mutual comovements between government bond yield spreads and credit ratings may be characterized by the nature of sovereign risk, information content of sovereign risk ratings, and industrial organization of rating industry. Finally, Forbes and Rigobon (2002) argue that Granger causality tests might be useful to determine the sources of financial crisis by capturing the extent of feedback from each country.

From the research discussed above it can be seen that the majority of Grangers causality studies were implemented to assess contagion from one financial market to the others, since the essence of the method is to find causal unidirectional relationship between commoving markets.

Lee and Kim (1993), Meric and Meric (1997), Coudert and Gex (2006), Bunda, Hamann and Lall (2009) and Meric et al. (2012) assessed comovements between financial markets by employing Principal Component Analysis (PCA). Sometimes being referred to as a version of Factor Analysis, according to Meric et al. (2012) PCA is a commonly used multivariate statistical technique to analyse simultaneous comovements between financial markets, enabling to cluster the markets into distinct principal component clusters based on the similarities of their comovements. Consequently, financial markets with correlated, similar patterns are not advised to be chosen for portfolio diversification. When using PCA, asset returns are decomposed into orthogonal factors of decreasing explanatory power, and the common variation asset returns can be expressed as a linear function of a set of factors.

Principal components, derived from PCA, are summary measures that capture comovements between the factors and (decreasingly) represent the largest variance. If the analysed series follow a common pattern, the first principal component should explain most of the variance, and consequently be a satisfactory summary of all the series (ECB, 2007).

Volosovych (2005) employed PCA to analyse international bond markets from 1875 to 2002 and concluded that market integration during the late 19th century was markedly lower than in the last 20 years. Similar data and methods were employed by Mauro et al. (2002) and the results showed that contagion in modern bond markets had become much greater than it historically was.

Meric et al. (2012) reveal strengthening contemporaneous comovements between Asian stock markets, indicating the reduction of diversification benefits. Kalotychou, Remolona and Wu (2014) firstly used PCA to assess the global risk factor for the changes of government CDS spreads and then computed country-specific time-varying weights on it. Sløk and Kennedy (2004) used PCA to identify a common risk premium trend in stock and bond markets and captured the impact of global macroeconomic and liquidity risks on the changes of security risk premium. Similarly, McGuire and Schrijvers (2003) used PCA to assess the risk premium in emerging financial markets and found the most important factor being the representation of global risk aversion. Finally, Bunda, Hamann and Lall (2009) employed PCA to quantify the excess comovements for all emerging countries and found evidence of market inconsistencies and investor discrimination between the markets. In addition to PCA, the researchers used cluster analysis to exclude similar groups of financial markets.

Assessing comovements between financial institutions or markets through cluster analysis is not new in academic literature. Some of the first authors adapting network theory and in particular cluster analysis to financial data were Panton et al. (1976), employing the method to investigate comovements between stock markets. Mantegna (1999) argued that time evolution of stock returns is well described by random processes, assesses comovements among the stocks in the US, basing them on stock price correlations, and constructs hierarchical network of these stocks. Onnela et al. (2005) and Namaki et al. (2011), among others, analysed financial markets as structured networks with vertices representing financial assets and edges representing correlations between their returns. Onnela et al. (2005), Tumminello et al. (2007) revealed the existence of financial networks within stocks traded in NYSE. In money markets, Adamic et al. (2017) used network metrics to demonstrate the comovements between trading strategies and transaction prices, trading volumes, duration, and liquidity.

Clusters forming in the networks of financial institutions have been analysed by Cetorelli and Peristiani (2009), assessing the relative importance of global financial centers and examining network characteristics of cross-border flows. Amini, Cont and Minca (2011) identified a network among financial institutions as a complex dependence structure where stress of some institutions propagates to others due to a dependence structure. Battiston et al. (2012) found that a cluster of strongly connected financial institutions is extremely systemically important at the peaks of financial crises. Boss et al. (2004) analysed how network structure affects the banking system stability and identified central institutions, the removal of which would lead to collapse of entire financial system.

Even though many authors treat financial networks as static, there exists a wide range of literature evaluating contagion spreading within financial networks. Some of the authors who

implemented this type of research were Allen and Gale (2000), Amini, Cont and Minca (2011), Acemoglu et al. (2013), Kocheturov, Batsyn and Pardalos (2014) and others, and the obtained results were not unilateral. For example, Allen and Gale (2000) argue that in a denser financial network, the impact of negative shocks to individual institutions is reduced. Acemoglu et al. (2013) confirm that weakly connected financial networks are less fragile than more complete networks. Kocheturov, Batsyn and Pardalos (2014) found that financial cluster structures change more chaotically in normal periods and show more stable behaviour in crises.

Cluster analysis is destined to group financial markets into clusters, with all markets inside one cluster exhibiting similar behaviour that is different from that of markets in other clusters. As a result, markets within a cluster should react similarly to different systemic factors. As Gautam (2012) noticed, a drawback of this classification is potential overlap of systemic factors: a high distance between the clusters leads to the conclusion that clusters are impacted by factors specific to them while a small distance represents the existence of overlapping systemic factors. Consequently, it is important to examine whether this kind of clusters (with small within-cluster and large between-cluster distance) exist among global government bond markets. The main assumptions of cluster analysis are as follows:

1. There exists some known structure of grouping the data examined. It is questionable if the countries could be described as a homogenous group in terms of index returns, or there exist distinct groups of different countries, forming the clusters with considerable differences among the groups.

2. Certain parameters of this structure are known and can be estimated.

As Berkhin (2002) noticed, clustering techniques are traditionally divided into partitioning and hierarchical. Partitioning clustering is designed to cluster data units into a single classification of k clusters, where k is usually specified in advance. The main idea is to choose initial partitions of data units and alter the cluster memberships in order to obtain better partition. Contrarily, hierarchical clustering allows to reveal hierarchies of separate clusters. Hierarchical algorithms build clusters gradually and, in doing so, they either try to discover clusters by relocating points between subsets, or try to identify clusters as dense area of data. Some researchers further divide hierarchical clustering into divisive and agglomerative (Berkhin, 2002; Fraley and Raftery, 1998).

Panton et al. (1976) suggested that, when implementing Agglomerative Hierarchical Clustering (AHC), each entity is firstly considered as a separate cluster. By using a defined measure of similarity, the two most similar clusters are found, merged and treated as single cluster, leading to n-1 clusters. In each subsequent step, the two closest clusters are merged. The process is continuously repeated either until a desired number of clusters is formed or until all the entities are merged into one large cluster.

It should be noted that out of a wide range of studies of network and cluster structures between financial markets, there exist not many studies dedicated to government bond markets. One of the few to be mentioned is a study of Gilmore, Lucey and Boscia (2010), who analysed the comovements between 20 government bond markets and proved that the EU markets commove most strongly. They also identified a subset of EMU countries with the strongest linkages in between, while the non-EU government bond markets behaved more independently. In addition, the authors caught a tendency of increasing integration among the analysed markets.

Some researchers implemented analysis of dependence between stock and bond markets, concentrating on correlation (conditional and unconditional) between the markets (Shiller and Beltratti, 1992; Campbell and Ammer, 1993; Longin and Solnik, 1995; among others). After implementing correlation analysis between financial markets with more than a century's worth of data, Quinn and Voth (1998) showed that correlations increase as financial markets are liberalized. Nevertheless, as argued by Dornbusch and Claessens (2000), a marked increase in correlations among different countries' markets may not be a sufficient proof of contagion: if markets are historically correlated, a sharp change in one market leads to changes in other markets with markets exhibiting an appreciable increase in correlations during crises. According to Forbes and Rigobon (1999), under heteroskedasticity of asset price movements, an increase in correlations could simply be a continuation of strong transmission mechanisms existing in more stable periods. The authors also showed that an increase in asset price correlations could be a result of changes in economic fundamentals, risk perception, and preferences.

Forbes and Rigobon (2002) demonstrated that measured correlations are affected by return volatility: a marked increase in correlations among different countries' markets is identified as a proof of contagion. According to Dornbusch and Claessens (2000), most of the studies assessing correlations among markets found evidence of strong comovements in a variety of asset returns, although there is less consensus on whether such comovements increase during crises.

It should be noted that the purpose of multivariate factor analysis slightly differs from the others investigated, since it is mostly destined to assess the factors influencing market characteristics or relationship among them. Kalotychou, Remolona and Wu (2014) used a multivariate factor model to reveal the transmissions and common mechanisms of shocks between government bond markets. Stephan, Maurer and Durr (2000) noticed that multivariate factor models are destined to explain the dependence of asset returns and their covariances on a limited number of risk factors, and are usually based on one of the key principles of financial theory: return does not come without the risk. These models were firstly adapted by investment practitioners because they allow for differentiated risk-return analysis. Stephan, Maurer and Durr (2000) listed three main methods used in factor models:

1. Time series analysis
2. Sectional analysis
3. Statistical factor analysis

In time series analysis, the matrix of weights is assessed according to the known factor values with the factors chosen being possible to control. Berry, Burmeister and McElroy (1988) argued that linear regression is most commonly used for this assessment, based on the assumption that parameters are stable. It should be noted that if the parameters used do not present high stability, the methods based on time-series require adaptation to sudden changes. Bracker and Koch (1999) used pooled regression as a system of seemingly unrelated regressions describing economic determinants of correlation structure while Pretorius (2002) implemented pooled regressions on averages of explanatory variables in order to explain why stock markets are correlated and to reveal the part of correlations that can be explained.

One of the most commonly employed assumptions in sectional analysis is that the sensitivity of securities is known. Regression is implemented simultaneously for all the securities rather than for a separate security in all periods. Weight matrix serves as regression matrix, and the evaluated parameter vector is interpreted as the vector of factor estimates. This kind of regression is implemented for several periods in order to obtain the time series of factor estimates. Starting with this type of time series, it is later possible to obtain the factor covariance matrix. The drawback of this analysis is the initial assumption since sensitivity is not always known in advance.

The third method used in multivariate factor models is statistical factor analysis, built to simultaneously assess both weights and factors. It enables explaining a number of linear combinations between random observations (interpreted as factors). All the model variables can be assessed from historical returns under the assumption that asset returns have multivariate normal distribution. The advantage of statistical factor analysis is the "objectivity" of the method: sensitivity and factors are not described in advance but are assessed from the data. Nevertheless, the parameters in factor analysis have to be stable.

The main strengths of factor analysis, listed by Malhotra et al. (2010), are the following: 1) it gives a reasonable risk description and the characteristics of asset returns; 2) there is no pressure to adequately assess market portfolio; 3) factor analysis can be useful for hedging the risks: it excludes specific risk factors rather than searches for optimal market portfolio. As the main drawbacks of factor analysis, Malhotra et al. (2010) listed: 1) it does not indicate specific factors influencing securities' returns, so there is no equality between different versions of factor analysis; 2) factors are time-varying, reducing the benefits of the model; 3) factors can change independently from an individual security; 4) model requires big dataset.

To sum up, even if multivariate factor analysis can be used more precisely than univariate models to assess dynamic comovements between financial markets, one of the main drawbacks of these models is uncertainty of the chosen factors. Researchers do not unanimously agree on the factors that should be included into these models, with the choice of the factors depending more on a specific market, and leading to lack of consistency between the obtained results. In spite of that, the majority of researchers agree with the existence of the primary sources of risk constantly affecting the securities' returns. It is expected that identification of these sources as well as strengthening integration between financial markets will lead to consolidation of the results obtained by different researchers in the field.

It should be noted that the methods discussed here are undoubtedly not the only methods used to assess comovements between financial markets. Other researchers also used Generalized Dynamic Covariance (GDC) or Asymmetric Dynamic Covariance (ADC) models and determined the dynamics of conditional correlations and volatilities between different asset classes' markets in the same country (Kroner and NG, 1998; Scruggs and Glabadanidis, 2003). Nevertheless, these methods will not be used in the further analysis, so they are not discussed in more details.

A detailed analysis of the methods used to assess the factors influencing financial market comovements is given in the following pages, and is summarised in Table 4.

Bracker and Koch (1999) analysed whether, how, and why the correlation structure between financial markets changes over time by testing correlation matrix stability over different periods, and modelling economic determinants of correlation structure in stock markets. The authors developed a theoretical model with time series of pairwise correlations depending on the factors that characterize and influence economic integration across two markets.

Caramazza, Ricci and Salgado (2000) used panel probit estimation to analyse the role of financial linkages and weaknesses while controlling for external and internal imbalances and trade spillovers in emerging and industrial markets. When these factors are controlled for, financial linkages/weaknesses explain emerging market spreads, while exchange rates and capital controls do not matter. The authors also showed that crises in industrial countries can have different nature.

Pretorius (2002) implemented cross-sectional analysis with pairwise simple correlations being pooled across all country pairs and regressed on the averages of explanatory variables in order to explain why stock markets are correlated.

Time-series approach was used to explain why this relationship change over time. The author showed that a substantial proportion of interdependence among emerging stock markets could be explained by fundamentals, leading to the conclusion that there was still place for diversification among emerging stock markets.

Table 4 Previous Research of the Factors Influencing Financial Market Comovements

AUTHORS	COUNTRIES AND PERIOD	METHOD	ESSENCE
Bracker and Koch (1999)	Australia, Canada, US, Japan, Germany, Hong Kong, UK, Singapore, Mexico, Switzerland; 1972-1993	Regression analysis	Estimated correlations between daily returns on a chosen quarter depend on the differences between the chosen country-specific factors. This dependence is assessed via regression equations.
Caramazza, Ricci and Salgado (2000)	61 industrial and emerging market economies, 1990-98	Panel probit estimation regression	Currency crises assumed to be influenced by economic indicators, inducing the crises, and financial linkages/weaknesses.
Pretorius (2002)	Argentina, Brazil, India, Mexico Greece, Malaysia, China, South Africa, Turkey, Korea, 1995-2000	Pooled regression	Cross-sectional and time-series models are used to aggregate more data and to obtain common tendencies on comovements between stock markets and the factors influencing them.
Forbes and Chinn (2003)	France, Germany, Japan, UK, US and 40 developing markets; 1986-2000	Two-stage factor model	A country's market returns are a function of global, sectorial, cross-country (returns in other large financial markets) and country-specific factors.
Weigel and Gemmill (2006)	Argentina, Brazil, Mexico and Venezuela; 1994-2001	Structural model	Distance-to-default is a function of global, regional and country-specific factors. The influence assessed via the part of variance explained by those factors.
Rose and Spiegel (2009)	Cross-section of 85 countries 2006-2009	MIMIC model	Crisis indicator is a function of crisis cause and severity. MIMIC is a system of equations with proportional right-hand-sides, constraining the structure to "one-factor" model. MIMIC explicitly includes measurement error about the crisis incidence and severity.
Bunda, Hamann and Lall (2010)	18 of the 33 emerging bond markets included in the EMBI Global index; 1997-2008	Three-factor model	Comovements between the markets disentangled into global factors and residuals. The influence of country-specific factors identified by correlation changes after controlling for global factors.
Didier, Love and Martinez Peria (2012)	The US and 83 other global stock markets	One-step approach	Comovements between the US and other markets investigated are assessed to be influenced by country-level characteristics, representing the different channels of transmission.
Mensi et al. (2014)	BRICS countries; 1997-2013	Quintile regression approach	Enables examining conditional dependence of specific stock return quintiles with respect to conditioning variables. Reveals global factors' impact on stock market returns under different conditions.
Shinagawa (2014)	42 non-euro countries, the EMU countries, and emerging economies; 2001-2012	Arellano–Bond GMM and regression	Correlations of stock returns or bond yields in two markets are regressed on a set of bilateral factors (linkages) between the countries
Paniagua, Sapena and Tamarit (2015)	Greece, Portugal, Italy and Spain; 1990-2011	State-Space model and Kalman Filter	Vector state estimates were obtained by taking into account all the information, while state-space dynamic model representation enabled assessing observed vector dynamics in terms of unobserved one. Regression with time-varying parameters allowed decomposing determinants into fundamentals and market perceptions.

Forbes and Chinn (2003) used a two-stage factor model to assess the importance of different factors on financial market linkages. They estimated the factor model of returns, controlling for global, sectorial and cross-country factors, and decomposed cross-country factor loadings into

different bilateral linkages. They controlled for global and sectorial factors, and divided the countries into large countries (c countries) and small countries (i countries).

In order to assess the influence of cross-country factors on government bond market returns, they assume that shocks are only transferred from large countries to smaller and not vice versa, and assess the influence of bilateral linkages for every pair of large and small countries. The method enabled them to identify the way through which bilateral linkages between large country and smaller country influence the transmission of shocks.

Weigel and Gemmill (2006) used bond prices to assess how the emerging market's creditworthiness is influenced by global, regional and country-specific factors. Each country's monthly distance-to-default was assessed by changing the extended structural model of Cathcart and El-Jahel (2003), in order to relate distance-to-default measure to global, regional and country-specific factors. The authors found that distance-to-default is strongly driven by systemic global and regional factors, and recommend investors to treat credit risk in emerging markets as non-diversifiable.

Rose and Spiegel (2009) focused on international linkages that allow crises to spread across the countries. They used the MIMIC model, introduced by Goldberg (1972), to assess the influence of international linkages on crises' spread across the countries, and did not find strong evidence that international linkages could be clearly associated with the incidence of crises. In particular, countries heavily exposed to either American assets or trade behaved not a lot differently than other countries; if anything, countries seem to have benefited slightly from American exposure.

Didier, Love and Martinez-Peria (2012) empirically investigated factors that determine stock markets' vulnerability during the 2007-2008 crisis in 83 countries. The researchers employed one-step approach to assess transmission channels and explore the factors driving comovements between local and the US stock market returns: each markets' correlation with the US market was interacted with country-level characteristics. This methodology enabled identifying and comparing the extent to which different factors impact the sensitivity of domestic stock market returns to the US market returns. The researchers also analysed whether stronger bilateral linkages indicated stronger comovements between countries and the US stock markets and obtained positive results.

After assessing comovements in emerging markets' bond returns, Bunda, Hamann and Lall (2010) analysed the influence of external and domestic factors on these returns. They assumed comovements to be influenced by common external factors and other factors, estimated pure market comovements and reassessed them by controlling for the influence of global factors,

calculating simple (ρ) and adjusted ($\hat{\rho}$) correlation coefficients. The scheme of initial expectations, drawn by the authors, can be seen in Table 5.

The researchers argued that when ρ represents high positive values and $\hat{\rho}$ is positive, small but significant, returns in the two countries would be correlated with the global factor in the same way. Contrarily, when ρ is significantly smaller than true (residual) comovements outbalance the influence of global risk factor. Consequently, removing the impact of global risk factor strengthens the linkages. Finally, if both coefficients are the same, market comovements should be explained by country-specific factors.

Table 5 Changes in Bond Market Comovements and the Factors Influencing them

ρ_{unadj} (ρ_{ij})	ρ_{adj} ($\hat{\rho}_{ij}$)	**FACTORS**
↑	↓;≈	Global
↓;≈	↑	Country-specific
↑	↑	Global and country-specific
↓;≈	↓;≈	Investors lack of anticipation

Note: ↑ - increasing, ↓ - decreasing, ≈ relatively stable.
Source: adapted by the author, based on Bunda, Hamann and Lall (2005)

The wider the gap between the correlations is, the more these correlations depend on global factors, even though it does not indicate the direction.

Mensi et al. (2014) used regression to analyse dependence structure between stock markets in BRICS countries and influential global factors (S&P 500 index, commodity market uncertainty, global stock market uncertainty and economic policy uncertainty). The results indicate that BRICS stock markets exhibit asymmetric dependence with the global stock market, which has not changed since the onset of the global financial crisis.

Shinagawa (2014) proposed a model for the assessment of spillover for stock or bond markets as a function of financial market spillovers channels. The Arellano–Bond Generalized Method of Moments (GMM), as well as multiple regression analysis, is used to assess the model. The GMM is applied to dynamic panel data with lagged dependent variables, like instrumental, on the sample countries. To examine whether spillover channels became more or less important during the 2008-2010 crisis, a separate model, including interaction terms of crisis dummies and spillover channels, was estimated.

Paniagua, Sapena and Tamarit (2015) analysed the determinants of sovereign debt spreads in the peripheral EU countries. They employed Kalman Filter, a set of equations allowing to obtain the best vector state estimates taking into account all the available information, and state-space representation of dynamic models, allowing to estimate the dynamics of observed vector in terms of unobserved vector. This kind of models were used to measure public future expectations, influencing multiple economic models. The authors also used regression to decompose factors

into fundamentals and market perceptions, and used regression for government bond yield spreads as variables, dependent on country's fundamentals, market liquidity measures and a measure of global risk aversion. The results showed that risk-aversion, credit risk and liquidity risk influence the EMU bond yield spreads due to high degree of financial integration.

Generalizing the discussed methods, it can be stated that most of the analysed research incorporated factor and regression models to assess the factors influencing financial markets and their comovements. For example, Forbes and Chinn (2003) assumed separate country's security market returns to be a function of global, sectorial, cross-country and country-specific factors. Since the purpose of this dissertation is to assess the influence of different factors on government bond market comovements, there is no need to analyse sectorial factors – the only investigated sector is the government sector. Weigell and Gemmill (2006) were some of the firsts to assess regional factors as influencing financial market comovements. It was possible because the authors analysed only 4 countries in the same region. Nevertheless, identification of the regional factors influencing financial market comovements is usually not definitive, because the division into regions can be questioned.

As it was expected, analysis and synthesis of earlier scientific research and the methods used did not provide unanimous results. Despite of that, it enabled systematising the methods most commonly used for the analysis. Furthermore, it should be noticed that the difficulty in describing and segregating the methods was caused by the fact that many authors did not count on one method for assessing the factors influencing financial markets and relationship between them but rather used a combination of methods. As some authors argued (e.g. Bunda, Hamann and Lall, 2009; Cronin, 2014; Kalotychou, Remolona and Wu, 2014; among others), the use of different methods for the same analysis provided more robust results as well as revealed separate tendencies that could not be captured by a unique method.

The investigation of other research designed to assess the relationship between financial markets led to several results. It appeared that the obtained results highly depended on the made assumptions. Nevertheless, among the analysed studies, only little attention was given to the evaluation of comovements between government bond markets. This gap needs to be filled, since as a follow up of financial and sovereign debt crises, some of the countries in Europe and other continents have developed liquid and high capitalization government bond markets that have become very attractive to investors. Despite of that and the fact that they were previously treated as having a minimum risk, government bonds could be currently evaluated similarly as other financial assets, with their return strongly depending on a country's or global market conditions. As a result, it's important to assess the comovements between global government bond markets,

to highlight the existence of the closely commoving groups and to identify and assess the factors influencing the comovements in the global environment.

1.4. Results and Generalization of the Literature Analysis

Investigating the characteristics of the global financial environment, including financial markets and their comovements, and the factors influencing the markets, enabled to prepare a conceptual framework for the assessment of the factors influencing government bond market comovements in the global environment. Its graphic representation can be seen in Figure 5.

It has been mentioned that even though there exists a vast literature on the factors influencing financial markets, not many research investigate what factors influence government bond market comovements. In the global economic environment, comovements between government bond market *i* and government bond market *j* are by themselves an independent phenomenon, which should be separately investigated, and only then the influence of different factors on these comovements should be assessed.

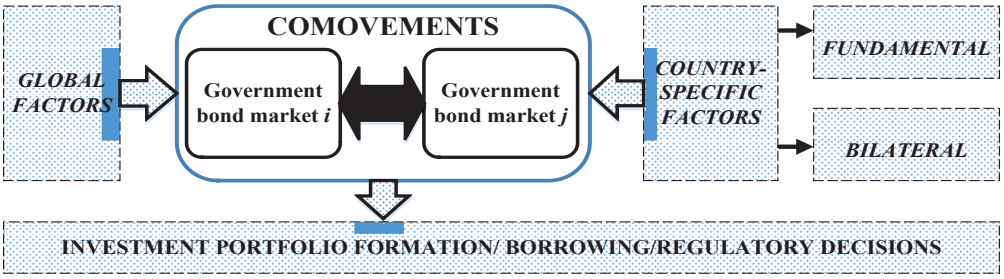


Figure 5 Conceptual Framework of the Comovements between Government Bond Markets and the Factors influencing them

Analysis of research literature enabled the author to determine that comovements between government bond markets were influenced by two groups of factors – global and country-specific – with the latter ones further divided into fundamental and bilateral factors.

Conceptually, global and country-specific (fundamental and bilateral) factors influence government bond market comovements and, through them, investment portfolio formation and borrowing or regulatory decisions. With strong influence of global factors on government bond market comovements, the capability of investors to diversify their investment portfolio diminishes. Moreover, in this situation, governments have less capacity to manage their debt in an efficient way, since the cost of debt and the ability to borrow depends more on the global financial situation and not on the country's characteristics or the actions taken by its government.

Finally, with a strong influence of global factors on government bond market comovements, regulatory institutions have a limited power to organise the distribution of funds and manage the regional and global financial processes, since they are more subject to overall contagion.

On the other hand, with government bond market comovements more strongly depending on country-specific factors, investors have more possibilities to benefit from diversification. Moreover, governments have more power over their cost of debt, while regulatory institutions are more capable to form longer-term policies, supported by the regulations and frameworks. Furthermore, with strong influence of bilateral factors on government bond market comovements, governments might not only strengthen their fundamentals, but their trade or financial linkages with the countries, they want their government bond markets to be associated with. It should be also taken into account that comovements and the influence of different factors/groups of factors on them might change over time, giving a chance to reflect the situation only for the certain periods of time. This, as well as other results from literature analysis are discussed below.

Analysis and the synthesis of related literature in the field enabled identifying the principal tendencies, common to the different research analysed and highlighting the main research gaps. This information is summarized in Table 6.

Firstly, it can be seen from the Table 6 researchers assessed the strength and the stability of the dependence between financial markets, only a small part of them investigated the common features among the countries and, in particular, among the groups of government bond markets. This left a gap for the assessment of government bond market comovements and identification of the groups of markets most closely commoving in between.

Secondly, there exists a tendency for researchers to concentrate on either developed or emerging government bond markets or comovements of these markets. A lot of researchers argued that developed government bond markets were highly integrated and displayed comovements in both short- and long-terms. Differently, emerging markets were proven to be the followers, taking over the shocks that originated in developed markets. Analyses of both developed and emerging government bond markets and their comovements are relatively rare, unless the developed market is used as a proxy for global financial situation (as it commonly happens with the US).

Thirdly, a large number of studies have been designed to assess the integration of financial markets in the EU or the EMU. Researchers have proven that the introduction of the common currency is a significant factor influencing financial market comovements in the EU and changing the patterns of the countries' price of debt. In addition, government bond yield spreads in the EU had a tendency to decrease before 2008 and have significantly increased ever since. Unfortunately, there is a lack of research in other regions, making it difficult to generalize the influence of regional factors on government bond markets and their comovements.

Table 6 Common Features Excluded from the Research in Government Bond Markets

DIRECTION	RESULTS	AUTHORS	LACK OF ATTENTION
Assessment of the strength and the stability of the dependence.	The comovements between financial markets are strong but unstable. International cash flows towards the strongest government bond markets reduced the government bond yields.	Ilmanen (1995), Moneta (2003), Mody (2009), Arghyrou and Kontonikas (2012), among others.	Adoption of classification techniques to assess government bond market comovements and identification of their clusters.
Assessment of the factors influencing developed vs. emerging government bond markets. Highest attention towards the US market.	Common result – the transmission of shocks from developed to emerging markets. The tendency for emerging markets to follow.	Brennan, Kobor and Rustaman (2011), Yang (2005a), Ciner (2007), Becker and Ivashina (2013). Emerging markets: Daniel (2008), Ebeke and Kyobe (2015), among others.	Common assessment of comovements, reflecting investment alternatives and including majority of global government bond markets.
Assessment of market integration (especially within the EMU). Argumentation: changes in integrated markets should be determined by global factors while segmented markets should commove less	• Strengthening convergence between the markets • Influence of financial integration on market comovements: higher integration causing stronger comovements and reducing diversification effect. • The government bond yield spreads in the EU decreased until 2008 and significantly increased since then. Less research in other regions.	Bunda, Hamann and Lall (2009), Arghyrou and Kontonikas (2012), Fang (2012), D'Agostino ir Ehrmann (2013), among others.	Assessment of the government bond market integration within other regions.
Assessment of the factors influencing government bond yields and their spreads rather than influencing comovements.	• Factors vary depending on the investigated period. • Division into country-specific (fundamental) and global factors. • The US macroeconomic factors treated as global.	Kim et al., 2006; Perego and Vermeulen, 2013; Dunne, Moore and Portes 2006; Gomez-Puig, Sosvilla-Rivero and Ramos-Herrera, 2014; among others.	Assessment of the factors influencing separate groups of government bond markets and extraction of groups among them.
Assessment of contagion and spillover mechanisms, especially within the EMU government bond markets.	Assessment of contagion is gaining the majority of attention of researchers in the field. Proven transfer of contagion/financial shocks between the markets under unstable economic environment.	Longin and Solnik (1995), Ehrmann et al., (2005), Bekaert et al. (2012), Belvisi, Pianeti and Urga (2014).	Assessment of the opposite relation: can shocks in emerging markets influence the developed ones?
Assessment of systemic risk in financial markets.	• Commonly analysed from the perspective of market contagion. • Assessed to frequently be irrational, even based on herding behaviour. • Most commonly assessed in banking sector, excluding the systemically important banks.	Kaminsky and Reinhart (1998), Kauffman and Scott (2003), Lehar (2005), Segoviano and Goodhart (2009), Billio et al. (2012), Rodríguez-Moreno and Peña (2013).	Attention to systemic risk in the formation of investment portfolios in goverment bond markets.

Fourthly, there exists a tendency to assess the factors influencing government bond market yields or their yield spreads rather than market comovements. Researchers have commonly divided the analysed factors into global and country-specific, putting more emphasis on the global ones, especially represented by the global risk aversion measures.

Fifthly, a high level of attention is given to the evaluation of contagion (and its mechanisms). For example, European government bond markets were recently gaining a lot of researchers' attention due to the sovereign debt crisis. Researchers went relatively far from the fundamentals and commonly investigated only the mechanisms through which the contagion transferred. On the other hand, almost no attention was given to the transmission of tendencies to/from other regions.

Finally, even though government bond market comovements in separate countries/regions have been analysed before, the samples of the analyses usually did not cover more than 20 markets, making it more difficult to see the global picture of the comovements. This is of particular importance under the current low interest rate environment, with government bond yields in developed countries getting closer to zero or even becoming negative (e.g. Germany's case). Investors, seeking to earn higher expected returns, move their cash flows to emerging, less liquid and riskier markets, creating a need for a general picture of the comovements between the markets in the global environment.

It should be noted that comovements between government bond markets are in the centre of the model. They depend not only on the country-specific factors, but on the global situation as well. From the other side, comovements are influenced by the countries' bilateral factors, such as bilateral portfolio investment, bilateral trade, home bias and country concentration. Comovements between government bond markets in separate countries also depend on country-specific fundamental factors.

The stronger the markets commove in between, the higher the systemic investment risk should be. When government bond price movements in one market are similar to the movements in another market, in case one market experiences a large decrease, similar tendencies might transfer to the other market as well. The existence of systemic risk at least partly determines the criteria for investment portfolio formation and investment diversification. As it has already been stated in the previous sections, an optimal investment portfolio should enable to hedge he various risks, so it should not include the financial assets closely commoving in between. Nevertheless, investment portfolio formation decisions are not the aim of this dissertation and, as a result, will not be investigated in more details.

The framework, suggested in Figure 5, is further developed to construct a conceptual model and to prepare the research methodology for assessing government bond market comovements and the factors influencing them. That is the purpose of the second part of this dissertation.

II. METHODOLOGY FOR THE ASSESSMENT OF THE FACTORS INFLUENCING GOVERNMENT BOND MARKET COMOVEMENTS

Fast integration of global financial markets is proven to leave less space for portfolio diversification as comovements of international markets are claimed to be driven by the same forces. Despite of that, in the search of diversification possibilities next to stock markets, increasingly more investors started considering government bond markets as well. During this process it is a question of essential significance whether the global government bond markets are strongly related and move together, or they can still be used to benefit from regional or international diversification.

Historically, risk-averse investors tended to choose investments in government bonds, being less volatile, providing smaller return and being seen as safe haven in times of stress in financial markets. In the context of a sovereign debt crisis, increased risk of countries themselves and the ongoing debate on whether government bonds can still be seen as securities representing minimum risk, government bonds have been gradually becoming substitutes for stocks and do not separate investors into risk-averse and risk-takers. Furthermore, due to proven changes of relationship between financial markets in times of financial stress, analysis of global government bond market comovements in this context becomes highly relevant. Furthermore, even if government bond markets are proven to commove together, another essential question is what triggers these comovements.

Being aware of whether comovements are caused by changes in the global environment or country-specific factors makes it easier to forecast future comovements and to use them in investment allocation. Moreover, this question is also relevant for national governments, regional and global regulatory organizations, and policymakers, when developing and implementing investment regulation policies as well as policies for countries borrowing/emissions. As Boffelli and Urga (2013) noticed, identification of the factors influencing government bond markets and their comovements helps policymakers to determine the probability of risk-materialization and enables taking appropriate policy actions. Moreover, it is also relevant to assess government bond market comovements in order to provide recommendations whether regional diversification inside the same asset class market is a reasonable solution in present environment.

Analysis and synthesis of scientific literature has revealed that most research concentrated on comovements between major stock markets with less attention being paid to bond, and, particularly, government bond markets. Research designated to assess comovements between government bond markets were mostly concentrated on the EU countries. The earliest studies in European government bond markets had a tendency to estimate the differences between bond

yields in developed versus developing financial markets and the determinants causing the differences (Bernoth et al., 2006; Gomez-Puig, 2006 among others). Another line of research concentrates on the EU government bond markets during the introduction of the common currency and assesses the effect of bond yield convergence within that time (Manganelli and Wolswijk, 2009). Later, the attention has been transferred to dependence between the EU government bond markets, especially in the period after the sovereign debt crisis.

A better understanding of the dynamic changes in government bond market comovements is critical, having in mind that this structure reflects the nature and the extent of global market integration, as well as the risk-return performance of international government bond portfolios. Recent situation in global government bond markets makes the ability to predict changes in comovements of high interest to market participants, national policymakers, and regulatory bodies involved in monitoring and managing global financial market behaviour. Changes in the comovements, changes in expected returns and the variations between the national government bond markets, imply the shifts in the international positioning of markets over time.

2.1. Proposed Model for the Assessment of the Factors Influencing Government Bond Market Comovements

Greater economic integration across the countries should lead to greater capital market integration with the idea that dependence between trade and capital flows among the countries leads to interdependence of investors' valuation decisions. If that's the case, the pairs of countries with greater economic integration should experience stronger comovements between their financial markets. In this research, the approach is adapted to test whether greater economic integration (stronger linkages) leads to greater government bond market integration (stronger comovements). Analysis of scientific literature and research gaps identified as the result of the bibliographic study enabled proposing a model to assess the factors influencing government bond market comovements which is presented in Figure 6.

To better understand the dynamics of government bond market comovements, country-specific factors are employed, hypothesising that the degree of global government bond market integration depends on the degree of country's integration with the other observed countries. This analysis is expected to reveal economic forces influencing market comovements over time and, simultaneously, global government bond market integration. Consequently, it supports the idea that divergent countries' economic behaviour could be associated with divergent behaviour across national government bond markets, resulting in lower comovements between them.

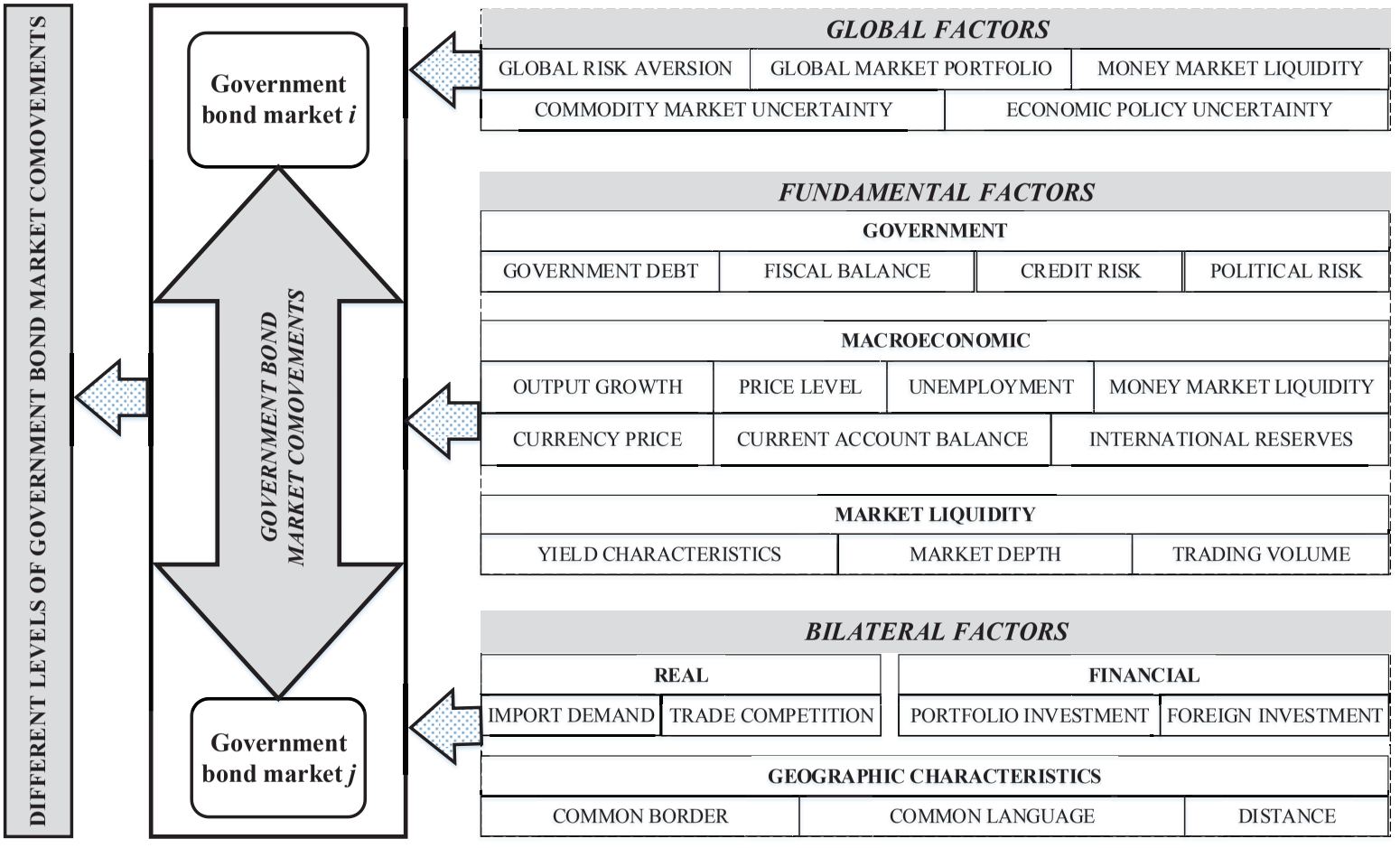


Figure 6 Proposed Model for the Assessment of the Factors Influencing Government Bond Market Comovements

The majority of previous studies concentrate on the assessment of dependence between stock markets, assuming that these markets are more often selected for investment diversification and their dependence is more worthy of investigation. The aim of this research is to assess comovements between government bond markets, treating these markets in a similar way as stock markets and testing whether the same dependence and integration patterns are applicable for them.

The proposed model, presented in Figure 6, is the basis for testing different levels of government bond market comovements. This model consists of two major parts: comovements between government bond markets and the factors influencing them. Despite the fact that the results of previous research enable to expect government bond market comovements to be significant, this argument still requires confirmation. If the existence of the comovements is confirmed, their assessment would be implemented.

Further on, the level of government bond market differentiation is determined by identifying the groups of markets most closely commoving in between and drawing the general map of their comovements. Even though clustering has been previously used to project the relationship between financial markets, to the best knowledge of the author, none of the previous authors employed it to analyse comovements between global government bond markets. Since there exists a variety of government bond markets in global context, in order to understand comovements between these markets, clustering methods are used. This dissertation connects research in government bond markets with research in cluster analysis in order to assess clusters appearing among global government bond markets.

Returns of government bond markets in two countries could commove due to a number of reasons. Firstly, comovements could appear because returns in both countries could be affected by global shocks, such as changes in global financial markets, world interest rate, or global risk aversion. Secondly, returns in both countries could be affected by country-specific fundamental factors, representing the strength of domestic economies or the characteristics of markets. Finally, comovements could appear because shocks to one country are transmitted to other countries through cross-country linkages, such as bilateral trade, export competition in third markets, bilateral bank lending, or bilateral investment flows.

Following the analysis of scientific research in the field, the results obtained by other authors and the conclusions made in the first part of this dissertation, the author was able to create a classification of these factors dividing them into three distinct groups.

The first group of factors, identified by the author of this dissertation, are global factors, expected to be common to every analysed government bond market and influence comovements between them in the same way. These factors represent the global economic situation, covering stock, money, commodity markets, global risk aversion and economic policy uncertainty.

Global volatility is commonly assessed by global risk aversion and its measures (Manganelli and Wolswijk, 2009; Codogno et al., 2003; Schuknecht et al., 2010; among others). As it has already been discussed in the first part of this research, global risk aversion might be represented by different measures. Some of the most commonly used ones are Global Risk Aversion Indicator, calculated by the ECB, and VIX. It is intuitive that the index, calculated by the ECB would rather reflect the situation in European markets, while VIX could be used as a more global measure. Consequently, based on the performed analysis, the author chose VIX index for the model.

Global liquidity measures were also found to be important determinants of global market situation (Kashiwase and Kodres, 2005; Gonzalez-Hermosillo, 2008; among others), so they have been included in the model. The second global measure identified as reflecting money market liquidity is the FED short-term interest rate. As Manganelli and Wolswijk (2007) argued, they are the main force driving government bond yield spreads, while Battern et al. (2004) showed that credit spreads were negatively related to changes in the US interest rates. As it has already been discussed in the first part of this research, one of the most common interest rates used as a proxy is 3-month-ahead federal funds futures rate, affecting monetary conditions by two channels: 1) a decline in FED rate indicates lower borrowing costs and increased liquidity in the economy; 2) it reduces the returns from safer investment (e.g. government bonds).

Stock market situation is reflected by global market portfolio, proxied by changes in Standard and Poors 500 index value (Bunda, Hamann and Lall, 2010; Mensi et al., 2014). Standard and Poor 500 stock market index (SPX) is commonly used as world stock market portfolio and represents mature markets. Since stocks can still be identified as alternative investments to bonds, the structure and changes in this index should reflect a competitive market environment. Moreover, sensitivity of government bond market returns to changes in stock market returns might reflect global portfolio reallocations between bonds and stocks. Investors' attitude towards stock markets partly depends on expected growth of home country: investors prefer domestic stocks when earnings' growth is high and may switch to riskless assets when the risk aversion increases.

Commodity market indicators are also chosen to reflect global financial situation. These indicators are changes in gold and oil price. Mensi et al. (2014) used WTI crude oil price expressed in US dollars per barrel, which is a global benchmark for determining the prices of other light crudes in the US. Moreover, oil market is also largely determined by political factors and internal situations in major producing/consuming countries, as well as international conflicts and tensions.

According to Simakova (2015), even if a significant component of gold demand results from its rarity, in practice it is an essential investment portfolio element. Moreover, price of gold is in many terms influenced by governments and central banks: monetary policy performed by governments, changes in interest rates, inflationary policy effects are related to price of gold, often

used as an official reserve asset. Consequently, changes in gold prices should influence government bond market comovements.

The final global factor included in the proposed model is economic policy uncertainty measured with an index (EPU). Leippold and Matthys (2015) showed that an increase in government policy uncertainty resulted in a decline in government bond yields and an increase in bond yield volatility, while monetary policy uncertainty had no simultaneous effect on yields and volatilities, but enabled predicting bond risk premium. As the authors argued, government policy uncertainty played an important role in determining the level of interest rates, and the level and shape of term structure of bond yield volatilities. Baker, Bloom and Davis (2012) found evidence that increases in EPU foreshadowed declines in output, employment and investment. This factor should be important in this analysis with the changes in government bond market comovements potentially being strongly driven by global political situation.

All the five global factors discussed above are further used for the assessment as influencing government bond market comovements. The second group of factors identified as influencing government bond market comovements are country-specific factors, further divided these factors into fundamental and bilateral.

As it has already been noticed by other researchers, occasional contagion effects appeared between certain groups of financial markets, making them commove and crash together in response to economic and/or political events, temporarily exhibiting excessive correlations. Since global government bond markets evolve and integrate, these processes can be described by changes over time in correlation matrix across national government bond market returns. Backer and Koch (1999) highlighted the importance of modelling, and forecasting dynamic movements in the correlation structure between these markets. Identified fundamental factors are factors specific to particular country and most commonly identified by other researchers as significant.

Even though fundamentals are commonly seen as reflecting a country's macroeconomic situation, in this research they are further divided into government factors, macroeconomic factors and market-characterizing factors. The latter reflect investor's required compensation for a non-zero country's probability of default.

The macroeconomic group includes the main factors commonly used to assess a country's economic situation: output growth, price level, unemployment, and money market liquidity . Other macroeconomic factors influencing government bond market comovements are a country's currency price, current account balance and international reserves. Currency price is commonly expressed in real or nominal exchange rate, assessed as the weighted average of a country's currency to a basket of major currencies. Current account balance and international reserves are commonly scaled by country's GDP (Barrios et al., 2009; d'Agostino and Ehrmann, 2013; Perego

and Vermeulen, 2013). Since the majority of government and macroeconomic factors are scaled to GDP, utilization of gross GDP as a separate factor would cause a multicollinearity problem.

The second group of fundamentals are the characteristics of governments, specific to this analysis due to the fact that government bond markets are investigated. Since government bonds are used for debt financing, changes in this set of factors are expected to significantly influence government bond markets in the global environment. The main factors excluded are government debt and fiscal balance, depending on the investigated time period (Yang, 2005b; among others). The most common measure of fiscal balance was the ratio of fiscal balance to GDP while the estimation of government debt could be further divided into gross debt, external/domestic debt or debt servicing costs, all scaled by country's GDP. Hallerberg and Wolff (2008), De Grauwe and Ji (2012) used gross debt to GDP ratio to reflect government debt's influence on government bond market comovements, while Attinasi et al. (2009), Arghyrou and Kontonikas (2011), used a ratio of fiscal deficit to GDP.

In addition to the main factors mentioned, some authors identify a country's credit risk (expressed in credit rating) or a country's political risk (expressed in the political risk index) as influencing government bond markets. Literature analysis has shown that a country's credit rating involved too much various information for it to be assessed as a single factor and was more often used as a substitute for measuring comovements themselves. Having in mind the political situation in 2016-2017, a country's political risk should also be taken into account. This is substantiated by the fact that the situation in government bond markets, as a reflection of a country's financial policy, might change depending on the stability of the political situation inside the country. Nevertheless, political risk index is a rather subjective and infrequently calculated measure, so its influence on government bond market comovements is difficult to assess.

The third group of identified fundamental factors includes all the characteristics related to government bond market liquidity. As it has been mentioned, researchers do not agree on how liquidity affects government bond markets. Some authors identified liquidity as a very important factor (Gomez-Puig, 2006; Attinasi et al., 2009; among others) while the others opposed its influence on government bond markets (Pagano and von Thadden, 2004). Nevertheless, liquidity factors are commonly included in the analyses of government bond markets.

The factors showing government bond market liquidity are: yield characteristics, measured by yield and bid-ask spreads; market depth, expressed in trading frequency and the size of one trade; and trading volume, expressed as a ratio of government bond market capitalization to a country's GDP. The latter factor is more often chosen for investigation of every country due to data availability. In addition, some other factors, such as yield spread, have been used to demonstrate comovements between government bond markets themselves. Even though many

other authors use the aforementioned factors as determinants of government bond yields, the author of this dissertation takes a novel approach to assess the influence of fundamental factors influence on government bond market comovements.

The third group of factors in the model are bilateral factors. An incentive to include them is based on the idea that if two countries present strong bilateral economic and financial dependence, their government bond markets should also commove strongly. The importance of these factors for the comovements of global economies has been proven by Forbes and Chinn (2003), Didier, Love and Martinez Peria (2012). Even though researchers do not agree on the classification of these factors, the author of this dissertation include real, financial and geographic factors in the model to explain government bond market comovements.

Real linkages refer to trade effects when changes in prices affect a country's ability to compete in foreign market (trade competition), or when there is a reduction of income and demand for import (import demand). On the other hand, financial linkages primarily reflect a country's direct and indirect financial accounts. Direct financial linkages arise due to direct financial exposure between two countries (assessed via foreign direct investment) while indirect financial linkages (portfolio investment) describe the actions of international investors that lead to financial market comovements. Some researchers showed that trade linkages between the countries were important determinants of how financial difficulties spread, while others argued that bilateral financial flows may have been even more important than trade flows, even if it could be difficult to isolate their independent effects. As Forbes and Chinn (2003) argued, one limitation of all of the studies was that many bilateral linkages were highly correlated, making these linkages difficult to measure and only allowing to include a subset of them. Consequently, studies that, for example, only assessed the trade and not financial linkages between countries, might result in an overestimation of the importance of trade linkages.

Finally, the idea of geographic characteristics influencing government bond markets has been exploited by Rose and Spiegel (2009), Teiletche and Xu (2008). The most common proxy for geographical characteristics is the distance between the countries, expressed in kilometres between their capitals, as well as common border and language.

The set of all the factors is expected to shed light on how bilateral dependence between the countries as well as their geographical/cultural positioning influences government bond market comovements and which markets have the strongest influence on the others in this field.

The proposed model is designed to assess the factors influencing government bond market comovements rather than returns on market indices. To the best knowledge of the author, other researchers did not investigate this aspect. Since this research is aimed to analyse the factors influencing government bond market comovements and not the market yields/returns, it becomes

more complex and the results contribute to the research field. The model is at least one of the first attempts to consequently assess the influence of global, fundamental and bilateral factors on government bond market comovements and reveal the role of each set of factors on these comovements.

2.2. Research Hypotheses

As it has been noticed, results of the studies conducted by other researchers in the field were not unanimous and did not allow to confirm tendencies to all markets. The first part of this research was designed to disclose characteristics of government bond market comovements and, as a result of the analysis, a model to assess the factors influencing government bond market comovements has been proposed in the previous section. Research hypotheses are made in order to empirically test the proposed model. Research aim and the proposed model allowed formulating five hypotheses that are presented further. The first two hypotheses are designed to assess government bond market comovements while the following three hypotheses concern the factors influencing these comovements in the global environment. Since government bond market comovements can generally be recorded by assessing correlation of bond returns, these returns can be driven by a wide range of underlying factors, either external or internal to the issuing country. Consequently, comovements are expected to be explained by heterogeneous factors.

In financial theory, government bond markets are traditionally assumed to be less volatile and providing more stable returns, being one of the safest investments and chosen by risk-averse investors. Nevertheless, these markets have also been experiencing fast integration and, as it has been noticed, most government bond market researches were conducted on the US (Reilly, Kao and Wright, 1992; Becker and Ivashina, 2013) or other big economies (Clare and Lekkos, 2000; Brennan, Kobor and Rustaman, 2011). Research carried out on the EU (Black et al., 2010; Bofelli and Urga, 2013) did not provide unified results and the question of government bond market comovements remained unanswered, presupposing the first hypothesis (H1) to be tested:

Hypothesis 1: Government bond market comovements in the global environment are significant.

Confirmation or rejection of H1 is intended to determine the existence of significant comovements between government bond markets. As it has been discussed, researchers have proven that global financial markets were related and dependent on each other, particularly concentrating on stock markets and arguing that government bond markets were less related to each other due to strong connection with politics. Even though there exists a relative lack of attention towards government bond markets, H1 questions the general existence of comovements between government bond markets. Comovements in different regions and smaller data samples

have already been proven by various authors, such as Sutton (2000), Ciner (2007), Manganelli and Wolswijk (2007), Brennan, Kobor and Rustaman (2011) and others. Some authors also highlighted the fact that comovements tend to strengthen in periods of high volatility in financial markets. Strong comovements between financial markets in the analysed period would not necessarily mean that the situation in the markets depended on the same external (global) factors – it may be the case that countries' fundamentals have also changed according to similar patterns. Nevertheless, this hypothesis enables estimating the existence of comovements between government bond markets in the period of analysis.

H1 is expected to be accepted with government bond market comovements being significant. Nevertheless, comovements should be stronger between certain countries and weaker between others. As Bunda, Hamann and Lall (2005) argued, average correlations may not have been useful when summarizing the results of government bond market comovements. Their robustness decreased if the underlying distribution of returns was not unimodal and there existed some underlying groups with high within-group comovements and low between-group comovements. These characteristics could be evaluated by grouping the markets based on their comovements, leading to the second step of the analysis – identification of different levels of government bond market comovements. In order to test differentiation between the markets, Hypothesis 2 (H2) is made:

Hypothesis 2: Differentiation of government bond market comovements in the global environment is significant.

Confirming this hypothesis indicates that global government bond markets are still not fully integrated and there exists differentiation in their comovements. Moreover, it is expected to separate the groups of government bond markets in clusters and revealing regional dependence among them. In this sense, a region is assumed to be a group of closely commoving government bond markets and does not refer to geographic region, even if this might be related.

After testing the first two hypotheses, designed to assess comovements between government bond markets in the global environment, the next hypotheses are made to reveal the influence of different groups of factors on these comovements.

As it has been mentioned, the novelty of this research also comes from the fact that many related papers concentrated on cross-market linkages between financial markets, mostly measuring them by high-frequency data and analysing whether comovements between stock markets strengthen during financial crises. Contrarily to that, here the author of this research concentrates on global, fundamental and bilateral factors driving government bond market comovements and heterogeneity among them. This research is also designed to examine longer-

term patterns of linkages between government bond markets in different countries, rather than to estimate short-term fluctuations.

Forbes and Chinn (2003), among others, noticed that financial asset returns and comovements in different countries were primarily influenced by global shocks. The authors described these shocks as changes in interest rates, commodity prices, global risk aversion or other global factors. Even though scientists agreed and results of various studies confirmed that stock market comovements were strongly influenced by global factors, not enough attention has been paid to estimate whether the same tendencies were valid for government bond markets.

Some researchers conducted this type of studies (see, for example, Bunda, Hamann and Lall (2010)) and revealed that until the recent financial crisis, comovements between bond markets had been driven to a lesser extent by country-specific factors and to a larger extent by external global factors. On the other hand, they argued that a decline in bond yield spreads could also be attributed to countries' improved fundamentals. The following hypotheses are made to assess the factors influencing government bond market comovements:

Hypothesis 3: Global factors have significant influence on government bond market comovements in the global environment.

Formulation of the third hypothesis (H3) can be justified by results obtained by Bunda, Hamann and Lall (2010), Comelli (2012) and others. The authors argued that the influence of global factors on government bond market comovements could be assessed by calculating correlations between government bond index returns and comparing them with adjusted correlations after controlling for the influence of global factors. If after controlling for this influence, correlations change significantly, then comovements are strongly influenced by global market conditions. On the contrary, if controlling for global factors does not change the comovements, the influence of these factors is not significant. Bunda, Hamann and Lall (2010) suggested treating adjusted correlations as a measure of excess comovements among the markets, or the ones that are not explained by global external factors. Moreover, the authors indicated that increases in this measure during crisis episodes could be interpreted as contagion. In order to test H3, global financial factors reflecting the situations in stock, money, commodity markets, as well as global risk aversion and political risk have been chosen and described in the section 2.1.

It should be noted that the fact that global factors influence government bond market comovements does not necessarily mean that their influence is uniform. In order to assess the influence of each factor on government bond market indices, in this dissertation separate regression equations for every country's government bond market index are compiled. The purpose is to disentangle the influence of each separate global factor on government bond market returns and evaluating which of them has the strongest power on returns. After testing H3 and

determining the influence of global factors on government bond market comovements, Hypothesis 4 (H4) is made:

Hypothesis 4: Fundamental factors have significant influence on government bond market comovements in the global environment.

This hypothesis is inspired by the results obtained by other authors, stating that the importance of fundamental factors is much bigger for government bond market comovements than global patterns. As it has been discussed in the first part of dissertation, researchers commonly classified the factors influencing government bond market comovements into global and country-specific. Country-specific factors have been analysed by various authors, including but not limited to Ang and Piazzesi (2003), Alexopoulou, Bunda and Ferrando (2009), Bunda, Hamann and Lall (2009), Miyajima, Mohanty and Chan (2012), Piljak (2013), and Ebeke and Kyobe (2015). Paniagua, Sapena and Tamarit (2015) showed an increase in explanatory power of fundamental factors during the sovereign debt crisis. Others, such as Gapenet al. (2005) found that government bond market yields were strongly influenced by fundamental factors reflecting a country's creditworthiness as well as government bond market liquidity.

It should be highlighted that even if different authors analysed fundamental factors as strongly influencing government bond market returns, to the best knowledge of the author, there was only few research assessing this kind of influence on government bond market comovements. It substantiates the need for this research stage and the contribution of results to academic literature. In order to test H4, the influence of a country's fundamentals, described in the previous section, is estimated. Confirmation of H4 would lead to the conclusion that a strong relationship between two countries, represented by comovements of their fundamentals, would cause a strong relationship between government bond markets in these countries.

Nevertheless, the latter argument might not always be valid. What if fundamentals in two countries do not present strong comovements in between but these countries are strongly connected through trade or financial linkages? For example, most of fundamentals in Germany will probably be different from fundamentals in Lithuania, but a big part of Lithuanian export is orientated to Germany. Should it influence comovements between government bond markets in these countries? Moreover, what if fundamentals in the countries are absolutely different but these countries speak the same language or are close to each other? Do these connections influence comovements between their government bond markets? In order to answer these questions, Hypothesis 5 (H5) has been made:

Hypothesis 5: Bilateral factors have significant influence on government bond market comovements in the global environment.

Even if the assessment of the influence of global and fundamental factors on government bond market comovements made it possible to indicate the strongest drivers of comovements, some research showed the importance of the influence of bilateral factors on these comovements. It was shown that financial market comovements were most probably driven by other linkages between the countries (Didier, Love and Martinez Peria, 2012; Shinagawa, 2014; among others). Consequently, the assessment of the factors influencing government bond market comovements would not be fully implemented without considering bilateral linkages between the countries.

Different authors agreed that returns in two markets could commove when changes in one country were transmitted to other countries through cross-country linkages, such as bilateral trade, exports, bilateral bank lending, investment flows and other channels (Ehrmann and Franzcher, 2009; Rose and Spiegel, 2009; Didier, Love and Martinez Peria, 2012; among others). Nevertheless, the influence of these channels on government bond market comovements has not been widely investigated, leaving a gap to be filled. Testing H5 will fulfil that purpose.

Didier, Love and Martinez Peria (2012) classified bilateral factors influencing stock market comovements into real linkages, financial linkages and demonstration effects. Real linkages referred to trade effects, divided into competitiveness effects (when changes in relative prices affect a country's ability to compete in foreign markets) and income effects (when a crisis causes the reduction of the income and the demand for the import). Financial linkages reflected primarily direct and indirect financial accounts of the countries belonging to the international financial system. Direct financial linkages arose due to direct financial exposure between a crisis-hit country and other markets, while indirect linkages described investor actions that led to comovements between financial markets.

Finally, comovements can even be a result of a new interpretation of existing information, stimulating learning and awareness of investors. According to Caramazza, Ricci and Salgado (2000), financial linkages could be a channel for spillover and contagion effects with the occurrence of crisis potentially inducing investors to rebalance their portfolios for risk management, liquidity or other reasons. By simultaneously controlling for different bilateral linkages, research in this dissertation is intended to estimate the importance of different trade and financial channels in explaining cross-country comovements in government bond markets. The bilateral factors to be estimated have been described in the previous section.

Testing the full set of hypotheses is expected to reveal the situation in government bond markets as well as the factors influencing comovements between these markets in the global environment. In order to fulfil these objectives, empirical research is carried out. The next section describes the empirical research logic and stages as well as the methods that are used.

2.3. Empirical Research Logic, Stages and Methods

The proposed model for the assessment of government bond market comovements and the factors influencing them as well as the made research hypotheses are further transformed into empirical research stages and a set of methods. Chapter 2.3 gives an exhaustive description of logics and contents of the preparatory and five other research stages.

2.3.1. Empirical Research Logic and Preparatory Stage

The empirical research stages along with the hypotheses tested by each of them are presented in Figure 7. It can be seen that the assessment of government bond market comovements in the global environment carried out through six research stages – a preparatory stage and five stages designed for testing each of the five hypotheses. A comprehensive description of every empirical research stage is provided in the rest of chapter 2.3.

As it has been noticed, researchers in the field tended to concentrate on different data frequencies, usually depending on research aim and/or methods used. The objective of the preparatory stage is to convert government bond market index data into government bond index returns for further investigation. The benefit of using returns on market indices rather than their value is a normalization, required in multidimensional statistical analysis: comparable scale enable to evaluate dependence between the indices despite their unequal values. When running the further analysis, different frequency data are used.

Despite of arithmetic return's popularity in economic calculations, financial asset prices are not deterministic but random variables, and fluctuations in their prices in short holding periods are often assumed to be lognormal random variables. Therefore, logarithmic returns are a better choice for high-frequency financial market data analysis (see, Alexander, 2011).

Viitanen (2011) calculate logarithmic returns on market indices by taking the first difference of natural log of closing prices. Firstly, prices of securities are assumed to be log-normally distributed, leading to $\log(1 + r_i)$ also being normally distributed because:

$$1 + r_i = \frac{P_{i,t}}{P_{i,t-1}} = e^{\log\left(\frac{P_{i,t}}{P_{i,t-1}}\right)} \quad (1)$$

where: r_i is the return of a government bond market index *i;* $P_{i,t}$ – is the price of the index *i* at time t; $P_{i,t-1}$ – is the price of the index *i* at time t-1.

Secondly, when returns are very small, approximate raw-log equality ensures that they are close in value to raw returns:

$$\log(1 + r) \approx r, r \leq 1 \quad (2)$$

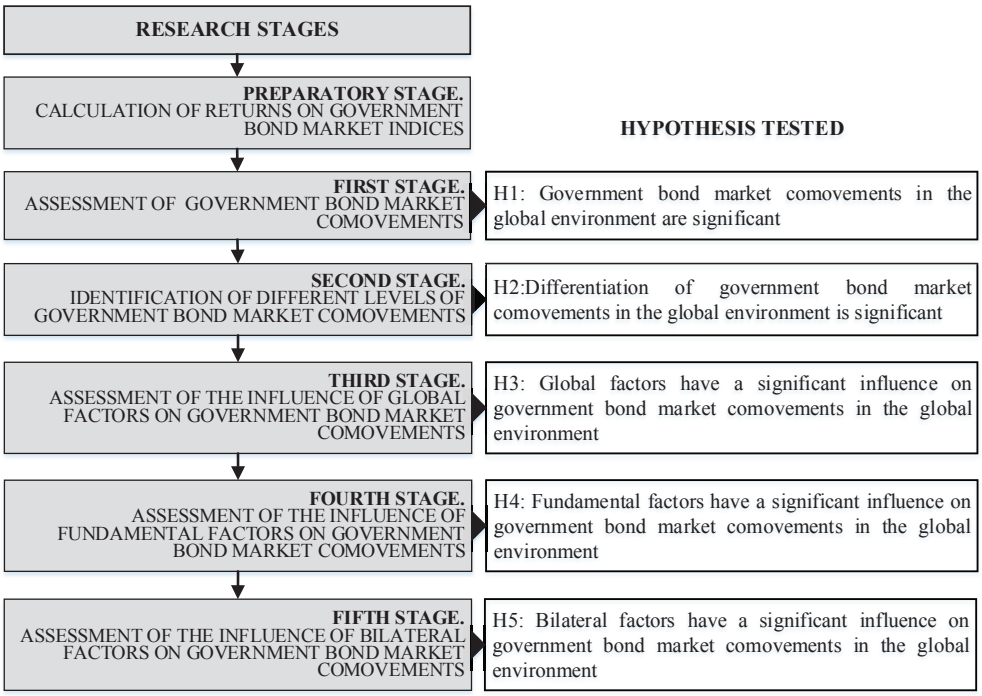


Figure 7 Empirical Research Logic based on the Relationship between Research Stages and Hypotheses Tested

Finally, due to numerical stability, adding small numbers is safe while multiplying small numbers is a subject to arithmetic underflow (Hudson and Gregoriou, 2010). For these reasons, logarithmic returns are used in this empirical research:

$$r_i = \log(\frac{P_{i,t}}{P_{i,t-i}}) \tag{3}$$

where: $P_{i,t}$ represents the closing cumulative total return index level on day t and $P_{i,t-i}$the last total index return on the previous trading day; R_t denotes logarithmic net rate of return between dates t-1 and t; t is trade date.

Log daily returns are calculated for government bond market indices of all the observed countries. Originally, there were 2130 daily government bond index returns obtained from the data. Since all the data came from the same source (Thomson Reuters Datastream), there was no issue with infrequent trading dates or indices not being quoted. The set of government bond index returns calculated in the preparatory stage is later used to analyse government bond market comovements and their dependence on global and country-specific factors.

2.3.2. Method for the Assessment of Government Bond Market Comovements

The objective of the first research stage is to assess the existence of comovements between government bond markets and to test H1:

Hypothesis 1: Government bond market comovements in the global environment are significant.

This stage sets the structure for the rest of the research: to assess the factors influencing government bond market comovements, it is important to check whether comovements exist and are significant. A detailed scheme for implementing this research stage can be seen in Figure 8.

With a wide range of countries analysed and this stage considered to be the base for further stages, chosen method for the assessment of government bond market comovements between is Pearson correlation coefficient. It is also justified by the fact that comovements assessed are between country pairs with no differentiation among directions of their dependence.

This measure of the strength and direction of the linear statistical relationship between two variables is influenced by variable distribution in the sample and is defined as follows:

$$\rho_{ij} = \frac{\mathrm{Cov}(i,j)}{\sigma_i \sigma_j} \tag{4}$$

where: ρ_{ij} is the correlation coefficient between the returns of government bond market indices i and j; *Cov(i,j)* is the covariance between log returns of indices i and j ; σ_i is the standard deviation of log return of the first index; σ_j is the standard deviation of log return of the second index.

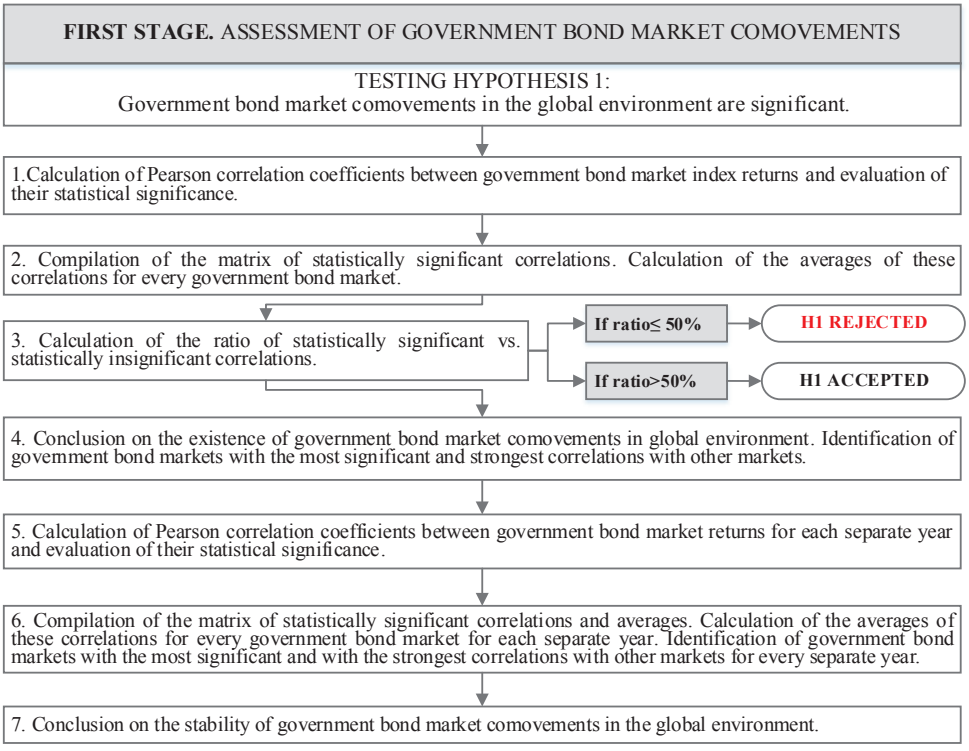


Figure 8 Logics and Contents of the First Stage of Empirical Research

Values and interpretation of correlation analysis results can be seen in Table 7. Independent variables are uncorrelated. Contrarily, a value close to 1 (resp. -1) indicates very strong linear positive (resp. negative) relationship between the variables.

Table 7 Interpretation of the Results of Correlation Analysis

VALUE OF CORRELATION COEFFICIENT	INTERPRETATION
From 0.7 to 1 (resp. from -0.7 to -1)	Strong positive (resp. negative) linear relationship
From 0.5 to 0.7 (resp. from -0.5 to -0.7)	Medium positive (resp. negative) linear relationship
From 0.3 to 0.5 (resp. from -0.3 to -0.5)	Weak positive (resp. negative) linear relationship
From 0.0 to 0.3 (resp. from -0.3 to 0.0)	Very weak positive (resp. negative) linear relationship

Source: compiled by the author according to Mudelsee (2003).

Correlations themselves are not sufficiently reliable measures of comovements. According to Fenton and Neil (2013), confidence in a relationship is formally determined not only by the correlation coefficient but also by the number of data pairs. With a very few pairs, the coefficient needed to be very close to 1 or -1 to be statistically significant, while with many pairs, a coefficient closer to 0 could still be significant.

One common way to measure the statistical significance of an analysis is to perform a Fisher two-tailed test, used to compare two samples. The test starts with the formulation of a null hypothesis to be tested:

H_0: $\rho_{ij} = 0$ — correlation is statistically insignificant, variables are independent;

H_1: $\rho_{ij} \neq 0$ — correlation is statistically significant, variables are dependent.

In order to check the validity of the null hypothesis, a level of statistical significance α[3] is chosen (also known as Type I error rate). The smaller this level is, the less likely it is to make a Type I error (false positive), and the more likely it is to make a Type II error (false negative, the null hypothesis is false, but is not rejected). Consequently, the chosen α should balance two opposing risks of error based on their consequences in certain situation. A larger α is selected with a need to be sure to detect any potential difference, while a smaller α is chosen to detect only a

[3] α is the probability of rejecting a given null hypothesis in favor of the alternative hypothesis while the null hypothesis is correct, usually expressed as a fixed number between 0.1 and 0.01.

difference that really matters. H_0 is rejected if $p^4 < \alpha$ and H_0 is not rejected if $p \geq \alpha$. Before further discussing the implementation of the assessment of government bond market comovements in the global environment, it is needed to separate two notions – number of statistically significant correlations for a country and strength of statistically significant correlations for the country. The first refers to the overall amount of statistically significant pairwise correlations a country's government bond market has with other markets. For statistical evaluation of correlations obtained in this research, the selected level of significance is 0.05, that is, there is a 5% risk of concluding that a difference exists when there is no actual difference. With the analysed daily data (high frequency data), very high correlations are not expected to be obtained. Nevertheless, their statistical significance is crucial.

Following studies conducted by other authors in the field, H1 is accepted if more than 50% of the analysed duplex correlations appear to be statistically significant at a 0.05 level of confidence. In order to calculate this ratio, all statistically significant correlation coefficients are compiled into a correlation matrix. For a particular country i, Pearson correlation coefficients ρ_{ij} between the country and the rest of the countries ($i \neq j$) are estimated and the average ρ_i for a country i is obtained by using the following equation:

$$\rho_i = \frac{\sum_{j=1, j \neq i}^{n} \rho_{ij}}{n-1} \tag{6}$$

where: n is the number of observed government bond markets; ρ_i is an average correlation coefficient between country's i government bond market index with government bond market indices of other countries.

These coefficients are referred to as unadjusted correlation coefficients. The higher is the overall coefficient calculated, the stronger are the positive comovements between the chosen government bond market and the rest of the markets. It should be noted once more that correlation coefficients themselves do not indicate neither direction, nor statistical significance of the relationship analysed. In order to increase the robustness of the obtained results, only statistically significant correlations, based on p-value, are used to reflect government bond market comovements. In order to do that, the ratio of statistically significant correlations vs. all the correlations is calculated:

$$SIGN = \frac{2n_S}{n(n-1)} \tag{7}$$

[4] *p (p-value)* is the probability to obtain a test statistic at least as extreme as the observed one, assuming that the null hypothesis is true. If the *p-value* is less than the significance level, the null hypothesis is rejected. Since a value of 0.05 is used for α, if *p-value* is less than or equal to 0.05, H_0 should be rejected.

where: n_s is the number of significant correlations between all possible (order-independent) pairs of government bond markets.

If the ratio *SIGN* is higher than 50%, H1 is accepted: comovements between government bond markets are considered to be significant. Contrarily, if the ratio is smaller than 50%, comovements are insignificant. After assessing comovements between government bond markets, the next research stage is designed to identify the different levels of these comovements.

2.3.3. Method for Identification of Different Levels of Government Bond Market Comovements

The objective of this stage is to identify whether comovements between government bond markets are homogeneously distributed, or there exist certain groups of markets that commove more strongly in between. This identification is important for investors when making their investment portfolio formation decisions – in order to benefit from diversification effect they should not invest in markets belonging to the same group and commoving more strongly. This research stage tests H2:

Hypothesis 2: Differentiation of government bond market comovements in the global environment is significant.

Differentiation in this context is defined as existence of separate groups of government bond markets (clusters) that more strongly commove with each other than with the rest of the markets. The robustness of clusters excluded highly depends on the fact that same clusters can be created by using different clustering techniques.

As it has been previously discussed, differentiation of markets can be assessed by different methods. According to Focardi (2001), clustering helped to find stable-in-time dependencies and to separate noise from information, so that stable relationship appeared only within clusters. Moreover, temporary changes in comovements between government bond markets might disappear after reducing the data frequency, so an estimation of daily government bond market index returns is expected to allow the detection of different effects of comovements. In order to test this argument, differentiation between government bond markets is assessed by using two data grouping techniques – Principal Component Analysis (PCA) and Agglomerative Hierarchical Clustering (AHC). AHC is chosen based on previous studies using this approach (Gavrilov et al., 2000; Wittman 2012; among others) and the fact that agglomerative clustering is more frequently used in practice (Musmeci, Aste and Mateo, 2015).

Other researchers noticed that using only one classification technique significantly reduced the robustness of the results. With a wide set of analysed data, PCA and AHC are suitable methods to classify/cluster government bond markets in order to determine the groups of markets most

strongly commoving in between and assess the level of differentiation between the markets. This is expected to show the full picture of government bond markets in the global environment and enable to choose markets to invest depending on comovements between them.

H2 is accepted if the two techniques used allow identifying same government bond market clusters and these clusters are stable across the observed period. In that case, clusters identified are treated as significant. A detailed scheme of the implementation of this stage of research is presented in Figure 9.

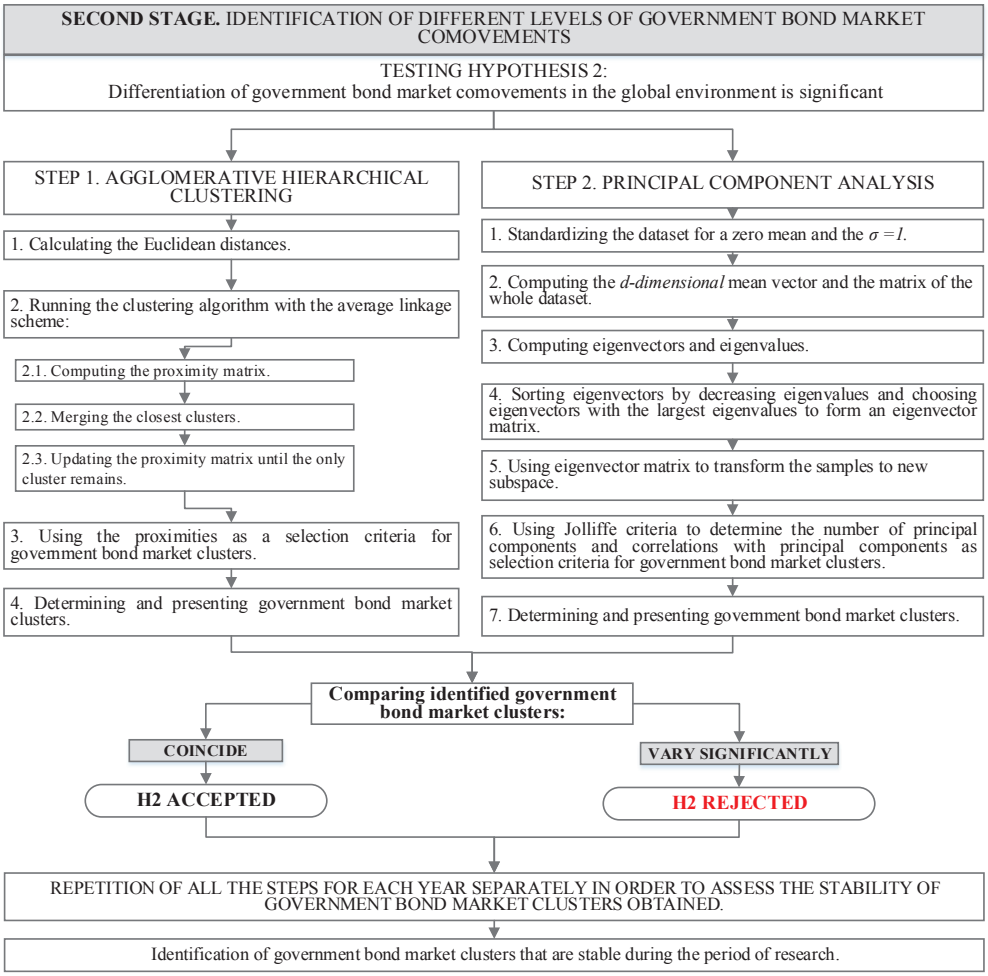


Figure 9 Logics and Contents of the Second Stage of Empirical Research

The second stage of research is divided into two parallel analyses of government bond market data – clusters are identified by employing both AHC and PCA. If the obtained results coincide, the clusters are treated as significant. Since both techniques are rather different, similar

results are expected to be the quality indicator of clusters identified. The implementation of the two techniques is described next.

As it has been mentioned, two parts of the second stage are designed to determine differentiation between government bond markets in the global environment. Similarly as in Panton et al. (1976), Hawkesby, Marsh and Stevens (2004), the implementation of AHC begins with the calculation of the metric distance between the markets, and the compilation of a proximity matrix. As Bailey (1994) noticed, an advantage of distance measures, compared to correlation, is that distance has a positivity property and an absolute zero point. In addition, if a distance between two objects is zero, it indicates that the two objects are identical. As gets larger, markets are assumed to be further apart.

A more comprehensive mathematical description of distances can be found in Appendix 1. Distances used in this research are Euclidean.

In order to use it it is necessary to have observations of i_t and j_t made at the same time.In this analysis, each government bond market i is treated as a separate cluster (*n* clusters). Using the distances and a linkage scheme, the two most similar clusters are found, merged and treated as single cluster, leading to n-1 clusters. Here, the average linkage scheme is chosen based on other researches in the field (e.g. Hawkesby, Marsh and Stevens, 2004, and others).

In the subsequent steps, the cluster merging process repeats either until a desired number of clusters is formed or all the entities are merged into one cluster.

In parallel with AHC, PCA is implemented to identify the level of differentiation between government bond markets. Calculation of the principal components from linear combinations of government bond market indices is performed from data series with weights given by eigenvectors. Principal components capture comovements between the indicators, (decreasingly) representing the largest variance. Since the PCA results are orthogonal (uncorrelated) factors, the higher is the degree of market comovements, the smaller is the number of factors explaining a given portion of variance, because the same components tend to explain more comovements.

According to Hartmann (2016), from a set of n correlated quantitative variables, a set of k new variables $f_1, \dots \dots f_k (k \leq n)$,uncorrelated with each other, is extracted. Only the k first factors, explaining the biggest proportion of total variance, should be considered. The proportion explained by these factors is a measure of PCA quality.

In order to do the calculations analysis, dataset of observations is firstly standardized. If i_t is government bond market index return in country i (i=1,…n) at time t, system's aggregate return is $i_s = \sum_1^n i_t$, average of i is $E(i) = \mu_i$ and variance of i is $\mathrm{Var}(i) = \sigma_i^2$. The aggregate variance of the system is:

$$\sigma_s^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} \sigma_i \sigma_j \, E\left[z_i z_j\right] \tag{8}$$

where: $z_k \equiv \frac{i_k - \mu_k}{\sigma_k}, k = i, j$; z_k is the standardized return of government bond index k and σ_s^2 is the system's variance.

Later on, the whole dataset with d-dimensional samples is introduced and d-dimensional mean vectors are calculated. These n zero-mean uncorrelated variables ξ_k have to satisfy the following condition:

$$E[\xi_k \xi_l] = E[\xi_k \xi_l] = \begin{cases} \lambda_k & if\ k = l \\ 0 & if\ k \neq l \end{cases} \quad (9)$$

All the higher-order co-moments are equal to those of z, where λ_k is the k^{th} eigenvalue. All z's can be expressed as linear combinations of ξ_k's:

$$z_i = \sum_{k=1}^{N} L_{ik} \xi_k \quad (10)$$

where: L_{ik} is a factor loading for ξ_k for a government bond market *i*; *N* is the number of factor loadings.

Thus, we get:

$$E[z_i z_j] = \sum_{k=1}^{N} \sum_{l=1}^{N} L_{ik} L_{jl}\, E[\xi_k \xi_l] = \sum_{k=1}^{N} L_{ik} L_{jk}\, \lambda_k \quad (11)$$

and

$$\sigma_s^2 = \sum_{i=1}^{N} \sum_{j=1}^{N} \sum_{k=1}^{N} \sigma_i \sigma_j L_{ik} L_{jl} \lambda_k \quad (12)$$

We end up with a matrix used to generate eigenvectors and eigenvalues. The eigenvectors are then sorted by decreasing eigenvalues and k eigenvectors with the largest eigenvalues chosen to form the matrix. With this matrix, samples are transformed into new subspace, where eigenvectors are used as selection criteria for clusters.The markets, correlated most strongly with one eigenvector, are selected to the same cluster.

Selection of clusters identified is a matter of discussion among researchers. Coudert and Gex (2006), ECB (2007) identified Jolliffe criteria and Kaiser Criteria, commonly used to choose the number of distinct factors. Bunda, Hamann and Lall (2010) stated that factors with low eigenvalue had a small contribution to the explanation of variances and could be ignored. To determine the number clusters formed among government bond markets, the author of dissertation uses Joliffe criteria, keeping enough factors to account for 80-90 % of overall variance.

If the analysis only leads to two significant principal components, countries highly correlated with the first component exhibit negative correlations with the second. It is an intuitive criteria for exclusion of clusters to group the markets, highly correlated with the first factor and

negatively correlated with the second, in one cluster. Contrarily, government bond markets, less correlated with the first factor and positively correlated with the second factor, should appear in the second cluster. This strategy assures that even though countries in the second cluster aren't always significantly correlated with all the countries in their cluster, within-cluster correlations are higher than between-cluster. The robustness of results is assessed with Bartlett's sphericity test and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy.

Both AHC and PCA are applied on daily data. Assessment of the level of differentiation between government bond markets is carried out with statistical program package IBM SPSS Statistics 22.

After classification of government bond markets based on their comovements, the identified clusters are compared, their quality is assessed and H2 is tested. If the identified clusters, obtained from the analysis of the full research period, are significant and coincide, it can be confirmed that there exists a strong differentiation among government bond markets in the global environment. Consequently, if different groups of closely commoving markets can be distinguished, markets belonging to different groups would be recommended for investment diversification.

The previously described steps allow testing H2. Nevertheless, going further, in order to determine the stability of identified clusters, all the steps are repeated for every separate year from 2008 to 2015 (8 full years). Government bond market clusters are identified for each year separately and then compared among the years. This allows seeing whether clusters change depending on the year investigated, or they are rather stable, and which part of clusters stays steady. Finally, when this part is implemented, conclusions can be drawn about the level of differentiation and its stability in government bond markets.

Even if groups of markets strongly commoving in between exist, another important question – what influences these comovements – remains unanswered. The third, fourth and fifth stages of this empirical research are designed to answer this question.

2.3.4. Method for the Assessment of the Influence of Global Factors on Government Bond Market Comovements

The objective of the third stage of this research is to assess whether government bond market comovements are strongly dependent on global factors included in the proposed model. In order to check this argument, Hypothesis 3 is made and tested.

Hypothesis 3: Global factors have a significant influence on government bond market comovements in the global environment.

A detailed scheme of the third empirical research stage implementation is presented in Figure 10.

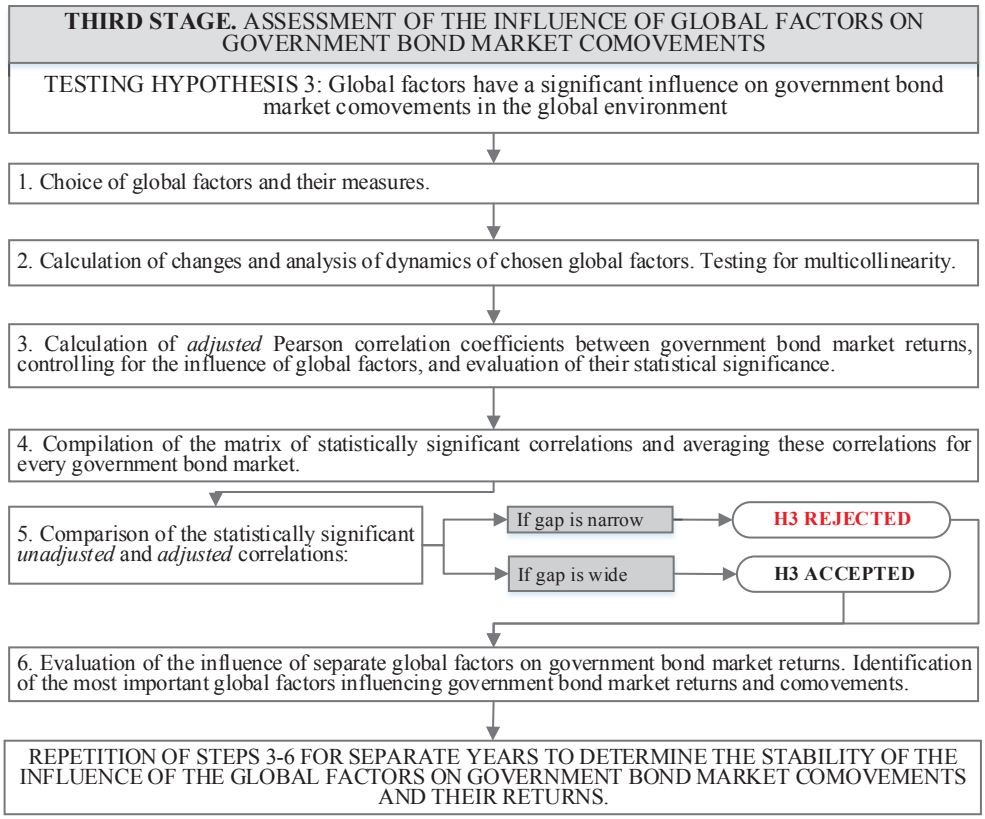


Figure 10 Logics and Contents of the Third Stage of Empirical Research

Global factors chosen for the analysis as well as their measures have been previously described. After collecting the data, daily changes of variables are calculated and their dynamic during research period is assessed.

Financial measures included in economic policy uncertainty index capture stock market volatility, and since the other factors (SPX or VIX indices) could also reflect this volatility, it is needed to test for multicollinearity. Existence of multicollinearity would mean that the estimated regression coefficient of any variable depends on some of other predictor variables that are included in the model. Moreover, when predictor variables are correlated, the precision of estimated regression coefficients decreases with more predictors added to the model. The marginal contribution of any predictor variable in reducing the error sum of squares depends on which other variables are already in the model.

Assessing correlations only among pairs of predictors might be limiting, since it is possible that pairwise correlations are small and yet linear dependence exists among three or even more

variables. This leads to the need of multicollinearity detection, which is met by calculating a Variance Inflation Factor *(*VIF*)*. Details of VIF calculation are presented in Appendix 2.

After estimating the multicollinearity between global factors, analysis of their influence on government bond market comovements is carried out in order to specify the parts of comovements influenced by country-specific and global factors, and to unravel the importance of global and country-specific factors, unadjusted correlation coefficients (calculated in the previous section) are compared to adjusted ones (calculated by taking the influence of global factors into account).

Adjusted correlation coefficients $\hat{\rho}$ for every country are equivalent to Pearson correlation coefficients between residuals ε_i and ε_j. These residuals are factors that are left in the correlation after controlling for the influence of global factors. The Pearson correlation coefficient of residuals, from now on referred to as adjusted correlation coefficient, and reflecting comovements between government bond market index returns after removing the influence of common global factors ,is calculated by using the following equation:

$$\hat{\rho}_{ij} = \rho(\varepsilon_i, \varepsilon_j) = \frac{(\varepsilon_i{}'*\varepsilon_j)}{(\varepsilon_i{}'*\varepsilon_i)^{\frac{1}{2}}*(\varepsilon_j{}'*\varepsilon_j)^{\frac{1}{2}}} \tag{13}$$

where: $\hat{\rho}_{ij}$is adjusted correlation coefficient (correlation coefficient of residuals); ε_i, ε_j denote idiosyncratic, country-specific factors.

$\hat{\rho}_{ij}$ could be used as a measure of government bond market comovements after eliminating the influence of global external shocks. A significant increase in adjusted correlation coefficient is interpreted as excess comovements. Moreover, it should be noted that an increase in $\widehat{\rho}_{ij}$ should lead to an increase of ρ_{ij}. If ρ_{ij} does not change, for $\widehat{\rho}_{ij}$ to increase, an initial increase in excess comovements should be compensated by simultaneous decline in correlations, driven by a common factor. Consequently, changes in both indicators should be assessed together.

If inclusion of control variables strengthens the correlations, these variables have significant negative effect on correlations between the markets and dilute them. If after controlling for global factors, both statistical significance and strength of correlations decreases, factors should significantly influence correlations and their fixation leads to markets less depending on each other.

In order to test H3, adjusted correlations (after controlling for the chosen global factors) are compared to unadjusted correlations for all the country pairs. Only statistically significant correlations are taken into account. H3 is accepted if for more than 50% of country pairs correlations significantly change after controlling for the tested global variables.

Once the influence of a group of global factors on government bond market comovements is assessed, the next step is to determine whether separate factors influence government bond market returns. In order to reveal that, regression analysis is implemented with dependent variable being government bond market index returns and independent variables – global factor changes for the same period. The general regression equation has the following form:

$$r_{it} = \beta_0 + \beta_1 VIX_t + \beta_2 SPX_t + \beta_3 FED_t + \beta_4 GOLD_t + \beta_5 OIL_t + \beta_6 EPU + \varepsilon_{it} \quad (14)$$

where: r_{it} is daily government bond market i index return at time t; $GlobN_t$ is daily change in specific global factor values at time t; ε_{it} is the disturbance term, assumed to be iid $N(0, \sigma^2)$.

The list of global factors used in empirical research, as well as their measures and interpretation can be seen in Table 8.

In order to determine the stability of the influence of global factors on government bond markets and their comovements, all the steps are repeated for every separate year from 2008 to 2015 (8 full years). The influence of global factors on government bond market returns and comovements is identified for each year separately and then compared between the years. This allows seeing if the influence changes, or stays stable. In addition, it shows if certain global factors affect the markets in particular periods, or constantly. When this part is implemented, final conclusions can be drawn about the existence and stability of influence of a group of global factors on government bond market comovements, as well as separate factor's influence on each market returns.

Table 8 Global Factors Used in Empirical Research

FACTOR	MEASURE	SYMBOL	INTERPRETATION
Global risk aversion	VIX volatility index	VIX_t	Daily change in VIX index at time *t*
Global market portfolio	Standard and Poors 500 stock market index	SPX_t	Daily return on SPX index at time *t*
Commodity market uncertainty	Gold price	$GOLD_t$	Daily change in gold price in US dollars per ounce at time *t*
	Oil price	OIL_t	Daily change in WTI crude oil price in US dollars per barrel at time *t*
Money market liquidity	FED short-term interest rate	FED_t	Daily change in 3-month-ahead federal funds futures interest rate at time *t*
Economic policy uncertainty	Economic policy uncertainty index	EPU_t	Daily change in EPU index in at time *t*

As it has already been noticed, even if government bond market comovements are influenced by global factors, these factors might not be the only determinants of these

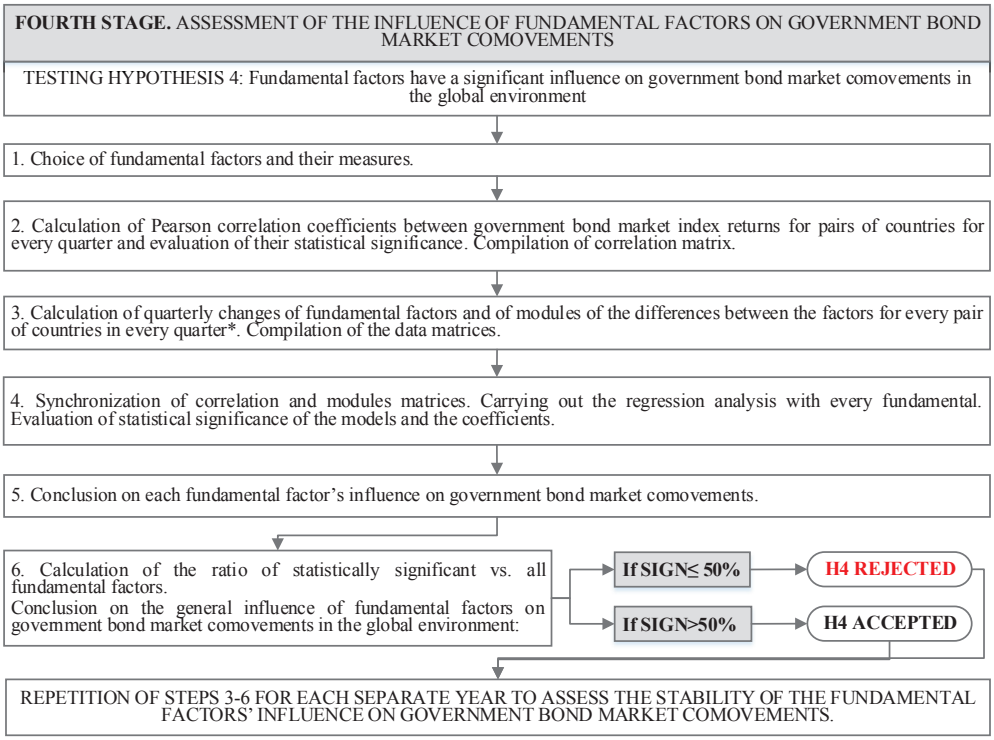
comovements. Various authors argued and proved that the comovements are more strongly dependent on country-specific, rather than the general global economic conditions. This statement is tested in the fourth and the fifth stage of this empirical research.

2.3.5. Method for the Assessment of the Influence of Fundamental Factors on Government Bond Market Comovements

The objective of the fourth stage of empirical research is to determine the influence of fundamental factors included in the proposed model on government bond market comovements. This stage is also designed to test H4:

Hypothesis 4: Fundamental factors have a significant influence on government bond market comovements in the global environment.

A detailed scheme of this research stage is presented in Figure 11. The set of fundamental factors chosen to test H4 has already been presented in the chapter 2.1 of this dissertation.



*In case the factors are related to national accounts, the absolute values are scaled to respective country's GDP.

Figure 11 Logics and Contents of the Fourth Stage of Empirical Research

It should be highlighted that even though most discussions concentrate on the potential determinants of the government bond market returns, in this research the interest is directed towards modelling the factors influencing government bond market comovements. This influence is assessed by using general economic model presented below:

$$\rho_{ij_t} = \beta_0 + \beta_1 \left| FundA_i - FundA_j \right|_t + \cdots \beta_n \left| FundN_i - FundN_j \right|_t + \varepsilon_{ijt} \quad (15)$$

where: ρ_{ij_t} is estimated correlation between daily government bond market index returns in countries i and j during the quarter t; $\left|\mathrm{FundN_i} - \mathrm{FundN_j}\right|_t$ is the modulus of difference between certain fundamental factor values in country i and country j at quarter t; ε_{ijt} is the disturbance term, assumed to be iid $N(0, \sigma^2)$.

Implementation of the fourth stage of this empirical research begins with the choice of fundamental factors and their measures. Daily returns of national government bond market indices from all the set of countries for the period of January 2008-March 2016 employed to construct quarterly time series of correlation matrix.These time series involve all the variations in correlations that happened during the sample period, and are also used to test the hypothesis that the correlation matrix does not change over time. Quarterly correlations between daily government bond market index returns are calculated by using equation 4. To analyse the influence of fundamental factors on government bond market comovements, the 3-month correlation window is chosen as the majority of fundamentals are estimated on quarterly basis.

Correlation coefficients between all the pairs of countries analysed are then composed into correlation matrix that, in the case of all data available, consists of 91575 entries[5].

In the subsequent step, the data of fundamental factors for every country is collected and compared to of government bond market return data. In case data of a specific fundamental factor isare not available for some countries, they are is excluded from the correlation matrix. This leads every fundamental factor having different correlation matrix that it is compared to. As a consequence, every (analysed) fundamental factor is compared to a correlation matrix of different dimensions in order to match the data. When factor's data is equal to the data of quarterly comovements, differences between fundamental factors in each pair of calculated.

It should be noted that when fundamental factors are assessed in the relative term (for example, unemployment rate or consumer price index), difference is calculated by deducting one country's measure from the other country's measure for a certain quarter. It gets more complicated when the analysed fundamental factor analysed is expressed in absolute terms: to obtain differences of these factors (e.g. international reserves) for a pair of countries, the factors are

[5] With the 75 government bond markets analysed, the number of pairs is 2775. This number is multiplied with the number of analysed quarters – 33 quarters from January 2008 to March 2016. The final outcome is 91575 entries.

firstly scaled by countries' GDP and only then the differences are calculated. The full list of analysed factors analysed and methods for their calculation can be seen in Table 9.

Table 9 Fundamental Factors Used in Empirical Research

FACTOR	MEASURE	SYMBOL	INTERPRETATION
Government debt	Gross government debt	DEB_{it}	Gross central government debt in country *i**
Fiscal balance	Government budget balance	FIS_{it}	Government budget deficit/surplus in country *i**
Output growth	GDP growth rate	GRO_{it}	Seasonally adjusted GDP growth in country *i*, (expenditure approach, compared to the previous quarter)
Price level	Consumer price index (CPI)	INF_{it}	Seasonally adjusted CPI in country *i*
Unemployment	Unemployment rate	UNM_{it}	Seasonally adjusted unemployment rate in country *i*
Currency price	Real effective exchange rate	RER_{it}	Real effective exchange rate in country *i*
International reserves	Foreign reserves	RES_{it}	Foreign reserves in country *i**
Trading volume	Market capitalization	MAR_{it}	Government bond market capitalization in country *i*

Note. All the measures are estimated for a quarter *t*. *Scaled by country's *i* GDP

It should be mentioned that since correlation between the markets does not have a direction, neither should the differences between separate countries' fundamentals have it. In order to make sure that the influence of differences between fundamentals does not depend on the arbitrary choice of the difference direction, modulus of differences is used.

Finally, with full matrices of government bond market comovements and fundamental factor differences regression analysis is carried out. The final model with all the fundamental factors analysed has the following form:

$$\rho_{ijt} = \beta_0 + \beta_1\left|DEB_i - DEB_j\right|_t + \beta_2\left|FIS_i - FIS_j\right|_t + \beta_3\left|GRO_i - GRO_j\right|_t + \beta_4\left|INF_i - INF_j\right|_t + \beta_5\left|UNM_i - UNM_j\right|_t + \beta_6\left|RER_i + RER_j\right|_t + \beta_7\left|RES_i - RES_j\right|_t + \beta_8\left|MAR_i - MAR_j\right|_t + \varepsilon_{ijt} \quad (16)$$

The model's and coefficients' statistical significance is assessed by testing Fisher's null hypothesis with a two-tailed test (the level of significance α is set to 0.05). After implementing the calculations and estimating the robustness of the results, conclusions about each fundamental

factor's and group's influence on government bond market comovements in the global environment are drawn.

Nevertheless, in order to test H4, results are generalized by calculating the ratio of statistically significant vs. all the fundamental factors:

$$SIGN = \frac{f_S}{f} \tag{17}$$

where: f_S is the number of significant fundamentals influencing government bond market comovements; f is the total effective number of fundamentals (i.e. for which data were available).

If the calculated ratio is higher than 50%, H4 is accepted, indicating that fundamental factors significantly influence government bond market comovements in the global environment. If the ratio is lower than 50%, the influence of these factors is assumed to be heterogeneous, but there still exists a possibility to determine the influcence of a separate factor.

To determine the stability of the influence of fundamental factors on government bond market comovements, steps 3-6 (Figure 11) are repeated for separate years from 2008 to 2015 (8 full years). Only first quarter of 2016 has been analysed, so the year 2016 are not analysed here. The influence of fundamental factors on government bond comovements is assessed separately for each year and then compared between the years. It indicates the stability of this influence. In addition, it shows if certain factors affect the markets only in particular periods, or constantly. Once this part is implemented, final conclusions can be drawn about the existence and stability of influence of fundamental factors on government bond market comovements, as well as the influence of each separate factor on the comovements. After analysing the influence of country-specific fundamental factors on government bond market comovements, the final stage of this empirical research is aimed to assess the influence of bilateral factors on these comovements.

2.3.6. Method for the Assessment of the Influence of Bilateral Factors on Government Bond Market Comovements

The fifth and last stage is to assess the influence of bilateral factors on government bond market comovements and to test H5:

Hypothesis 5: Bilateral factors have a significant influence on government bond market comovements in the global environment.

Similarly to previous stages, H5 is accepted if more than half of the chosen bilateral factors significantly influence government bond markets comovements. With a wide range of analysed government bond markets, it is virtually impossible to assess bilateral linkages between all the markets due to data availability. Nevertheless, as multiple authors showed, bilateral linkages can

be important factors influencing returns or relationship between stock markets (Didier, Love and Martinez Peria, 2012; among others), so they are worth investigating.

Since the assessment of bilateral linkages between all the analysed countries would be exhaustive and data availability would be an issue, following the methods of Forbes and Chinn (2003) and Didier, Love and Martinez Peria (2012), analysed markets are divided into large and smaller countries. Then, the method used in stock markets by Forbes and Chinn (2003) is modified and adapted to assess the influence of bilateral factors on government bond market comovements. A detailed scheme of the actions undertaken in this stage of the empirical research can be seen in Figure 13.

Firstly, all analysed government bond markets are divided into large economies (denoted as a set of countries c) and smaller economies (denoted as a set of countries i) with countries C separated from countries i. For example, Chile and the Philippines could be excluded as countries i, while the US and Japan could be classified as countries c. In this work, countries c are the US, Japan, Germany, the UK, and France. These countries were among the 6 biggest global economies in 2016[6] and have also been identified by Forbes and Chinn (2003).

The second biggest global economy, China, has been excluded from the set of large countries due to its exceptionally fast growth during the recent years and lack of exhaustive economic and financial data. A detailed description of how the analysed bilateral factors are calculated and assessed is given next, and is summed up in Table 10.

Table 10 Bilateral Factors Used in Empirical Research

FACTOR	CALCULATION	INTERPRETATION
Trade linkage	$TradComp_i^c = \frac{Exports_i^c}{GDP_c}$	$TradComp_i^c$ is the total exports from country *c* to country *i**
Import demand	$ImpDem_i^c = \frac{Imp_i^c}{GDP_c}$	$ImpDem_i^c$ is the total imports to country *c* from country *i**
Foreign direct investment	$ForInv_i^c = \frac{Outward\_Investment_i^c}{GDP_c}$	$ForInv_c^i$ is the total foreign direct outward investment from country *c* to country *i**
Portfolio investment	$PortInv_i^c = \frac{Portfolio\_Investment_i^c}{GDP_c}$	$PortInv_i^c$ is the total portfolio transactions and positions involving debt or stock securities, other than those included in direct investment or reserve assets, from country *c* to country *i**
Distance	*Dist* reflects geographic distance between the capitals of country *c* and country *i* (in km)	

Note. All the measures are estimated for a year *t.* *Scaled by country's c GDP

[6] As rated by *Statistics Times (2016).* Internet source: http://statisticstimes.com/economy/countries-by-projected-gdp.php.

Trade competition and import demand represent real bilateral linkages between two countries. $ImpDem_c^i$ shows how important are the imports to country c from country i while $TradComp_i^c$ represents the importance of exports to country i for country c.

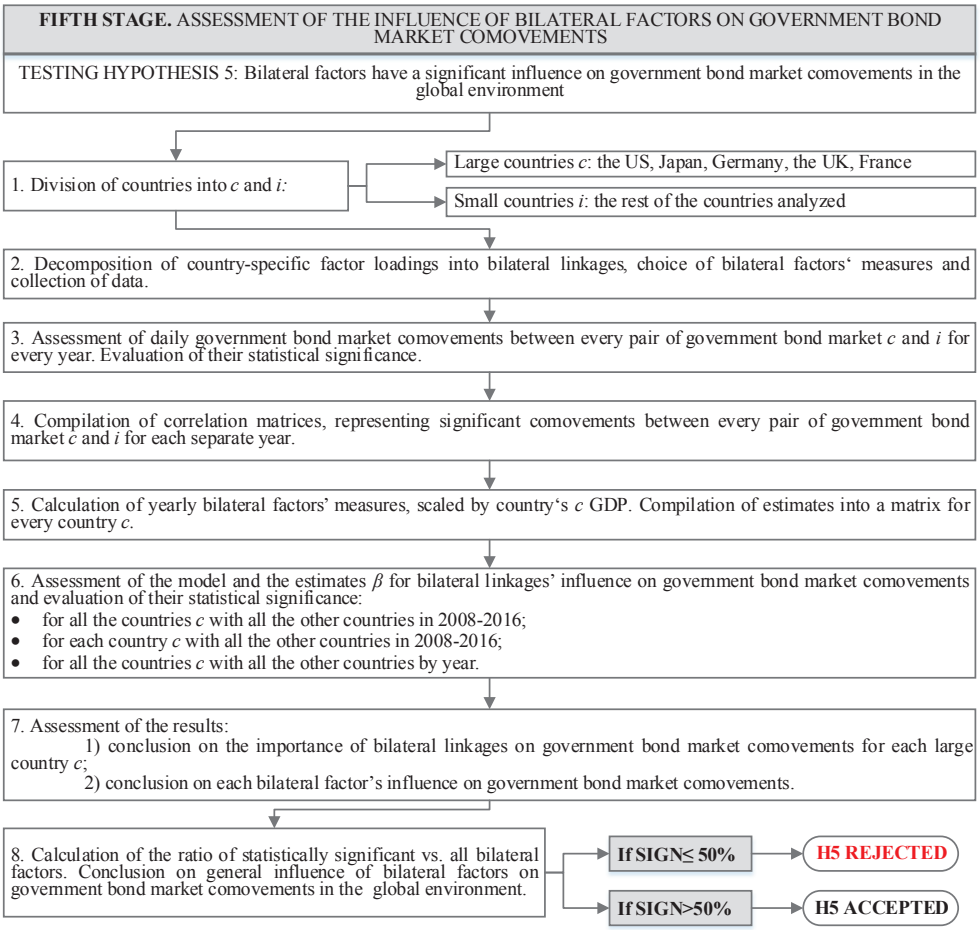


Figure 12 Logics and Contents of the Fifth Stage of Empirical Research

Financial linkages between two countries are represented by foreign direct investment and portfolio investment factors. $ForInv_i^c$ shows the importance of foreign investment from country c to country i and $PortInv_i^c$ represents the importance of total other portfolio transactions from country c to country i. The last selected measure is geographical distance between the capitals of country c and country i, expressed in kilometres.

Government bond market comovements expressed in annual correlations among daily government bond market index returns are used as dependent variables, while the bilateral factors

– as determinants. Calculations provide five correlation matrices for every analysed factor (for every large country *c* with the set of countries *I*). Comovements between the pairs of *c* countries and the pairs of *i* countries are not separately estimated.

When correlation between government bond markets *c* and *i* is assessed, only statistically significant correlations at α=0.05 level are kept, removing the insignificant ones from the matrices. This enables only investigating statistically significant comovements in order to determine what influences them. If this step would not have been taken, insignificant correlations could distort comovement patterns in the global environment. Then, bilateral factors' data for all the pairs of countries are collected and compared to government bond market comovement data. In case the data of a bilateral factor is not available for a country, this data is removed from the data matrix.

When the separate bilateral factor's data is equalized with comovements' data, it is used to test the model for every pair of countries c and *i*. The generic model is described as follows:

$$\rho_{ct} = \alpha_{ct} + \sum_{b=1}^{5} \beta_{ct}^{b} f_{ct}^{b} + \varepsilon_{ct} \quad (18)$$

where: ρ_{ct} is the correlation between government bond market index returns in countries c and i in year t; β_{ct}^{b} are bilateral factor loadings, revealing the effect of government bond market returns in country c on country i; f_{ct}^{b} are c bilateral factors corresponding to each large country c; α_{ct} is a country-specific effect; ε_{it} is a zero-mean normally-distributed error term with $E[\varepsilon_{it}^2] = \sigma_i^2$ and $E[\varepsilon_{it}\varepsilon_{jt}] = \sigma_{ij}^2$ for every pair of countries c and i with $c \neq i$.

In the beginning factor loadings are assumed to be constant across given period for each country and allowed to vary across the countries. Later on, factor loadings are evaluated by separate year. The estimates of bilateral factor loadings β_{ct}^{b} are obtained for every large country c separately. These estimates are expected to capture the effect of bilateral movements between large and small countries on their government bond market comovements. It is important to notice that the model is constructed to reveal what effect bilateral factors from larger countries to smaller countries have on government bond market comovements, rather than estimating simultaneous equations among all the markets. This decision is also backed by data availability for bilateral linkages between smaller countries.

When the calculations are implemented for every large country for every factor and pooled analysis of all the data is executed as well, stability of the results is determined by assessing the influence of bilateral factors on government bond market comovements for each separate year. Finally, the results obtained are summarized with conclusions made about the influence of separate bilateral factors on government bond market comovements and the stability of this influence. In order to test H5, results are generalized. Instead of the results of the analysis of fundamental factors, in this stage bilateral factors are used and the ratio of significant bilateral

factors is calculated. If this ratio is higher than 50%, H5 is accepted, indicating that bilateral factors significantly influence government bond market comovements. In the opposite case influence of these factors is assumed to be heterogeneous, but there still exists a possibility to exclude separate factor's influence. Moreover, since the model is implemented for every large country separately, it also enables assessing characteristics of large countries, most strongly influencing their comovements with other government bond markets.

Section 2.3 presented all the methods used in empirical research in order to test the proposed model for the assessment of the factors influencing government bond market comovements. Consisting of five research stages and the preparatory one, this section covered all the methods and tools, needed to test whether the proposed model can be confirmed in the global environment. The next step is to collect and describe the data needed to test the model.

2.4. Empirical Research Data

To assess the factors influencing government bond market comovements in the global environment, a large set of data is employed. The dataset consists of government bond market index data, global, and country-specific factors data. All data used in the separate research stages, are presented in Figure 14. Most of the data is obtained either from Thomson Reuters DataStream and Bloomberg databases, or from websites of global financial institutions, such as the IMF, World Bank, OECD or BIS. Government bond markets investigated are presented in Figure 13.

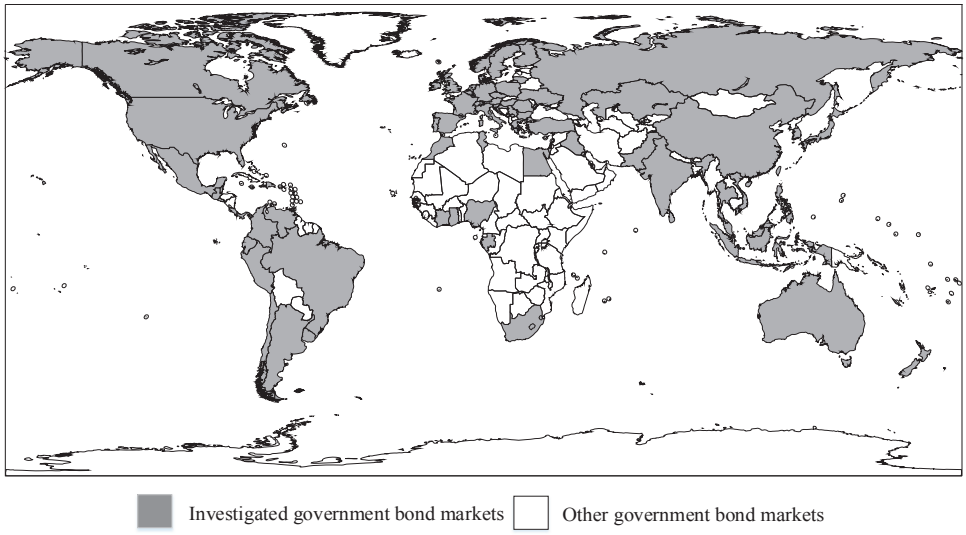


Figure 13 Geographical Representation of Government Bond Markets Covered by the Empirical Research

RESEARCH STAGE	DATA USED	DATA SOURCE
FIRST STAGE. ASSESSMENT OF GOVERNMENT BOND MARKET COMOVEMENTS **SECOND STAGE.** IDENTIFICATION OF DIFFERENT LEVELS OF GOVERNMENT BOND MARKET COMOVEMENTS	Government bond market index data	• Thomson Reuters Datastream database • Federation of European Securities Exchanges (FESE) database (http://www.fese.eu/statistics-market-research/statistics) **DAILY QUOTATIONS**
THIRD STAGE. ASSESSMENT OF THE INFLUENCE OF GLOBAL FACTORS ON GOVERNMENT BOND MARKET COMOVEMENTS	**GLOBAL FACTORS' DATA** • VIX index • Standard and Poors 500 index • US FED 3-month futures interest rate • Gold price in USD per ounce • Crude oil price in USD per barrel • Economic Policy Uncertainty index	• Thomson Reuters Datastream database • Board of Governors of Federal Reserve System (https://www.federalreserve.gov/releases/h15/data.htm) • Deutche Bundesbank database (https://www.quandl.com/data/BUNDESBANK/BBK01_WT5511-Gold-Price-USD) • US Energy Information Administration (https://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm) • Official Economic Policy Uncertainty website (http://www.policyuncertainty.com/) **DAILY QUOTATIONS**
FOURTH STAGE. ASSESSMENT OF THE INFLUENCE OF FUNDAMENTAL FACTORS ON GOVERNMENT BOND MARKET COMOVEMENTS	**FUNDAMENTAL FACTORS' DATA** • International reserves • Inflation • Unemployment • Government debt • Real effective exchange rate • GDP and GDP growth • Market capitalization	• Thomson Reuters Datastream database • World Bank Development Indicators (http://data.worldbank.org/data-catalog/world-development-indicators) • Organization for Economic Co-operation and Development (OECD) (https://data.oecd.org/) • IMF Direction of Trade Statistics (https://www.imf.org/external/pubs/cat/longres.aspx?sk=19305.0) • IMF International Financial Statistics (https://www.imf.org/en/Data) • Bank for International Settlements (BIS) database (http://www.bis.org/statistics/secstats.htm) **QUARTERLY QUOTATIONS**
FIFTH STAGE. ASSESSMENT OF THE INFLUENCE OF BILATERAL FACTORS ON GOVERNMENT BOND MARKET COMOVEMENTS	**BILATERAL FACTORS' DATA** • Import • Export • Foreign investment • Portfolio investment • Distances between capitals	• World Bank Development Indicators (http://data.worldbank.org/data-catalog/world-development-indicators) • OECD International Direct Investment Statistics (http://www.oecd.org/corporate/mne/statistics.htm) • IMF Direction of Trade Statistics (https://www.imf.org/external/pubs/cat/longres.aspx?sk=19305.0) • IMF International Financial Statistics (https://www.imf.org/en/Data) • IMF Coordinated Portfolio Investment Survey (http://data.imf.org/?sk=B981B4E3-4E58-467E-9B90-9DE0C3367363) • Statistics' Canada database, accessed through the Worldview Trade Analyzer (http://www.statcan.gc.ca/daily-quotidien/030903/dq030903e-eng.htm) • Bank for International Settlements (BIS) database (http://www.bis.org/statistics/secstats.htm) **ANNUAL QUOTATIONS** • Kristian Skrede Gleditsch database (http://privatewww.essex.ac.uk/~ksg/data-5.html)

Figure 14 Empirical Research Data and Data Sources

It can be seen from the Figure 13 that this research covers the majority of American, Asian and European markets. Government bond markets in Middle-East and African countries are less investigated but that can be justified by the fact that most of the countries do not have well-functioning government bond markets and, consequently, government bond market indices are not calculated there. Nevertheless, the full sample includes 75 countries, which, under the author's consideration, is enough to reflect the global environment of government bond markets. Some countries, even if they officially have government bond markets, were not included in the model due to lack of data or very infrequent trading that could distort the results (e.g. Latvia, Estonia, Belarus, some African and Middle East countries). The full list of analysed government bond markets, as well as government bond market indices chosen for research and their characteristics are presented in Appendix 3.

Other researchers implement their analyses in government bond markets by using government bond market yields (Abad, Chuliá and Gómez-Puig, 2009; Poghosyan, 2012; Conefrey and Cronin, 2013 among others), yield spreads (Hilsher and Nosbusch, 2012; Fang, 2012; Gomez-Puig, Sosvilla-Rivero, and Ramos- Herrera, 2014 among others) or returns on (changes of) government bond market indices (Bunda, Hamann and Lall, 2009; Perego and Vermeulen, 2013, Piljak, 2013 among others). Regardless of that, the majority of research still concentrate on 10-year duration government bondsLike in stock markets, a wide range of available bond market indices can be classified as broad-market indices and specialized market indices. Differently from stock market indices, investors usually know little about bond market indices – this concept is relatively new and not widely investigated. According to Reilly and Brown (2011), the knowledge regarding these indices is becoming increasingly more important due to the growth of fixed income mutual funds and the consequent need to have a reliable benchmark to use for evaluation of their performance. There is a big variety of bond market indices that can be classified by issuer (government, municipal and corporate), type of calculation (price or total return), maturity (all maturities, 1-3 years, 5-7 years, 10 years, etc.), currency (USD, EUR, national currencies).

According to Baur and Lucey (2006), selection of long-term government bonds over short term government bonds was prioritised because they could be seen as closer maturity substitutes to stock investment. In addition, monetary policy operations were more likely to show vivid influence on long-term government bonds, commonly used as a benchmark. Kim et al. (2006) argued that government bonds with maturity of 10 or more years should be used to effectively match their duration with stocks, often generally viewed as long-term investment, while Cappiello et al. (2008), contrarily, used five-year average maturity indices. Andersson et al. (2004) and other authors employed 10-year government bond indices as benchmarks. Due to the reasons above,

mostly 10-year government bond market indices are used in this research. If a country does not calculate 10-year maturity government bond market index, all-maturity bond market index will is used for the analysis. This is identified as one of the limitations of this empirical research.

When selecting a government bond index, it is important to choose between return and price indices. Andersson et al. (2004), Bessembinder et al. (2008) used clean price indices in their research, while Cappiello et al. (2008), and Viitanen (2011) chose total return government bond market indices. The main difference between these two types is that clean price indices exclude interest accrued on bonds and only take into account changes in bond prices, while total return indices are calculated assuming that all coupon payments and redemptions are reinvested by buying more bonds included in index. Estimating total index return is commonly considered to be a more accurate measure of performance, while the main global benchmark indices are considered to be daily price indices.

There exist some debates concerning the currency in which the analysed government bonds should be denominated. Discussions are mainly based on the fact that currency risk is one of the risks influencing government bond markets and their comovements. In order to avoid this issue, the author of the thesis is using government bond indices, denominated in US dollars (USD). This decision is supported by the fact that the US indicators are used in research as proxies of global financial situation, so it is only fair to use indices denominated in the same currency. Moreover, as Sobrun and Turner (2015) argued, the yield of 10-year US government bonds was a common benchmark driven by global developments. The big amount of transactions between non-US residents in dollar bond markets (not borrowing from the US residents and not closely linked with the US economic development) has made dollar bond markets global. Despite the arguments mentioned here, it should be noted that benchmark government bond market indices in major economies are quoted in their national currencies. Due to that and in order to use the most accurate measures for the government bond market situation in each country, benchmark government bond market indices denominated in local currency are used for some markets. It will be discussed further in section 2.5: Research Limitations.

When choosing the period for analysis, previous studies have also been considered. Some authors concentrated on long-term analysis of historical data, for example, Scruggs and Glabadanidis (2003) covered a period of 44 years (1953-1997); Sutton (2000) evaluated market changes with 33 years of data while Reilly, Kao and Wright (1992) analysed 25 years. Baur and Lucey (2006) covered 20 years with his research ans Ciner (2007), similarly, 18 years. It should be noted that availability of long-term data increases with the time passing, potentially prolonging the periods for analysis. Nevertheless, with data quantity significantly increased, researchers tended to analyse shorter periods. Average-period researches were carried out by Christiansen

(2003), Cappiello et al. (2008) (15 years), Brennan, Kobor and Rustaman (2011) (12 years) as well as Kim et al. (2006), Clare and Lekkos (2000), Abad, Chuliá and Gómez-Puig (2009) (10 years). Shorter-time researches include Boffelli and Urga (2013) (6 years), Caceres, Guzzo and Segoviano (2010) (4 years), or Favero, Pagano and von Thadden (2005) (2 years).

Short research periods are commonly associated with high data frequency, and while the lower data frequency is used when analysing longer-periods. Since financial market data are obtained in high frequency, it's not very common for researchers in that field to analyse annual data. Nevertheless, some authors, such as Sutton (1997) or Niehof (2014), used quarterly data for their calculations. Monthly frequency is employed by Scruggs and Glabadanidis (2003), Yang (2005a), Zhu and Rahman (2009), Gilmore, Lucey and Boscia (2010). Clare and Lekkos (2000), Cappiello et al. (2008), analysed weekly changes in data. Finally, some researchers concentrated on relatively high-frequency data, investigating daily observations, for example Chordia, Sarkar and Subrahmanyam (2003), Kim, Moshirian and Wu (2004), Favero, Pagano and von Thadden (2005), Kim et al. (2006), Bunda, Hamann and Lall (2010), Perego and Vermeulen (2013) .

Studies that concentrated on average-period analysis have been chosen as a reference point, with the author of dissertation choosing 8-year research period from 2008 to 2016. This has been done in order to be able to examine the situation during a volatile period for the global financial environment. Moreover, longer period would have extremely widened the study. Finally, it should be noted that there commonly exists a tradeoff between the length and the width of the analysis. In order to enlarge the set of analysed countries and to cover as many government bond markets as possible, this research covers 8 years from January 2008 to March 2016.

Daily time series' data is collected from Thomson Reuter's Datastream. In order to obtain statistical estimates of correlation, historic data on two asset returns needs to have the same frequency or be measured at synchronous points in time to assure that all observations match. Daily frequency is chosen for calculation of returns due to several reasons, out of which the most important is that daily series enable more frequent estimations. Other authors argued that data frequency did not influence final results and used daily, weekly or monthly returns.

All the data used in the empirical research and its sources are presented in Figure 14. As it has already been discussed in the previous section, five global factors (six measures) have been chosen to test for their influence on government bond market comovements in the global environment.

Global risk aversion data, represented by VIX index, were obtained from Thomson Reuters DataStream, as well as values of Standard and Poors 500 stock market index (representing global market portfolio). Historical values of FED short-term interest rate, representing global money market liquidity, have been downloaded from Board of Governors of Federal Reserve System

official website, as the US Federal Funds 3-month futures daily interest rate. Gold price data were obtained from official Deutche Bundesbank Data Repository database and oil price data – from the US Energy Information Administration. These two measures together reflect global commodity market uncertainty. Finally, EPU index data, representing economic policy uncertainty, have been obtained from an official economic policy uncertainty website[7]. The index is calculated from newspaper coverage of policy-related economic uncertainty; the number of federal tax code provisions to expire in future years; and disagreement among economic forecasters.

Most of fundamental factors data used in this empirical research are from Thomson Reuters DataStream; World Bank database, mostly providing the data of global development; Organization for Economic Cooperation and Development (OECD); the International Monetary Fund (the IMF); Bank for International Settlements (BIS), providing a range of data on lending, exchange rates and other economic and financial indicators. Even with a wide database coverage, it has been impossible to obtain data of fundamental factors for all the analysed countries. Consequently, countries with no data available to represent a specific factor have been excluded from that part of research.

Following the research of Didier, Love and Martinez Peria (2012), bilateral factors data has been obtained from the IMF Direction of Trade Statistics. Data on broader trade indicators, such as exports, is from the IMF International Financial Statistics and World Bank World Development Indicators. GDP data used as a denominator for many of statistics are taken from World Bank's World Development Indicators (reported in US dollars), while trade data used to calculate import demand are obtained from Statistics' Canada's database, accessed through Worldview Trade Analyzer service. Foreign investment data are obtained from the OECD database (International Direct Investment Statistics Yearbook), while portfolio investment data come from Coordinated Portfolio Investment Survey (CPIS) of the IMF. Finally, distances between capitals have been extracted from Kristian Skrede Gledlitsch database. It should be noted that the fact that data on bilateral investment have only been quoted annually only allowed to implement the assessment of bilateral factors influence on government bond market comovements on an annual basis.

Wide-scale research requires big datasets with not all data needed being available for every analysed country. After describing the proposed model and the hypotheses made to test it, as well as the methods and data used in the empirical research, the final part of methodology for the assessment of the factors influencing government bond market comovements in the global environment, is the identification of research limitations.

[7] http://www.policyuncertainty.com/

2.5. Research Limitations

Analysis and synthesis of scientific literature enabled identifying the main research gaps in the investigation of government bond markets and their comovements as well as to propose a model to assess the factors influencing government bond market comovements. Nevertheless, the following research limitations should be listed:

1. The proposed model does not include all the factors and measures. Researchers didn't agree on the groups of factors influencing government bond market comovements, so this limitation arose from aiming to execute a complex assessment of the factors, not to concentrate on one factor group: only several bilateral factors commonly analysed by researchers are included in the model. Moreover, the influence of regional effects is not investigated.

1. Analysis of government bond market comovements is only one of different methods to assess the relationship between the markets. Since this research is complex and its sample is very wide, and the method has been used by other authors for a similar purpose, correlation analysis has been chosen to determine the comovements.

2. Not all the factors included in the proposed model have been empirically analysed. The number of factors has been restricted to scope of research, as well as data availability. Nevertheless, the factors included have already been investigated in similar contexts and have been proven significant in separate markets or market groups.

3. Assessment of the factors influencing government bond market comovements in separate clusters is not carried out. Identification of different levels of government bond market comovements is used to determine clusters of markets, more strongly commoving in between, but these clusters are not further employed. This limitation leaves space for further empirical research and investigation of the factors influencing government bond markets in separate market clusters.

4. Assessment of the factors influencing government bond market comovements in separate clusters is not carried out. Identification of different levels of government bond market comovements is used to determine clusters of markets more strongly commoving in between, but these clusters are not further employed. This limitation leaves space for further empirical research and investigation of the factors influencing government bond markets in separate market clusters.

5. Empirical research covers 75 government bond markets, assumed to represent the global government bond market environment. It is caused by the development of markets and the data availability, but the dataset covers the main government bond markets.

6. Government bond market indices used do not always represent the true rates of return due to the difficulties in computing and infrequent trading. Bond market is constantly changing due to new issues and volatility of prices changes caused by duration, which depends on changes

in maturity, coupon and market yield. In addition, when it was not possible to get the data of 10-year government bond market index, all-bonds or all-maturities index is used.

7. Empirical research only covers a 8-years period, chosen to examine the situation under changing economic conditions. This period might not be long enough to detect all the tendencies in government bond market comovements, but it enables to analyse a large set of countries and to reflect global government bond market situation. On the other hand, the length of the period does not allow analysing even more countries, because some of them only recently started assessing and disclosing their government bond market situation.

8. Regression equations for factors' influence on government bond market comovements are only constructed for fundamental and bilateral factors. When analysing the influence of global factors on comovements only correlations of residuals are used to directly identify their influence and only as a group.

9. The influence of different groups of factors on government bond market comovements is not assessed at the same frequency for all the groups of factors. Global factors are quoted daily, values of fundamental factors are recorded on quarterly basis while bilateral factors are assessed annually. This fact does not allow implementing multiple regressions for all the groups of factors at once. Nevertheless, the models for their influence on government bond market comovements have been estimated separately and then compared for the same year or on the full-period basis. It allows to make conclusions about the influence and its stability during the period investigated.

10. Data were not available for some fundamental or bilateral factors, particularly from emerging countries. It was not possible to assess the influence of bilateral factors on government bond market comovements between all the analysed countries.

11. Exhaustive insights on separate factor's influence on government bond market comovements for each pair of countries are not disclosed due to a wide range of markets investigated and a big set of factors included. It is mainly limited by the volume of dissertation and leaves space for further research in the area.

The number of listed research limitations the fact that the proposed model for the assessment of the factors influencing government bond market comovements, as well as the results of testing it in the global environment cannot be interpreted as definitive for all the markets and situations. Nevertheless, it does not diminish the importance of the results in both theoretical and practical levels. In theoretical level, to the best knowledge of the author, the proposed model is one of the first attempts to comprehensively assess not only government bond market comovements but different groups of factors influencing them. In practical level, the empirical research covers a big part of global government bond markets, presenting the map of different level of comovements, as well as the assessment of the influence of different groups of factors on these comovements.

III. TESTING THE PROPOSED MODEL FOR THE ASSESSMENT OF THE FACTORS INFLUENCING GOVERNMENT BOND MARKET COMOVEMENTS IN THE GLOBAL ENVIRONMENT

Assessment of the factors influencing government bond market comovements in the global environment is based on the proposed model (Figure 6)) and the subsequently presented research methods. The model is tested on a sample of 75 government bond markets, representing global environment. Empirical research is started by assessing government bond market comovements and different levels of these comovements and is continued by determining the influence of different groups of factors on government bond market comovements.

It is expected that government bond markets should commove together but these comovements would not be stable. It is also expected that all the different selected groups of factors would influence the comovements with the strongest influence being from global factors.

3.1. Results of the Assessment of Government Bond Market Comovements and Their Differentiation in the Global Environment

Assessment of government bond market comovements in the global environment is implemented by calculating correlation coefficients between daily government bond market returns for each pair of markets in 2008-2016, determining their statistical significance and summarizing the significant coefficients for each market. Later on, the stability of comovements is determined by estimating changes in comovements for each separate year. Different levels of government bond market comovements are determined by forming the clusters of markets based on their comovements. Stability of these clusters is assessed as well.

3.1.1. Results of the Assessment of Government Bond Market Comovements in the Global Environment

This stage of empirical research is designed to present the results of testing Hypothesis 1: government bond market comovements in the global environment are significant.

The results are presented in two phases. Firstly, significance of government bond market comovements is assessed and H1 is tested. Secondly, stability of comovements is evaluated by providing calculations by year. As it has been described in the second part of this dissertation, significance of government bond market comovements is assessed and H1 is tested by determining the ratio of significant to all the correlations between the markets during the full research period (equation 7). As it has been stated, comovements between government bond markets are considered to be significant if half of the values in the correlation matrix are

statistically significant. In order to test this hypothesis, daily correlation coefficients between all government bond markets have been calculated and used to construct a correlation matrix (an extract of which is presented in Appendix 5). Later on, only statistically significant correlations have been kept.

Calculation of the ratio of statistically significant versus all the correlations showed that 69.66% of the correlations in (2008-2016) were statistically significant, leading to the acceptance of H1 – comovements between government bond markets are significant in the global environment. This average has been obtained from the correlation matrix, containing the correlation with other government bond markets for every country. Representation of results for each government bond market separately can be seen in Table 11.

Results obtained are interesting: it can be seen from the Table 11 that government bond markets in Hong Kong, Peru, Kazakhstan, Costa Rica, Poland, Turkey, Malaysia, Chile, Colombia, Romania, Hungary, Venezuela, Argentina, Indonesia, Brazil, Iraq and Uruguay exhibited the biggest share of significant comovements with other markets – more than 90% of their comovements with other markets were statistically significant during 2008-2016.

Table 11 Average Share of Significant Comovements with other Markets for Every Analysed Government Bond Market in 2008-2016

COUNTRY	SIGNIFICANT COMOVEMENTS	COUNTRY	SIGNIFICANT COMOVEMENTS	COUNTRY	SIGNIFICANT COMOVEMENTS
HKG, PER	**93.33%**	BGR, PAN, TUN	**77.33%**	CIV, DNK, EGY, IRL, JAM, PRT	**62.67%**
KAZ	**92.00%**	GTM, PHL, SRB, PRK	**76.00%**		
CRI	**90.67%**	ZAF, LKA, THA	**74.67%**	NZL, NGA, CHE, USA	**61.33%**
POL, TUR	**89.33%**	SVN	**73.33%**	CAN, ECU	**58.67%**
MYS	**88.00%**	CZE, GRC, MEX, SLV	**72.00%**	HRV, DOM	**57.33%**
CHL, COL, ROU	**86.67%**	ISR, ITA, ESP, VNM	**70.67%**	UKR	**56.00%**
HUN, VEN	**85.33%**	NOR, SWE	**69.33%**	JPN, LBN	**45.33%**
ARG, IDN	**82.67%**	GAB, GHA, PAK	**68.00%**	BLZ	**30.67%**
BRA, IRQ, URY	**81.33%**	AUT, NLD, GBR	**66.67%**	RUS	**21.33%**
BHR, MAR, SGP	**80.00%**	AUS, FRA, DEU	**65.33%**	CHN	**12.00%**
LTU, TWN	**78.67%**	BEL, FIN	**64.00%**	IND	**8.00%**

*Note. Country codes are presented in Appendix 4.

It should be noted that within the top 10 markets there are almost none of the G20 countries. These markets have actually exhibited significant comovements with the other markets in less than 70% of the analysed pairwise cases and were not even included in the first half of strongest

share of comovements. Consequently, it means that developed government bond markets on average tend to commove with less other government bond markets. For example, Italy, Spain, Norway, Sweden, Austria, the Netherlands, Australia, France and Germany significantly commoved with the other markets in 65-70% of the pairwise cases, the same range as Vietnam, Gabon, Ghana and Pakistan.

Contrarily, government bond markets in India, China, Russia and Belize were only commoving with other government bond markets in less than 30% of the analysed pairwise cases during the research period. It allows to conclude that these markets are the most independent actors in the global environment. Nevertheless, the existence of statistically significant comovements between government bond markets does not indicate the strength of comovements. In order to determine that, values of significant correlations with other markets are averaged for every analysed government bond market. Average significant comovements between daily government bond market index returns for every country are presented in Figure 15.

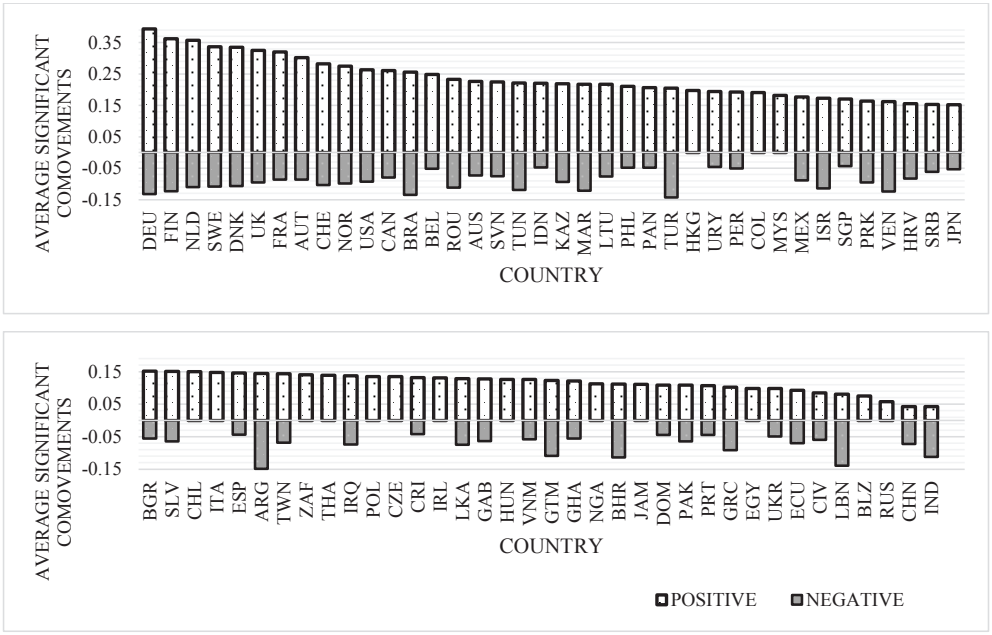


Figure 15 Average Significant Government Bond Market Comovements in 2008-2016

*Note. Country codes are presented in Appendix 4.

It should be noted that since government bond market comovements can represent both positive and negative directions, pooling them together would potentially diminish the differences between positive and negative comovements. For example, if market *i* strongly positively

commoves with market *j* (let's assume that $\rho_{ij} = 0.8$) and strongly negatively commoves with market *k* ($\rho_{ik} = -0.8$), in case these coefficients are pooled together, their values compensate each other and it appears that market *i* does significantly commove with markets *j* and *k*, but the average strength of these comovements is 0. Consequently, in order to avoid this situation, the significant comovements have been divided into positive and negative, and averaged separately.

Average government bond market comovements for every country are listed in descending order in Figure 15 showing which markets commoved with the others most strongly during research period. It is indicated that government bond markets in Germany, Finland, the Netherlands, Sweden, Denmark, the UK, France and Austria were commoving most strongly with the other analysed markets (average positive comovements for every market were more than 0.3 for these countries during the full research period). It should be noted that even though the ratios of comovements might not seem very high for all the analysed markets, since the sample for each pair of markets includes almost three thousand observations, these correlations should be treated as high. This fact is also re-assured by their statistical significance. Contrarily, weakest positive average comovements with the other government bond markets have been registered in India, China, Russia, Belize, Lebanon, Cote D'Ivoire, Ecuador, Ukraine and Egypt (average ρ was smaller than 0.1). The rest of government bond markets exhibited average significant positive comovements with other government bond markets with the values ranging from 0.1 to 0.3.

The strongest significant negative comovements for separate government bond markets have been registered for Argentina, Turkey, Lebanon, Brazil and Germany, correspondingly varying from -0.13 to -0.15, so it cannot be stated that come markets exhibit very strong negative comovements with the others. In case the bar in the Figure 15 is missing, negative comovements with other government bond markets were not registered for that country.

Even though the comovements between government bond markets have already been assessed, a question of equal importance is whether these comovements were stable during the research period or not. In order to answer this question, the existence and strength of government bond market comovements has been assessed for each year separately. With a research period covering 2008 to 2016, 8 separate years were considered for the stability analysis (data for 2016 only covers 3 months, so it has been excluded from this analysis). The results obtained can be seen in Table 12.

It can be noted that a comparison of government bond market comovements in each separate year does not indicate their stability. When looking at generalized results, the share of significant comovements varies from 30.01% in 2009 to more than double in 2013 (77.19%), allowing to conclude that comovements between government bond markets are in general time-varying.

Table 12 Assessment of the Stability of Government Bond Market Comovements in 2008-2015

YEAR / ASSESSMENT CRITERIA	2008	2009	2010	2011	2012	2013	2014	2015
Percentage of significant comovements	46.61	**30.01**	49.78	51.38	45.01	**77.19**	46.04	46.60
Average positive comovements	0.305	0.291	0.304	0.293	**0.262**	**0.333**	0.297	0.331
Average negative comovements	-0.165	-0.164	-0.192	**-0.220**	**-0.220**	-	-0.158	-0.166

Years 2008 and 2009 can be identified as the starting years of the financial crisis, but it has been proven by multiple authors that the crisis has spread to government bond markets as late as in 2011 and later (De Grauwe and Ji, 2014; Kilponen, Laakkonen and Vilmunen, 2012). This can be proven by excessive comovements between government bond markets in 2013.

When estimating average positive government bond market comovements by separate year it can be seen that the strongest average comovements between the pairs of markets were also registered in 2013 and were equal to 0.33. Nevertheless, on average comovements tended not to vary a lot – the smallest positive average comovements between government bond markets have been registered in 2012 and was 0.26. Analysis of negative comovements between government bond markets showed that these comovements varied similarly – from -0.16 in 2014 to -0.22 in 2011 and 2012. Nevertheless, it should be noted that the averages of negative comovements are only based on few observations per year, since this phenomenon is much less frequent than the opposite one.

Since the analysis of the structure of distribution of government bond market comovements for each year and each market would require extensive space, the author highlighted the markets that demonstrated the biggest share of significant comovements with the other markets in each year (Table 13). This table represents the top 3 national government bond markets by share of significant comovements with other markets for each year.

It can be seen from Table 13 that the maximum share of significant comovements between government bond markets has varied by year within the range from 54.67% to 94.67%. Moreover, the government bond markets, mostly commoving with the other markets changed a well. It is interesting that Kazakhstan's government bond market has been most frequently experiencing significant comovements with the other markets (in 2008, 2010, 2011 and 2012). Panama's and Russian government bond markets have been mostly significantly commoving in 3 years (respectively 2008, 2014, and 2015; and 2011, 2012, and 2013), and Indonesian government bond market most significantly commoved with the other markets in 2010 and 2013.

Table 13 Biggest Share of Significant Government Bond Market Comovements with other Markets by Year

2008		2009		2010		2011	
COUNTRY	SIGNIFICANT COMOVEMENTS	COUNTRY	SIGNIFICANT COMOVEMENTS	COUNTRY	SIGNIFICANT COMOVEMENTS	COUNTRY	SIGNIFICANT COMOVEMENTS
PAN	**74.67%**	TUR	**54.67%**	KAZ	**77.33%**	RUS	**81.33%**
MYS	**73.33%**	DEU, SWE, TUN	**53.33%**	BGR		ARG	**78.67%**
KAZ	**72.00%**			IDN	**74.67%**	KAZ	**76.00%**
2012		2013		2014		2015	
COUNTRY	SIGNIFICANT COMOVEMENTS	COUNTRY	SIGNIFICANT COMOVEMENTS	COUNTRY	SIGNIFICANT COMOVEMENTS	COUNTRY	SIGNIFICANT COMOVEMENTS
KAZ	**82.67%**	RUS, SLV, URY, PHL, IDN	**94.67%**	COL	**78.67%**	HUN	**78.67%**
RUS	**76.00%**			CHL	**77.33%**	PAN	
VEN	**72.00%**			PAN	**76.00%**	PER	

*Note. Country codes are presented in Appendix 4.

Most of the countries, representing the majority of significant comovements for each year, could be identified as developing countries and only few European countries have been included in the table (Turkey, Germany and Sweden in 2009), Bulgaria in 2010 and Hungary in 2011, triggering the question and a discussion whether developed government bond markets are the most integrated as it is commonly assumed or if this integration is more regional (with region not necessarily being geographic).

Nevertheless, as it has been noted, the number of significant comovements with the other markets does not show the strength of these comovements. In order to determine it, the average strength of comovements for every government bond market has been assessed by year. The results can be seen in Table 14, where the top 10 government bond markets by average significant comovements with the other markets, are presented in each separate year.

When looking at daily average significant positive government bond market comovements by year, it can be seen that the top 10 government bond markets by comovements' strength did not vary significantly within the years. This list has been dominated by developed, mostly G20, countries, getting closer to the initial insights about how government bond markets were expected to commove in between. Government bond markets in Austria, Belgium, Canada, Denmark, Germany, France, Spain, Sweden, Finland, UK, US, Italy, the Netherlands, and Portugal demonstrated the strongest average comovements with the other markets, and this position was relatively stable until 2013. In addition to these markets, Slovenian and Brazilian government bond markets were also strong on average comovements. It should be also noted that when assessing comovements by separate year, the strength of them significantly increases (when compared to data provided in Table 12) due to shorter observation time.

Table 14 Average Significant Positive Comovements between Government Bond Markets by Year

2008		2009		2010		2011	
COUNTRY	CORRELATION COEFFICIENT	COUNTRY	CORRELATION COEFFICIENT	COUNTRY	CORRELATION COEFFICIENT	COUNTRY	CORRELATION COEFFICIENT
AUT	0.520	AUT	0.559	AUT	0.423	BRA	0.414
BEL	0.529	BEL	0.577	CHE	0.458	CAN	0.458
DEU	0.478	DEU	0.543	DEU	0.566	DEU	0.458
ESP	0.511	ESP	0.548	DNK	0.503	DNK	0.484
FIN	0.470	FIN	0.592	FIN	0.546	FIN	0.510
GBR	0.486	FRA	0.579	FRA	0.487	GBR	0.465
IRL	0.521	GBR	0.490	GBR	0.443	NLD	0.545
ITA	0.489	ITA	0.503	NLD	0.493	SVN	0.419
NLD	0.504	NLD	0.554	SVN	0.425	SWE	0.470
PRT	0.490	PRT	0.445	SWE	0.481	USA	0.456
2012		2013		2014		2015	
COUNTRY	CORRELATION COEFFICIENT	COUNTRY	CORRELATION COEFFICIENT	COUNTRY	CORRELATION COEFFICIENT	COUNTRY	CORRELATION COEFFICIENT
BRA	0.391	AUT	0.423	AUT	0.460	AUT	0.499
CAN	0.399	BEL	0.432	BEL	0.480	BEL	0.502
DEU	0.456	DNK	0.425	DEU	0.428	DEU	0.498
DNK	0.411	HKG	0.458	DNK	0.400	FRA	0.511
FIN	0.490	KAZ	0.486	FIN	0.483	HRV	0.555
GBR	0.446	MYS	0.467	FRA	0.479	MAR	0.661
MAR	0.389	NLD	0.425	GBR	0.383	NLD	0.491
NLD	0.455	PHL	0.436	KAZ	0.384	ROU	0.618
SWE	0.410	RUS	0.478	LTU	0.381	SVN	0.509
USA	0.415	SGP	0.450	NLD	0.498	TUN	0.750

*Note. Country codes are presented in Appendix 4.

In the first part of the research period, government bond markets most strongly commoving with the other markets were very stable – the list of top 10 repeated within the years up until 2013. In 2013, in addition to the fact that government bond markets tended to commove more significantly than in all the other years, the government bond markets most strongly commoving with the other markets also changed – Asian markets have occupied half of the list (Hong Kong, Malaysia, Philippines, Russia, and Singapore). The author of this dissertation would attribute this change to the fact, that at that time, European governments had been experiencing difficulties to borrow and their government bond markets were seen as lacking trust by international investors.

Developed EU countries dominated the top 10 by average comovements in 2014, while in 2015 their share had decreased again with government bond markets in Morocco and Tunisia, as well as Croatia, Romania and Slovenia demonstrating high significant comovements with the other markets. Lithuanian government bond market was among the ones with strongest comovements in 2014.

When generalizing the results on the significance of government bond market comovements in the global environment, it can be concluded that significant comovements exist between the markets, enabling to accept Hypothesis 1.

Analysis has shown that government bond markets in Hong Kong, Peru, Kazakhstan and Costa Rica demonstrated the biggest share of significant comovements with the other markets, and could be seen as the central points, having most connections with the other analysed markets. Contrarily, by the strength of significant comovements, government bond markets in Germany, Finland, the Netherlands, Sweden, Denmark, the UK, France, and Austria were most strongly connected to the other markets during research period. In this situation the question of quantity versus quality is faced – the first group of mentioned markets tend to commove with more other markets, while the latter markets tend to commove more strongly with the markets they were interrelated with. It allows interpreting the markets with the biggest part of significant comovements as more versatile ones. It can be argued that developed markets do not commove with the biggest share of other markets, but with the ones they do commove, their comovements are strongest on average. Nevertheless, none of the mentioned markets would be advisable to be included in the same investment portfolio formation. On the other hand, government bond markets that were most independent and did not commove with the other markets during the research period, were India and China.

Results of assessing the stability of government bond market comovements by year showed that the biggest share of significant comovements has been registered in 2013, while the smallest – in 2009. The list of top 10 countries by strongest average comovements was relatively stable and included the strongest developed economies until 2013, while in 2013 the Asian markets were commoving more strongly. These results can be attributed to the fact, that at that time, European governments had been experiencing difficulties borrowing and the government bond markets were seen as lacking trust by the international investors.

The results obtained only raised more questions and encouraged to investigate whether there existed different levels of government bond market comovements and if so, did these levels change. The results of this investigation are provided in the next sections.

3.1.2. Results of Identification of Different Levels of Government Bond Market Comovements in the Global Environment

This stage of empirical research is designed to present the results of analying the differentiation of government bond market comovements. This differentiation is determined by employing Hierarchical Cluster Analysis and Principal Component Analysis. The results of analysis are expected to enable confirming or denying H2:

Hypothesis 2: Differentiation of government bond market comovements in the global environment is significant.

As it has been mentioned, H2 will be accepted if the combination of two different methods allows identifying the same government bond market clusters and if these clusters are stable with time. Consequently, results are presented in two stages. Firstly, significance of differentiation of government bond market comovements is assessed for the full research period and the H2 is tested. Secondly, the stability of differentiation is evaluated by separate year. In this sense it is expected to reveal not only if the analysed government bond markets are clustered together, but if so, whether there exist stable government bond market groups that are robust to changes in the global environment.

Bartlett's test has been carried out and Kaiser-Mayer-Olkin (KMO) measure has been calculated in order to test whether the results of the PCA are robust. Their values are presented in Appendix 6. The results of the robustness testing show that the KMO measure for daily clusters equals to 0.904, indicating that PCA is a proper method to identify clusters between government bond markets. Results of KMO enabled rejecting the null hypothesis that the correlation matrix is the identity matrix and indicated that there is some scope for reducing the number of dimensions in the dataset.

As a result of performing PCA, a scree plot is generated which can be used to visually determine the number of clusters to be obtained. Scree plot for government bond market data in 2008-2016 can be seen in Figure 16. Interpretation of scree plot is rather straight-forward – the points with big distances in between are principal components, the number of which is four. After the 4^{th} one, distances between the components tend to decrease a lot. Since government bond market clusters based on the correlation of every market returns with principal components, the number of clusters from PCA should be 4. An extract from the component matrix used to determine the markets for each separate cluster can be seen in Appendix 7.

Results of using AHC for clustering government bond markets come in the form of a dendrogram. Dendrogram indicates the path and steps followed to achieve that particular clustering: observations are grouped starting from pairs of individual observations closest to each other and merging smaller groups into larger depending on the groups closest to each other.

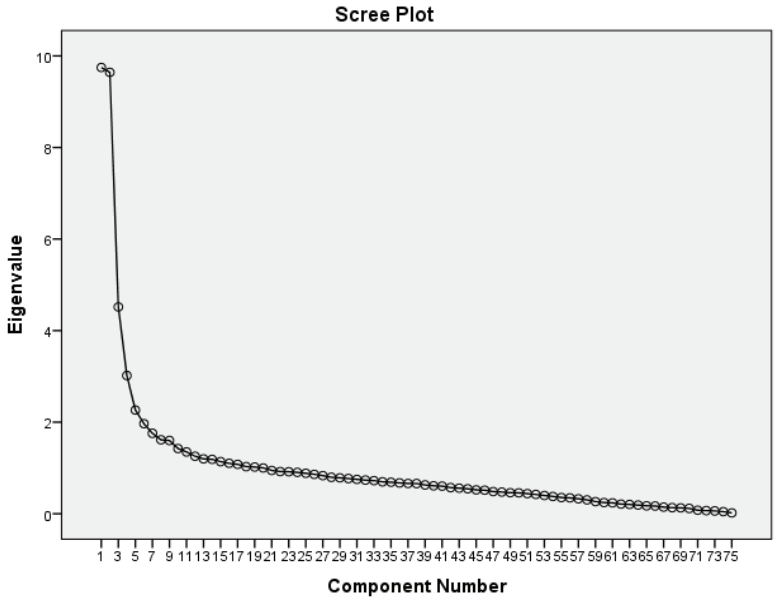


Figure 16 Scree Plot Resulting from using Principal Component Analysis to Cluster Government Bond Market Data in 2008-2016

Eventually all data is merged into one segment with the heights of the branches indicating how different are the clusters at that level of tree. The heights of branches increase with traversing the tree from the end leaves to the tree root, since data points are merged from the closest ones to the furthest. Dendrograms, as the one presented in Figure 17, are a good tool to identify differentiation among government bond market clusters. Even with large number of observations, the tree typically grows logarithmically with the data. Nevertheless, once two data points are merged into same segment, they remain there throughout the tree, sometimes leading to suboptimal segmentations.

Results provided by both methods discussed allowed differentiating government bond markets based on their comovements in the global environment. This differentiation has firstly been assessed by employing daily government bond market index data for 2008-2016 and common results generated by both methods were joined together and presented in Figure 18.

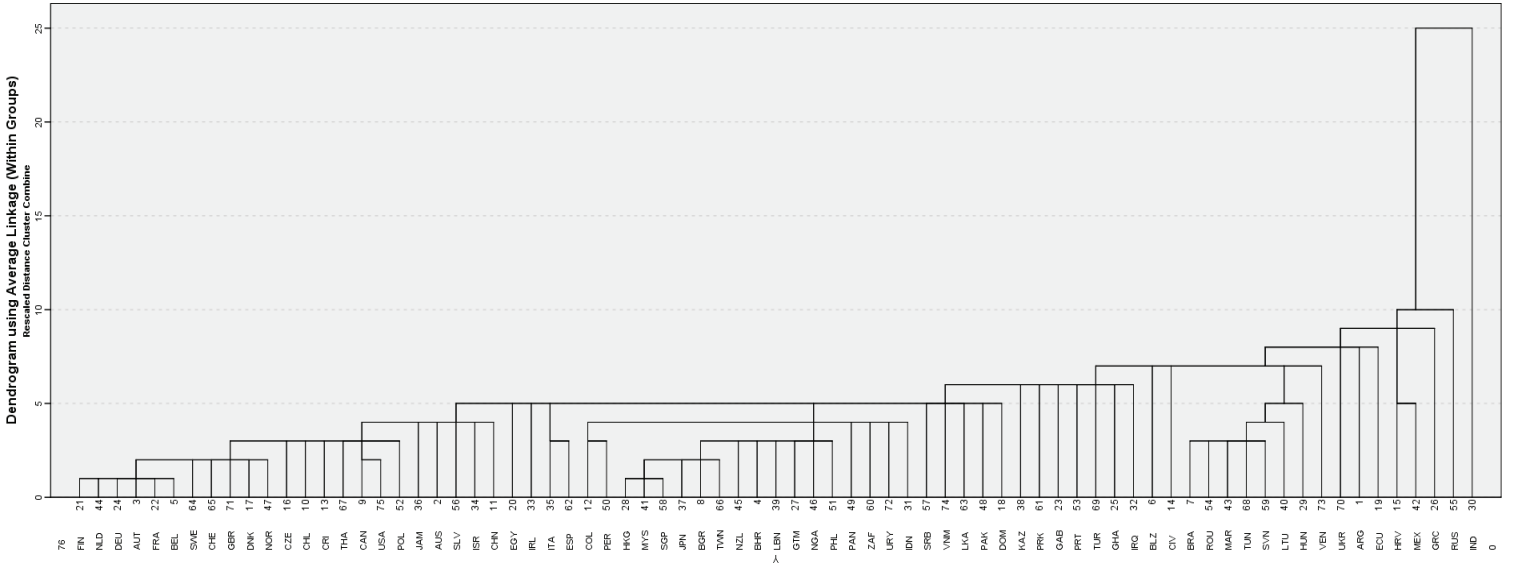


Figure 17 Dendrogram Resulting from using AHC to Cluster Government Bond Market Data in 2008-2016

*Note. Country codes are presented in Appendix 4.

Each small item represents a separate government bond market (for interpretation of country codes see Appendix 4). These government bond markets form groups or clusters, most strongly commoving in between that with the other government bond markets, as excluded based on PCA and HCA. The markets that were not included in the picture could not be assigned to separate groups, meaning that they commove more independently with each other.

Figure 18 shows that when assessing daily government bond market comovements, three big and one small cluster were formed. By consecutively using PCA and AHC, four government bond market clusters have been identified.

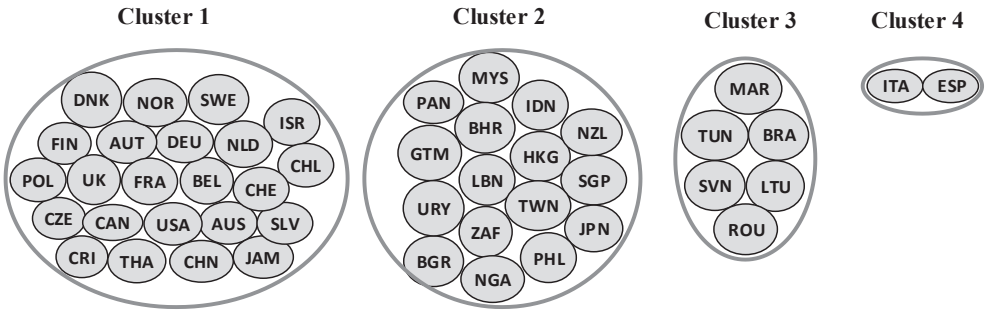


Figure 18 Clusters Formed on the Basis of Identified Government Bond Market Comovements, based on full-period analysis in 2008-2016

*Note. Country codes are presented in Appendix 4.

The first cluster consists of 23 countries, out of which the majority are the strongest developed European government bond markets: Austria, Germany, Belgium, France, the Netherlands, the UK, Denmark, Finland, Norway, Sweden and Switzerland, as well as the US, Canada and Australia. In addition, this cluster includes two Asian markets (China and Thailand), four markets from Central and South America (Chile, Costa Rica, Jamaica and El Salvador), as well as Czech Republic, Poland, and Israel. These results contradict the statement made in the previous section that China's government bond market is one of the most independent ones – it has been assigned to a cluster of developed markets. This fact is only one of the examples that a market can on average weakly commove with all the rest of the markets while at the same time it can exhibit strong comovements with a separate group (cluster) of markets. These comovements could not have been detecting when looking at averaged values.

The second cluster obtained when analysing the full research period consists of sixteen government bond markets. Markets included in this cluster are South and Central American (Panama, Guatemala and Uruguay), African (Nigeria and South Africa), and Asian (Bahrain,

Indonesia, Hong Kong, Lebanon, Taiwan, Philippines, Malaysia, Singapore, and Japan), as well as New Zealand and Bulgaria. This cluster seems to be relatively diverse with the government bond markets representing different geographic regions and the different stages of economic development). Nevertheless, after comparing the results with the ones of the section 3.1.1, it can be again seen that such government bond markets as the ones of Belize, Lebanon or Japan, that have been identified as having the smallest share of comovements with the other markets, exhibit strong comovements with a certain group of markets.

The third cluster includes six government bond markets: Brazil, Morocco, Tunisia, Slovenia, Romania and Lithuania. This is a relatively small cluster, with three European government bond markets, some of the most recent members of the EU, two northern African neighbours and a huge government bond market in South America. All these markets were among those with the biggest share of significant comovements with the other markets assessed in the previous section.

Finally, the last cluster, which is actually only a pair of government bond markets, identified as strongly commoving in between in 2008-2016, is Italy and Spain – two European government bond markets that have been experiencing difficulties during the sovereign debt crisis. This is not surprising, since it has been widely known that Italy and Spain were some of the countries with huge government budget deficits to be at least partly funded by governments bonds and that experienced significantly increased cost of debt during the observed period.

Results obtained by joining two methods for clustering allowed to identify differentiation of government bond market comovements and to confirm H2: differentiation of government bond market comovements in the global environment is significant.

Nevertheless, even if the robustness of methods has been checked and clusters between government bond markets have been identified, what does that really tell about the existence of the government bond market differentiation? Can't it be the case that the identified clusters are random, and do not represent longer-term tendencies? Or maybe the results have been distorted by one or a few specific episodes in government bond markets? These questions can be answered by assessing government bond market differentiation by year in order to determine stability of the identified clusters. The same methods that have been used to analyse the data for the full research period are again employed for data analysis year by year.

Data are divided into 8 full years from 2008 to 2015 (2016 is not a fully covered by the data, so it is excluded) and the PCA and AHC are again performed. The process creates 8 more dendrograms as well as 8 more component matrices (not included in the Appendices, but can be provided if needed). The measures of robustness of the analysis of government bond market differentiation by year are presented in Appendix 7.

The author of this dissertation gathered all the sets of clusters identified by each separate year and searched for common country combinations repeating in each separate year. The final result of this analysis is a map of government bond market clusters, consisting of the markets most strongly moving in between and being consequently the same during every separate year of the analysis. This map reveals the stability of government bond market differentiation based on their comovements, and can be seen in Figure 19.

This map differs from the one in Figure 18 because the clusters presented in it have been stable within the each separate year. Assessment of the stability of government bond market clusters allowed identifying 2 big and 4 small clusters. Even though four of these clusters only involve two markets, the significance of their connection should not be diminished.

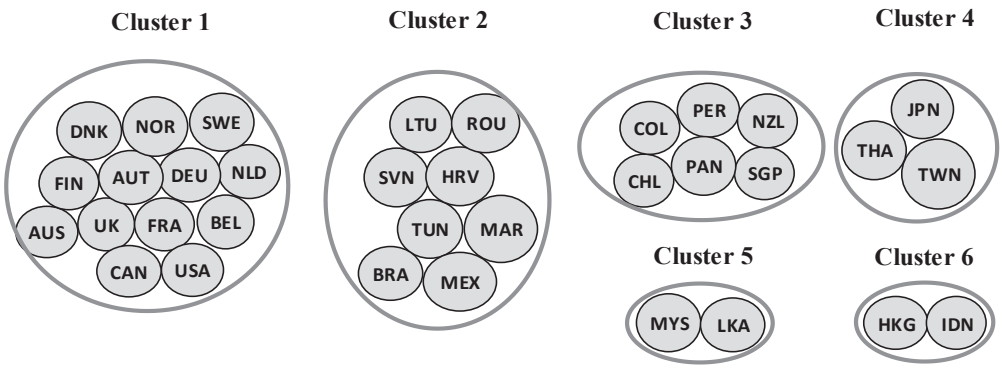


Figure 19 Clusters Formed on the Basis of Identified Government Bond Market Comovements, based on Separate Year Analysis in 2008-2016

*Note. Country codes are presented in Appendix 4.

The first and most anticipated government bond market cluster consists of 10 big developed European government bond markets – Finland, Norway, Sweden, Denmark, the Netherlands, Belgium, France, Austria, Germany and the UK – as well as the US, Canada and Australia. These markets were expected to strongly commove together. In addition, the mentioned government bond markets are the majority of the markets identified as most strongly commoving with the other markets in the previous stage of this empirical research.

The second biggest cluster of government bond markets consists of eight markets most strongly commoving in between. This cluster involves Morocco and Tunisia (geographical neighbours), Brazil and Mexico; Lithuania, Romania, Slovenia and Croatia (recent members of the EU). The four latter government bond markets in this cluster belong to the countries with similar economic situation, based on GDP per capita (from 22 to 32 thousands International

dollars per person in 1993 to 2016) and the first four are of similar weak economic development (from 8 to 19 thousands of International dollars per person) based on the CIA[8] (2017) data.

Government bond markets found to be forming a separate third cluster in every analysed year, are Peru, Colombia, Chile, Panama, New Zealand and Singapore. It can be seen that this cluster is formed of four Central-South American government bond markets and two neighbouring economies that are included in the list of developed countries. It can be concluded that this cluster, stable at each separate analysed years, is rather diverse as well.

The fourth cluster, stable in each separate analysed year, is constituted of Japanese, Taiwanese and Thai markets, all representing Southeast Asia. It is rather interesting that these government bond markets steadily commove in between having in mind that the Japanese government debt is the highest in the world (234.7 % of GDP in 2016)[9] and most of it is financed by internal emissions. Nevertheless, these markets steadily clustering together can be one of signs of the importance of geographical factors for the comovements.

The two final identified clusters are actually two pairs of government bond markets closely commoving in between. One of these pairs is Malaysian and Sri Lanka's and the other – Hong Kong's and Indonesia's. The latter two countries have similar government debt levels in 2016 (respectively 38.4 and 29.4% of GDP), but both pairs are formed by two countries with very different levels of economic development (based on CIA's data). Consequently, the fact that government bond markets in these clusters are geographical neighbours cannot be overlooked.

The assessment of the different levels of government bond market comovements has been implemented in two stages – by investigating the full research period and by assessing the differentiation for each year separately in order to reveal the stability of clusters. Results show that around a half of analysed markets (34 out of 75) in the global environment form separate clusters that are stable independently from the situation in the global environment (this has been proven by the year-by-year analysis).

Position of the other half of the markets fluctuates depending on the year investigated, and some of the markets are relatively independent, not commoving with the other government bond markets most of the time (for example, Ecuador, Argentina or Ukraine). These markets could be considered a good investment choice for portfolio diversification. These results allow confirming Hypothesis 2: differentiation of government bond market comovements is significant in the global environment.

[8]Official data and estimations obtained from Central Intelligence Agency's website (https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html)
[9]Official data of Central Intelligence Agency (https://www.cia.gov/library/publications/the-world-factbook/rankorder/2186rank.html)

Results of the first part of research – assessing comovements between government bond markets and different levels of these comovements in the global environment – fulfiled some of the expectations. Comovements between government bond markets exist and are significant, independently on the data window used for the analysis. Differentiation between government markets can be identified as significant, with half of the markets being assigned to clusters, independently on the data frequency used. Moreover, there is a common tendency for neighboring government bond markets to cluster together.

Results obtained indicate that the combination of investment in government bond markets should not be chosen randomly, with the assumption that these markets, differently than stock markets, move independently from each other. In order to benefit from diversification, investors, investing in government bond markets, should combine investments among the markets, belonging to different clusters, or the ones, that have been found to commove independently during research period. The choice of the government bond markets should also depend on the risks that investor is willing to undertake.

Results of the first part of the research are as well expected to benefit national and international policy makers, since the existence of comovements and differentiation between government bond markets should be useful in forming the borrowing policies and regulations for bond issues when governments decide to borrow. Despite of that, even though the existence of comovements between government bond markets in the global environment has been identified, the question of which factors determine these comovements has not been answered yet. The following stage of empirical research results is designed to at least partly answer this question by presenting the results of the assessment of the factors influencing government bond market comovements in the global environment. The first set of investigated factors are global factors.

3.2. Results of the Assessment of the Factors Influencing Government Bond Market Comovements in the Global Environment

Assessment of the factors influencing government bond market comovements is carried out in three stages. Firstly, the influence of global factors on government bond market comovements is determined, then the influence of fundamental and bilateral factors is assessed.

3.2.1. Results of the Assessment of the Influence of Global Factors on Government Bond Market Comovements in the Global Environment

This stage presents the results of testing Hypothesis 3: global factors have a significant influence on government bond market comovements in the global environment.

To test H3, five global factors were chosen. These factors and their measures have already been described in the second part of the dissertation. After collecting the data for all the factors, their daily changes are calculated and their dynamics is assessed (*see* Appendix 8).

Since all the factors and their measures discussed above represent the global market situation, there is a threat of them duplicating each other. In order to avoid this threat, measures of all the investigated global factors have been tested for multicollinearity by calculating the VIF[10] for each pair of them. No investigated pairs show a possible threat of multicollinearity (see Appendix 9 for calculations). It can be seen that the VIF measurements for all the data frequencies have been smaller than 3, indicating that there is no potential multicollinearity threat. This fact allowed including all the five chosen global factors as control variables when assessing the influence of global factors on government bond market comovements as well as when estimating the influence of separate factors on government bond market returns.

After testing global factors for multicollinearity, the analysis of their influence on government bond market comovements is carried out and the results of calculating adjusted Pearson correlation coefficients are presented. Summarized results can be seen on Figure 20.

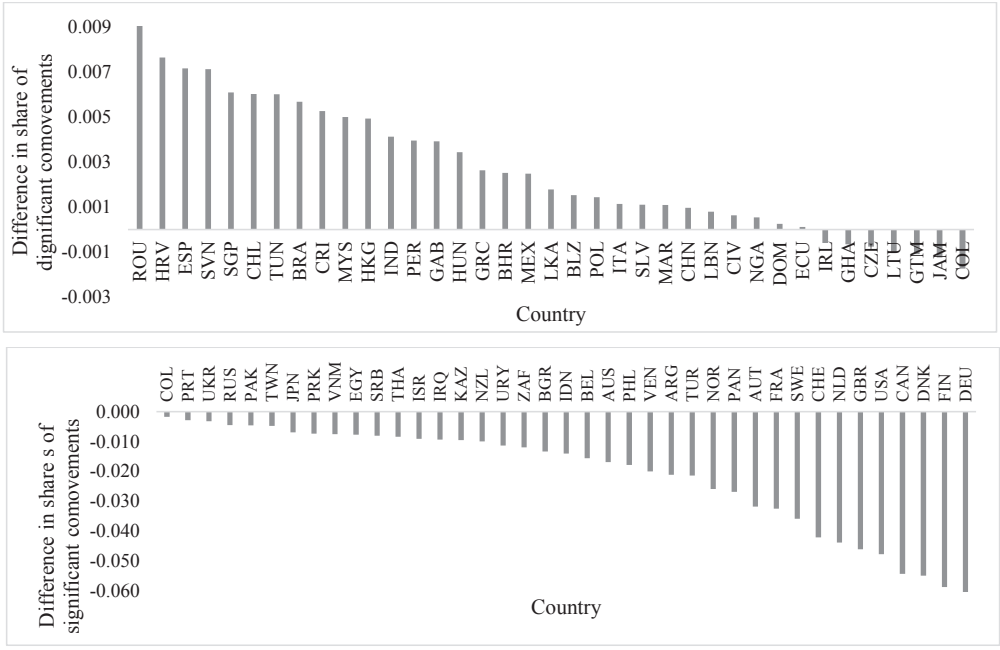


Figure 20 Differences in Share of Significant Government Bond Market Comovements before and after Controlling for the Influence ofGlobal Factors in 2008-2016

*Note. Country codes are presented in Appendix 4.

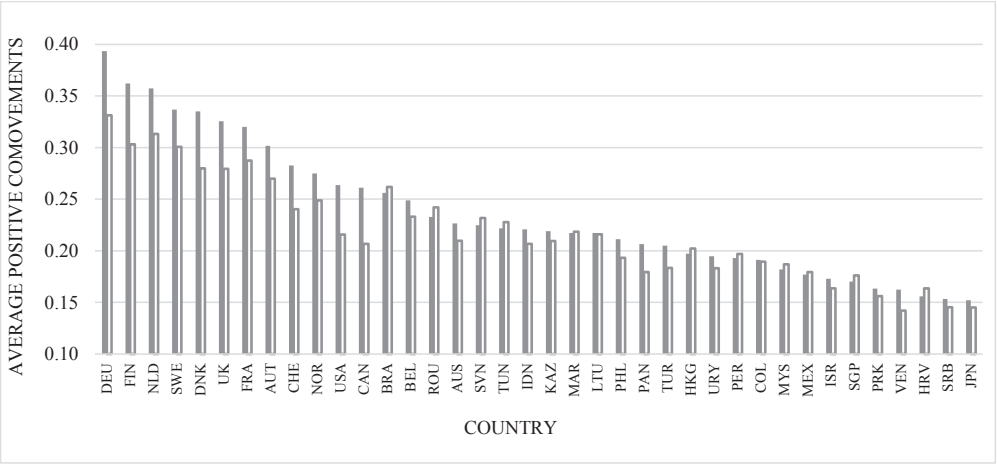
[10]VIF – Variance Inflation Factor.

In general, the results show that government bond market comovements have not changed significantly after controlling for the chosen global factors. The share of significant comovements in the whole sample of markets has decreased from 69.5% to 68.1%, while the average positive government bond market comovements decreased from 0.177 to 0.168. It can be seen that after removing the influence of common global factors, government bond market comovements did not change a lot. Moreover, comovements had a tendency to weaken for separate countries, but this weakening was not significant enough to conclude that the influence of global factors on government bond market comovements is significant.

When looking at each separate government bond market, it can be seen that a share of significant residual comovements with the other markets has most strongly increased for government bond markets in Colombia, Uruguay, Panama, South Africa and Thailand. On the other hand, the share of significant comovements with the other government bond markets has most strongly decreased for Kazakhstan, Romania, Iraq, Taiwan and Greece when controlled for the five investigated global factors. Both tendencies mentioned show that for these markets the comovements with the other markets strongly depend on the analysed global factors. For example, significant Greek government bond market comovements with the other markets have decreased from almost 75% to only 55% after controlling for the influence of global factors, allowing to conclude that this market has been strongly dependent on the factors in 2008-2016. Given that the country has severely suffered from the systemic sovereign debt crisis, it is not surprising that the global factors included in the model have decreased its comovements with the other markets. Analysis of how the average significant comovements change for every government bond market after controlling for the influence of global factors has been implemented as well and the results are presented in decreasing order in Figure 21.

It can be seen that the average positive comovements with other analysed government bond markets tended to strongly decrease after controlling for global factors for Germany, Finland, Netherlands, Sweden, Denmark, the UK, France, Austria, Switzerland, the US, and Canada. For the other government bond markets the average positive comovements with other markets either did not change a lot, or slightly increased.

After assessing the overall influence of global factors on government bond market comovements, it is also important to show how this influence changed during the research period. To do that, government bond market comovements are assessed for separate years by controlling for the influence of global factors. Generalized results by year are presented in Table 15.



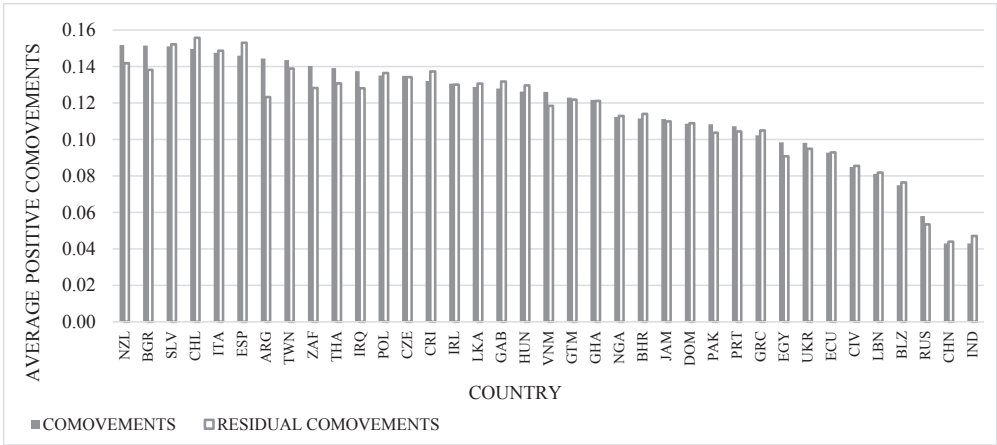


Figure 21 Average Positive Government Bond Market Comovements before and after Controlling for the Influence of Global Factors in 2008-2016

*Note. Country codes are presented in Appendix 4.

Changes in values presented in Figure 21 show that the share of significant comovements between government bond markets has changed up to 10 percentage points (ppt) in each separate analysed year, with the biggest changes being in 2011 (decrease of 8.12 ppt) and 2013 (decrease of 9.32 ppt). Average positive government bond market comovements have only slightly decreased in most of the years, after controlling for the influence of global factors, while negative comovements have slightly increased in most of the years. Results do not show strong influence of global factors on government bond market comovements.

The obtained results and revealed tendencies do not allow confirming H3: global factors do not have significant influence on government bond market comovements in the global environment**.**

Table 15 Changes in Government Bond Market Comovements after Controlling for the Influence of Global Factors by Year

YEAR / ASSESSMENT CRITERIA	2008	2009	2010	2011	2012	2013	2014	2015
Percentage of significant comovements	-4.23%	-3.09%	-6.88%	-8.12%	-6.88%	-9.32%	-5.23%	-3.95%
Average positive comovements	-0.003	-0.010	-0.035	-0.025	-0.011	-0.009	0.006	-0.002
Average negative comovements	-0.012	-0.006	0.024	0.063	0.034	–	0.001	0.009

These results deny an an assumption, that the analysis run over the period of financial crisis, with the markets being affected by the global economic and financial conditions, should reveal the influence of these factors on government bond market comovements. The fact that there is no significant influence of global factors as a group on government bond market comovements made it important to further check whether these factors influence government bond market returns in general. In order to determine that, multiple regression analysis has been implemented with daily data for every analysed government bond market with government bond index returns as the dependent variable and changes in five global factors (expressed in six measures) – as independent.

An extract of the full set of results is presented in Appendix 10. Summarized results are presented in Figure 22.

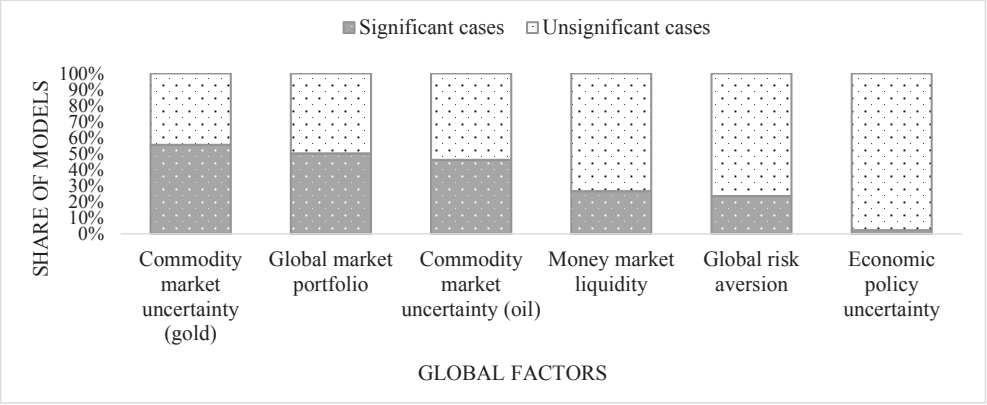


Figure 22 Influence of Global Factors on Government Bond Market Returns in 2008-2016

Results show that the factor that has almost no influence on government bond market returns for any of the analysed markets is global economic uncertainty, expressed in EPU index. Contrarily, global factors influencing government bond market returns in most of the countries

were commodity market uncertainty (expressed in both gold price changes and oil price changes) and global market portfolio (measured by S&P 500 stock market index changes).

On average, changes in gold price and S&P 500 index have significantly influenced government bond market returns in more than 50% of the cases, while oil price changes have a correspondingly significant influence on government bond market returns in 46.22% of analysed markets. Money market liquidity and global risk aversion have been found to be significantly influencing government bond market comovements in less than 30% of the markets (respectively 26.67% and 23.56%). The latter result is rather surprising since it has been proven by multiple authors that global risk aversion influences investment flows in stock markets.

The fact that global factors influence government bond market returns separately, does not support the fact that they should influence government bond market comovements. For example, if these factors significantly influence government bond market returns in Lithuania, and does not in France, comovements between these markets will not be influenced by global factors during the research period. It should be also noted that analysis with a lag of 1 and two quarters has been implemented to see if the effect of global factors on government bond market returns is delayed. Results show that the power of the model to explain market returns decreases with the lags. Consequently, further research has been implemented with the simultaneous time series of dependent and independent variables.

The next step of empirical research is to assess the influence of global factors on government bond market returns in every country for each separate year. When looking at a general picture, it can be seen that the influence of global factors on government bond market returns has been time-varying (Figure 23).

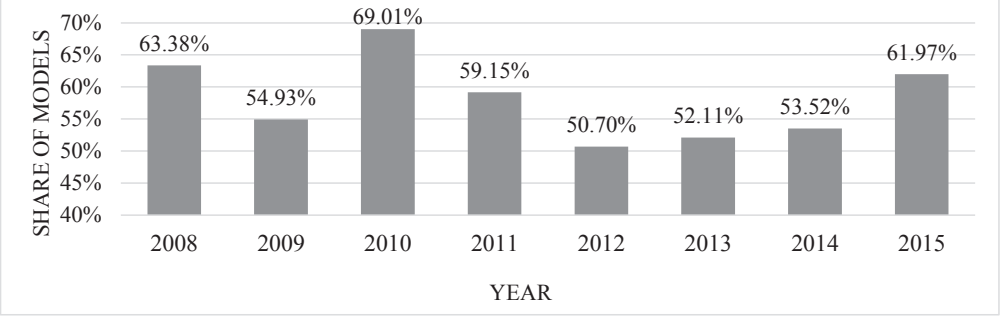


Figure 23 Share of Significant Models of the Influence of Global Factors on Government Bond Market Returns by Year

From a wide sample of 75 markets, there were 60 countries, whose government bond index returns have been influenced by the chosen global factors for at least one of the 8 investigated

years (from 2008 to 2015). It should be noted that in each separate year at least 50% of government bond market returns could have been explained by global factors.

The strongest influence has been recorded in 2008, 2010 and 2011, when respectively 63.38, 69.01 and 59.15 % of government bond market returns could have been explained by the variation of the investigated global factors. Contrary to that, the weakest influence of global factors on government bond index returns has been obtained in 2012 – 50.70 % of the markets.

Results of the influence of particular global factors on government bond market returns for each separate year can be seen in Figure 24. They are similar to the ones of the full research period.

The global factors that influence government bond market returns in the biggest share of models are commodity market uncertainty (expressed in gold and oil price changes) and global market portfolio (expressed in S&P 500 changes). Changes in oil price were explaining a bigger share of government bond market returns in the beginning of the research period, while gold price changes influenced the returns more in the second half of the research period. In 2013 and 2014 the oil price have only influenced government bond markets in a few countries. The influence of global market portfolio, expressed in S&P 500 changes, has been more stable within the years, with the exception of a decrease in 2015.

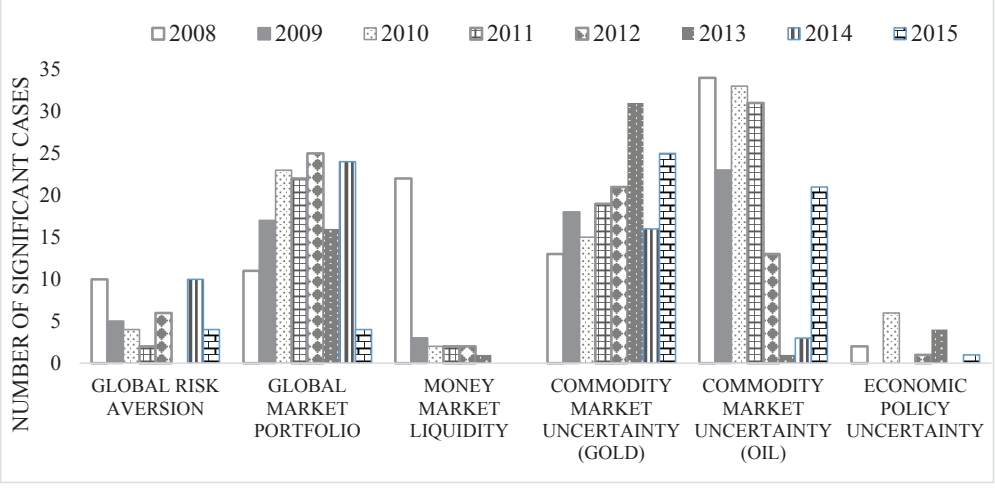


Figure 24 Number of Significant Global Factors in Explaining Government Bond Market Returns by Year

It should be noted that money market liquidity (expressed in FED interest rate) has been particularly important for government bond market returns in 2008, and afterwards its power diminished. That should be associated with the lowered interest rates and the implementation of the Quantitative Easing that left the rates in a relatively stable place. In addition, the influence of

global risk aversion has been relatively low on government bond market returns again showing that government bond markets are not as much exposed to global risk fear as expected.

Finally, results of analysing the distribution of the influence of global factors on government bond markets by countries are presented in Table 16. Results show that in all the eight separate analysed years global factors steadily explained government bond market returns in 13 markets.

It is not surprising that among these countries, the US, Germany and the UK are listed, but the inclusion of other countries is rather surprising: government bond markets in Brazil, Croatia, Hong Kong, Kazakhstan, Mexico, Morocco, Romania, Thailand, Tunisia and Venezuela were strongly influenced by the global factors during all the eight years. Government bond markets in Canada, Finland, the Netherlands, as well as Argentina, Israel, Lithuania, Slovenia, South Korea, Taiwan and Turkey have been strongly influenced by the global factors investigated seven out of 8 analysed years. On the other side of the graph, the countries that were not dependent on global tendencies at all, were China, Czech Republic, Dominican Republic, Egypt, India, Jamaica, Lebanon, Pakistan, El Salvador and Sri Lanka.

*Table 16 Assessment of the Stability of the Influence of Global Factors on Government Bond Market Returns by Countries**

NUMBER OF YEARS	COUNTRY
8	Brazil, Croatia, Germany, Hong Kong, Kazakhstan, Mexico, Morocco, Romania, Thailand, Tunisia, the UK, Venezuela, the US
7	Argentina, Canada, Finland, Israel, Lithuania, the Netherlands, Slovenia, South Korea, Taiwan, Turkey
6	Colombia, Italy, Malaysia, Norway, Russia, Singapore, Spain, Sweden, Switzerland
5	Indonesia, Panama, Peru, the Philippines, Serbia, South Africa, Ukraine, Uruguay
4	Australia, Austria, Chile, Denmark, France, Ghana, Poland
3	Belgium, Bulgaria, Gabon, Greece, Hungary, Iraq, Ireland, Vietnam
2	Costa Rica, Ecuador, Guatemala, New Zealand, Portugal
1	–
0	China, the Czech Republic, the Dominican Republic, Egypt, India, Jamaica, Japan, Lebanon, Pakistan, El Salvador, Sri Lanka

*a case is considered if at least one global factor influences government bond market returns in that country in that year.

*Note. Country codes are presented in Appendix 4.

Next to these countries, some government bond markets were only influenced by global factors for 1 year in all the research period, so this influence might as well be random. These government bond markets are Costa Rica's, Ecuador's, Guatemala's, New Zealand's and Portugal's.

Analysis shows that global factors steadily explain government bond market returns in Brazil, Croatia, Hong Kong, Kazakhstan, Mexico, Morocco, Romania, Thailand, Tunisia and

Venezuela – returns in these government bond markets continuously depend on the changes in global financial conditions. Contrary to that, global factors could not explain government bond market returns in China, the Czech Republic, the Dominican Republic, Egypt, India, Jamaica, Lebanon, Pakistan, El Salvador and Sri Lanka in any of the separate analysed years, allowing to conclude that these government bond markets did not suffer from changes in global financial conditions during the research period. Global factors could explain government bond market returns in other countries from seven to two out of the eight years.

When generalizing the empirical research results, several important tendencies were revealed. The identified global factors, as a group, do not significantly influence government bond market comovements in the full research period, but there exist certain cases of their influence being important. When assessing the general influence of global factors on government bond market comovements by separate year it has been shown that this influence was also absent in each separate year.

Analysis of the stability of global factors influence on government bond market comovements has been implemented by dividing research sample by years, by countries and by analysed factors. Analysis by separate year showed that global factors could most strongly explain the returns in government bond markets in 2010, while their effect was the weakest in 2012.

Analysis by separate factors show that on average commodity market uncertainty (expressed in oil and gold price changes) and global market portfolio are most strongly influencing government bond market returns during the research period. Even though the influence of oil price changes on government bond market comovements has been very strong in the beginning of the research period, in the second half of it this influence strongly decreased. Most probably it could be related to the fact that oil price fluctuates in cycles and 2014 has been the starting peak for the most recent cycle when OPEC changed its policy[11]. Contrarily, the majority of government bond markets have already been recovering from a decline, so the power of oil price changes was not significant.

Influence of gold price changes, as well as global market portfolio on government bond market returns during the period of empirical research has been more stable. Global market liquidity, expressed in changes of FED interest rates, was significant in 2008 and afterwards its power diminished. That should be associated with the fact that lowered interest rates and implementation of the Quantitative Easing that left the rates in a relatively stable place. Finally, global risk aversion has influenced the markets a lot less than expected, and the influence of economic policy uncertainty has been very weak.

[11] Information from Oil Price website (http://oilprice.com/Energy/Energy-General/Why-This-Oil-Crisis-Is-Different-To-2008.html) and Appendix 8.

Analysis of the influence of global factors on government bond market returns in separate countries showed that these factors could have steadily (in each separate year of the analysis) explained government bond market returns in 13 out of 75 markets investigated while their influence was fluctuating on the other analysed markets.

Due to these results Hypothesis 3 has been rejected: global factors do not have a significant influence on government bond market comovements in the global environment**.** This kind of results were obtained by Weigel and Gemmill (2006), Bunda, Hamann and Lall (2009), Miyajima, Mohanty and Chan (2012), Paniagua, Sapena and Tamarit (2015), among others.

The results are good news for investors, including government bonds in their investment portfolios. If government bond markets are not generally influenced by global factors, they do not crash down with the other markets when the global financial environment becomes volatile. As a result, investment in government bond markets could be used to hedge against the global risks that the investments are exposed to. In addition to that, identification of the markets that are mostly influenced by global factors enable avoiding including these markets in investment portfolio or at least not combining multiple government bond markets highly dependent on global factors.

Empirical research results obtained in this stage are also beneficial for governments: the fact that their government bond market returns and comovements with other markets are only partly influenced by global factors, or that this influence is unstable enables governments to adjust their borrowing policies. For example, if the returns of the Czech government bond market have not been influenced by any of the global factors in any year, this government might present its bonds as a good investment to hedge from global risks. In addition to that, this is an indication for the governments that in order to optimize their borrowing strategy, they should work on the country-specific factors, and do not expect global market conditions adjusting the price of their debt.

Nevertheless, the question of what factors influence government bond market comovements in global environment rests only partly answered. In reveal the other potential factors, the assessment of the influence of fundamental factors on government bond market comovements is implemented in the following section.

3.2.2. Results of the Assessment of the Influence of Fundamental Factors on Government Bond Market Comovements in the Global Environment

This stage of empirical research presents the results of the assessment of the influence of fundamental factors on government bond market comovements, in order to test Hypothesis 4: fundamental factors have a significant influence on government bond market comovements in the global environment. The fundamental factors chosen in order to test the prepared research methodology have been listed in the second part of dissertation. These factors were divided into

three groups: macroeconomic, government and market liquidity, and the assessment of each factor's influence on government bond market comovements has been implemented by using daily analysed data from government bond markets.

Eight fundamental factors have been chosen to assess their influence on government bond market comovements in the global environment. Similarly as in the previous research stages, this influence has been assessed in a two-step procedure. Firstly, the influence of fundamental factors on government bond market comovements during the whole research period (2008-2016) has been estimated in order to reveal the general tendency. Secondly, stability of this influence has been assessed investigating it for each separate year.

Division of the full empirical research period into sub-periods is expected to reveal the dynamics of the influence of fundamental factors on government bond market comovements in the global environment. Moreover, when implementing the estimation for the full research period, the 1-quarter and 2-quarters lags have also been used in order to assess whether the influence of the fundamentals only manifests in the following period. It should be noted that the lags on the fundamentals used did not increase the quality of the model, indicating that the relationship is revealed when estimating the parallel data and no-postponed influence on the comovements can be seen.

The model for the full research period has been formed from 3255 observations for the analysed government bond market comovements and fundamental factors. With the value of an adjusted coefficient of determination being 0.306, the model is able to explain more than 30% variation in data, which is a good quality characteristics given the amount of data points. Adjusted R^2 shows how well the data points fit a regression line, as well as adjusts it for the number of independent variables in a model. On the first look, it might be interpreted that 30% of explanation is not good enough to state that the model formulated is a good fit for the data obtained, but that should not be accepted as a statement. P-value for the model is smaller than 0.0005, which is a good quality characteristics for the obtained model.

Going further into interpretation of the results, it can be seen that out of eight independent variables chosen as influencing government bond market comovements, six have been found to be statistically significant. Two insignificant factors in the model during the full research period are fiscal deficit and international reserves. Government debt, output growth, inflation, unemployment, currency price and market volume have been found to be statistically significant predictors in the model, enabling to rewrite the model in the following form:

$$r_{ijt} = 0.836 - 0.066\left|DEB_i - DEB_j\right|_t - 0.078\left|GRO_i - GRO_j\right|_t - 0.013\left|INF_i - INF_j\right|_t - 0.036\left|UNM_i - UNM_j\right|_t - 0.005\left|RER_i + RER_j\right|_t - 0.506\left|MAR_i - MAR_j\right|_t + \varepsilon_{ijt} \quad (19)$$

Interpretation of equation 19 is not straight-forward. It determines the influence of the factors' difference on government bond market comovements and not the influence of the specific factor. This modification has been implemented due to the fact that the estimation of comovements (dependent variable) jointly include two government bond markets, so independent variables need to include characteristics of both markets as well (see Pretorius (2002)).

Regression analysis is implemented in such a way, that it allows determining how much the comovements between government bond markets in two countries depend on the differences of the fundamentals in the analysed countries during the research period. The notion of intercept is important in this context, because it shows how strong the comovements between the government bond markets would be, if there were no differences between fundamentals in the two analysed countries. In this case, the comovements between the returns of two markets would on average be almost 0.84.

Initially, the coefficients next to the differences of independent variables (fundamental factors) seem to be relatively small, but that should not be interpreted as diminishing their significance. Since the analysed factors are either expressed in percentages, or scaled by the country's GDP, even small coefficients next to their differences might indicate strong influence on the comovements. For example, the influence of government debt on government bond market comovements can be interpreted as follows: if debt to GDP ratio has grown by 0.94 in Denmark and by 1.57 in Germany (making the difference between the changes 0.63), under ceteris paribus it reduces comovements between government bond markets of the two government bond markets by 0.04.

It should be noted that all of significant coefficients next to the factor differences are negative, confirming expectations about the results – the bigger are the differences between fundamental factors in two countries, the weaker should be the comovements between government bond markets in these two countries.

The strength of all the coefficients representing the influence of fundamental factors on government bond market comovements in 2008-2016 is presented in Figure 25. It can be seen that the strongest beta coefficient obtained has been for market volume (lower than -0.5). The influence of output growth and government debt on government bond market comovements are of similar strength (-0.078 and -0.066 correspondingly). Differences in the levels of unemployment and inflation in two countries have a weaker influence on government bond market comovements (0.036 and 0.013 respectively).

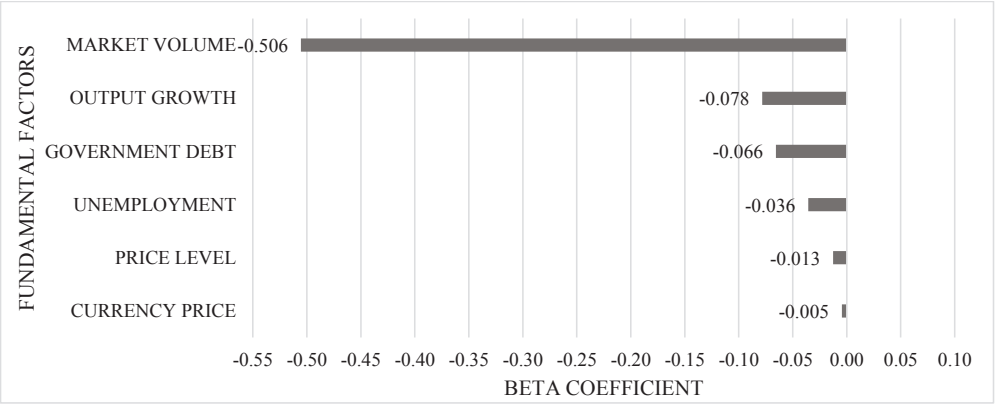


Figure 25 Significant Influence of Fundamental Factors on Government Bond Market Comovements in 2008-2016

Finally, even if indicated as statistically significant, currency price, expressed in differences of real effective exchange rates in two countries, has a very small influence on government bond market comovements. Results obtained are not surprising since market characteristics were reported to be important for the comovements by other researchers (Gomez-Puig, 2009; Haugh et al., 2009; Attinasi et al., 2009; Arghyrou and Kontonikas, 2011, and others).

Even though analysis of the full research period revealed common tendencies, it should be noted that the research period was characterized by high volatility in global financial markets and global economies, with the appearance of a global financial crisis, a sovereign debt crisis and other financial difficulties that countries had to face. Following that, running the analysis on the whole 8-years period, without taking into consideration events happening in a shorter time frame, showed only half the picture. Consequently, the next step of the assessment was to test the stability of the influence of fundamental factors on government bond market comovements within each separate year. In order to determine that multiple regression with the same dependent and independent variables has been performed for each separate year.

The share of variation of government bond market comovements explained by fundamental factors has been ranging from 40% in 2010 to 64.4 % in 2008. Fundamentals tended to explain a relatively higher share of variation in the beginning of the research period (particularly in 2008 and 2009) and their explanatory power has decreased afterwards. During the following years, adjusted coefficient of determination for annual models has been 40%, 48%, 44% and 47% correspondingly in 2010, 2011, 2012 and 2013. Explanatory power of the factors, included in the model, has again increased to more than 60% in 2014 and 2015.

It can be concluded that analysing each year separately revealed some tendencies that are otherwise hidden by the full-time analysis. It can be seen that the factor demonstrating the most

stable influence on government bond market comovements from year to year is government debt (see Figure 26).

Even though its influence on government bond market comovements is not very strong, it stayed relatively stable from 2010 (right until the beginning of the sovereign debt crisis) to 2015. Consequently, comovements between government bond market returns are most steadily influenced by the differences of government debt, financed by government bonds in the two countries. The higher the differences in government debt levels compared to GDP are, the weaker are comovements between government bond markets are.

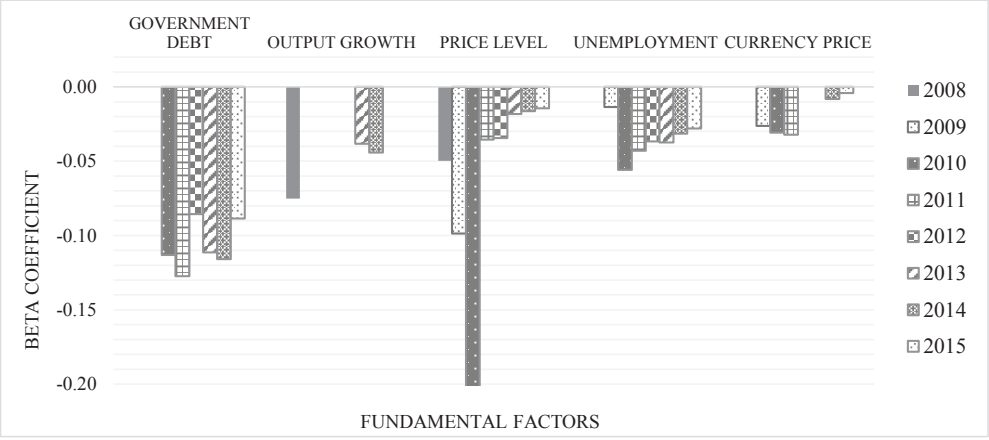


Figure 26 Stability of the Influence of Fundamental Factors on Government Bond Market Comovements in 2008-2015

On the other hand, in the same ways as in full-period analysis, differences in countries' fiscal deficits have not been found to be significantly influencing government bond market comovements in any of the separate analysed year. It can be again argued that fiscal deficits reflect more of a short-term position of government finances, while comovements might depend on longer-term tendencies in the markets.

Differences in output growth in two economies have been found to significantly influence government bond market comovements only in 2008, 2013 and 2014, while differences in price levels have been continuously influencing government bond market comovements. The strongest influence of these differences has been recorded in the beginning of the research period (in 2008-2010). It should be noted that inflation had a tendency to decrease and to be substituted by deflation during the second half of the research period. Moreover, real interest rates have been

steadily declining over the past 20 years. In addition to that, since the start of 2008 real long-term rates have fallen further and faster to negative values[12].

Differences in levels of unemployment tended to also take a constantly significant part as influencing government bond market comovements during the research period, with the exception of 2008, while the influence of differences in currency prices of two countries on government bond market comovements was very small and could be almost equated to zero, even if assessed to be significant in most of the years. Finally, results of analysing the influence of differences between international reserves and the volumes of government debt securities outstanding on government bond market comovements are separately presented in Figure 27.

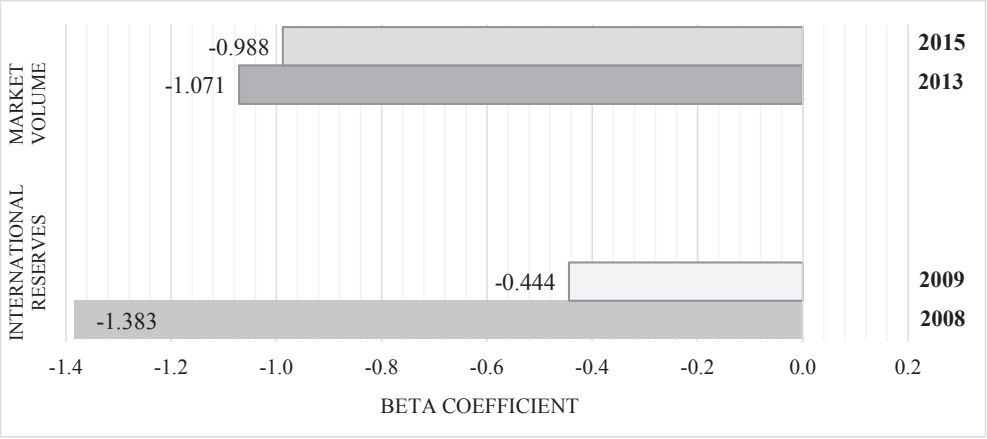


Figure 27 Influence of International Reserves and Market Volume on Government Bond Market Comovements by Year

The influence of these fundamental factors is portrayed separately due to different scales of their coefficients obtained. Differences in international reserves have been very strong explanatory variables of government bond market comovements in 2008 and 2009, but since then the power of this factor has diminished.

Contrarily, differences in government bond market volumes have been found to be statistically significant only in the end of the research period (2013 and 2015), while it wasn't significant in any other year. It shows that issued government bonds started influencing comovements between the government bond markets in two countries only after some time of debt accumulation. The full set of ANOVA tables can be seen in Appendix 11 and Appendix 12.

[12] Information of *the Economist (2016)*

Generally, the results obtained prove time-varying influence of the selected fundamental factors on government bond market comovements in the global environment with this influence being stronger in relatively calmer periods and being overshadowed by other factors when the global financial situation is volatile. Nevertheless, the results enabled accepting Hypothesis 4: fundamental factors have a significant influence on government bond market comovements in the global environment, with the notion that this influence is dynamic. Results show that the most stable influence on government bond market comovements is from government debt, levels of prices and unemployment, while fiscal deficit did not have a significant influence on comovements during the period of research.

The research results show that fundamental factors tended to explain a much bigger share of government bond market comovements in 2008, 2009, 2014 and 2015, while in the middle of the research period the model for the influence of fundamental factors on government bond market comovements was able to explain much less variance. Consequently, it can be argued that during the times of stress in financial markets, the government bond markets tend to not follow the regular patterns and instead depend on the influence of global factors. This insight is especially important to investors, when choosing in which markets to invest during high volatility periods in the global economy. Since government bonds are still assumed to be a relatively safer investment than stocks, investors might prefer these markets. When forming investment portfolios investors should know that volatility distorts not only the characteristics of government bond markets, but the influence of a country's fundamentals on these markets as well.

When adding these results to the results obtained when assessing the influence of global factors on government bond market comovements and the stability of this influence, it can be seen that the groups of global and fundamental factors were both significant when explaining government bond market comovements in 2008 and 2015. Nevertheless, during the high volatility periods in financial markets, the power of fundamental factors was much less evident. Since the method for the assessment of the influence of fundamental factors on government bond market comovements was pooled regression, it was not possible to identify the influence of these factors on the comovements in separate country pairs. Nevertheless, it can be clearly seen that fundamental factors influence government bond market comovements and this influence is not stable with time, allowing to accept H4: fundamental factors significantly influence government bond market comovements in the global environment.

When generalizing the results it can be stated that differences in debt levels already accumulated by the governments, have been the most important fundamental factor influencing government bond market comovements in the global environment. Contrarily, differences in level of fiscal deficit did not influence the comovements in any of the analysed years. Some authors

explain it by the fact that fiscal deficit tend to be rather random for separate quarters. These findings are in line with the results of others, such as Pandit (2013), who shows that comovements between long-term interest rates and fiscal deficits are insignificant. In addition, countries' macroeconomic characteristics, such as price level inflation and unemployment, have been steadily important factors, determining comovements between government bond markets in these countries.

Finally, in the end of the research period, after government bond markets have already experienced financial difficulties, the differences between government bond market volumes started to be significant factors influencing government bond market comovements. This indicates that the history of a country's borrowing and its situation is considered as reflecting its credibility, and as a result, is assessed by the investors before purchasing government bonds. Contrarily, differences in international reserves were found to be significant only in the first two years of research and their influence diminished later on.

After assessing the influence of global and fundamental factors on government bond market comovements and the stability of this influence, the influence of country specific bilateral factors on government bond market comovements is assessed. The results are presented in the next section.

3.2.3. Results of the Assessment of the Influence of Bilateral Factors on Government Bond Market Comovements in the Global Environment

This stage of empirical research presents the results of analysing the influence of bilateral factors on government bond market comovements. In addition, Hypothesis 5 is tested in this stage: bilateral factors have a significant influence on government bond market comovements in global environment. The selected bilateral factors have already been listed in Table 9. Five bilateral factors, representing trade linkages, financial linkages and geographic characteristics, have been selected, with the objective to assess their influence on government bond market comovements in the global environment. Assessment of each bilateral factor's influence on government bond market comovements has been implemented by using daily returns on government bond market indices and annual changes in the bilateral factors' values.

Similarly as in the previous research stages, the influence of bilateral factors on government bond market comovements has been assessed in two steps. Firstly, the influence of bilateral factors on government bond market comovements during the full research period has been assessed in order to reveal the general tendency. Secondly, the model was separately employed for every large country c, analysing its linkages with the smaller countries i. Thirdly, the influence has been

assessed for all the country pairs but differentiating by year in order to determine whether the relationship is stable, or time-varying.

It should be reminded that this stage of empirical research has been implemented by dividing all the analysed countries into large countries *c* (France, Germany, Japan, the UK and the US) and smaller countries *i*. An assumption made was that the effect of bilateral factors on government bond market comovements only manifested itself when assessing the linkages from larger to smaller countries and not the opposite.

Results of implementing the analysis for all the pairs of large countries with smaller countries for the full research period (2008-2016) have not been as revealing as expected. Out of five bilateral factors chosen as influencing government bond market comovements in the global environment, only one has been found to be statistically significant (see Appendix 13). This factor is foreign direct investment, representing financial linkages between the countries. The constructed model enabled to explain only 10% of variations in comovements, being not a qualitatively high characteristic. The influence of foreign direct investment from larger countries *c* to smaller countries *i* has been found to be positive – the obtained beta coefficient is 5.99. This result can be interpreted as follows – increase in foreign direct investment from country *c* to country *i* by 1% of country *c* GDP, increases comovements between government bond markets of these countries by almost 6%. The obtained numbers are relatively small due to the fact that foreign direct investment data has been scaled by the large countries' GDP.

It should be noted that the results of pooled regression did not reveal all the tendencies of the relationship between bilateral factors and government bond market comovements. The analysis was carried out between a set of larger countries *c* (France, Germany, Japan, the UK, and the US) with a set of smaller countries, so comovements in separate groups have been investigated as well. A separate group is considered to be one of the large countries and all the other smaller analysed countries. Summarized results of this investigation can be seen in Figure 28.

It can be seen from Figure 28 that the distribution of the influence of bilateral factors on government bond market comovements during the research period was uneven depending on a large analysed country. Firstly, it should be noted that the country models with Japan or the UK as a large country ended up insignificant –models did not fit the data. In other words, the bilateral factors did not have a statistically significant influence on government bond market comovements during the full period of empirical research. Models, applied to the data of the three other large countries have been valid for certain bilateral factors. Beta coefficients next to these factors vary significantly.

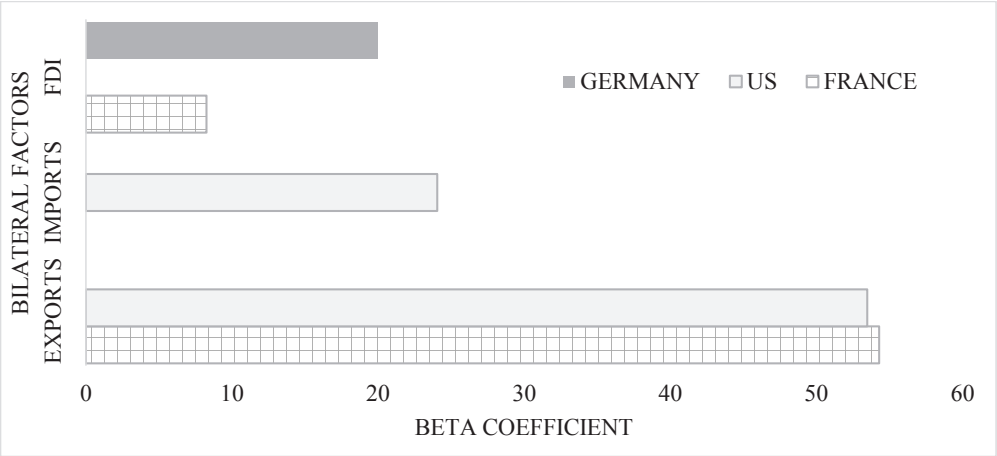


Figure 28 Influence of Bilateral Factors on Government Bond Market Comovements by Large Countries in 2008-2016

When analysing data cases by a large country, it has been revealed that comovements between France and smaller government bond markets were influenced by the biggest number of factors out of all the selected large countries. These factors are portfolio investment from France to other markets, exports from France to these markets as well as the foreign direct investment (FDI) from France to smaller markets. Two bilateral factors have been found to be significantly influencing government bond market comovements when taking the US as a large country (imports and exports from/to smaller markets to/from the US) and only one, FDI, when analysing Germany's case.

With France being the large country, the coefficient of the export variable was six times bigger than the coefficient of the FDI variable and even 27 times bigger than the portfolio investment, showing that export influenced comovements much more strongly that the FDI (both scaled by the country's *c* GDP). Similarly, exports to smaller economies has been found to be a strong significant factor to determine comovements of the US government bond market with the other markets. The beta coefficient associated to export in this model was of similar order as in the case of France. In addition, as it was mentioned, in the US case, government bond market comovements were also strongly influenced by the imports from the smaller markets to the US, scaled by the US GDP: the bigger was the import to the US from the markets, the stronger were government bond market comovements between these markets. Nevertheless, it should be noted that the influence of imports was more than two times smaller than the influence of exports (values of beta coefficients were 24.05 and 53.48 respectively).

Comovements of Germany's government bond market with the other markets have been influenced by FDI. This was the only statistically significant factor, allowing to explain the comovements in Germany's case, but its power was rather strong – the coefficient associated with it was 19.97. Finally, it should be noted that geographic distance between the capitals of the large and smaller markets did not have significant influence on government bond market comovements in any of the cases, neither did bilateral portfolio investment (another factor representing financial linkages between two countries).

It can be seen that the influence of bilateral factors on government bond market comovements strongly differs depending on the large country *c* chosen for the analysis. This fact proves that it was worthy dividing the analysed sample by separate large countries. Nevertheless, there is still a question whether the effect of timing exists: do the same bilateral factors influence government bond market comovements in each separate year? Is this influence stable or does it disappear when pooling the data for all the large countries *c* together and distributing it by year? Generalized results allowing to answer this question are presented in Figure 29. Regression models obtained for each separate year can be found in Appendix 14.

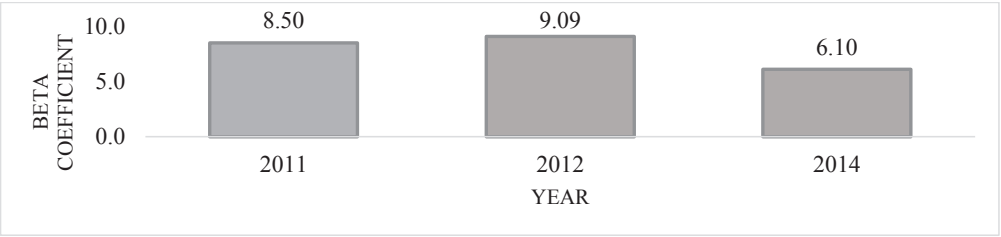


Figure 29 Influence of Foreign Direct Investment on Government Bond Market Comovements by Year

It can be seen from Figure 29 that when the data of all the large countries with the smaller countries were pooled together and differentiated by year the only significant bilateral factor influencing government bond market comovements has been found to be foreign direct investment from large country *c* to smaller countries. Moreover, the influence of this bilateral factor has been significant only in 2011, 2012 and 2014, while in other years the models could not detect any influence of the selected bilateral factors on government bond market comovements.

The values of beta coefficients associated to FDI do not vary significantly within a range from 9.09 in 2012 to 6.10 in 2014. This allows interpreting the empirical research results as follows: with foreign direct investment from country *c* to country *i*, scaled by the GDP of country *c*, strengthening by 0.01, comovements between government bond markets in these countries strengthen by 0.085 in 2011, by 0.0909 in 2012 and by 0.061 in 2014.

These empirical research results show that the influence of the bilateral factors chosen for investigation on government bond market comovements in general is weak with only one financial linkage, foreign direct investment, being important and only in some of the analysed years.

The author emphasised the fact that the influence of bilateral factors on government bond market comovements strongly differs depending on the analysed large country with bilateral factors from France and the US most strongly influencing comovements of their respective government bond markets with the others. Consequently, it allows to conclude that the influence of bilateral factors on the comovements is not stable and that country effect is much stronger than the effect of year.

Empirical research results obtained in this stage allow rejecting Hypothesis 5 even without the calculation of statistically significant bilateral factors. Since only one bilateral factor has been found to be a significant determinant of government bond market comovements in the full period analysis and in the analysis by year, Hypothesis 5 is rejected – bilateral factors did not have significant influence on government bond market comovements in the global environment. Nevertheless, this rejection is followed by a notion that there exist some country-specific effects with bilateral factors of few large markets influencing their government bond market comovements with the other markets, even if these effects could not be generalized.

When comparing the results obtained in this stage of empirical research with the ones from the previous stages it can be concluded that the influence of bilateral factors on government bond market comovements is the weakest out of the three investigated factor groups. Moreover, this influence could only be recorded on the second half of the research period.

This part of empirical research might have been limited by the fact that large countries *c* were chosen not according to the region (largest economies in the geographic regions), but rather because they are the top largest global economies. This choice has been made due to lack of data availability from the other countries, as well as adapting the method of Forbes and Chinn (2003) for a similar investigation in stock markets. These authors have found that some of bilateral factors were significant for comovements between stock markets, so their results could not be extended to government bond markets. Nevertheless, government bond markets were a priori expected to be less dependent on financial and trade linkages between two countries, since government bonds are more of a tool, used by the governments to finance their debt.

Another research limitation could be the bilateral factors, chosen for the investigation, since there exist other bilateral factors that could influence government bond market comovements in global environment. In spite of that, the majority of the selected factors have already been used in the investigation of Forbes and Chinn (2003), as well as those of Pretorius (2002), Rose and Spiegel (2009), and the influence of them has been confirmed for some of the markets. It should

be noted that to the best knowledge of the author of this dissertation, similar research has not been implemented in government bond markets, so the results obtained might strongly differ from the ones in stock markets. On the other hand, these results coincide with Didier, Love and Martinez Peria (2012) who show that the effects of real and trade linkages on comovements between the US and other stock markets were not significant.

3.3. Empirical Research Results and Discussion

The objective of this part of empirical research is to present generalized results on the assessment of government bond market comovements and the factors influencing them in the global environment and to encourage scientific discussion on the research and the obtained results.

Assessment of the factors influencing government bond market comovements has been implemented in five research stages, each designed to test one of the raised research hypotheses. Summarized results on the raised hypotheses and the results of their testing are presented in Table 17. It can be seen that out of five hypotheses made in the dissertation, three have been accepted and two have been rejected. The first two hypotheses, that were accepted, were aiming to assess government bond market comovements and the level of their differentiation in the global environment.

Hypothesis 1 has been accepted due to the fact that the ratio of statistically significant versus all the correlations showed that almost 70% of government bond market comovements were statistically significant during the period of empirical research. This allowed concluding that government bond market comovements are significant in the global environment. In spite of that, analysis of the stability of government bond market comovements showed that these comovements were time-varying with the biggest share of significant comovements registered in 2013, while the smallest – in 2009. It has also been found that more developed, stronger government bond markets exhibited stronger average comovements with the other markets, but they do not commove with the biggest share of them. The list of these has been relatively stable and included the strongest developed European markets until 2013, while in 2013 Asian markets were commoving more strongly. These results can be attributed to the fact that at the time, European governments had been experiencing difficulties borrowing and the government bond markets were seen as lacking trust by the international investors.

These results are generally in line with the results of other researchers, such as Reisen and Maltzan (1998), Sutton (2000), Barassi et al. (2001), Smith (2002), Ciner (2007), Brennan, Kobor and Rustaman (2011), and others. Sutton (2000) showed positive long-term comovements between government bond markets, but only in the biggest economies.

Table 17 Summary of Testing the Research Hypotheses

HYPOTHESIS TESTED		RESULT	ARGUMENTATION
H1	Government bond market comovements in the global environment are significant.	Accepted	Almost 70% of bilateral comovements have been statistically significant during the research period. Government bond markets commoving with the majority of other markets have been identified as well as the ones commoving most strongly with the other markets. Observed comovements are time-varying.
H2	Differentiation of government bond market comovements in the global environment is significant.	Accepted	Separate groups of government bond markets most closely commoving in between have been identified – around a half (34 out of 75) analysed markets form separate clusters that are stable, independently from the year of observation.
H3	Global factors have significant influence on government bond market comovements in the global environment	Rejected	Global factors, as a group, do not significantly influence government bond market comovements neither in the full research period, not in separate years. Nevertheless, strong influence of certain global factors (commodity market uncertainty and global market portfolio) on government bond market returns has been recorded.
H4	Fundamental factors have significant influence on government bond market comovements in the global environment	Accepted	6 out of 8 investigated fundamental factors have been found to be significantly influencing government bond market comovements in the full research period. In spite of that, this influence was not stable with time.
H5	Bilateral factors have significant influence on government bond market comovements in the global environment	Rejected	Only one factor, foreign direct investment, was found to be significant in the full period analysis and in the analysis by year. Rejection is justified by the notion that there exist some country-specific effects with bilateral factors of few large markets influencing their government bond market comovements with the other markets, even if these effects cannot be generalized.

Similarly, Brennan, Kobor and Rustaman (2011) proved the existence of comovements between G7 government bond market indices. Quinn and Voth (1998) showed that correlations between financial markets increased as financial markets were liberalized, while Reisen and Maltzan (1998) show mutual comovements between government bond yield spreads and credit ratings. Barassi et al. (2001), Smith (2002) and Ciner (2007) found a significant relationship between government bond markets.

Strengthened correlation between the spreads during the sovereign debt crisis has been found by Boffelli and Urga (2013), but these authors have only analysed government bond spreads in six EU countries and used ultra-high frequency data, which, differently from a longer-term analysis, was concentrated on volatility spreads inside the markets. The results of the research

carried out in this dissertation enabled to prove existing time-varying comovements between a wide range of government bond markets.

Hypothesis 2 was accepted due to the fact that different levels of government bond market comovements have been identified. Differentiation of government bond market comovements is significant in the global environment with approximately half of government bond markets forming separate clusters in between. Results show that 34 out of 75 analysed markets form clusters that are stable independently from the situation in the global environment (this has been proven by the analysis by separate year). The situation of the other half of government bond markets fluctuates depending on the investigated year. Nevertheless, several markets have been recorded to move relatively independently during all the period of research. These markets could be advised as a good investment choice for portfolio diversification.

Results of this stage of empirical research were in line with the ones obtained by Mantegna (1999), Onnela et al. (2005), Tumminello et al. (2007), Bunda, Hamann and Lall (2009), Namaki et al. (2011), Battiston et al. (2012) and others, who argued that there existed clusters among financial markets and institutions. Nevertheless, there are almost no researches designed to investigate whether government bond markets form separate clusters based on their comovements as well. In this context, the results are important because they complement the results of other researchers in different markets.

Onnela et al. (2005), Tumminello et al. (2007) revealed existence of financial networks and clusters within stocks, traded in NYSE. Similarly, Mantegna (1999) constructed a hierarchical network among stocks in the US. Adamic et al. (2017) showed that comovements between trading strategies and transaction prices, trading volumes, duration, and liquidity can be clustered as well. Clusters forming between financial institutions have been discovered by Cetorelli and Peristiani (2009), and Amini, Cont and Minca (2011). Battiston et al. (2012) found that a clusters of strongly connected financial institutions is extremely systemically important at the peaks of financial crises, while Boss et al. (2004) identified the central institutions whose removal would lead to the collapse of the entire financial system. The results of this research contribute to the mentioned literature, showing that certain government bond markets cluster together and these clusters are based on their comovements.

Hypothesis 3 was rejected because global factors, as a group, do not significantly influence government bond market comovements neither in the full research period, nor in separate years. Nevertheless, after rejecting this hypothesis, the influence of global factors on government bond market returns has also been tested. It allowed recording the existence of an influence of certain global factors on government bond market returns. On average, commodity market uncertainty and global market portfolio have been influencing government bond market returns most strongly

and steadily. Global market liquidity was only significant in 2008, while global risk aversion has influenced the markets a lot less than expected, and the influence of economic policy uncertainty has been proven to be weak. The analysis also showed that the influence of global factors on government bond market returns in separate countries could steadily explain government bond market returns in 13 out of 75 investigated markets while their influence was fluctuating on the other analysed markets.

The results deny the a priori assumption that analysis of the period of financial crisis, with markets being affected by global economic and financial conditions, should reveal the influence of these factors on market comovements and contradict to the results of McGuire and Schrijvers (2003), Weigel and Gemmill (2006), Gonzalez-Hermosillo (2008), Miyajima, Mohanty and Chan (2012), Leippold and Matthys (2015), Paniagua, Sapena and Tamarit (2015) and others. For example, Gonzalez-Hermosillo (2008) showed that if global financial factors were taken into account, contagion from emerging markets was very small or did not exist, concluding that creditworthiness of the markets was mainly driven by a common set of global factors. McGuire and Schrijvers (2003) find that global risk aversion is driving bond spreads, while Gonzales-Rozada and Levy-Yeyati (2008) added the importance of global liquidity.

On the other hand, results obtained coincide with those of Forbes and Chinn (2003), Bunda, Hamann and Lall (2010), Jaramillo and Weber (2012), Ziaei (2012), Mensi et al. (2014), and Simakova (2015). Forbes and Chinn (2003) showed that global factors were not often significant for comovements of stock returns while Jaramillo and Weber (2012) proved that with low global risk aversion domestic bond yields in emerging markets were mostly influenced by fundamental factors. Nevertheless, the authors analysed what influences the returns, and not the financial market comovements. Mensi et al. (2014) proved that financial market returns in different countries were a function of commodity market uncertainty (expressed in oil and gold price changes), and the same has been confirmed in this research. Bunda, Hamann and Lall (2010), Mensi et al. (2014) correspondingly implemented their studies in emerging and BRICS countries and emphasized that changes in global market portfolio influenced other financial markets. The research, carried our in this dissertation, proved the same type of relationship on a global level. Ziaei (2012) also found that gold market uncertainty influence bond and stock markets, while Simakova (2015) proved the same for oil. Finally, according to Mensi et al. (2014), economic policy uncertainty had no impact on stock markets, as it has also been proven in this research.

Hypothesis 4 was accepted because the results proved the general influence of fundamental factors on government bond market comovements in the global environment. It has also been shown that this influence was time-varying – stronger in relatively calmer periods and overshadowed by other factors when global financial situation was volatile.

Fundamental factors tended to explain a much bigger share of government bond market comovements in 2008, 2009, 2014 and 2015, while in the middle of research period models were less significant. Consequently, it could be argued that during more volatile periods government bond markets tended to not follow regular patterns and instead depended on the influence of certain global factors (as identified previously). When adding these results to the results obtained when assessing the influence of global factors on government bond market comovements and the stability of this influence, it could be seen that the groups of global and fundamental factors were both significantly explaining government bond market comovements in 2008 and 2015. Nevertheless, in high volatility periods the power of fundamental factors was much less evident. The influence of fundamental factors has not been investigated in separate government bond market pairs but it could be clearly seen that fundamental factors influenced government bond market comovements and the influence was time-varying.

Generalization of results showed that differences in debt levels already accumulated by the governments have been the most important fundamental factor influencing government bond market comovements in the global environment while differences in fiscal deficit levels were not significant. In addition to that, countries' macroeconomic characteristics, such as price level inflation and unemployment, have been steadily important factors, determining comovements between government bond markets in these countries. In the end of the research period differences in government bond market volumes started to be significant factors influencing government bond market comovements, indicating that the history of a country's borrowing was considered as reflecting its credibility, and as a result, was assessed by the investors before purchasing government bonds. Contrarily, differences in international reserves were found to be significant only in the first two analysed years and their influence diminished later on.

Results obtained contradict the conclusions of Caceres, Guzzo and Segoviano (2010), Manasse and Zavalloni (2012) Boffelli and Urga (2013), and Perego and Wermeulen (2013). Boffelli and Urga (2013) found that strengthened correlation between bond spreads could not be explained by macroeconomic factors, and Perego and Wermeulen (2013) showed that comovements of government bond yields in the EU were not affected by differences in government debt levels. Caceres, Guzzo and Segoviano (2010) argued that government bond yields increased with worsening fiscal balance, which has not been the case in this research. Finally, Manasse and Zavalloni (2012), as well as Caceres, Guzzo and Segoviano (2010), proved that the influence of fundamentals on sovereign bond spreads strengthened in financial crises, but the tendency has not been confirmed in this research.

Contrarily, findings of this research are in line with the results of Bailey and Chung (1995), Pretorius (2002), Ang and Piazzesi (2003), Forbes and Chinn (2003), Baldacci and Kumar (2010),

Perego and Wermeulen (2013), Ebeke and Kyobe (2015), Paniagua, Sapena and Tamarit (2015) and others. Ang and Piazzesi (2003) were some of the firsts to prove that fundamental factors explained the biggest share of government bond yield variance, and Brennan, Kobor and Rustaman (2011) also showed their significant influence on bond returns. Pretorius (2002) showed that stock market correlation wass expected to increase with countries' fundamentals converging while Ebeke and Kyobe (2015) associated stronger fundamentals with lower government bond yields and Forbes and Chin (2003) indicated that importance of fundamental factors on stock market comovements is much smaller than that of global factors. d'Agostino and Ehrmann (2013), Paniagua, Sapena and Tamarit (2015) proved that unemployment had a positive influence on government bond yields in different countries, and this influence on government bond market comovements has been recorded in this research as well.

Pandit (2013) showed insignificant relationship between long-term interest rates and fiscal deficits, while Baldacci and Kumar (2010, and Peiris (2010) proved that higher government debt increased long-term bond yields with an influence of fiscal deficits as well. Ebeke and Kyobe (2015) argued that higher output growth volatility increased government bond yields and Pretorius (2002), Perego and Wermeulen (2013) found that comovements between financial markets were determined by output growth. Finally, Caramazza, Ricci and Salgado (2000) and Ebeke and Kyobe (2015) showed the influence of currency price being one of the factors influencing government bond market yields. Jaramillo and Weber (2012) found that during tranquil times in global markets, fiscal variables were not significant determinants of domestic bond yields in emerging economies, but the relationship changed when market participants wee on edge – they paid greater attention to country-specific fiscal fundamentals, getting more informed about the risk of default. Having in mind that this research has been implemented on a volatile period of financial markets, it wasn't surprising that a country's fundamentals were important in determining government bond market comovements.

Hypothesis 5 has not been accepted because the empirical research results obtained showed that the influence of bilateral factors on government bond market comovements was weak with only one factor, foreign direct investment, being important and only in certain years of investigation. The influence of bilateral factors on government bond market comovements strongly differed depending on the large country analysed – bilateral factors from France and the US, compared to the other large countries, most strongly influenced comovements of their government bond markets with the other markets. It allowed concluding that the influence of bilateral factors on government bond market comovements was not stable and that country effect was much stronger than the time effect.

When comparing results obtained in this stage with the ones from previous stages it can be concluded that the influence of bilateral factors on government bond market comovements is the weakest out of the three factor groups investigated.

This part of empirical research might have been limited by the fact that due to lack of data large countries c were chosen not by geographic regions but because they were the top largest global economies. Since Forbes and Chinn (2003) showed that bilateral factor loadings vary depending on the investigated region, with the major economy in each region being the most important for nearby markets, choosing the biggest economies might have diminished the results. In addition, bilateral factors chosen for the investigation could be affecting stock markets but not government bond markets, and the list of bilateral factors might be supplemented. It should be noted that to the best knowledge of the author, similar research has not been implemented in government bond markets and the results obtained might strongly differ from the ones in stock markets.

Forbes and Chinn (2003) have found that some bilateral factors were significant for comovements between stock markets, so the results obtained in government bond markets are different from their conclusions. Nevertheless, government bond markets were expected to be less dependent on financial and trade linkages between two countries, since government bonds are more of a too, used by the governments to finance their debt. Pretorius (2002) and Morgado and Tavares (2007) found that bilateral trade positively affected correlation between stock markets, but these results were not confirmed in the analysis of government bond markets. Forbes and Chinn (2003) identified import demand as the most important bilateral factor for how shocks to large economies were transmitted to other markets, but the influence of this factor on government bond market comovements has only been proven in the US. Teiletche and Xu (2008) showed that trade linkage variables and, to a lesser extent, geographical distance, appeared to be the most important determinants of extreme dependencies in financial markets. Rose and Spiegel (2009) showed that geographical distance worsened information symmetries between financial markets, and Flavin, Hurley and Rousseau (2001) argued that distance and common border influence dfinancial market comovements. In this research, geographic distance has not been found to be significant factor influencing government bond market comovements.

On the other hand, Caramazza, Ricci and Salgado (2000) and Didier, Love and Martinez Peria (2012) obtained results that were in line with the ones of this research. Didier, Love and Martinez Peria (2012) showed that effects of real and trade linkages on stock market comovements were insignificant with financial linkages being the dominant determinant of stock market comovements. Caramazza, Ricci and Salgado (2000) revealed that financial linkages are significant in explaining the spreads of financial crises even when fundamentals and trade

spillovers were controlled for. Shinagawa (2014) proved that if a country had large bilateral foreign investment or bank lending in another country, correlation between the two financial markets should have been stronger. Consequently, countries with extensive bilateral portfolio exposure were likely to have larger spillovers between their bond markets.

Generalization of the results obtained allow concluding that integration in global financial markets is not yet complete. Nevertheless, a big part of these markets commove together and form clusters that are robust to changes in the global environment. As Abad, Chuliá and Gómez-Puig (2009) argued, even the integration of the EMU government bond markets is still incomplete with the markets still showing differences in their liquidity and default risks. Furthermore, the EMU countries are not highly integrated with the US and only partially integrated with German bond market, suggesting that the benefits from portfolio diversification are possible within the Union. Consequently, government bond markets in other regions are even further from full integration, allowing investors to have the possibility to benefit from that.

This research can be further developed towards different directions. Since researchers disagree on the factors influencing government bond market comovements and the choice of the factors included in the model was rather arbitrary, future research should complement each group of factors by additional ones, especially the global group. Analysis of comovements is only one of a variety of different methods to assess the relationship between government bond markets, Due to width and complexity of this research, only correlation, used by other researchers, has been employed to determine the comovements, but there exist multiple other methods that could be used to reach the research aim.

Government bond market clusters based on their comovements have been identified but not employed in further research mostly due to lack of data, leaving space for further investigation of the factors influencing government bond market comovements in separate clusters. In addition, lack of available data allowed analysing only 75 government bond markets, spread over all the continents, leaving space for further research to incorporate more markets. With the possibility to obtain more data, research period should also be extended in order to determine longer-term patterns and to catch several economic cycles. That is especially important when assessing the stability of government bond market comovements.

The influence of bilateral factors on government bond market comovements could be investigated by assessing all the bilateral interactions between all the pairs of countries, and not only from large to smaller countries. This has not been implemented due to data unavailability. Finally, a wide range of markets investigated and a big set of factors included does not allow to propose exhaustive insights on the influence of a separate factor on government bond market

comovements for each pair of countries and the reasons for this influence to exist. It is mainly limited by the volume of dissertation and leaves space for further research in the area.

The results obtained in this research are relevant for investors because significant comovements among the chosen markets increase portfolio risks and reduce diversification effect. Country credit ratings are insufficient to determine the dynamic relationship between the markets and they do not reflect dependence between government bond markets in different countries. Results are also relevant for governments seeking to reduce their cost of debt and target the time for bond emission. Determination of factors influencing government bond market comovements enables governments to form more efficient borrowing policies and shorter-term strategies. Formation of borrowing policy requires knowledge about the environment and to correctly position the market it the global context. In addition, it shows if improving fundamentals strengthens comovements with other markets, or if they are dependent on global financial conditions.

Finally, the results are relevant for supervisory institutions because identification of the level of differentiation among government bond markets enable regional supervisory institutions to set the regulations on countries' borrowing. Moreover, determination of the factors influencing government bond market comovements enable global supervisory institutions to form their regulatory policies and to modify requirements for the countries' borrowing. In addition to the parties identified, this research is expected to benefit fellow researchers that are analysing the dependence structure of financial markets in the global environment. The results (obtained here) could be further used to investigate the differences between government bond market comovements in different countries and to investigate the differences in the influence of various factors on these comovements.

CONCLUSIONS AND RECOMMENDATIONS

This research is one of the first designed to assess the influence of different groups of factors on government bond market comovements, making it complex and increasing the contribution of the results obtained to the scientific field. The results obtained in this research are summarized with the following conclusions:

1. Analysis of characteristics of government bond markets and their comovements, based on previous research, revealed that:

- Financial integration is an ongoing process involving different countries and paces. It directly and indirectly influences economic growth and is difficult to measure. There would be no incentive to analyse financial market comovements if markets were not integrated, since each market would move independently. Contrarily, full market integration with no transaction costs and no market-entering barriers would also make investigation of financial market comovements irrelevant, because changes in all the markets would only depend on global tendencies. Studies on financial integration showed that developed markets were more integrated and demonstrated short- and long-term comovements, while emerging markets tended to follow.
- Analysis of characteristics of government bond markets showed that they were both a place for distributing financial funds and an instrument for government policy implementation. These markets participate in the global financial environment by borrowing abroad, are subject to contagion and exposed to changes in international financial conditions. A well-developed government bond market is the basis for the development of common bond market, identified by regular issues, variety of investor base, low transaction costs, competitive market structure and other features.
- Previous research literature mostly analysed the relationship between financial markets, and not their comovements. The investigation of the latter is a relatively new category that became more widely used after the financial crisis of 2008. Given the aim of this research and as a result of the analysis and synthesis of scientific literature, in this doctoral dissertation government bond market comovements were identified as a mutual dependence between two government bond markets. Applying this new approach and assessing the comovements between government bond markets allowed to further search what influences these comovements and to fill the gap in scientific literature.
- Researchers have concentrated their studies on comovements between stock markets or financial institutions, with a lack of attention to government bond markets. Scientists assessed the strength and stability of the dependence between financial markets, but only a small part of them investigated the common features among the countries and, in particular, among the groups of

government bond markets. In addition, they tended to concentrate on either developed or emerging markets, or comovements of these markets – analyses of both were relatively rare.

2. By distinguishing the methods to assess government bond market comovements and the factors influencing them, it was possible to make the following conclusions:

- Even though there exists vast literature on the factors influencing financial markets, not many analysed the factors influencing government bond market comovements. This was caused by the fact that both comovements and the influence of certain factors on these comovements were separate phenomenon, making it more complicated to assess both simultaneously.
- The most commonly used methods to assess the relationship between government bond markets were GARCH models, cointegration, Granger's causality method, and correlation analysis, less common – principal component analysis, and cluster analysis.
- The difficulty of describing and segregating the methods used to assess government bond market comovements and the factors influencing them was mainly caused by researchers using multiple methods. Some researchers employed factor models and multiple regression models to assess the factors influencing financial markets and their comovements. One of the main drawbacks of these models being the disagreement about the selected factors – they depend on a specific market, leading to lack of consistency between the results obtained. In addition, results of different researches highly depend on the assumptions that were made.

3. Identification of the factors influencing government bond markets and their comovements allowed concluding that:

- Global and country-specific factors were most commonly identified as influencing government bond markets, dividing the latter ones into fundamental and bilateral factors.
- Changes in global factors related to systemic risk, influencing all the economies in a global level, while country-specific risks could be assigned to fundamental and bilateral factors.
- Global factors influencing government bond markets represent global risk aversion, situation in stock, commodity and money markets and uncertainty of global economic policy.
- Fundamental factors influencing government bond markets, could be grouped to macroeconomic, government and market liquidity factors. Government factors represent a government's financial/political situation, macroeconomic factors relate to a country's economic situation and market liquidity factors are specific to a separate government bond market.
- Multiple authors agreed that the most important bilateral factors influencing financial markets were associated with real and financial linkages. Import and export (trade) factors were identified as the real ones, while financial factors include portfolio and foreign direct investment. In addition, geographic characteristics have been proven to be significant in certain contexts.

- One of the reasons, explaining the variety of results in other researches could be the fact that the influence of different factors on government bond yields/markets was unstable over time. Researchers separately assessed the factors before and after financial crises and proved that during financial crises markets tended to punish certain governments for their weak fundamentals. In addition, increased investor's risk aversion during a financial crisis led to additional pricing of comovements between risk aversion and credit/liquidity risks.

4. The proposed model for the assessment of government bond market comovements and the factors influencing them had the following characteristics:

- The complexity of the model was demonstrated through the different levels of the assessment of government bond market comovements and the factors influencing them. The model allowed assessing government bond market comovements and their differentiation as well as three groups of factors influencing these comovements. The model is universal because it is designed to be applied in the global environment, and it can be adapted to different regions and country groups. Five global, fourteen fundamental and seven bilateral factors have been included in the model, on the basis of which a complex methodology for the assessment of the factors influencing government bond market comovements has been prepared.
- The prepared research methodology described the ways of assessing government bond market comovements and the factors influencing them. It combined the methods of correlation, principal component analysis, hierarchical clustering, pooled and multiple regression and other econometric/statistical methods. The prepared research methodology consisted of a preparatory and five research stages: the first two stages allowed to identify government bond market comovements and to cluster the markets based on them, while the third, the fourth and the fifth research stages were designed to assess the influence of global, fundamental and bilateral factors on these comovements. The methodology has been tested in the global environment, represented by 75 government bond markets. This coverage allowed to see a broad picture of market comovements and not only to assess the influence of different groups of factors on these comovements but to determine the stability of this influence as well. Five research hypotheses have been made to test the validity of the proposed model.

5. The results of empirical research of government bond market comovements and the factors influencing them allowed to make the following conclussions:

- Government bond markets commove significantly with these comovements manifesting in different clusters. Most government bond markets with a big share of significant comovements were situated in developing countries, while developed markets showed the biggest strength of the comovements with the other markets. These results triggered a discussion on whether developed government bond markets were truly most integrated or market integration was more

regional. The expectations about government bond market comovements are confirmed: half of the analysed markets formed six stable government bond market clusters. Some government bond markets, such as Ecuador, Argentina or Ukraine, did not commove with the other markets most of the analysed period. These markets could be advised as a choice for portfolio diversification. Contrarily, the markets inside the six identified clusters have been moving together within the different years.

- The influence of global factors on government bond market comovements has been less strong than expected and Hypothesis 3 has been rejected. It leaves space for government bond investment portfolio to hedge against the losses under extreme volatilities in financial markets. Testing the influence of global factors on government bond market returns showed that commodity market uncertainty and global market portfolio were most strongly influencing government bond market returns, while global market liquidity was only significant in 2008. These results are positive news for investors: if markets in general are not strongly influenced by global factors, they are more robust to volatility in the global environment. In addition, the fact that government bond market returns and comovements were only episodically influenced by global factors enables governments to adjust their borrowing policies.

- Fundamental factors had a strong influence on government bond market comovements and, as a result, Hypothesis 4 was accepted: the more similar two countries are in their fundamentals, the stronger their government bond markets commove. Moreover, the governments' ability to borrow depended on their policy and the fundamentals of the countries, so governments could improve their financial situation by ameliorating their debt ratio as well as the unemployment situation, and controlling price levels (if possible). Differences in government debt levels was one of the most important fundamental factors influencing government bond market comovements in the global environment.

- The influence of bilateral factors on government bond market comovements was weak with only foreign direct investment being important in certain years. That allowed to reject Hypothesis 5. Bilateral factors from France and the US most strongly influence comovements of their government bond markets with the other markets. Consequently, there exist country-specific effects with bilateral factors of few large markets influencing their government bond market comovements, even if the effects are not generalized. This knowledge may allow governments to strengthen this financial linkage with the countries, they want their government bond markets to be associated with.

- Empirical assessment of government bond market comovements and the factors influencing them in the global environment generally revealed that in order to effectively diversify investment portfolio investors should choose markets assigned to different government bond market clusters,

stable independently from the changes in the global financial environment. Results also indicated that similar fundamentals caused government bond markets to commove more strongly while the influence of global factors and bilateral factors on these comovements was relatively weak.

6. Comparison of the empirical research results with the other studies on the same subject allowed to conclude that:

- Results are in line with Reisen and Maltzan (1998), Sutton (2000), Barassi et al. (2001), Smith (2002), Ciner (2007), Brennan, Kobor and Rustaman (2011) showing significant government bond market comovements between certain groups of markets. This research complemented their studies by confirming the phenomenon for a wider set of markets.
- Evidence of government bond market differentiation and identification of government bond market clusters based on their comovements complemented the results of Mantegna (1999), Onnela et al. (2005), Bunda, Hamann and Lall (2009) and others, arguing that there existed clusters among financial markets and institutions. Results of this research contributed to the literature mentioned, showing that some government bond markets commoved in clusters.
- Showing that global factors did not significantly influence government bond market comovements denied the assumption that the influence of these factors on the comovements should manifest during financial crises and was not in line with the results of McGuire and Schrijvers (2003), Paniagua, Sapena and Tamarit (2015) and other researchers. Contrarily, these results coincide with the results of Ziaei (2012), Mensi et al. (2014).
- Fundamental factors explaining government bond market comovements in the global environment contradicted the conclusions of Boffelli and Urga (2013) and Perego and Wermeulen (2013), who did not find this influence to be significant on bond spreads or bond yields. Contrarily, this research findings were in line with the results of Pretorius (2002), Paniagua, Sapena and Tamarit (2015) and others, proving that certain fundamental factors determined financial market returns, yield variance or market comovements.
- Concluding that the only significant bilateral factor for government bond market comovements is foreign direct investment did not confirm the results of Forbes and Chinn (2003), who found some bilateral factors being significant for comovements between stock markets. The results of Pretorius (2002) and Morgado and Tavares (2007) stating that bilateral trade positively affected correlation between stock markets were not confirmed in this research. On the other hand, Didier, Love and Martinez Peria (2012) showed that effects of real and trade linkages on stock market comovements were insignificant for stock market comovements while Shinagawa (2014) proved that countries with bilateral portfolio exposure were likely to have larger spillovers between their bond markets, which fell in line with the results of this research.

7. Theoretical and empirical research results as well as research limitations led to the following conclusions on the directions for future research:

- The proposed model only includes some of the factors influencing government bond market comovements, so future research could include more factors.
- Another method could be used to reach the research aim. Analysis of government bond market comovements is only one of different methods to assess the relationship between the markets. Since this research is complex and has a wide sample, and the method was used by other authors for a similar purpose, correlation was chosen to determine the comovements.
- There is still space for further investigation of the factors influencing government bond market comovements in separate clusters, because government bond market clusters have been identified but not employed further in this study.
- Future research could include more markets. Lack of available data limited the analysis to only 75 government bond markets, covering all the continents. If more data was available, the research period could also be extended in order to determine longer-term patterns.
- The influence of bilateral factors on government bond market comovements could be assessed with all bilateral interactions of country pairs – not only from large to smaller ones.
- Future research could propose exhaustive insights on the influence of each separate factor on government bond market comovements for each pair of countries and the reasons for this influence to exist. A wide range of markets investigated and a big set of factors included as well as the volume of this research did not allow to carry that out.

Generalization of theoretical and empirical research results allowed stating that the prepared research methodology revealed a complex approach towards government bond markets, their comovements, and the factors influencing them. In the context of globalization and strengthened financial integration, determining these factors was beneficial as a basis for investment decision-making as well as for further scientific researches.

Knowledge of which markets commoved together and whether the comovements were caused by global or country-specific factors would make it easier to forecast future comovements and use them for investment allocation. Moreover, this question was relevant for national governments, regional and global regulatory organizations and policymakers, when developing and implementing investment regulation policies as well as policies for countries borrowing/emissions. In addition, research results should benefit the fellow researchers analysing the dependence structure of financial markets in the global environment.

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APPENDICES

Appendix 1 Estimation of the Distances in AHC Based on Linkage Schemes

Agglomerative clustering algorithm is focused on proximity matrix by storing $\frac{1}{2}m^2$ proximities), with *m* data points. After merging the clusters *i* and *j* to cluster $i \cup j$, the proximity of the new cluster $i \cup j$ to the existing cluster *k* could be expressed as a linear function of the proximities of *k* with respect to the original clusters *i* and *j*. Depending on the hierarchical clustering linkage scheme used, the Lance-Williams coefficients for the linear function of the proximities can be seen below.

Lance-Williams coefficients for common hierarchical clustering approaches

Hierarchical clustering linkage scheme	α_i	β	γ	**Cluster center coordinates, agglomerating *i* and *j***	**Dissimilarity between cluster centers *i* and *j***
Single linkage	0.5	0	-0.5 or (min $\{d_{ik}, d_{jk}\}$)		
Complete linkage	0.5	0	0.5 or (max $\{d_{ik}, d_{jk}\}$)		
Average linkage	$\frac{\lvert i\rvert}{\lvert i\rvert + \lvert j\rvert}$	0	0		
Ward's method	$\frac{\lvert i\rvert + \lvert k\rvert}{\lvert i\rvert + \lvert j\rvert + \lvert}$	$-\frac{\lvert k\rvert}{\lvert i\rvert + \lvert j\rvert + \lvert k\rvert}$	0	$g_{i\cup j} = \frac{\lvert i\rvert g_i + \lvert j\rvert g_j}{\lvert i\rvert + \lvert j\rvert}$	$\frac{\lvert i\rvert\lvert j\rvert}{\lvert i\rvert + \lvert j\rvert}\lVert g_i + g_j\rVert^2$

Source: compiled by the author, based on Murtagh and Contreras (2011)

Since data grouping properties are not known before implementation, the number of clusters cannot be determined in advance, creating difficulties for checking the robustness of the results and the clusters identified. Moreover, the function of the clustering algorithms is susceptible to the properties of the data and the assumptions for the definition of the groups (Halkidi et al., 2002). Singh (2008) argued that once the cluster was formed, it cannot be decomposed, so inaccurate cluster formed early influences further classification, so evaluation and validation of clustering techniques is an essential part of cluster analysis. In addition, comparing the outcomes from the different clustering techniques can also lead to different results for the same dataset (Jakonienė and Lambrix, 2007).

Appendix 2 Calculation of Variance Inflation Factor for Testing the Multicollinearity

VIF enables identifying how much of the variance of the model has been inflated. In the model $y_i = \beta_0 + \beta_k x_{ik} + \varepsilon_i$ it can be shown that the variance of the $\beta_k$is:

$$Var(\beta_k)_{min} = \frac{\sigma^2}{\sum_{i=1}^{n}(x_{ik}-\overline{x_k})^2} \quad (1)$$

This variance is the smallest variance possible for the model. If correlated predictors are added to this model, the model gets the following form:

$$y_i = \beta_o + \beta_1 x_{i1} + \cdots + \beta_k x_{ik} + \cdots + \beta_{p-1} x_{i,p-1} + \varepsilon_i \quad (2)$$

If some of the predictors are correlated with the predictor $\overline{x_k}$, the variance of $\beta_k$is inflated:

$$Var(\beta_k) = \frac{\sigma^2}{\sum_{i=1}^{n}(x_{ik}-\overline{x_k})^2} \times \frac{1}{1-R_k^2} \quad (3)$$

where: R_k^2 is the R^2-value obtained by regressing the k^{th} predictor on the remaining predictors.

The greater is the linear dependence among the predictor x_k and the other predictors, the larger are the value R_k^2 as well as the variance of β_k. In order to estimate the difference between the two variance, the following equation is used:

$$\frac{Var(\beta_k)}{Var(\beta_k)_{min}} = \frac{\left(\frac{\sigma^2}{\sum_{i=1}^{n}(x_{ik}-\overline{x_k})^2} \times \frac{1}{1-R_k^2}\right)}{\left(\frac{\sigma^2}{\sum_{i=1}^{n}(x_{ik}-\overline{x_k})^2}\right)} = \frac{1}{1-R_k^2} \quad (4)$$

This proportion is called the Variance Inflator Factor (VIF) and can be estimated for every predictor in a multiple regression model. Since VIF is the measure of how much the variance of the estimated regression coefficient $b_k$is *inflated* by the existence of the correlation among the predictor variables in the model, a VIF of 1 indicates that no correlation among the k^{th} predictor and the remaining predictor variables exists, leading to the value of $\beta_k$being not inflated at all. As it has been widely used among the researchers, VIFs exceeding 4 are considered to experience the threat of multicollinearity, and the VIFs exceeding 10 are the signal of a serious multicollinearity[13].

[13] Information taken and adapted from PennState Eberly College of Science Regression Methods course. Internet source: https://onlinecourses.science.psu.edu/stat501/node/347 [consulted on 2016-08-01]

Appendix 3 Bond Market Indices used in the Empirical Research

COUNTRY	ISO3	INDEX USED	ISSUER	TYPE	MATURITY	CURR
ARGENTINA	ARG	JPM EMBI GLOBAL ARGENTINA	GOV	TOTAL RETURN	ALL	USD
AUSTRALIA	AUS	AU BENCHMARK	GOV	BENCHMARK	10-YEAR	AUD
AUSTRIA	AUT	OE BENCHMARK	GOV	BENCHMARK	10-YEAR	EUR
BAHRAIN	BHR	BOFA ML EMRG SOV BAHRAIN	GOV	TOTAL RETURN	ALL	USD
BELGIUM	BEL	BG BENCHMARK	GOV	BENCHMARK	10-YEAR	EUR
BELIZE	BLZ	JPM EMBI GLB.DIVERS BELIZE	ALL	TOTAL RETURN	ALL	USD
BRAZIL	BRA	BOFA ML EUR EMRG SOV BRAZIL	GOV	TOTAL RETURN	ALL	USD
BULGARIA	BGR	JPM EMBI GLB.DIVERS BULGARIA	ALL	TOTAL RETURN	ALL	EUR
CANADA	CAN	CN BENCHMARK	GOV	BENCHMARK	10-YEAR	CAD
CHILE	CHL	BOFA ML USD EMRG SOV CHILE	GOV	TOTAL RETURN	ALL	USD
CHINA	CHN	CH BENCHMARK	GOV	BENCHMARK	10-YEAR	CNY
COLOMBIA	COL	BOFA ML EMRG SOV COLOMBIA	GOV	TOTAL RETURN	ALL	USD
COSTA RICA	CRI	BOFA ML EMRG SOV COSTA RICA	GOV	TOTAL RETURN	ALL	USD
COTE D'IVOIRE	CIV	JPM EMBI GLB.DIVERS COTE D'IVOIRE	ALL	TOTAL RETURN	ALL	USD
CROATIA	HRV	BOFA ML EMRG SOV CROATIA	GOV	TOTAL RETURN	ALL	USD
CZECH REPUBLIC	CZE	CZ BENCHMARK	GOV	BENCHMARK	10-YEAR	CZK
DENMARK	DNK	DK BENCHMARK	GOV	BENCHMARK	10-YEAR	DKK
DOMINICAN REPUBLIC	DOM	CGBI EMUSDGBI-CE DOMINICAN REP.	ALL	TOTAL RETURN	ALL	USD
ECUADOR	ECU	BOFA ML EMRG SOV ECUADOR	GOV	TOTAL RETURN	ALL	USD
EGYPT	EGY	BOFA ML EMRG SOV EGYPT	GOV	TOTAL RETURN	ALL	USD
FINLAND	FIN	FN BENCHMARK	GOV	BENCHMARK	10-YEAR	EUR
FRANCE	FRA	FR BENCHMARK	GOV	BENCHMARK	10-YEAR	EUR
GABON	GAB	BOFA ML EMRG MKT SOV GABON	GOV	TOTAL RETURN	ALL	USD
GERMANY	DEU	BD BENCHMARK	GOV	BENCHMARK	10-YEAR	EUR
GHANA	GHA	BOFA ML EMRG MKT SOV GHANA	GOV	TOTAL RETURN	ALL	USD
GREECE	GRC	GR BENCHMARK	GOV	BENCHMARK	10-YEAR	EUR
GUATEMALA	GTM	BOFA ML USD EMRG SOV GUATEMALA	GOV	TOTAL RETURN	ALL	USD
HONG KONG	HKG	JPM JACI HONG KONG	ALL	TOTAL RETURN	ALL	USD
HUNGARY	HUN	BOFA ML EMRG SOV HUNGARY	GOV	TOTAL RETURN	ALL	USD
INDIA	IND	JPM JACI INDIA	ALL	TOTAL RETURN	ALL	USD
INDONESIA	IDN	JPM JACI INDONESIA	ALL	TOTAL RETURN	ALL	USD
IRAQ	IRQ	JPM EMBI GLB.DIVERS IRAQ	ALL	TOTAL RETURN	ALL	USD
IRELAND	IRL	IR BENCHMARK	GOV	BENCHMARK	10-YEAR	EUR
ISRAEL	ISR	JPM ELMI+ ISRAEL	ALL	TOTAL RETURN	ALL	USD

ITALY	ITA	IT BENCHMARK	GOV	BENCHMARK	10-YEAR	EUR
JAMAICA	JAM	BOFA ML EMRG SOV JAMAICA	GOV	TOTAL RETURN	ALL	USD
JAPAN	JPN	JP BENCHMARK	GOV	BENCHMARK	10-YEAR	JPY
KAZAKHSTAN	KAZ	JPM EMBI GLB.DIVERS KAZAKHSTAN	ALL	TOTAL RETURN	ALL	USD
LEBANON	LBN	CGBI EMUSDGBI LEBANON	ALL	TOTAL RETURN	ALL	USD
LITHUANIA	LTU	BOFA ML EMRG SOV LITHUANIA	GOV	TOTAL RETURN	ALL	USD
MALAYSIA	MYS	JPM JACI MALAYSIA	ALL	TOTAL RETURN	ALL	USD
MEXICO	MEX	BOFA ML EMRG SOV MEXICO	GOV	TOTAL RETURN	ALL	USD
MOROCCO	MAR	BOFA ML EMERGING SOV.MOROCCO	GOV	TOTAL RETURN	ALL	USD
NETHERLANDS	NLD	NL BENCHMARK	GOV	BENCHMARK	10-YEAR	EUR
NEW ZEALAND	NZL	NZ BENCHMARK	GOV	BENCHMARK	10-YEAR	NZD
NIGERIA	NGA	CGBI EMUSDGBI NIGERIA	ALL	TOTAL RETURN	ALL	USD
NORWAY	NOR	NW BENCHMARK	GOV	BENCHMARK	10-YEAR	NOK
PAKISTAN	PAK	JPM JACI PAKISTAN	ALL	TOTAL RETURN	ALL	USD
PANAMA	PAN	BOFA ML EMRG SOV PANAMA	GOV	TOTAL RETURN	ALL	USD
PERU	PER	BOFA ML EMRG SOV PERU	GOV	TOTAL RETURN	ALL	USD
PHILLIPINES	PHL	JPM JACI PHILIPPINES	ALL	TOTAL RETURN	ALL	USD
POLAND	POL	PO BENCHMARK	GOV	BENCHMARK	10-YEAR	PLN
PORTUGAL	PRT	PT BENCHMARK	GOV	BENCHMARK	10-YEAR	EUR
ROMANIA	ROU	BOFA ML EMRG SOV ROMANIA	GOV	TOTAL RETURN	ALL	USD
RUSSIA	RUS	BOFA ML EMRG SOV RUSSIA	GOV	TOTAL RETURN	ALL	USD
EL SALVADOR	SLV	BOFA ML EMRG SOV EL SALVADOR	GOV	TOTAL RETURN	ALL	USD
SERBIA	SRB	JPM EMBI GLB.DIVERS SERBIA	ALL	TOTAL RETURN	ALL	USD
SINGAPORE	SGP	JPM JACI SINGAPORE	GOV	TOTAL RETURN	ALL	USD
SLOVENIA	SVN	BOFA ML SLOVENIA	GOV	TOTAL RETURN	ALL	USD
SOUTH AFRICA	ZAF	SA BENCHMARK	GOV	BENCHMARK	10-YEAR	ZAR
SOUTH KOREA	PRK	BOFA ML SOUTH KOREAN	GOV	TOTAL RETURN	ALL	USD
SPAIN	ESP	ES BENCHMARK	GOV	BENCHMARK	10-YEAR	EUR
SRI LANKA	LKA	JPM JACI SRI LANKA	ALL	TOTAL RETURN	ALL	USD
SWEDEN	SWE	SD BENCHMARK	GOV	BENCHMARK	10-YEAR	EUR
SWITZERLAND	CHE	SW BENCHMARK	GOV	BENCHMARK	10-YEAR	CHF
TAIWAN	TWN	BOFA ML TAIWANESE	GOV	TOTAL RETURN	ALL	USD
THAILAND	THA	BOFA ML THAILAND	GOV	TOTAL RETURN	ALL	USD
TUNISIA	TUN	BOFA ML EMRG SOV TUNISIA	GOV	TOTAL RETURN	ALL	USD
TURKEY	TUR	BOFA ML TURKEY	GOV	TOTAL RETURN	ALL	USD
UKRAINE	UKR	CGBI EMUSDGBI UKRAINE	ALL	TOTAL RETURN	ALL	USD
UNITED KINGDOM	GBR	UK BENCHMARK	GOV	BENCHMARK	10-YEAR	GBP
URUGUAY	URY	BOFA ML EMRG SOV UY	GOV	TOTAL RETURN	ALL	USD
VENESUELA	VEN	BOFA ML EMRG SOV VE	GOV	TOTAL RETURN	ALL	USD
VIETNAM	VNM	JPM EMBI GLB.DIVERS VIETNAM	ALL	TOTAL RETURN	ALL	USD

Source: compiled by the author based on *Thomson Reuters* and *FESE* data.

Appendix 4 Country Codes Used in Research

COUNTRY	CODE	COUNTRY	CODE	COUNTRY	CODE
ARGENTINA	ARG	GREECE	GRC	EL SALVADOR	SLV
AUSTRALIA	AUS	GUATEMALA	GTM	SERBIA	SRB
AUSTRIA	AUT	HONG KONG	HKG	SINGAPORE	SGP
BAHRAIN	BHR	HUNGARY	HUN	SLOVENIA	SVN
BELGIUM	BEL	INDIA	IND	SOUTH AFRICA	ZAF
BELIZE	BLZ	INDONESIA	IDN	NIGERIA	NGA
BRAZIL	BRA	IRAQ	IRQ	NORWAY	NOR
BULGARIA	BGR	IRELAND	IRL	PAKISTAN	PAK
CANADA	CAN	ISRAEL	ISR	PANAMA	PAN
CHILE	CHL	ITALY	ITA	PERU	PER
CHINA	CHN	JAMAICA	JAM	SOUTH KOREA	PRK
COLOMBIA	COL	JAPAN	JPN	SPAIN	ESP
COSTA RICA	CRI	KAZAKHSTAN	KAZ	SRI LANKA	LKA
COTE D'IVOIRE	CIV	LEBANON	LBN	SWEDEN	SWE
CROATIA	HRV	LITHUANIA	LTU	SWITZERLAND	CHE
CZECH REPUBLIC	CZE	MALAYSIA	MYS	TAIWAN	TWN
DENMARK	DNK	MEXICO	MEX	THAILAND	THA
DOMINICAN REPUBLIC	DOM	MOROCCO	MAR	TUNISIA	TUN
ECUADOR	ECU	NETHERLANDS	NLD	TURKEY	TUR
EGYPT	EGY	NEW ZEALAND	NZL	UKRAINE	UKR
FINLAND	FIN	PHILLIPINES	PHL	UNITED KINGDOM	UK
FRANCE	FRA	POLAND	POL	URUGUAY	URY
GABON	GAB	PORTUGAL	PRT	VENESUELA	VEN
GERMANY	DEU	ROMANIA	ROU	VIETNAM	VNM
GHANA	GHA	RUSSIA	RUS	UNITED STATES	US

Appendix 5 Extraction from Correlation Matrix of Daily Government Bond Market Returns in 2008-2016

	ARG	AUS	AUT	BHR	BEL	BLZ	BRA	BGR	CAN	CHL	CHN	COL	CRI	CIV	HRV	CZE	DNK	DOM	ECU	EGY	FIN	FRA	GAB	DEU	GHA	GRC	GTM	HKG	HUN	IND	IDN	IRQ	IRL	ISR	ITA	JAM	JPN	KAZ	LBN	LTU	MYS	MEX	MAR
ARG	1	-,116	-,126	,077	-,055	,081	,236	,201	-,170	,074	-,008	,373	,062	,073	,075	-,001	-,118	,070	,164	,058	-,188	-,129	,052	-,213	,074	,080	,096	,117	,112	-,006	,272	,134	,013	,167	,042	,024	-,036	,275	,050	,165	,042	,117	,161
AUS	-,116	1	,217	-,003	,153	-,015	-,080	-,035	,189	,161	-,030	,047	,053	,015	-,046	,137	,328	-,047	-,064	-,013	,282	,229	,004	,334	-,043	-,103	,023	,231	-,016	,018	-,044	-,052	,005	-,065	,007	,005	,352	-,080	-,004	-,061	,316	-,059	-,064
AUT	-,126	,217	1	,068	,816	-,010	-,105	,055	,444	,193	-,002	,065	,115	,014	-,029	,290	,590	,051	-,048	,032	,855	,916	-,013	,791	,008	,000	,077	,222	,151	,018	,048	-,008	,275	-,092	,344	,052	,136	-,047	,032	,029	,254	-,038	-,077
BHR	,077	-,003	,068	1	,067	,066	,074	,042	,095	,134	,041	,163	,208	,111	,057	,075	,029	,037	-,114	,208	,075	,059	,162	,044	,160	,040	,157	,119	,180	-,025	,184	,204	,042	,051	,048	,087	-,019	,190	,075	,061	,103	,062	,062
BEL	-,055	,153	,816	,067	1	-,017	,006	,085	,316	,174	-,001	,085	,118	,021	,018	,265	,412	,039	-,048	,071	,684	,832	,001	,591	,005	,093	,084	,191	,167	-,003	,071	,037	,389	-,019	,545	,044	,088	-,008	,010	,135	,193	,021	,028
BLZ	,081	-,015	-,010	,066	-,017	1	,022	,052	-,014	-,019	,014	,077	,050	,009	,026	,006	-,034	,074	,007	,041	-,009	-,020	,021	-,023	,119	-,004	,048	,057	,014	-,042	,069	-,015	,010	,021	,003	,081	-,026	,116	,051	,001	,038	,032	,017
BRA	,236	-,080	-,105	,074	,006	,022	1	,232	-,072	,122	-,013	,337	,054	,053	,361	,025	-,181	,041	,054	,029	-,190	-,114	,036	-,216	,028	,093	,015	,183	,132	,007	,320	,138	,076	,451	,135	,040	-,003	,315	,055	,753	,092	,501	,834
BGR	,201	-,035	,055	,042	,085	,052	,232	1	-,015	,080	-,003	,238	,115	,054	,097	,127	-,046	,074	,072	,071	,011	,026	,042	-,016	,105	,100	,123	,208	,186	,002	,345	,225	,104	,094	,111	,133	,007	,309	,126	,246	,167	,128	,166
CAN	-,170	,189	,444	,095	,316	-,014	-,072	-,015	1	,224	-,001	,054	,049	-,077	-,022	,095	,433	,013	-,056	-,038	,545	,440	-,046	,541	-,008	-,082	,015	,090	,126	,018	,015	-,068	,075	-,088	,024	,021	,119	-,065	,026	-,031	,116	-,027	-,071
CHL	,074	,161	,193	,134	,174	-,019	,122	,080	,224	1	,000	,308	,233	,128	,019	,141	,195	,099	,065	,112	,196	,181	,100	,188	,029	,031	,164	,256	,168	,009	,251	,130	,085	,082	,101	,088	,107	,226	,030	,099	,221	,049	,080
CHN	-,008	-,030	-,002	,041	-,001	,014	-,013	-,003	-,001	,000	1	,004	-,042	-,010	,023	,002	-,016	-,027	-,097	-,006	,002	,005	,006	-,001	-,053	-,020	-,109	-,010	-,025	-,007	,021	,043	-,017	,001	,012	-,005	-,009	,021	-,016	-,030	-,032	,019	,004
COL	,373	,047	,065	,163	,085	,077	,337	,238	,054	,308	,004	1	,173	,102	,054	,095	,101	,156	,120	,078	,060	,069	,100	,033	,106	,059	,138	,322	,178	-,041	,499	,276	,056	,195	,089	,043	,052	,508	,086	,172	,241	,134	,154
CRI	,062	,053	,115	,208	,118	,050	,054	,115	,049	,233	-,042	,173	1	,106	,029	,096	,064	,104	,063	,108	,107	,112	,235	,080	,222	,050	,457	,179	,158	-,010	,145	,161	,076	,029	,136	,179	,052	,148	,042	,086	,173	,046	,074
CIV	,073	,015	,014	,111	,021	,009	,053	,054	-,077	,128	-,010	,102	,106	1	,037	,059	-,023	,033	,036	,174	-,008	,011	,087	-,033	,088	,057	,098	,086	,087	-,020	,088	,161	,033	,043	,085	,053	,019	,128	,024	,050	,062	,037	,047
HRV	,075	-,046	-,029	,057	,018	,026	,361	,097	-,022	,019	,023	,054	,029	,037	1	,014	-,084	,009	,009	,028	-,065	-,038	,038	-,088	,041	,071	,011	,065	,076	-,219	,103	,021	,051	,188	,064	,021	,008	,103	,022	,337	,043	,967	,353
CZE	-,001	,137	,290	,075	,265	,006	,025	,127	,095	,141	,002	,095	,096	,059	,014	1	,226	,052	,014	,152	,264	,260	,035	,257	,038	,028	,068	,219	,076	,011	,097	,067	,084	-,011	,098	,106	,142	,110	,035	,059	,192	,035	,009
DNK	-,118	,328	,590	,029	,412	-,034	-,181	-,046	,433	,195	-,016	,101	,064	-,023	-,084	,226	1	,036	-,031	,003	,711	,593	-,013	,744	-,038	-,141	,027	,245	,013	,022	,037	-,046	,043	-,122	,003	,003	,226	-,081	-,012	-,110	,299	-,100	-,174
DOM	,070	-,047	,051	,037	,039	,074	,041	,074	,013	,099	-,027	,156	,104	,033	,009	,052	,036	1	,058	,063	,038	,029	,076	,026	,069	,012	,150	,179	,078	,034	,150	,100	,032	,046	,029	,186	-,043	,191	,174	,027	,150	,024	-,001
ECU	,164	-,064	-,048	-,114	-,048	,007	,054	,072	-,056	,065	-,097	,120	,063	,036	,009	,014	-,031	,058	1	,014	-,059	-,054	,115	-,073	,154	,025	,086	,061	,072	-,016	,155	,009	-,010	,017	,010	,074	-,015	,185	,079	,046	,018	,023	,000
EGY	,058	-,013	,032	,208	,071	,041	,029	,071	-,038	,112	-,006	,078	,108	,174	,028	,152	,003	,063	,014	1	,036	,030	,151	,006	,103	,070	,081	,105	,105	-,013	,117	,149	,080	,017	,071	,129	,005	,121	,077	,022	,107	,035	,044
FIN	-,188	,282	,855	,075	,684	-,009	-,190	,011	,545	,196	,002	,060	,107	-,008	-,065	,264	,711	,038	-,059	,036	1	,844	-,011	,935	,018	-,058	,071	,222	,115	,022	,025	-,036	,218	-,157	,186	,038	,162	-,086	,028	-,061	,270	-,085	-,173
FRA	-,129	,229	,916	,059	,832	-,020	-,114	,026	,440	,181	,005	,069	,112	,011	-,038	,260	,593	,029	-,054	,030	,844	1	-,016	,785	,007	,007	,074	,215	,131	,000	,038	-,008	,264	-,091	,395	,048	,144	-,055	,010	,010	,242	-,048	-,096
GAB	,052	,004	-,013	,162	,001	,021	,036	,042	-,046	,100	,006	,100	,235	,087	,038	,035	-,013	,076	,115	,151	-,011	-,016	1	-,028	,417	,057	,106	,078	,093	-,053	,166	,207	,005	,053	,043	,208	-,014	,265	-,139	,068	,093	,057	,028
DEU	-,213	,334	,791	,044	,591	-,023	-,216	-,016	,541	,188	-,001	,033	,080	-,033	-,088	,257	,744	,026	-,073	,006	,935	,785	-,028	1	-,018	-,128	,054	,226	,085	,027	-,004	-,071	,154	-,173	,094	,039	,199	-,133	,025	-,095	,295	-,111	-,195
GHA	,074	-,043	,008	,160	,005	,119	,028	,105	-,008	,029	-,053	,106	,222	,088	,041	,038	-,038	,069	,154	,103	,018	,007	,417	-,018	1	,070	,125	,121	,137	-,044	,154	,046	,023	,016	,049	,175	,009	,214	,039	,065	,116	,043	,038
GRC	,080	-,103	,000	,040	,093	-,004	,093	,100	-,082	,031	-,020	,059	,050	,057	,071	,028	-,141	,012	,025	,070	-,058	,007	,057	-,128	,070	1	,040	,014	,082	-,031	,072	,091	,253	,068	,258	,001	-,074	,095	,022	,100	-,009	,071	,097
GTM	,096	,023	,077	,157	,084	,048	,015	,123	,015	,164	-,109	,138	,457	,098	,011	,068	,027	,150	,086	,081	,071	,074	,106	,054	,125	,040	1	,196	,144	,009	,114	,126	,072	,001	,085	,191	,058	,081	,062	,026	,169	,027	,027
HKG	,117	,231	,222	,119	,191	,057	,183	,208	,090	,256	-,010	,322	,179	,086	,065	,219	,245	,179	,061	,105	,222	,215	,078	,226	,121	,014	,196	1	,201	-,009	,428	,146	,080	,104	,103	,155	,203	,327	,089	,202	,807	,109	,129
HUN	,112	-,016	,151	,180	,167	,014	,132	,186	,126	,168	-,025	,178	,158	,087	,076	,076	,013	,078	,072	,105	,115	,131	,093	,085	,137	,082	,144	,201	1	-,005	,197	,086	,086	,032	,141	,113	-,010	,230	,069	,237	,109	,086	,115
IND	-,006	,018	,018	-,025	-,003	-,042	,007	,002	,018	,009	-,007	-,041	-,010	-,020	-,219	,011	,022	,034	-,016	-,013	,022	,000	-,053	,027	-,044	-,031	,009	,009	-,005	1	-,007	-,042	-,003	,010	-,041	-,010	,024	-,021	,005	,001	,015	-,200	,012
IDN	,272	-,044	,048	,184	,071	,069	,320	,345	,015	,251	,021	,499	,145	,088	,103	,097	,037	,150	,155	,117	,025	,038	,166	-,004	,154	,072	,114	,428	,197	-,007	1	,214	,066	,169	,074	,136	-,002	,532	,098	,223	,286	,177	,194
IRQ	,134	-,052	-,008	,204	,037	-,015	,138	,225	-,068	,130	,043	,276	,161	,161	,021	,067	-,046	,100	,009	,149	-,036	-,008	,207	-,071	,046	,091	,126	,146	,086	-,042	,214	1	,069	,076	,081	,082	-,046	,270	,050	,108	,107	,053	,089
IRL	,013	,005	,275	,042	,389	,010	,076	,104	,075	,085	-,017	,056	,076	,033	,051	,084	,043	,032	-,010	,080	,218	,264	,005	,154	,023	,253	,072	,080	,086	-,003	,066	,069	1	,023	,395	-,001	-,015	,055	,018	,170	,070	,061	,100
ISR	,167	-,065	-,092	,051	-,019	,021	,451	,094	-,088	,082	,001	,195	,029	,043	,188	-,011	-,122	,046	,017	,017	-,157	-,091	,053	-,173	,016	,068	,001	,104	,032	,010	,169	,076	,023	1	,074	-,024	,003	,179	-,019	,367	,069	,255	,418
ITA	,042	,007	,344	,048	,545	,003	,135	,111	,024	,101	,012	,089	,136	,085	,064	,098	,003	,029	,010	,071	,186	,395	,043	,094	,049	,258	,085	,103	,141	-,041	,074	,081	,395	,074	1	,049	-,006	,073	,009	,223	,072	,084	,136
JAM	,024	,005	,052	,087	,044	,081	,040	,133	,021	,088	-,005	,043	,179	,053	,021	,106	,003	,186	,074	,129	,038	,048	,208	,039	,175	,001	,191	,155	,113	-,010	,136	,082	-,001	-,024	,049	1	,037	,185	,082	,090	,160	,039	,052
JPN	-,036	,352	,136	-,019	,088	-,026	-,003	,007	,119	,107	-,009	,052	,052	,019	,008	,142	,226	-,043	-,015	,005	,162	,144	-,014	,199	,009	-,074	,058	,203	-,010	,024	-,002	-,046	-,015	,003	-,006	,037	1	-,037	-,020	,024	,253	,009	,026
KAZ	,275	-,080	-,047	,190	-,008	,116	,315	,309	-,065	,226	,021	,508	,148	,128	,103	,110	-,081	,191	,185	,121	-,086	-,055	,265	-,133	,214	,095	,081	,327	,230	-,021	,532	,270	,055	,179	,073	,185	-,037	1	,060	,198	,194	,180	,172
LBN	,050	-,004	,032	,075	,010	,051	,055	,126	,026	,030	-,016	,086	,042	,024	,022	,035	-,012	,174	,079	,077	,028	,010	-,139	,025	,039	,022	,062	,089	,069	,005	,098	,050	,018	-,019	,009	,082	-,020	,060	1	,042	,134	,023	,074
LTU	,165	-,061	,029	,061	,135	,001	,753	,246	-,031	,099	-,030	,172	,086	,050	,337	,059	-,110	,027	,046	,022	-,061	,010	,068	-,095	,065	,100	,026	,202	,237	,001	,223	,108	,170	,367	,223	,090	,024	,198	,042	1	,149	,429	,744
MYS	,042	,316	,254	,103	,193	,038	,092	,167	,116	,221	-,032	,241	,173	,062	,043	,192	,299	,150	,018	,107	,270	,242	,093	,295	,116	-,009	,169	,807	,109	,015	,286	,107	,070	,069	,072	,160	,253	,194	,134	,149	1	,063	,055
MEX	,117	-,059	-,038	,062	,021	,032	,501	,128	-,027	,049	,019	,134	,046	,037	,967	,035	-,100	,024	,023	,035	-,085	-,048	,057	-,111	,043	,071	,027	,109	,086	-,200	,177	,053	,061	,255	,084	,039	,009	,180	,023	,429	,063	1	,462
MAR	,161	-,064	-,077	,062	,028	,017	,834	,166	-,071	,080	,004	,154	,074	,047	,353	,009	-,174	-,001	,000	,044	-,173	-,096	,028	-,195	,038	,097	,027	,129	,115	,012	,194	,089	,100	,418	,136	,052	,026	,272	,074	,744	,055	,462	1
NLD	-,170	,293	,866	,071	,705	-,009	-,175	,018	,523	,191	,007	,071	,112	-,018	-,063	,256	,697	,035	-,066	,032	,941	,864	-,015	,914	,006	-,058	,082	,228	,122	,006	,040	-,027	,225	-,145	,221	,037	,166	-,092	,022	-,052	,280	-,080	-,156
NZL	-,075	,449	,136	,024	,090	,011	-,060	-,046	,059	,135	-,020	,001	,096	-,019	-,019	,124	,209	-,046	-,009	,052	,159	,134	-,002	,217	,005	-,103	,059	,144	,012	,011	-,048	-,086	-,025	-,064	,022	,056	,288	-,089	,047	-,018	,222	-,024	-,025
NGA	,073	-,001	,010	,239	,026	,017	,085	,017	-,027	,109	-,006	,161	,160	,164	,024	,036	-,001	,068	,063	,118	,010	,010	,223	-,007	,201	,092	,108	,099	,101	,011	,122	,198	,036	,022	,059	,057	,014	,207	,059	,034	,093	,037	,043
NOR	-,138	,330	,461	-,005	,329	-,027	-,170	-,018	,322	,130	,014	-,030	,063	-,009	-,059	,220	,496	-,043	-,017	-,007	,531	,475	-,048	,588	-,078	-,130	,071	,198	,051	,028	-,054	-,109	,040	-,104	,071	,061	,237	-,141	,019	-,061	,282	-,083	-,128
PAK	,109	-,012	,008	,056	,024	,075	,121	,232	-,052	,087	-,006	,124	,084	,031	,046	,060	-,008	,062	,090	,056	-,002	,007	,162	-,018	,112	,049	,071	,168	,070	-,004	,241	,087	,038	,034	,025	,116	-,039	,181	,082	,081	,074	,076	,110
PAN	,258	,054	,024	,148	,037	,096	,276	,216	,014	,263	-,001	,577	,278	,070	,076	,153	,052	,141	,105	,148	,022	,028	,215	-,006	,140	,054	,196	,312	,144	-,005	,436	,179	,057	,176	,052	,180	,051	,458	,028	,169	,208	,151	,185
PER	,319	,069	,082	,170	,110	,074	,305	,220	,073	,308	-,051	,691	,261	,113	,082	,118	,107	,198	,124	,090	,085	,094	,114	,058	,189	,059	,229	,380	,199	-,015	,476	,226	,073	,157	,090	,113	,067	,426	,103	,177	,272	,149	,162
PHL	,207	-,043	,035	,147	,056	,108	,264	,216	-,002	,190	,015	,491	,114	,079	,065	,155	,018	,202	,077	,135	,013	,032	,152	-,007	,160	,045	,088	,438	,161	-,002	,725	,218	,033	,153	,039	,097	-,009	,523	,086	,123	,289	,153	,129
POL	,080	,089	,185	,137	,217	,048	,133	,156	,053	,158	,007	,212	,170	,085	,018	,245	,071	,072	-,027	,143	,129	,189	,072	,098	,115	,125	,123	,131	,131	-,030	,189	,188	,142	,081	,215	,143	,050	,170	,089	,094	,115	,054	,134
PRT	,054	-,058	,137	,050	,234	-,005	,053	,083	-,004	,076	-,004	,070	,091	,041	,037	-,005	-,038	,022	,010	,034	,079	,122	,060	,025	,055	,333	,059	,041	,083	-,038	,074	,076	,489	,022	,367	,019	-,022	,071	,024	,126	,026	,047	,070
ROU	,196	-,072	-,040	,074	,078	,026	,893	,274	-,050	,089	-,001	,207	,100	,057	,376	,058	-,188	,034	,024	,050	-,147	-,060	,080	-,179	,069	,135	,039	,177	,181	,020	,251	,138	,138	,440	,185	,099	,006	,250	,070	,822	,094	,494	,863

Appendix 6 Quality Characteristics of Principal Component Analysis

The robustness of clusters obtained has been tested by using Bartlett's sphericity test and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. Bartlett's sphericity test and KMO index enable detecting if we can or cannot summarize the information provided by initial variables in a few number of factors. Nevertheless, these measures do not give indication about the appropriate number of factors. Both tests have been implemented with government bond market clusters formed by using the PCA

KMO shows the size of partial correlations relative to original (zero-order) correlations for each pair of variables in factor analysis (Cerny and Kaiser, 1977; Dziuban and Shirkey, 1974). When variables share common factor(s), partial correlations should be small and KMO should be close to 1. According to Cerny and Kaiser (1977), while KMO ranges from 0 to 1, the widely-accepted index is over 0.6 and KMO values greater than 0.8 can be considered very good, that is, an indication that PCA is a useful method for dataset.

The second measure of PCA robustness, Bartlett's Test of Sphericity relates to the significance of the study and thereby shows validity and suitability of the responses collected to the problem being addressed through the study. In order for PCA to be considered as suitable, Bartlett's Test of Sphericity must be less than 0.05. The results obtained with the analysed data can be seen below.

PCA Quality Characteristics Obtained

2008			2009			2010			2011		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.823	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.835	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.879	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.870
Bartlett's Test of Sphericity	Approx. Chi-Square	21122.474	Bartlett's Test of Sphericity	Approx. Chi-Square	13731.508	Bartlett's Test of Sphericity	Approx. Chi-Square	17069.191	Bartlett's Test of Sphericity	Approx. Chi-Square	15817.539
	df	2415		df	2346		df	2701		df	2775
	Sig.	0.000		Sig.	0.000		Sig.	0.000		Sig.	0.000
2012			**2013**			**2014**			**2008-2016**		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.864	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.933	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.874	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.904
Bartlett's Test of Sphericity	Approx. Chi-Square	13525.247	Bartlett's Test of Sphericity	Approx. Chi-Square	19984.493	Bartlett's Test of Sphericity	Approx. Chi-Square	17527.873	Bartlett's Test of Sphericity	Approx. Chi-Square	92533.832
	df	2775		df	2775		df	2701		df	2775
	Sig.	0.000		Sig.	0.000		Sig.	0.000		Sig.	0.000

Appendix 7 Principal Component Matrix of Daily Government Bond Market Returns in 2008-2016

Component Matrix[a]

	Component																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
HKG	.621	.042	.252	-.286	.087	-.358	-.280	-.028	-.090	.211	-.164	.043	-.017	.003	-.071	-.090	-.028	-.113	.034	.036
BEL	.578	-.439	-.276	.378	-.074	-.069	-.043	-.005	-.020	-.010	.121	.041	-.074	-.007	-.047	-.065	-.002	-.079	.008	.076
PER	.569	.275	.315	-.060	-.190	.048	.114	-.212	-.067	-.192	-.075	-.091	.051	-.010	-.087	-.119	.024	.031	-.011	-.027
MYS	.557	-.089	.214	-.320	.179	-.403	-.223	.034	-.072	.184	-.154	.013	.009	.062	-.104	-.103	.017	-.042	.073	-.008
COL	.534	.311	.289	-.053	-.370	.030	.207	-.192	-.097	-.144	-.036	-.041	.073	-.037	-.097	-.108	.037	.062	.009	-.009
IDN	.534	.363	.285	-.065	-.324	.012	-.180	.011	-.035	.073	-.014	-.046	-.002	-.055	.073	.106	-.022	-.053	-.091	-.004
PAN	.504	.317	.319	-.057	-.131	.055	.111	-.121	-.033	-.197	.078	-.086	-.006	-.227	.077	-.063	-.006	.061	-.074	-.027
URY	.498	.268	.339	-.008	.071	.120	-.037	-.033	.097	-.196	-.034	-.030	.014	-.193	-.149	.047	-.035	-.070	-.033	.011
PHL	.488	.326	.335	-.091	-.355	-.059	-.197	.092	-.036	.023	.003	-.062	.000	-.106	.158	-.027	-.034	-.060	-.064	.020
SGP	.485	-.126	.197	-.311	.236	-.388	-.204	.025	-.070	.232	-.122	-.047	-.002	-.031	-.199	-.105	-.063	-.073	.035	-.008
CHL	.442	-.016	.143	-.047	.019	.045	.212	-.125	.017	-.041	-.247	-.026	.095	-.064	.064	.031	-.201	.193	-.120	.154
POL	.390	.078	.042	.168	-.056	-.128	.168	.259	.164	-.269	.104	.022	.113	-.114	.140	.032	-.107	.051	.175	-.048
CZE	.357	-.134	.048	-.011	.023	-.143	.037	.191	.036	-.122	.262	.233	-.012	-.037	.234	.107	-.223	-.015	-.050	.108
HUN	.355	.085	.043	.109	.093	.164	-.026	-.037	.077	.068	-.189	.003	.247	.051	-.147	.222	-.163	-.320	-.001	.257
ZAF	.351	.192	-.038	.014	-.109	-.094	.296	.137	.081	-.193	-.015	-.048	-.095	.050	.086	.028	-.118	-.070	.117	.026
THA	.346	.177	-.031	-.164	-.011	-.257	.210	.240	.143	-.049	-.099	-.191	-.174	.061	-.048	.158	.068	-.010	-.106	.029
BGR	.338	.255	.074	.075	-.043	.012	-.196	-.043	.066	-.023	.121	.309	.191	-.124	-.139	.309	-.077	-.057	-.009	-.223
DEU	.504	-.775	-.076	-.075	-.074	.124	-.007	.023	-.001	.040	.082	.016	-.026	.028	-.034	-.012	.034	.019	-.030	-.063
FIN	.557	-.738	-.101	.053	-.099	.138	-.012	.034	-.007	.045	.084	.014	-.045	.036	-.040	-.017	.033	-.005	-.022	-.048
NLD	.570	-.727	-.114	.060	-.092	.104	-.013	.029	-.010	.024	.097	.021	-.050	.014	-.061	-.022	.042	-.019	-.016	-.045
SWE	.403	-.657	-.047	-.191	-.041	.086	.091	-.051	-.031	-.014	.041	.034	-.055	.059	.040	-.022	.023	.051	-.011	-.013
GBR	.470	-.643	-.135	-.120	-.056	.150	-.004	-.022	.027	.023	-.054	-.012	.001	-.015	.041	-.022	.007	.032	-.035	-.074
BRA	.410	.637	-.481	-.206	-.018	.069	.038	-.113	.078	.032	.047	.000	.058	.006	.005	-.084	.002	.015	-.007	-.027
FRA	.579	-.636	-.188	.213	-.096	.023	-.030	.017	-.020	.008	.141	.029	-.086	.009	-.070	-.061	.012	-.056	.011	.044
AUT	.591	-.628	-.189	.194	-.086	.045	-.052	.027	.003	.019	.133	.050	-.071	.023	-.073	-.044	.014	-.046	-.005	.032
DNK	.428	-.620	.029	-.203	-.115	.047	.061	.002	-.037	.011	.106	-.023	-.082	.053	-.036	-.058	-.007	.061	-.016	-.094
ROU	.432	.590	-.555	-.146	.117	.061	-.022	-.058	.135	.061	.075	.036	.068	-.038	.010	-.021	.006	-.003	-.010	-.028
CHE	.376	-.563	-.064	-.076	.015	.010	.079	.034	-.019	-.002	.120	.078	-.002	.099	.041	.022	.053	.053	-.001	-.044
NOR	.324	-.548	-.038	-.194	.094	-.069	.045	-.039	-.029	-.046	.136	.091	-.062	.038	.032	.101	.036	.002	.004	.030
TUR	.329	.529	-.013	-.025	-.204	-.049	.233	-.011	.029	-.142	.060	.015	-.129	.053	.020	.016	-.031	-.061	.090	-.016
USA	.331	-.509	-.133	-.108	-.045	.387	.000	-.061	.109	.079	-.380	-.149	.157	-.033	.070	.142	-.050	.001	.055	.081
CAN	.341	-.487	-.115	-.120	-.114	.390	.010	-.046	.096	.057	-.308	-.159	.155	-.061	.068	.143	-.042	.055	.086	.019
KAZ	.423	.442	.327	.051	-.225	.095	-.021	-.023	-.117	.146	.060	.005	.129	-.056	.067	.024	-.049	.053	.053	.130
ISR	.211	.411	-.254	-.136	-.058	-.051	.098	-.014	.066	.062	-.006	-.067	-.243	-.008	.027	-.098	.051	.080	.064	.126
ARG	.177	.399	.155	.043	-.194	-.013	.097	-.251	-.110	-.097	.136	.092	.023	.142	-.158	.006	.137	-.134	.017	.017
VEN	.225	.388	.215	.160	-.149	.081	.280	-.136	-.137	.088	.128	-.033	.082	.144	-.182	-.078	.130	.040	.048	-.088
AUS	.233	-.349	.035	-.331	.191	-.330	.235	-.077	-.122	-.066	.008	-.050	.223	-.055	.125	.019	.057	.100	.019	-.088
SVN	.442	.451	-.640	-.045	.080	.032	.011	-.104	.103	.076	.024	.003	.013	.009	.020	-.085	.018	-.002	-.004	-.003
MAR	.345	.559	-.569	-.188	.128	.057	.029	-.070	.133	.043	.051	.021	.042	.003	.039	-.050	.044	-.003	-.016	-.044
TUN	.338	.554	-.569	-.198	.103	.057	.031	-.090	.133	.070	.085	-.021	.045	.030	.022	-.018	.018	-.031	-.043	-.045
LTU	.429	.473	-.535	-.108	.154	.021	-.051	-.095	.102	.106	.040	.012	.039	.002	-.060	.012	-.021	-.043	-.005	.040
ESP	.359	-.050	-.304	.631	.019	-.267	-.043	-.061	-.052	-.045	-.036	-.065	.019	-.055	.006	-.036	.007	-.029	.073	.177
ITA	.367	-.013	-.281	.612	.053	-.289	-.023	-.071	-.066	-.060	-.004	-.041	.010	-.057	-.033	-.047	.004	-.057	.089	.212
PRT	.205	.051	-.134	.527	.023	-.206	-.080	-.106	-.102	.020	-.231	-.155	.079	-.022	.078	.098	.097	.170	-.090	-.211
IRL	.301	-.048	-.226	.494	.000	-.202	-.098	-.076	-.045	-.019	-.160	-.078	.051	-.026	.068	.045	.056	.081	-.108	-.186
GRC	.111	.184	-.093	.446	.013	-.161	-.029	-.026	-.086	.049	-.173	-.063	.060	.059	.158	.135	-.021	.140	-.041	-.154
JPN	.201	-.182	.007	-.305	.199	-.300	.174	-.060	-.096	-.057	.022	-.068	.089	-.029	.086	.148	.042	.117	.079	-.001
SLV	.328	.119	.347	.138	.563	.191	-.119	-.016	.169	-.152	-.003	.055	-.147	-.099	-.105	.000	.006	.022	-.008	-.052
CRI	.372	.076	.253	.145	.436	.149	.147	-.046	.126	-.203	-.073	-.041	-.229	-.084	-.153	-.002	.041	-.017	.003	-.121
GTM	.297	.054	.282	.116	.429	.122	.000	-.192	.111	-.249	-.156	.123	-.348	.062	-.014	.018	.037	-.070	.019	-.084
JAM	.234	.075	.204	.050	.341	.147	-.195	.119	.164	-.064	.180	.031	.141	-.163	.085	.029	-.039	.201	.081	.224
NZL	.168	-.231	.036	-.274	.280	-.315	.233	.010	-.049	-.231	.067	-.092	.253	-.035	.066	.128	.143	.047	-.016	.042
LKA	.297	.178	.170	-.024	-.120	.003	-.366	.116	.136	-.166	.016	-.216	.067	.125	.161	-.250	-.164	-.047	-.072	-.179
PRK	.237	.348	.001	-.067	-.317	-.040	-.163	.412	.207	.009	-.020	-.137	-.210	.039	-.046	.183	.113	.117	-.003	.003
TWN	.273	.291	-.035	-.021	-.136	-.102	-.055	.403	.177	.047	-.055	-.070	-.287	.066	-.168	.264	.123	.182	.008	.099
EGY	.197	.090	.142	.131	.127	-.013	.104	.320	.079	-.018	.043	.128	.190	.174	.242	-.091	-.181	-.197	-.209	.047
BHR	.274	.097	.160	.099	.080	.192	.267	.306	.067	.134	-.279	.039	.071	.079	.142	-.076	.209	-.258	-.048	-.078
HRV	.197	.301	-.361	-.136	.157	.239	-.126	.268	-.627	-.214	-.094	.051	-.048	.057	-.010	.008	-.041	.053	-.021	-.020
MEX	.274	.392	-.385	-.162	.126	.238	-.118	.224	-.572	-.199	-.071	.046	-.050	.030	.006	-.009	-.042	.061	-.026	-.018
IND	-.005	-.041	.014	-.062	-.037	-.081	.053	-.220	.488	.156	.059	.033	-.010	.053	.108	-.074	.021	.047	-.088	-.037
GAB	.201	.164	.266	.144	.303	.178	.118	.162	-.113	.370	.277	-.320	-.008	-.153	.010	-.048	-.069	.119	-.048	-.014
IRQ	.251	.243	.200	.172	-.017	.003	.215	.139	-.011	.231	-.068	.395	.040	-.075	-.264	-.085	-.096	.156	.021	-.188
GHA	.205	.150	.254	.151	.292	.185	-.019	.108	-.060	.213	.239	-.377	.120	.053	-.034	.081	.132	-.106	.088	.021
SRB	.297	.271	.186	.077	.016	.068	.127	-.104	-.109	.288	-.092	.331	-.067	-.095	.090	.113	.040	.057	.052	.059
LBN	.133	.056	.071	-.018	.005	.017	-.219	.059	.172	-.202	-.110	.314	.270	.431	-.022	.188	.349	.178	.050	.046
CHN	-.022	-.002	-.033	.005	-.124	-.007	.102	.206	-.073	.142	-.023	.255	.090	-.413	-.100	-.027	.267	.072	.036	.245
ECU	.079	.145	.168	.027	.014	.049	-.108	-.265	-.109	-.014	.312	-.189	.049	.363	-.200	.316	-.144	.134	.011	.231
CIV	.147	.115	.111	.117	.098	-.054	.231	.140	-.042	.066	-.017	.153	.047	.350	.008	-.145	-.245	-.136	-.095	.103
NGA	.202	.140	.193	.149	.108	.065	.307	.180	-.031	.228	-.006	-.094	.088	.343	-.042	-.094	.142	.131	.032	-.120
UKR	.143	.137	.161	.072	.137	.090	.058	-.176	-.103	.237	.033	.123	-.253	.044	.488	.039	.093	.180	.100	.162
VNM	.300	.144	.263	-.068	-.024	-.007	-.136	-.291	-.156	.067	-.084	.063	-.294	.152	.308	.125	.117	-.191	-.066	.091
DOM	.199	.076	.218	.054	.031	.102	-.337	.013	.138	-.109	-.048	.073	.102	.156	.019	-.462	.003	.416	.078	.166
BLZ	.073	.079	.115	.020	.011	.075	-.145	.078	-.018	-.146	.124	-.065	.152	-.074	.149	-.148	.505	-.312	.259	.044
RUS	.072	.061	.006	-.003	-.055	.010	-.059	.014	.008	.087	.006	.025	-.022	.060	.104	.094	-.261	-.032	.770	-.293
PAK	.207	.173	.146	.030	.027	.047	-.224	-.024	-.028	.117	.289	.101	.081	-.075	.150	.169	.088	.001	-.265	-.329

Extraction Method: Principal Component Analysis.

a. 20 components extracted.

Appendix 8 Dynamics of Global Factors Analysed in 2008-2016

As it has already been indicated, five global factors were chosen for the theoretical model, representing the factors influencing government bond market comovements in the global environment. These five factors have been expressed in six measures, and the dynamics of the measures during the research period is analysed below It has already been discussed that the global risk aversion significantly influences the government bond markets. For the representation of global risk aversion the CBOE Volatility index (VIX) was chosen. Figure 4.1 represents the dynamics VIX during the research period.

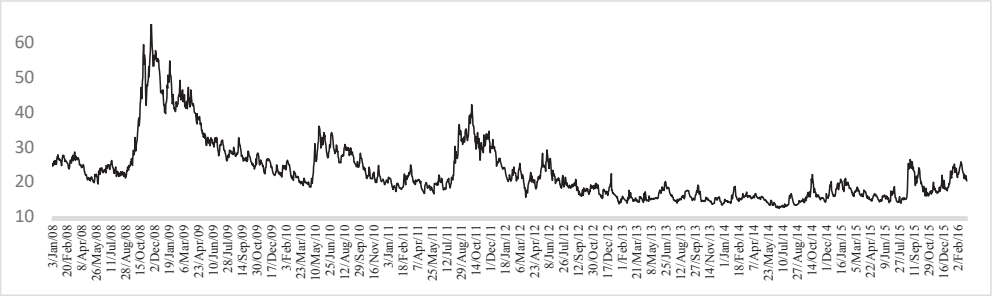

Figure A4 CBOE Volatility Index (VIX) Values in 2008-2016

Source: *Datastream* and author's calculations

It can be seen from Figure A4 that the value of VIX was very low in the beginning of 2008 and then extremely increased in the end of 2008, indicating the huge fear that existed in financial markets after the bankruptcy of Lehman Brothers, AIG, as well as the US Congress passing the Troubled Asset Relief Program (TARP). The investors' risk aversion significantly increases. The fluctuation between high values continued until March 2009, then continued decreasing after the US bank stress test results have been released. The minimum has been reached in May 2010, and the index arose again afterwards. At this time the first Eurozone-the IMF rescue plan was completed. The two following peaks were reached in June 2010 and September 2012, with the index indicating the increased fear in the markets during European debt crisis. Afterwards, the index decreased with the ECB offering loans to distressed banks in December 2012. Smaller peak could also be seen in May 2012 with the Greek debt crisis, but it did not increase the global risk aversion as strongly as other events mentioned.

The dynamics of the second global factor analysed, global market portfolio, expressed as the value and value changes of the S&P 500 stock market index, can be seen in Figure A5. It is very vivid that during the research period the S&P 500 was much less volatile than the VIX. Nevertheless, the index started strongly decreasing already in July 2008, confirming its role as one of the leading indicators of global economic situation. The global market portfolio strongly fluctuated in the beginning of the financial crisis and reached its bottom point in March 2009. After that, it had the tendency to grow, with a setback in August 2011, and another, smaller one, in August 2015.

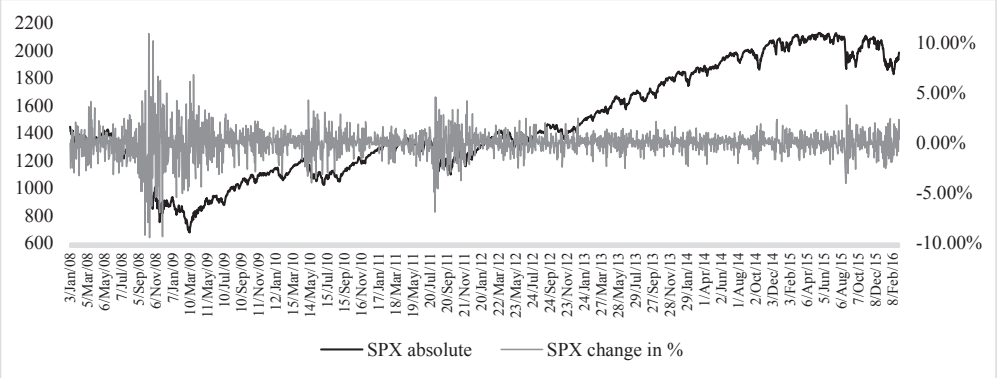

Figure A5 S&P 500 Stock Market Index Values and Changes in Values in 2008-2016

Source: *Datastream* and author's calculations

As it has already been discussed in the second part of the dissertation, the third global factor, representing commodity market uncertainty, has been divided into two separate measures: changes gold price and oil price. The dynamics of both measures can be seen in Figure A6.

Even though both commodity market uncertainty measures could be expected to demonstrate similar tendencies, the gold price tended to fluctuate much more during the research period. Oil price had dropped much more significantly when the financial crisis started (from September 2008), with its value decreasing almost 4 times. The fluctuations in gold price at that time were smaller with about 30% drop. Gold price has been increasing from December 2008 till December 2011, with relatively short periods of decrease and has been mostly decreasing afterwards. During the research period the oil price did not have a vivid tendency of moving. That can be explained by the fact that it is basically determined by the supply and demand. Nevertheless, in the beginning of 2016 the price of oil was at the same level as during the peak of financial crisis (around 30 USD per barrel) and the gold price was twice higher than its lowest point during the crisis (1200 USD per ounce, when compared to 600 USD per ounce).

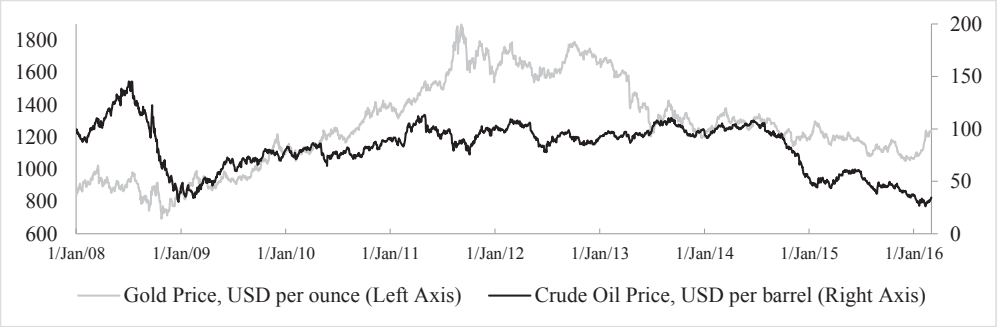

Figure A6 Gold and Crude Oil Prices in 2008-2016 (in USD per ounce and USD per barrel, respectively)

Source: Deutche Bundesbank, US Energy Information Administration and author's calculations

The fourth global factor, money market liquidity, is represented by the FED 3-month futures interest rate, the dynamics of which can be seen in Figure A7.

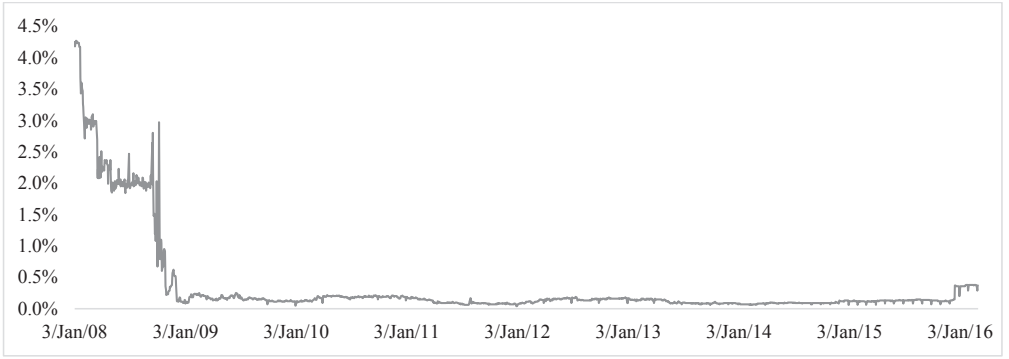

Figure A7 Bank of Federal Reserves (FED) 3-Month Futures Interest Rate in 2008-2016
Source: Board of Governors of Federal Reserve System

The dynamics of this factor is particularly interesting since it actually reflects the US monetary policy, implemented in order to stop and to reduce the consequences of the financial crisis. The policy is identified as quantitative easing (the term has already been discussed). At the beginning of 2008, the 3-month futures interest rate was more than 4%. Within the next half of the year it had dropped to 2%, and remained at this level for the rest of the year. Despite of few short increases, and a value of almost 3%, reached in December 2008, in January 2009 it has been reduced to 0.1% and stayed at this threshold ever since, reflecting the low-interest-rate environment, surrounding the research period.

The dynamics of the final measure, the EPU index, representing economic policy uncertainty, can be seen in Figure A8. It should be noted that the observed measure of uncertainty is based on the combination of newspaper articles' measures, finance measures and forecaster disagreement measures[14] (see, for example, Moore, 2016). The EPU has been fluctuating significantly during all the research period, with the highest peaks being reached in September and November 2008, February 2009, October 2011 and January 2013. From then on, the economic policy uncertainty has not been strong with the index having relatively low values.

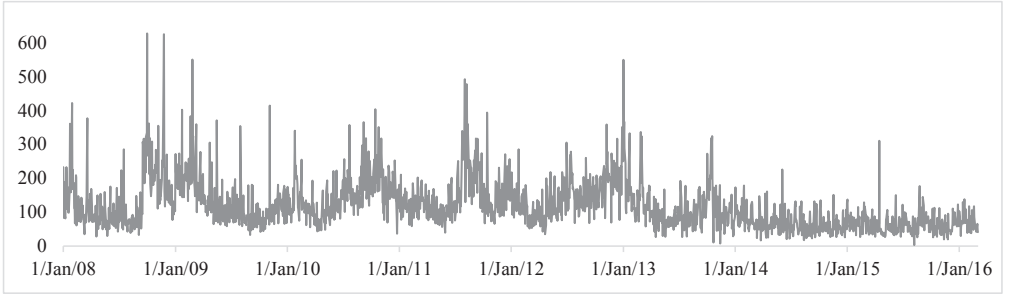

Figure A8 Daily Values of Economic Policy Uncertainty Index in 2008-2016
Source: *Economic Policy Uncertainty*

[14] It is of particular interest to the author of the dissertation that the forecaster disagreement measures are included in the uncertainty index, reasoning that the heightened economic uncertainty should increase the dispersion of the potential outcomes of the forecasts (Moore, 2016).

Appendix 9 Variance Inflation Factors for Global Factors Analysed

Coefficients[a]		Coefficients[a]		Coefficients[a]		Coefficients[a]		Coefficients[a]		Coefficients[a]	
	VIF		VIF		VIF		VIF		VIF		VIF
FED	1.004	VIX	1.067	GOLD	1.003	EPU	1.001	OIL	1.174	SPX	2.017
OIL	1.173	FED	1.010	EPU	1.002	SPX	2.014	GOLD	1.011	VIX	1.847
GOLD	1.010	OIL	1.066	SPX	1.832	VIX	1.846	EPU	1.002	FED	1.011
EPU	1.001	GOLD	1.010	VIX	1.847	FED	1.010	SPX	2.017	OIL	1.175
SPX	1.165	EPU	1.002	FED	1.010	OIL	1.164	VIX	1.836	GOLD	1.012
a. Dependent Variable: VIX		a. Dependent Variable: SPX		a. Dependent Variable: OIL		a. Dependent Variable: GOLD		a. Dependent Variable: FED		a. Dependent Variable: EPU	

Appendix 10 Extraction of the Results on the Influence of Global Factors on Government Bond Market Returns in 2008-2016

Regression Statistics						2008 ARGENTINA					
Multiple R	0.352					Multiple R	0.196				
R Square	0.124					R Square	0.038				
Adjusted R Square	0.103					Adjusted R Square	0.016				
Standard Error	0.025					Standard Error	0.007				
Observations	260.000					Observations	260.000				
ANOVA						ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*		*df*	*SS*	*MS*	*F*	*Significance F*
Regression	6.000	0.022	0.004	5.961	0.000	Regression	6.000	0.000	0.000	1.685	0.125
Residual	253.000	0.153	0.001			Residual	253.000	0.012	0.000		
Total	259.000	0.175				Total	259.000	0.012			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*		*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	-0.003	0.002	-1.658	0.099	-0.006	Intercept	0.001	0.000	1.650	0.100	0.000
VIX INDEX	-0.067	0.057	-1.179	0.239	-0.178	VIX INDEX	0.024	0.015	1.536	0.126	-0.007
SPX	0.186	0.098	1.905	0.058	-0.006	SPX	0.018	0.027	0.678	0.498	-0.035
FED RATE	-0.003	0.011	-0.265	0.791	-0.024	FED RATE	0.004	0.003	1.474	0.142	-0.001
GOLD PRICE	0.022	0.074	0.301	0.763	-0.124	GOLD PRICE	-0.004	0.020	-0.197	0.844	-0.044
OIL PRICE	0.110	0.044	2.491	0.013	0.023	OIL PRICE	-0.023	0.012	-1.935	0.054	-0.047
EPU	-0.001	0.003	-0.246	0.806	-0.007	EPU	0.001	0.001	0.781	0.435	-0.001
Regression Statistics						2009 ARGENTINA	*Regression Statistics*					2009 AUSTRALIA
Multiple R	0.359						Multiple R	0.190				
R Square	0.129						R Square	0.036				
Adjusted R Square	0.108						Adjusted R Square	0.013				
Standard Error	0.020						Standard Error	0.007				
Observations	261.000						Observations	261.000				
ANOVA							ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*			*df*	*SS*	*MS*	*F*	*Significance F*
Regression	6.000	0.016	0.003	6.261	0.000		Regression	6.000	0.000	0.000	1.582	0.153
Residual	254.000	0.105	0.000				Residual	254.000	0.011	0.000		
Total	260.000	0.121					Total	260.000	0.011			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*			*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.003	0.001	2.101	0.037	0.000		Intercept	0.000	0.000	-1.031	0.303	-0.001
VIX INDEX	-0.052	0.059	-0.887	0.376	-0.169		VIX INDEX	0.030	0.019	1.591	0.113	-0.007
SPX	0.225	0.125	1.800	0.073	-0.021		SPX	0.022	0.040	0.541	0.589	-0.058
FED RATE	-0.006	0.012	-0.537	0.592	-0.030		FED RATE	-0.005	0.004	-1.333	0.184	-0.013
GOLD PRICE	0.009	0.099	0.095	0.924	-0.185		GOLD PRICE	0.011	0.032	0.331	0.741	-0.052
OIL PRICE	0.106	0.044	2.418	0.016	0.020		OIL PRICE	-0.023	0.014	-1.581	0.115	-0.051
EPU	-0.003	0.003	-1.135	0.257	-0.009		EPU	0.000	0.001	0.047	0.963	-0.002
Regression Statistics						2010 ARGENTINA	*Regression Statistics*					2010 AUSTRALIA
Multiple R	0.604						Multiple R	0.338				
R Square	0.365						R Square	0.115				
Adjusted R Square	0.350						Adjusted R Square	0.094				
Standard Error	0.011						Standard Error	0.004				
Observations	261.000						Observations	261.000				
ANOVA							ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*			*df*	*SS*	*MS*	*F*	*Significance F*
Regression	6.000	0.018	0.003	24.353	0.000		Regression	6.000	0.000	0.000	5.476	0.000
Residual	254.000	0.031	0.000				Residual	254.000	0.004	0.000		
Total	260.000	0.048					Total	260.000	0.004			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*			*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.001	0.001	1.112	0.267	-0.001		Intercept	0.000	0.000	0.587	0.558	0.000
VIX INDEX	-0.031	0.026	-1.230	0.220	-0.082		VIX INDEX	0.012	0.009	1.295	0.197	-0.006
SPX	0.460	0.100	4.618	0.000	0.264		SPX	-0.021	0.035	-0.606	0.545	-0.089
FED RATE	0.010	0.008	1.315	0.190	-0.005		FED RATE	-0.005	0.003	-1.909	0.057	-0.010
GOLD PRICE	0.053	0.068	0.770	0.442	-0.082		GOLD PRICE	0.010	0.024	0.423	0.673	-0.037
OIL PRICE	0.158	0.047	3.341	0.001	0.065		OIL PRICE	-0.048	0.016	-2.941	0.004	-0.081
EPU	0.000	0.002	0.214	0.831	-0.003		EPU	0.000	0.001	0.777	0.438	-0.001

Appendix 11 Results on the Influence of Fundamental Factors on Government Bond Market Comovements in 2008-2016

2008-2016				
Regression Statistics				
Multiple R	0.555			
R Square	0.308			
Adjusted R Square	**0.306**			
Standard Error	0.339			
Observations	3255			
ANOVA				
	df	*SS*	*MS*	*F*
Regression	8	165.524	20.691	180.316
Residual	3246	372.466	0.115	
Total	3254	537.990		
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.836	0.015	55.608	0.000
DEBT	-0.066	0.007	-9.713	0.000
FISCAL DEFICIT	0.038	0.043	0.877	0.380
GDP GROWTH	-0.078	0.006	-12.207	0.000
INFLATION	-0.013	0.001	-13.642	0.000
UNEMPLOYMENT	-0.036	0.001	-25.485	0.000
REER	-0.005	0.001	-3.503	0.000
INTERN RESERVES	-0.035	0.023	-1.504	0.133
DEBT SEC AMOUNT OUTSTANDING	-0.506	0.106	-4.784	0.000

2008-2016				
WITH A LAG OF 1 QUARTER				
Regression Statistics				
Multiple R	0.549			
R Square	0.301			
Adjusted R Square	**0.299**			
Standard Error	0.340			
Observations	3255			
ANOVA				
	df	*SS*	*MS*	*F*
Regression	8	161.265	20.1581	174.7511
Residual	3246	374.436	0.1154	
Total	3254	535.700		
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.823	0.015	54.612	0.000
DEBT	-0.060	0.007	-8.792	0.000
FISCAL DEFICIT	-0.113	0.043	-2.634	0.008
GDP GROWTH	-0.082	0.006	-12.805	0.000
INFLATION	-0.013	0.001	-14.376	0.000
UNEMPLOYMENT	-0.034	0.001	-24.284	0.000
REER	-0.004	0.001	-3.031	0.002
INTERN RESERVES	-0.011	0.023	-0.465	0.642
DEBT SEC AMOUNT OUTSTANDING	-0.304	0.106	-2.872	0.004

2008-2016				
WITH A LAG OF 2 QUARTERS				
Regression Statistics				
Multiple R	0.544			
R Square	0.296			
Adjusted R Square	**0.294**			
Standard Error	0.339			
Observations	3150			
ANOVA				
	df	*SS*	*MS*	*F*
Regression	8	151.810	18.976	165.244
Residual	3141	360.706	0.115	
Total	3149	512.516		
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.822	0.015	53.808	0.000
DEBT	-0.051	0.007	-7.379	0.000
FISCAL DEFICIT	-0.226	0.044	-5.192	0.000
GDP GROWTH	-0.075	0.006	-11.543	0.000
INFLATION	-0.015	0.001	-14.310	0.000
UNEMPLOYMENT	-0.033	0.001	-22.945	0.000
REER	-0.004	0.001	-2.570	0.010
INTERN RESERVES	0.010	0.023	0.418	0.676
DEBT SEC AMOUNT OUTSTANDING	-0.667	0.107	-6.263	0.000

Appendix 12 Results on the Influence of Fundamental Factors on Government Bond Market Comovements for Separate Year

2008					2009				
R Square		0.653			R Square		0.637		
Adjusted R Square		**0.644**			Adjusted R Square		**0.630**		
Observations		315			Observations		419		
				F					*F*
Regression				71.876	Regression				90.121
	Coefficients	*Standard Error*	*t Stat*	*P-value*		*Coefficients*	*Standard Error*	*t Stat*	*P-value*
Intercept	0.917	0.041	22.112	0.000	Intercept	0.884	0.033	26.475	0.000
DEBT	0.025	0.027	0.938	0.349	**DEBT**	0.014	0.021	0.678	0.498
FISCAL DEFICIT	0.560	0.154	3.641	0.000	**FISCAL DEFICIT**	0.060	0.063	0.951	0.342
GDP GROWTH	-0.075	0.018	-4.264	0.000	**GDP GROWTH**	-0.005	0.010	-0.447	0.655
INFLATION	-0.050	0.005	-10.072	0.000	**INFLATION**	-0.099	0.011	-8.735	0.000
UNEMPLOYMENT	-0.013	0.007	-1.916	0.056	**UNEMPLOYMENT**	-0.014	0.004	-3.668	0.000
REER	0.017	0.004	4.481	0.000	**REER**	-0.026	0.003	-8.544	0.000
INTERN RESERVES	-1.383	0.107	-12.870	0.000	**INTERN RESERVES**	-0.444	0.051	-8.704	0.000
DEBT SEC AMOUNT OUTSTANDING	-0.140	0.169	-0.830	0.407	**DEBT SEC AMOUNT**	-0.089	0.138	-0.646	0.519
2012					**2013**				
R Square		0.450			R Square		0.478		
Adjusted R Square		**0.440**			Adjusted R Square		**0.468**		
Observations		419			Observations		419		
				F					*F*
Regression				41.985	Regression				46.988
	Coefficients	*Standard Error*	*t Stat*	*P-value*		*Coefficients*	*Standard Error*	*t Stat*	*P-value*
Intercept	0.688	0.040	17.029	0.000	Intercept	0.900	0.036	25.263	0.000
DEBT	-0.086	0.015	-5.548	0.000	**DEBT**	-0.111	0.015	-7.632	0.000
FISCAL DEFICIT	0.042	0.120	0.349	0.727	**FISCAL DEFICIT**	0.401	0.123	3.271	0.001
GDP GROWTH	0.002	0.027	0.084	0.933	**GDP GROWTH**	-0.038	0.019	-1.973	0.049
INFLATION	-0.034	0.004	-8.684	0.000	**INFLATION**	-0.018	0.003	-5.855	0.000
UNEMPLOYMENT	-0.037	0.003	-11.288	0.000	**UNEMPLOYMENT**	-0.037	0.003	-13.022	0.000
REER	-0.001	0.006	-0.218	0.828	**REER**	0.006	0.005	1.122	0.263
INTERN RESERVES	0.075	0.053	1.407	0.160	**INTERN RESERVES**	0.197	0.055	3.562	0.000
DEBT SEC AMOUNT OUTSTANDING	-0.717	0.473	-1.518	0.130	**AMOUNT OUTSTANDING**	-1.071	0.231	-4.632	0.000
2010					**2011**				
R Square		0.413			R Square		0.489		
Adjusted R Square		**0.402**			Adjusted R Square		**0.479**		
Observations		419			Observations		419		
				F					*F*
Regression				36.089	Regression				48.963
	Coefficients	*Standard Error*	*t Stat*	*P-value*		*Coefficients*	*Standard Error*	*t Stat*	*P-value*
Intercept	0.922	0.048	19.240	0.000	Intercept	0.803	0.040	19.983	0.000
DEBT	-0.113	0.026	-4.321	0.000	**DEBT**	-0.127	0.019	-6.838	0.000
FISCAL DEFICIT	-0.063	0.096	-0.654	0.513	**FISCAL DEFICIT**	0.010	0.120	0.085	0.932
GDP GROWTH	-0.006	0.017	-0.385	0.700	**GDP GROWTH**	-0.035	0.023	-1.531	0.127
INFLATION	-0.207	0.022	-9.608	0.000	**INFLATION**	-0.036	0.009	-4.079	0.000
UNEMPLOYMENT	-0.056	0.005	-12.088	0.000	**UNEMPLOYMENT**	-0.043	0.004	-12.031	0.000
REER	-0.031	0.011	-2.779	0.006	**REER**	-0.032	0.005	-6.855	0.000
INTERN RESERVES	0.062	0.063	0.988	0.324	**INTERN RESERVES**	0.112	0.056	1.985	0.048
DEBT SEC AMOUNT OUTSTANDING	-0.728	0.473	-1.540	0.124	**DEBT SEC AMOUNT**	-0.044	0.383	-0.115	0.909
2014					**2015**				
R Square		0.614			R Square		0.622		
Adjusted R Square		**0.606**			Adjusted R Square		**0.614**		
Observations		419			Observations		419		
				F					*F*
Regression				81.356	Regression				84.244
	Coefficients	*Standard Error*	*t Stat*	*P-value*		*Coefficients*	*Standard Error*	*t Stat*	*P-value*
Intercept	0.982	0.029	34.362	0.000	Intercept	0.938	0.028	33.440	0.000
DEBT	-0.116	0.011	-10.215	0.000	**DEBT**	-0.089	0.011	-8.200	0.000
FISCAL DEFICIT	-0.031	0.091	-0.339	0.735	**FISCAL DEFICIT**	0.205	0.087	2.361	0.019
GDP GROWTH	-0.044	0.013	-3.507	0.001	**GDP GROWTH**	0.028	0.015	1.802	0.072
INFLATION	-0.016	0.001	-11.726	0.000	**INFLATION**	-0.015	0.001	-18.937	0.000
UNEMPLOYMENT	-0.032	0.002	-13.797	0.000	**UNEMPLOYMENT**	-0.028	0.002	-11.697	0.000
REER	-0.008	0.003	-2.979	0.003	**REER**	-0.004	0.001	-3.190	0.002
INTERN RESERVES	0.166	0.047	3.562	0.000	**INTERN RESERVES**	0.038	0.034	1.131	0.259
DEBT SEC AMOUNT OUTSTANDING	-0.171	0.420	-0.407	0.684	**AMOUNT OUTSTANDING**	-0.988	0.343	-2.883	0.004

Appendix 13 Results on the Influence of Bilateral Factors on Government Bond Market Comovements (Pooled and by Large Country) in 2008-2016

POOLED REGRESSION 2008-2016					
Regression Statistics					
Multiple R	0.323				
R Square	0.104				
Adjusted R Square	0.093				
Standard Error	0.307				
Observations	412				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	4.466	0.893	9.453	0.000
Residual	406	38.361	0.094		
Total	411	42.827			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.38	0.03	14.03	0.00	0.33
EXPORTS	-3.41	5.43	-0.63	0.53	-14.10
IMPORTS	5.09	4.93	1.03	0.30	-4.59
OUTWARD FDI	5.99	1.45	4.14	0.00	3.14
PORTFOLIO	-0.03	0.86	-0.04	0.97	-1.72
DISTANCE	0.00	0.00	-1.43	0.15	0.00

FRANCE 2008-2016					
Regression Statistics					
Multiple R	0.521				
R Square	0.272				
Adjusted R Square	0.233				
Standard Error	0.260				
Observations	99				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	2.347	0.469	6.942	0.000
Residual	93	6.288	0.068		
Total	98	8.635			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.46	0.04	10.85	0.00	0.37
EXPORTS	54.30	17.94	-3.03	0.00	40.32
IMPORTS	17.98	17.46	1.03	0.31	-16.71
OUTWARD FDI	8.25	3.40	2.43	0.02	1.50
PORTFOLIO	1.95	1.14	1.71	0.11	-0.32
DISTANCE	0.00	0.00	1.26	0.21	0.00

GERMANY 2008-2016					
Regression Statistics					
Multiple R	0.307				
R Square	0.094				
Adjusted R Square	0.046				
Standard Error	0.392				
Observations	100				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1.507	0.301	1.957	0.022
Residual	94	14.479	0.154		
Total	99	15.986			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.39	0.07	5.68	0.00	0.25
EXPORTS	-9.13	10.59	-0.86	0.39	-30.15
IMPORTS	7.01	9.79	0.72	0.48	-12.42
OUTWARD FDI	19.97	8.04	2.48	0.01	4.01
PORTFOLIO	-4.05	3.41	-1.19	0.24	-10.83
DISTANCE	0.00	0.00	0.22	0.82	0.00

JAPAN 2008-2016					
Regression Statistics					
Multiple R	0.605				
R Square	0.366				
Adjusted R Square	0.207				
Standard Error	0.112				
Observations	26				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	0.144	0.029	2.305	0.083
Residual	20	0.249	0.012		
Total	25	0.393			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.02	0.14	0.13	0.90	-0.28
EXPORTS	24.80	51.04	0.49	0.63	-81.68
IMPORTS	-9.12	19.24	-0.47	0.64	-49.26
OUTWARD FDI	-18.86	14.57	-1.29	0.21	-49.26
PORTFOLIO	17.48	10.65	1.64	0.12	-4.73
DISTANCE	0.00	0.00	0.67	0.51	0.00

THE UK 2008-2016					
Regression Statistics					
Multiple R	0.354				
R Square	0.125				
Adjusted R Square	0.051				
Standard Error	0.290				
Observations	65				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	0.714	0.143	1.693	0.150
Residual	59	4.978	0.084		
Total	64	5.692			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.38	0.06	6.43	0.00	0.26
EXPORTS	8.89	11.48	0.77	0.44	-14.07
IMPORTS	13.42	12.63	1.06	0.29	-11.84
OUTWARD FDI	2.90	3.13	0.93	0.36	-3.36
PORTFOLIO	-3.23	2.29	-1.41	0.16	-7.82
DISTANCE	0.00	0.00	0.45	0.65	0.00

THE US 2008-2016					
Regression Statistics					
Multiple R	0.496				
R Square	0.246				
Adjusted R Square	0.213				
Standard Error	0.249				
Observations	122				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	2.346	0.469	7.555	0.000
Residual	116	7.202	0.062		
Total	121	9.548			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.270	0.067	3.998	0.000	0.136
EXPORTS	53.48	19.66	2.72	0.008	14.54
IMPORTS	24.05	13.16	-1.83	0.070	50.12
OUTWARD FDI	3.76	2.89	1.30	0.196	-1.96
PORTFOLIO	-0.15	4.05	-0.04	0.970	-8.17
DISTANCE	0.00	0.00	0.08	0.933	0.00

Appendix 14 Results on the Influence of Bilateral Factors on Government Bond Market Comovements for Separate Year

2008

Regression Statistics	
Multiple R	0.576
R Square	0.332
Adjusted R Square	0.054
Standard Error	0.213
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	0.271	0.054	1.194	0.368
Residual	12	0.544	0.045		
Total	17	0.815			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.67	0.20	3.31	0.01	0.23
EXPORTS	-48.17	110.97	-0.43	0.67	-289.96
IMPORTS	47.28	83.77	0.56	0.58	-135.24
OUTWARD FDI	9.74	10.39	0.94	0.37	-12.90
PORTFOLIO	-13.32	20.09	-0.66	0.52	-57.09
DISTANCE	0.00	0.00	-1.48	0.17	0.00

2009

Regression Statistics	
Multiple R	0.578
R Square	0.334
Adjusted R Square	0.001
Standard Error	0.252
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	0.318	0.064	1.004	0.463
Residual	10	0.633	0.063		
Total	15	0.951			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.32	0.28	1.16	0.27	-0.30
EXPORTS	5.67	161.09	0.04	0.97	-353.27
IMPORTS	11.96	149.98	0.08	0.94	-322.22
OUTWARD FDI	4.19	12.44	0.34	0.74	-23.53
PORTFOLIO	3.26	15.01	0.22	0.83	-30.18
DISTANCE	0.00	0.00	-0.43	0.68	0.00

2010

Regression Statistics	
Multiple R	0.373
R Square	0.139
Adjusted R Square	0.058
Standard Error	0.344
Observations	59

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1.014	0.203	1.715	0.147
Residual	53	6.271	0.118		
Total	58	7.285			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.35	0.09	3.98	0.00	0.17
EXPORTS	-0.53	20.31	-0.03	0.98	-41.26
IMPORTS	12.30	17.70	0.70	0.49	-23.19
OUTWARD FDI	3.71	3.63	1.02	0.31	-3.57
PORTFOLIO	-1.50	2.42	-0.62	0.54	-6.36
DISTANCE	0.00	0.00	-0.49	0.62	0.00

2011

Regression Statistics	
Multiple R	0.391
R Square	0.153
Adjusted R Square	0.072
Standard Error	0.354
Observations	58

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1.177	0.235	1.878	0.114
Residual	52	6.517	0.125		
Total	57	7.694			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.39	0.09	4.15	0.00	0.20
EXPORTS	-15.12	14.64	-1.03	0.31	-44.49
IMPORTS	3.71	11.43	0.32	0.75	-19.23
OUTWARD FDI	8.50	4.31	1.97	0.05	-0.14
PORTFOLIO	0.06	3.21	0.02	0.99	-6.38
DISTANCE	0.00	0.00	-1.65	0.11	0.00

2012

Regression Statistics	
Multiple R	0.396
R Square	0.157
Adjusted R Square	0.078
Standard Error	0.343
Observations	59

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1.165	0.233	1.976	0.097
Residual	53	6.252	0.118		
Total	58	7.417			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.29	0.09	3.18	0.00	0.11
EXPORTS	-14.37	18.32	-0.78	0.44	-51.12
IMPORTS	14.69	21.93	0.67	0.51	-29.29
OUTWARD FDI	9.09	4.82	1.89	0.06	-0.57
PORTFOLIO	-2.44	2.88	-0.85	0.40	-8.22
DISTANCE	0.00	0.00	-0.62	0.54	0.00

2013

Regression Statistics	
Multiple R	0.604
R Square	0.365
Adjusted R Square	0.315
Standard Error	0.210
Observations	70

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1.626	0.325	7.359	0.00
Residual	64	2.828	0.044		
Total	69	4.454			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.59	0.05	11.53	0.00	0.48
EXPORTS	-1.35	7.40	-0.18	0.86	-16.12
IMPORTS	10.43	7.18	1.45	0.15	-3.91
OUTWARD FDI	3.46	2.97	1.16	0.25	-2.48
PORTFOLIO	-2.42	1.29	-1.88	0.06	-4.99
DISTANCE	0.00	0.00	-3.86	0.00	0.00

2014

Regression Statistics	
Multiple R	0.436
R Square	0.190
Adjusted R Square	0.117
Standard Error	0.292
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1.098	0.220	2.583	0.036
Residual	55	4.675	0.085		
Total	60	5.773			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.54	0.07	7.74	0.00	0.40
EXPORTS	7.33	14.69	0.50	0.62	-22.12
IMPORTS	-7.31	12.68	-0.58	0.57	-32.73
OUTWARD FDI	6.10	3.28	1.86	0.07	-0.48
PORTFOLIO	-0.82	1.97	-0.42	0.68	-4.76
DISTANCE	0.00	0.00	-2.35	0.02	0.00

2015

Regression Statistics	
Multiple R	0.532
R Square	0.283
Adjusted R Square	0.229
Standard Error	0.253
Observations	73

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1.684	0.337	5.281	0.000
Residual	67	4.272	0.064		
Total	72	5.956			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.49	0.06	8.24	0.00	0.37
EXPORTS	-0.99	12.24	-0.08	0.94	-25.43
IMPORTS	7.69	13.76	0.56	0.58	-19.77
OUTWARD FDI	2.71	3.45	0.79	0.43	-4.17
PORTFOLIO	1.06	1.85	0.57	0.57	-2.63
DISTANCE	0.00	0.00	-2.57	0.01	0.00

Eglė ALEKNEVIČIŪTĖ

ASSESSMENT OF THE FACTORS INFLUENCING GOVERNMENT BOND MARKET COMOVEMENTS IN THE GLOBAL ENVIRONMENT

Doctoral Dissertation

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