The dynamics of bond market development, stock market development and economic growth

Evidence from the G-20 countries

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Abstract

Purpose – The paper investigates whether Granger causal relationships exist between bond market development, stock market development, economic growth and two other macroeconomic variables, namely, inflation rate and real interest rate. The study aims to expand the domain of economic growth by including a more in-depth analysis of the possible impact that bond market and stock market development has on economic growth than is normally found in the literature.

Design/methodology/approach – This paper uses a panel data set of the G-20 countries for the period 1991-2016. It uses a panel vector auto-regression model to reveal the nature of any Granger causality among the five variables.

Findings – The paper provides empirical insights that both bond market development and stock market development are cointegrated with economic growth, inflation rate and real interest rate. The most robust result from the panel Granger causality test is that bond market development, stock market development, inflation rate and real interest rate are demonstrable drivers of economic growth in the long run.

Research limitations/implications – Because of the chosen research approach, the research results may lack theoretical foundations. Therefore, perhaps the more fully grounded interactive findings of this study can inspire theorists to fill the missing gap.

Practical implications – This paper includes lessons for policymakers in the G-20 countries seeking to stimulate economic growth in the long run and how they need to ensure greater stability of the interest rate and inflation rate as well as fully developing their financial markets, as both bond markets and stock markets are obvious drivers of economic growth.

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Originality/value – This paper fulfills an identified need to study causal relationships between bond market development, stock market development, economic growth and two other macroeconomic variables, i.e. inflation rate and real interest rate.

Keywords Bond market development, Stock market development, Economic growth, G-20 countries, 20 countries

Paper type Research paper

1. Introduction

There is widespread argument that well-developed financial markets play a key role in promoting economic growth (see, for instance, Adeniyi *et al.*, 2015; Capasso, 2008; Jedidia *et al.*, 2014; Levine, 1997; Otchere *et al.*, 2016; Pradhan *et al.*, 2015; Uddin *et al.*, 2013; Wachtel, 2001). The importance of the relationship between the development of financial markets and economic growth is well recognized throughout the financial literature (Bhattarai, 2015; Greenwood and Scharfstein, 2013; Iyare and Moore, 2011; Peia and Roszbach, 2015; Samargandi *et al.*, 2015). Theoretically, financial development[1] contributes to economic growth through a variety of channels, such as ameliorating risk, reducing information asymmetries, monitoring enterprises and promoting corporate governance, liberalizing the exchange of goods and services and mobilizing savings (Pradhan *et al.*, 2017a; Ngare *et al.*, 2014; Owusu and Odhiambo, 2014; Thumrongvit *et al.*, 2013; Hsueh *et al.*, 2013; Zhang *et al.*, 2012; Levine, 2005; Levine, 2003; Levine *et al.*, 2000; King and Levine, 1993a, 1993b). Several studies[2] provide supporting evidence that financial development contributes to economic growth (see, for instance, Pradhan *et al.*, 2014a, 2014b, 2014c). However, many of these studies focus on the overall development of financial markets with little to no attention being given to the development of either stock markets or bond markets[3]. Moreover, the research on the relationships between bond market development and economic growth is scarce in the growth and financial literature alike (Egert, 2015; Mu *et al.*, 2013; Sharma, 2001).

It can be noted that both stock market development and bond market development have links to economic growth through a variety of sub-connections (Bui *et al.*, 2018; Benczúr *et al.*, 2018; Pradhan *et al.*, 2016a, 2016b; Peregoa and Vermeulena, 2016; Mu *et al.*, 2013; Thumrongvit *et al.*, 2013; Bhattacharyay, 2013; Sophastienphong *et al.*, 2008). Furthermore, the stock market and bond market developments also correlate with each other (Kourtellos *et al.*, 2013; Checherita-Westphal and Rother, 2012; Fink *et al.*, 2003; Rahman and Mustafa, 1997). Evidently, there is no shortage of research on the links between stock and bond market development and economic growth. While the direction of Granger causality between economic growth and these variables is not always uniform across studies, the weight of the evidence supports the notion that both stock and bond market development positively impact economic growth. At the same time, an under-researched area is the link between stock market development and bond market development itself. In this paper, we focus on the inter-links between *all* of these variables. In addition, we examine the nature of causality in the presence of two additional key macroeconomic variables, namely inflation rate and real interest rate – bringing our full set of variables to five. The empirical question is whether there is Granger causality[4] among these five variables.

Having a better understanding of the dynamics between stock market development and bond market development and their simultaneous connection to economic growth and other macroeconomic variables offers important lessons for policymakers. For instance, our study asks whether the *co-development* of the stock market and bond market is necessary for economic growth and whether feedback causality exists (i.e. whether causality flows in the opposite direction as well). Moreover, we report on both short- and long-run causality among the variables.

The remainder of this paper is organized as follows. Section 2 presents the theoretical framework. Section 3 presents a review of the literature. Section 4 describes our data, variables, and model. Section 5 describes our econometric methodology. Section 6 presents and discusses the results. Section 7 concludes with policy implications.

2. Theoretical framework

It is a well-established fact that long-run economic growth solely depends on the ability to increase the speed of the accumulation of physical and human capital, to use the resulting productive assets more efficiently and to guarantee access of the whole population to these assets. Financial intermediation provides this investment process by mobilizing savings for investment by firms:

- ensuring that these funds are allocated to the most productive use; and
- spreading risk and providing liquidity so that the firms can operate the innovative capacity efficiently.

Therefore, financial development involves the formation and development of institutions, instruments, and markets that support this investment process and to achieve economic growth. Usually, the role of banks and non-bank financial intermediaries, ranging from pension funds to stock markets, has been to translate household savings into enterprise investment, monitor investments and allocate funds, and to price and spread risk. Yet financial intermediation has strong externalities in this context, which are generally positive, such as information and liquidity provision, but can also be negative in the systematic financial crises which are endemic to market systems. Financial development and economic growth are thus clearly related, and this relationship has occupied the minds of great economists such as Robinson, Schumpeter and Goldsmith (Levine *et al.*, 2000; Levine, 1997).

In the development literature, the financial system is the nerve center of a country's development. Hence, an efficient provision of financial services determines the economic growth and prosperity of a country (see, for instance, Pradhan *et al.*, 2017a, 2017b). Financial development can contribute to economic growth in the following ways:

- ensuring financial stability;
- supporting trade and commerce;
- mobilizing domestic savings;
- allowing different risks to be managed more recently by encouraging the accumulation of new capital;
- increasing a more efficient allocation of domestic capital; and
- aiding to reduce or mitigate losses.

Historically, the role of financial development on economic growth has received considerable attention since the emergence of endogenous growth theory. The theoretical contributions on this area can be divided into various strands. First, the allocative role of financial systems (Greenwood and Jovanovic, 1990). Second, financial markets allow firms to diversify portfolios, to increase liquidity, which reduces risks, and hence stimulates growth (Levine, 1997). Third, financial development provides an exit mechanism for agents and improves the efficiency of financial intermediation (Arestis *et al.*, 2001). Fourth, the financial market's ability to impact economic growth through changes in incentives for corporate control (see, for instance, Demirguc-Kunt and Levine, 1996). Moreover, there are also theoretical studies that examine the role of financial development on economic growth by clustering financial development into various sub-categories such as banking sector development, stock market development and bond market development (Durusu-Ciftci *et al.*, 2017). These studies, both theoretically and empirically, justify that all these financial activities have significant contributions to economic growth.

Financial development is a broad concept and consists of all kinds of financial development activities, such as banking, stock markets and bond markets. However, in this paper, we mostly focus on stock market development and bond market development and their impact on economic growth and two other macroeconomic indicators, namely inflation and real interest rate. The choice of these two financial development activities (bond and stock markets) in this research is mostly because of the paucity of research in these two markets compared to banking sector development activities. The findings of this link will add value to the overall impact of the finance–growth nexus.

3. Literature review

The link between financial market development and economic growth is commonly suspected and has been empirically tested, particularly since the seminal works of Schumpeter (1911). Imperative studies in this area of research tried to substantiate the existence of any relationship between financial development and economic growth. Other studies have tried to validate the nature and direction of Granger causality – whether financial markets development promotes economic growth or whether causality flows in the opposite direction (see, for instance, King and Levine, 1993a, 1993b). There can be four possible hypotheses with respect to the Granger causal relationships between financial market development (FMD)[5] and economic growth (Fink *et al.*, 2003).

First, the *supply-leading hypothesis*, which contends that financial market development Granger causes economic growth (as argued in Puente-Ajovin and Sanso-Navarro, 2015; Kolapo and Adaramola, 2012; Kar *et al.*, 2011; Colombage, 2009; Enisan and Olufisayo, 2009; Nieuwerburgh *et al.*, 2006; Tsouma, 2009).

Second, the *demand-leading hypothesis*, which contends that economic growth Granger causes financial markets development (as purported in Puente-Ajovin and Sanso-Navarro, 2015; Kar *et al.*, 2011; Panopoulou, 2009; Liu and Sinclair, 2008; Odhiambo, 2007, 2010; Fink *et al.*, 2006; Ang, 2008; Liang and Teng, 2006; Dritsakis and Adamopoulos, 2004).

Third, the *feedback hypothesis*, which contends that economic growth and financial markets development Granger cause each other. Meaning that they can complement and reinforce one another, making financial market development and economic growth mutually cause each other (as maintained in Puente-Ajovin and Sanso-Navarro, 2015; Marques *et al.*, 2013; Cheng, 2012; Hou and Cheng, 2010; Rashid, 2008; Darrat *et al.*, 2006; Caporale *et al.*, 2004; Hassapis and Kalyvitis, 2002; Wongbangpo and Sharma, 2002; Huang *et al.*, 2000; Muradoglu *et al.*, 2000; Masih and Masih, 1999; Nishat and Saghir, 1991).

Fourth, the *neutrality hypothesis*, which suggests that financial market development and economic growth are independent of each other (Pradhan, 2018; Puente-Ajovin and Sanso-Navarro, 2015; Pradhan *et al.*, 2013b).

Table I presents a synopsis of research on the causal nexus between financial market development and economic growth.

4. Data, specification of variables and model

This paper attempts to investigate whether Granger causal relationships exist between bond market development, stock market development, economic growth in

Study	Study area	Method	Period covered
Group 1: Studies that support supply-leading hypothesis			
Puente-Ajovin and Sanso-Navarro (2015)	16 OECD countries	BVGC	1980-2009
Hsueh *et al.* (2013)	OECD countries		
Matei (2013)	14 ENEMU countries	BVGC	2002-2012
Pradhan *et al.* (2013a)	16 Asian countries	MVGC	1988-2012
Kolapo and Adaramola (2012)	Nigeria	MVGC	1990-2010
Tsouma (2009)	22 MMs and EMs	BVGC	1991-2006
Enisan and Olufisayo (2009)	7 sub-Saharan African	MVGC	1980-2004
Colombage (2009)	5 countries	MVGC	1995-2007
Nieuwerburgh *et al.* (2006)	Belgium	TVGC	1830-2000
Group 2: Studies that support demand-following hypothesis			
Puente-Ajovin and Sanso-Navarro (2015)	16 OECD countries	BVGC	1980-2009
Kar *et al.* (2011)	15 MENA countries	MVGC	1980-2007
Panopoulou (2009)	5 countries	MVGC	1995-2007
Odhiambo (2007)	Kenya	TVGC	1969-2005
Liu and Sinclair (2008)	China	BVGC	1973-2003
Ang (2008)	Malaysia	MVGC	1960-2001
Liang and Teng (2006)	China	MVGC	1952-2001
Dritsakis and Adamopoulos (2004)	Greece	TVGC	1988-2002
Group 3: Studies that support feedback hypothesis			
Puente-Ajovin and Sanso-Navarro (2015)	16 OECD countries	BVGC	1980-2009
Cheng (2012)	Taiwan	MVGC	1973-2007
Hou and Cheng (2010)	Taiwan	MVGC	1971-2007
Rashid (2008)	Pakistan	MVGC	1994-2205
Darrat *et al.* (2006)	EMs	TVGC	1970-2003
Caporale *et al.* (2004)	7 countries	BVGC	1977-1998
Wongbangpo and Sharma (2002)	ASEAN 5	MVGC	1985-1996
Huang *et al.* (2000)	USA, Japan, China	TVGC	1992-1997
Muradoglu *et al.* (2000)	EMs	MVGC	1976-1997
Masih and Masih (1999)	8 countries	MVGC	1992-1997
Nishat and Saghir (1991)	Pakistan	BVGC	1964-1987
Group 4: Studies that support neutrality hypothesis			
Puente-Ajovin and Sanso-Navarro (2015)	16 OECD countries	BVGC	1980-2009
Pradhan *et al.* (2013a)	16 Asian countries	MVGC	1988-2012

Notes: The definition of financial market development varies across studies; MMs: Mature markets; EMs: Emerging markets; MENA: Middle East and North Africa region; ASEAN: Association of Southeast Asian Nations; OECD: Organization for Economic Co-operation and Development ENEMU: European Non-EMU countries; BVGC: Bivariate Granger Causality; TVGC: Trivariate Granger Causality; QVGC: Quadvariate Granger Causality; and MVGC: Multivariate Granger Causality
Source: Authors' tabulations

Table I. Summary of the studies showing a causal link between financial market development and economic growth

the presence of two other key macroeconomic variables: the inflation rate and the real interest rate[6]. We use a panel data set of the G-20[7] countries for the period 1991-2016[8].

The G-20 was founded in 1999. Its objective is reviewing and promoting high-level discussion of policy issues pertaining to the promotion of international financial stability (Duca and Stracca, 2015). It seeks to address issues that go beyond the responsibilities of any one organization. Together, in 2014, the G-20 economies accounted for around

90 per cent of the world's gross domestic product, 80 per cent of world trade (75 per cent if EU intra-trade is excluded), and 67 per cent of the world's population (Fu *et al.*, 2015; Yao *et al.*, 2015). The individual macroeconomic profiles of these countries are provided in Table AI in Appendix 1.

Our analysis uses three samples. The first sample consists of the G-20 developing (emerging) group. This includes the bottom ten countries among the G-20, ranked based on the purchasing power parity of their income per capita, as classified by the World Bank. These developing (emerging) countries are Argentina, Brazil, China, India, Indonesia, Mexico, the Russian Federation, Saudi Arabia, South Africa and Turkey. The second sample consists of the G-20 developed group. This includes the top nine countries in the G-20, ranked based on the purchasing power parity of their income per capita, as classified by the World Bank (2006). These nine countries are Australia, Canada, France, Germany, Italy, Japan, the Korean Republic, the UK and the USA. Our third sample includes all 19 member countries of the G-20.

The variables used in this study are real per capita economic growth (variable: *GDP*), bond markets development index (variable: *BMD*), stock markets development index (variable: *SMD*), inflation rate (variable: *INF*) and real interest rate (variable: *RIR*). *BMD* is the composite index of three bond markets indicators: public sector bonds (variable: *PUB*), private sector bonds (variable: *PRB*), and international bonds (variable: *INB*); while *SMD* is the composite index of three stock markets indicators: market capitalization (variable: *MAC*), turnover ratio (variable: *TRU*), and traded stocks (*TRA*).

Usually, stock market development is defined as a process of improvements in the quantity, quality and efficiency of stock market services. This process involves the interaction of many activities, and consequently cannot be captured by one single measurement. Accordingly, this study applies three commonly used measures of stock market activities (*MAC*, *TRA* and *TUR*). We create a composite indicator for stock market development (*SMD*) using these three measures, through principal component analysis (PCA). The detailed description of the construction of BMD is available in Appendix 2 (see Table AII for PCA results). Analogously, our indicator for bond market development (*BMD*) is derived by PCA using three measures of bond market activities: *PUB*, *PRB* and *INB* (see Table AIII in Appendix 2 for a detailed discussion). Table II presents the detailed definition of these variables.

Table III supplies the descriptive statistics and the correlations of these variables, respectively. The results of the correlation matrix indicate that the three indicators of bond market development (i.e. *PUB*, *PRB*, and *INB*) and the three indicators of stock market development (i.e. *MAC*, *TUR* and *TRA*) are highly correlated. Clearly, the problem of multicollinearity would arise if the indicators of *BMD* and *SMD* were used simultaneously. This affirms our conviction that these indicators should be combined into two composite indices.

We use the following general model to describe the long-run relationship between *GDP*, *BMD*, *SMD*, *INF* and *RIR*.

$$GDP_{it} = \mu_{it} + \theta_{1i}BMD_{it} + \theta_{2i}SMD_{it} + \theta_{31i}INF_{it} + \theta_{4i}RIR_{it} + \varepsilon_{it} \quad (1)$$

where $i = 1, 2, \ldots$, N represents each country in the panel; and $t = 1, 2, \ldots$, T refers to year in the panel.

In other variations of equation (1), the other variables (*BMD*, *SMD*, *INF* and *RIR)* serve as the dependent variable to allow for the possibility that causation may flow in either

Variable code	Variable definition
Group 1: Bond market variables	
BMD	*Bond market development index*: A composite index of bond market development, which is the weighted average of the three bond market indicators: PUB, PSB and INB
PUB	*Public sector bonds*: Ratio of public sector bonds to the gross domestic product (in percentage)
PRB	*Private sector bonds*: Ratio of private sector bonds to the gross domestic product (in percentage)
INB	*International bonds*: Ratio of international sector bonds to the gross domestic product (in percentage)
Group 2: Stock market variables	
SMD	*Stock market development index*: A composite index of stock market development, which is the weighted average of the three stock market indicators: MAC, TRA and TUR
MAC	*Market capitalization*: Value of listed shares as a percentage of the gross domestic product
TRA	*Traded stocks*: Total value of shares traded on the stock markets as a percentage of the gross domestic product
TUR	*Turnover ratio*: Value of total shares traded as a percentage of market capitalization
Group 3: Macroeconomic variables	
GDP	*Per capita economic growth (in percentage)*: Percentage change in per capita gross domestic product, used as an indicator of economic growth
INF	*Inflation rate (in percentage)*: Percentage change in consumer price index
RIR	*Real interest rate (in percentage)*: Real interest rate is the lending interest rate adjusted for inflation (using the gross domestic product deflator)

Notes: All monetary measures are in real US dollars; Variables above are defined in the *World Development Indicators* and *Financial Development and Structure Dataset*, both published by the World Bank; we use only BMD and SMD in our empirical investigation, not the individual indicators (see text)
Source: Authors' tabulations

Table II. Definition of variables

direction. The parameters θ_j (for j = 1, 2, 3, and 4) represent the long-run elasticity estimates of *GDP* with respect to *BMD*, *SMD*, *INF*, and *RIR*, respectively, given the natural logarithmic forms for the variables in our empirical model.

The primary objective of this study is to estimate the parameters in equation (1) and conduct panel tests on the causal nexus between these five variables. It is postulated that $\theta_1 > 0$ meaning that an increase in bond market development will cause an increase in per capita economic growth. Similarly, we expect $\theta_2 > 0$ which is consistent with the notion that an increase in stock market development will cause an increase in per capita economic growth.

5. Econometric methodology

We test the following main hypotheses:

- *FMD* Granger-causes economic growth and vice versa
- *INF* Granger-causes economic growth and vice versa
- *RIR* Granger-causes economic growth and vice versa
- *INF* Granger-causes *FMD* and vice versa
- *RIR* Granger-causes *FMD* and vice versa
- *RIR* Granger-causes *INF* and vice versa

Variables	GDP	BMD	SMD	PUB	PRB	INB	MAC	TUR	TRA	INF	RIR
Part 1: Summary statistics (for total sample)											
Mean	1.23	0.01	0.17	1.37	1.12	1.07	1.64	1.80	1.41	0.81	1.46
Median	1.23	0.11	0.24	1.45	1.33	1.07	1.65	1.84	1.54	0.74	1.45
Maximum	1.46	0.78	0.91	2.28	2.08	2.10	2.41	2.73	2.52	3.32	2.01
Minimum	−0.19	−2.30	−1.14	−0.63	−2.75	−0.50	−1.90	0.58	−1.15	−0.23	−0.40
SD	0.12	0.53	0.34	0.46	0.74	0.49	0.41	0.38	0.58	0.43	0.14
Skewness	−4.53	−1.34	−0.75	−0.91	−1.66	−0.39	−1.78	−0.67	−0.91	1.80	4.27
Kurtosis	42.3	2.05	0.71	1.02	3.71	−0.02	11.7	0.58	1.07	7.07	66.9
IQR	0.09	0.70	0.49	0.57	0.84	0.59	0.53	0.52	0.81	0.40	0.10
Part 2: Correlation matrix (for total sample)											
GDP	1.00										
BMD	−0.10**	1.00									
SMD	0.10**	0.38*	1.00								
PUB	−0.10**	0.90*	0.25*	1.00							
PRB	−0.10**	0.80*	0.39*	0.60*	1.00						
INB	−0.27*	0.52*	0.22*	0.34*	0.30*	1.00					
MAC	0.13**	0.56*	0.63*	0.47*	0.51*	0.35*	1.00				
TUR	0.12*	0.10**	0.71*	−0.11**	0.10**	0.10**	0.02	1.00			
TRA	0.10	0.52*	0.93*	0.37*	0.49*	0.35*	0.75*	0.65*	1.00		
INF	−0.17*	−0.55*	−0.30*	−0.50*	−0.58*	−0.38*	−0.48*	−0.10**	−0.44*	1.00	
RIR	0.20*	0.11**	−0.10**	0.17**	0.12**	−0.03	−0.01	−0.10**	−0.10**	−0.10**	1.00

Notes: GDP: Per capita economic growth; BMD: Bond market development index; PUB: Public sector bonds; PRB: Private sector bonds; INB: International bonds; SMD: Stock market development index; MAC: market capitalization; TUR: Turnover ratio; TRA: Traded stocks; INF: Inflation rate; RIR: Real interest rate; and IQR: Inter-quartile range; Values reported in square brackets are the probability levels of significance; *and **indicate significance at 1% and 5% levels, respectively
Source: Authors' calculations

Table III. Descriptive statistics and correlation matrix for the variables

More specifically, we test the following sub-hypotheses:

H1A, B. Bond market development Granger-causes economic growth and vice versa.

H2A, B. Stock market development Granger-causes economic growth and vice versa.

H3A, B. Inflation rate Granger-causes economic growth and vice versa.

H4A, B. Real interest rate Granger-causes economic growth and vice versa.

H5A, B. Bond market development Granger-causes inflation rate and vice versa.

H6A, B. Stock market development Granger-causes inflation rate and vice versa.

H7A, B. Bond market development Granger-causes real interest rate and vice versa.

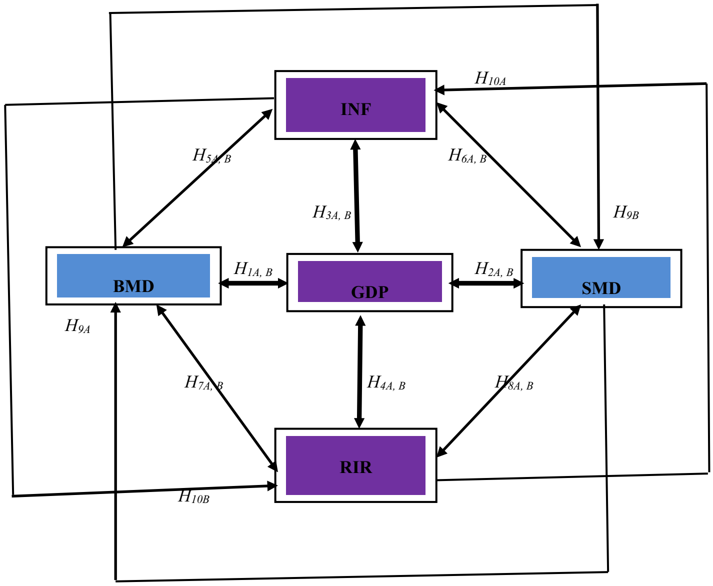
H8A, B. Stock market development Granger-causes real interest rate and vice versa.

H9A, B. Stock market development Granger-causes bond market development and vice versa.

H10A, B. Real interest rate Granger-causes inflation rate and vice versa.

Figure 1 summarizes all the sub-hypotheses, which describe the direction of possible causality among these variables.

We use the following vector error-correction model (*VECM*)[9] to examine the direction of Granger causal relationships between *GDP, BMD, SMD, INF* and *RIR*.



Notes: GDP: Per capita economic growth; BMD: Bond market development index; SMD: Stock market development index; INF: Inflation rate; and RIR: Real interest rate; H1A, B: Bond market development Granger-causes economic growth and vice versa; H2A, B: Stock market Granger-causes economic growth and vice versa; H3A, B: Inflation rate Granger-causes economic growth and vice versa; H4A, B: Real interest rate Granger-causes economic growth and vice versa; H5A, B: Bond market development Granger-causes inflation rate and vice versa; H6A, B: Stock market development Granger-causes inflation rate and vice versa; H7A, B: Bond market development Granger-causes real interest rate and vice versa; H8A, B: Stock market development Granger-causes real interest rate and vice versa; H9A, B: Stock market development Granger-causes bond market development and vice versa; H10A, B: Real interest rate Granger-causes inflation rate and vice versa
Source: Authors' design

Figure 1.
Possible causality between bond market development, stock market development, economic growth, inflation rate and real interest rate

$$\Delta GDP_{it} = \eta_{GDPj} + \sum_{k=1}^{p_1} \alpha_{GDPik} \Delta GDP_{it-k} + \sum_{k=1}^{p_2} \beta_{GDPik} \Delta BMD_{it-k} + \sum_{k=1}^{p_3} \delta_{GDPik} \Delta SMD_{it-k} + \sum_{k=1}^{p_4} \mu_{GDPik} \Delta INF_{it-k} + \sum_{k=1}^{p_5} \lambda_{GDPik} \Delta RIR_{it-k} + \omega_{GDPi} ECT_{GDPit-1} + \varepsilon_{GDPit} \quad [2]$$

H_0^1: $\alpha_{GDPik}) = 0$; $\beta_{GDPik} = 0$; $\delta_{GDPik} = 0$; $\mu_{GDPik} = 0$; $\lambda_{GDPik} = 0$; $\omega_{GDPik} = 0$; *for* $k = 1, \ldots, p_i$ (for i =1–5)

H_1^1: $\alpha_{GDPik} \neq 0$; $\beta_{GDPik} \neq 0$; $\delta_{GDPik} \neq 0$; $\mu_{GDPik} \neq 0$; $\lambda_{GDPik} \neq 0$; $\omega_{GDPik} \neq 0$;
for at least one k

$$\Delta BMD_{it} = \eta_{BMDj} + \sum_{k=1}^{p_1} \alpha_{BMDik} \Delta BMD_{it-k} + \sum_{k=1}^{p_2} \beta_{BMDik} \Delta GDP_{it-k} + \sum_{k=1}^{p_3} \delta_{BMDik} \Delta SMD_{it-k} + \sum_{k=1}^{p_4} \mu_{BMDik} \Delta INF_{it-k} + \sum_{k=1}^{p_5} \lambda_{BMDik} \Delta RIR_{it-k} + \omega_{BMDi} ECT_{BMDit-1} + \varepsilon_{BMDit} \quad [2]$$

H_0^2: $\alpha_{BMDik} = 0$; $\beta_{BMDik} = 0$; $\delta_{BMDik} = 0$; $\mu_{BMDik} = 0$; $\lambda_{BMDik} = 0$; $\omega_{BMDik} = 0$;
for $k = 1, \ldots, p_{\mathrm{i}}$ (*for* $i = 1 - 5$)
H_1^2: $\alpha_{BMDik} \neq 0$; $\beta_{BMDik} \neq 0$; $\delta_{BMDik} \neq 0$; $\mu_{BMDik} \neq 0$; $\lambda_{BMDik} \neq 0$; $\omega_{BMDik} \neq 0$;
for at least one k

$$\Delta SMD_{it} = \eta_{SMDj} + \sum_{k=1}^{p_1} \alpha_{SMDik} \Delta SMD_{it-k} + \sum_{k=1}^{p_2} \beta_{SMDik} \Delta BMD_{it-k} + \sum_{k=1}^{p_3} \delta_{SMDik} \Delta GDP_{it-k} + \sum_{k=1}^{p_4} \mu_{SMDik} \Delta INF_{it-k} + \sum_{k=1}^{p_5} \lambda_{SMDik} \Delta RIR_{it-k} + \omega_{SMDi} ECT_{SMDit-1} + \varepsilon_{SMDit} \quad [3]$$

H_0^3: $\alpha_{SMDik} = 0$; $\beta_{SMDik} = 0$; $\delta_{SMDik} = 0$; $\mu_{SMDik} = 0$; $\lambda_{SMDik} = 0$; $\omega_{SMDik} = 0$;
for $k = 1, \ldots, p_{\mathrm{i}}$ (*for* $i = 1 - 5$)
H_1^3: $\alpha_{SMDik} \neq 0$; $\beta_{SMDik} \neq 0$; $\delta_{SMDik} \neq 0$; $\mu_{SMDik} \neq 0$; $\lambda_{SMDik} \neq 0$; $\omega_{SMDik} \neq 0$;
for at least one k

$$\Delta INF_{it} = \eta_{INFj} + \sum_{k=1}^{p_1} \alpha_{INFik} \Delta INF_{it-k} + \sum_{k=1}^{p_2} \beta_{INFik} \Delta SMD_{it-k} + \sum_{k=1}^{p_3} \delta_{INFik} \Delta BMD_{it-k} + \sum_{k=1}^{p_4} \mu_{INFik} \Delta GDP_{it-k} + \sum_{k=1}^{p_5} \lambda_{INFik} \Delta RIR_{it-k} + \omega_{INFi} ECT_{INFit-1} + \varepsilon_{INFit} \quad [4]$$

H_0^4: $\alpha_{INFik} = 0$; $\beta_{INFik} = 0$; $\delta_{INFik} = 0$; $\mu_{INFik} = 0$; $\lambda_{INFik} = 0$; $\omega_{INFik} = 0$;
for $k = 1, \ldots, p_{\mathrm{i}}$ (*for* $i = 1 - 5$)
H_1^4: $\alpha_{INFik} \neq 0$; $\beta_{INFik} \neq 0$; $\delta_{INFik} \neq 0$; $\mu_{INFik} \neq 0$; $\lambda_{INFik} \neq 0$; $\omega_{INFik} \neq 0$;
for at least one k

$$\Delta RIR_{it} = \eta_{RIRj} + \sum_{k=1}^{p_1} \alpha_{RIRik} \Delta RIR_{it-k} + \sum_{k=1}^{p_2} \beta_{RIRik} \Delta INF_{it-k} + \sum_{k=1}^{p_3} \delta_{RIRik} \Delta SMD_{it-k} + \sum_{k=1}^{p_4} \mu_{RIRik} \Delta BMD_{it-k} + \sum_{k=1}^{p_5} \lambda_{RIRik} \Delta GDP_{it-k} + \omega_{RIRi} ECT_{RIRit-1} + \varepsilon_{RIRit} \quad [5]$$

H_0^5: $\alpha_{RIRik} = 0$; $\beta_{RIRik} = 0$; $\delta_{RIRik} = 0$; $\mu_{RIRik} = 0$; $\lambda_{RIRik} = 0$; $\omega_{RIRik} = 0$;
for $k = 1,\ldots, p_i$ *(for* $i = 1\text{-}5$*)*
H_1^5: $\alpha_{RIRik} \neq 0$; $\beta_{RIRik} \neq 0$; $\delta_{RIRik} \neq 0$; $\mu_{RIRik} \neq 0$; $\lambda_{RIRik} \neq 0$; $\omega_{RIRik} \neq 0$;
for at least one k

where Δ is the first difference operator; i is the country, t is the year in the panel and ε_{it} is a normally distributed random error term for all i and t with a zero mean and a finite heterogeneous variance.

The *ECT*s are error-correction terms, derived from the cointegrating equations (see, for instance, Engle and Granger, 1987). The lagged *ECTs* represent the long-run dynamics, while the differenced variables represent the short-run dynamics between the variables. The above model is meaningful if the time series variables are *I*(1) and are cointegrated[10]. If the time series variables are *I* (1) and are not cointegrated, the lagged *ECT* component will be removed in the estimation process. We look for both short-run and long-run causal relationships between *GDP*, *BMD*, *SMD*, *INF* and *RIR*. The short-run causal relationship is measured through *F*-statistics and the significance of the lagged changes in the independent variables, whereas the long-run causal relationship is measured through the significance of the *t*-test of the lagged *ECTs*. Based on equations (2)-(6), Table IV presents the synopsis of various possible hypotheses concerning the causal relationships among the variables.

6. Empirical results and discussion

The empirical investigation starts with unit root and cointegration between five sets of variables: *GDP*, *BMD*, *SMD*, *INF* and *RIR*. Both the unit root test and cointegration tests are the pre-requisite for the Granger causality tests (see, for instance, Engle and Granger, 1987; Granger, 1988). The unit root test examines the order of integration [i.e. *I (n)*, for n =1, 2,., N]

Causal flows	Restrictions
BMD => GDP	$\beta_{GDPik} \neq 0$; $\omega_{GDPi} \neq 0$
GDP => BMD	$\beta_{BMDik} \neq 0$; $\omega_{BMDi} \neq 0$
SMD => GDP	$\delta_{GDPik} \neq 0$; $\omega_{GDPi} \neq 0$
GDP => SMD	$\delta_{SMDik} \neq 0$; $\omega_{SMDi} \neq 0$
INF => GDP	$\mu_{GDPik} \neq 0$; $\omega_{GDPi} \neq 0$
GDP => INF	$\mu_{INFik} \neq 0$; $\omega_{INFi} \neq 0$
RIR => GDP	$\lambda_{GDPik} \neq 0$; $\omega_{GDPi} \neq 0$
GDP => RIR	$\lambda_{RIRik} \neq 0$; $\omega_{RIRi} \neq 0$
SMD => BMD	$\delta_{BMDik} \neq 0$; $\omega_{BMDi} \neq 0$
BMD => SMD	$\beta_{SMDik} \neq 0$; $\omega_{SMDi} \neq 0$
INF => BMD	$\mu_{BMDik} \neq 0$; $\omega_{BMDi} \neq 0$
BMD => INF	$\delta_{INFik} \neq 0$; $\omega_{INFi} \neq 0$
RIR => BMD	$\lambda_{BMDik} \neq 0$; $\omega_{BMDi} \neq 0$
BMD => RIR	$\mu_{RIRik} \neq 0$; $\omega_{RIRi} \neq 0$
INF => SMD	$\mu_{SMDik} \neq 0$; $\omega_{SMDi} \neq 0$
SMD => INF	$\beta_{INFik} \neq 0$; $\omega_{INFi} \neq 0$
RIR => SMD	$\lambda_{SMDik} \neq 0$; $\omega_{SMDi} \neq 0$
SMD => RIR	$\delta_{RIRik} \neq 0$; $\omega_{RIRi} \neq 0$
RIR => INF	$\lambda_{INFik} \neq 0$; $\omega_{INFi} \neq 0$
INF => RIR	$\beta_{RIRik} \neq 0$; $\omega_{RIRi} \neq 0$

Notes: GDP: Per capita economic growth; BMD: Bond market development index; SMD: Stock market development index; INF: Inflation rate; and RIR: Real interest rate
Source: Authors' tabulations

Table IV. Hypotheses tested in this study where the time series variables attain stationarity, while cointegration tests examine the existence of long-run equilibrium relationships between the variables.

We use panel unit root tests to determine the degree, or order, of integration between *GDP*, *BMD*, *SMD*, *INF* and *RIR*. While several panel unit root tests are accessible to estimate, we use three different panel unit root tests: *LLC*, *ADF* and *PP* tests [the unit root tests proposed by Levin *et al.* (2002) and Maddala and Wu (1999)] to identify the order of integration of these variables. Because these panel unit root tests are widely used in many research papers and are described in advanced econometrics textbooks, we choose not to elaborate on them here.

Table V shows the results of the panel unit root tests for each variable. These tests confirm that all the variables are (*GDP*, *BMD*, *SMD*, *INF* and *RIR*) integrated of order one, i.e. *I* (1). As the test-statistics of the unit root test at levels are below the critical values for all the various approaches, the null hypothesis of unit root at the 1 per cent significance level is accepted. However, as the test-statistics of the unit root test in first difference are above the

Variable	GDP	BMD	SMD	INF	RIR
			Sample 1: G-20 Developed countries		
Case 1: Level data					
LLC	−0.80 (0.21)	3.35 (0.99)	2.77 (0.99)	−0.61 (0.27)	−0.51 (0.17)
ADF	10.3 (0.92	1.54 (1.00)	2.28 (1.00)	13.4 (0.77)	22.7 (0.22)
PP	17.8 (0.47)	0.23 (1.00)	1.89 (1.00)	15.4 (0.64)	31.79 (0.20)
Case 2: First differenced data					
LLC	−11.7* (0.00)	−4.27* (0.00)	−7.34* (0.00)	−11.1* (0.00)	−8.35* (0.00)
ADF	125.5* (0.00)	69.23* (0.00)	70.9* (0.00)	116.2* (0.00)	95.00* (0.00)
PP	174.9* (0.00)	69.57* (0.00)	104.4* (0.00)	164.9* (0.00)	141.7* (0.00)
			Sample 2: G-20 developing countries		
Case 1: Level data					
LLC	−0.122 (0.45)	1.55 (0.94)	1.57 (0.94)	−0.47 (0.30)	−0.11 (0.21)
ADF	2.267 (0.97)	3.73 (0.96)	2.04 (0.99)	13.76 (0.29)	13.01 (0.20)
PP	5.437 (0.86)	1.27 (0.94)	2.86 (0.98)	10.97 (0.36)	11.06 (0.23)
Case 2: First differenced data					
LLC	−31.1* (0.00)	−8.51* (0.00)	−5.90* (0.00)	−8.58* (0.00)	−12.92* (0.00)
ADF	77.51* (0.00)	50.59* (0.00)	47.8* (0.00)	71.75* (0.00)	76.86* (0.00)
PP	109.4* (0.00)	59.2* (0.00)	77.82* (0.00)	100.06* (0.00)	102.17* (0.00)
			Sample 3: All G-20 countries		
Case 1: Level data					
LLC	−0.692 (0.24)	3.676 (0.99)	3.177 (0.99)	−1.015 (0.20)	−0.95 (0.26)
ADF	13.6 (0.98)	5.267 (1.00)	4.323 (1.00)	37.17 (0.15)	35.71 (0.15)
PP	23.23 (0.72)	1.503 (1.00)	4.744 (1.00)	26.32 (0.55)	42.85 (0.20)
Case 2: First differenced data					
LLC	−31.64* (0.00)	−8.96* (0.00)	−9.426* (0.00)	−13.67* (0.00)	−15.09* (0.00)
ADF	202.9* (0.00)	119.8* (0.00)	118.7* (0.00)	187.9* (0.00)	171.9* (0.00)
PP	284.3* (0.00)	128.7* (0.00)	182.2* (0.00)	265.0* (0.00)	243.87* (0.00)

Notes: GDP: Per capita economic growth; BMD: Bond market development index; SMD: Stock market development index; INF: Inflation rate; and RIR: Real interest rate; LLC: Levin-Lin-Chu statistics; ADF: Augmented Dickey–Fuller statistics; PP: Phillips–Perron statistics; the null hypothesis is that the variable follows a unit root process; *indicates significance at the 1% level; methods used are based on Levin et al. (2002); Maddala and Wu (1999)
Source: Authors' calculations

Table V.
Results from panel unit root test

critical values for all the approaches, the null hypothesis of unit root at the 1 per cent significance level is rejected so that the variables are integrated of order one (see the results in Table V). These results reveal that there is the possibility of cointegration among per capita economic growth, bond market development, stock market development, inflation rate, and real interest rate.

We use a panel cointegration test to determine the long-run equilibrium relationship between *GDP, BMD, SMD, INF* and *RIR*. While several panel cointegration tests are available, this paper uses the Pedroni panel cointegration test (Pedroni, 1999) to determine the existence of cointegration among these five series. The null hypothesis of no cointegration is based on seven different test statistics (Pedroni, 2000), which includes four individual panel statistics [panel v-statistic, panel ρ-statistic, panel t-statistic (non-parametric), and panel t-statistic (parametric)] and three group statistics [group ρ-statistic, group t-statistic (non-parametric), and group t-statistic (parametric)]. Because these test statistics are described in advanced econometrics textbooks, we choose not to describe them here.

Table VI shows the results of the panel cointegration test. In nearly every case, the null hypothesis of no-cointegration is rejected by most of these test statistics at the 1 per cent level (see Table VI for the cases: the G-20 developed countries, the G-20 developing countries, and the G-20 countries in total, respectively). Remarkably, this is true in all three samples. Hence, this confirms the existence of a long-run equilibrium relationship between the variables in the three cases that we study. We will comment on the exact nature of the long-run relationships below.

The findings presented above support the final step in our investigation, which is using a VECM approach to examine the nature of causal relationships among the five sets of variables. The existence of I (1) stationarity and cointegration among the variables implies the possibility of Granger causality among them. Hence, we conduct a Granger causality test, using a VECM and using equations (2)-(6). The results are shown in Table VII. We report the panel-Granger causality test results for both the short run, through the significance of the F-statistic, and the long run, through the significance of the lagged *ECTs*. The tests were conducted for 1, 5 and 10 per cent significance levels. The results for the long- and short-run Granger causality tests are described below.

6.1 Long-run causality

From Table VII, it is evident that when ΔGDP serves as the dependent variable, the lagged error-correction term (ECT_{-1}) is statistically significant in all three samples at the conventional significance levels. This implies that *GDP* tends to converge to its long-run equilibrium path in response to changes in its regressors (*BMD*/*SMD*/*INF*/*RIR*). The significance of the ECT_{-1} coefficient in the ΔGDP equation in each of the three samples confirms the existence of a long-run equilibrium between real economic growth rate and its determinants, which are bond market development, stock market development, inflation rate, and the real rate of interest.

The estimated lagged *ECTs*, Samples 1-3, all carry negative signs, as expected. This implies that the change in the level of economic growth (ΔGDP) rapidly responds to any deviation in the long-run or short-run disequilibrium, for the t-1 period. In other words, the effect of an instantaneous shock to bond market development, stock market development, inflation rate and the real interest rate on economic growth will be completely adjusted in the long-run. However, the return to equilibrium occurs at different rates: 22 per cent in Sample 1, 13 per cent in Sample 2 and 50 per cent in Sample 3. The empirical results allow us to infer that if there is any deviation from the long-run equilibrium relationship between the

Test statistics	No. intercept and no trend	Deterministic intercept only	Deterministic intercept and trend
Sample 1: G-20 developed countries			
Panel *v*-Statistics	−0.81 (0.74)	−0.55 (0.74)	−1.50 (0.93)
Panel ρ- Statistics	−0.12 (0.25)	1.04 (0.85)	2.15 (0.98)
Panel PP- Statistics	−4.17* (0.00)	−5.03* (0.00)	−7.83* (0.00)
Panel ADF- Statistics	−234 (0.20)	−3.41 (0.00)	−2.14 (0.01)
Group ρ- Statistics	1.78 (0.67)	2.54 (0.99)	3.47 (0.99)
Group PP- Statistics	−7.08* (0.00)	−7.57* (0.00)	−11.2* (0.00)
Group ADF- Statistics	−2.98* (0.00)	−3.07 (0.00)	−1.88*** (0.10)
Inference: Cointegrated			
Sample 2: G-20 developing countries			
Panel v-Statistics	−0.67 (0.75)	−0.64 (0.74)	−1.34 (0.91)
Panel ρ- Statistics	−0.67 (0.25)	0.26 (0.60)	0.69 (0.76)
Panel PP- Statistics	−3.88* (0.00)	−2.25* (0.00)	−3.30* (0.00)
Panel ADF- Statistics	−2.84* (0.00)	−3.32* (0.00)	−2.51* (0.01)
Group ρ- Statistics	0.45 (0.67)	1.37 (0.91)	1.91 (0.97)
Group PP- Statistics	−5.81* (0.00)	−1.87** (0.03)	−2.23* (0.01)
Group ADF- Statistics	−2.22* (0.01)	−2.68* (0.00)	−0.91 (0.82)
Inference: Cointegrated			
Sample 3: All G-20 countries			
Panel v-Statistics	−1.07 (0.86)	−0.91 (0.82)	−2.10 (0.98)
Panel ρ- Statistics	−0.67 (0.25)	−0.83 (0.79)	1.87 (0.97)
Panel PP- Statistics	−5.90* (0.00)	−4.44* (0.00)	−6.37* (0.00)
Panel ADF- Statistics	−2.11* (0.01)	−1.42*** (0.07)	−0.54 (0.29)
Group ρ- Statistics	1.69 (0.96)	2.85 (0.99)	3.92 (0.99)
Group PP- Statistics	−9.15* (0.00)	−7.19* (0.00)	−10.3* (0.00)
Group ADF- Statistics	−3.17* (0.00)	−2.05** (0.05)	−2.28 (0.00)
Inference: Cointegrated			

Notes: Variables and regions shown above are defined in the text. Natural log forms are used in our estimation; the null hypothesis is that the variables are not cointegrated; figures in square brackets are probability levels indicating significance; *indicates significance at the 1% level; **indicates significance at the 5% level; and ***indicates significance at the 10% level; ADF: Augmented Dickey–Fuller statistics; PP: Phillips–Perron statistics; the other statistics are defined in Pedroni (1999, 2000)
Source: Authors' calculations

Table VI.
Results of Pedroni panel cointegration test

chosen economic variables, real economic growth is found to respond to correct this deviation.

From Table VII, when ΔINF serves as the dependent variable, the lagged error-correction term (ECT_{-1}) is also statistically significant in all three samples at the conventional significance levels. This implies that INF tends to converge to its long-run equilibrium path in response to changes in its regressors (*GDP*/*BMD*/*SMD*/*RIR*). The significance of the ECT_{-1} coefficient in the ΔINF equation in each of the three samples confirms the existence of a long-run equilibrium between inflation rate and their determinants, which are bond market development, stock market development, real economic growth rate and real rate of interest. In this case, the return to equilibrium occurs at different rates: 15 per cent in Sample 1, 88 per cent in Sample 2 and 66 per cent in Sample 3.

Table VII. Granger causality test results

Dependent variable	Independent variables ΔGDP	ΔBMD	ΔSMD	ΔINF	ΔRIR	Lagged ECT ECT_{-1}
Sample 1: G-20 developed countries						
ΔGDP	–	31.45* (0.00)	8.43* (0.00)	22.19* (0.00)	10.46* (0.00)	−0.15* (−5.79)
ΔBMD	3.831** (0.05)	–	6.03* (0.00)	4.74** (0.05)	3.69* (0.00)	−0.02* (−4.271)
ΔSMD	3.568** (0.05)	8.41* (0.00)	–	0.49 (0.00)	3.535** (0.00)	−0.04* (−4.189)
ΔINF	6.451** (0.00)	1.255 (0.74)	3.912** (0.00)	–	0.989 (0.80)	− 0.05* (−3.83)
ΔRIR	6.31** (0.00)	7.677* (0.00)	7.444* (0.00)	8.35* (0.00)	–	−0.002 (−0.23)
Sample 2: G-20 developing countries						
ΔGDP	–	8.123* (0.00)	5.967* (0.00)	3.872** (0.05)	4.866* (0.00)	−0.052* (−6.22)
ΔBMD	4.822** (0.05)	(0.00)	9.804* (0.00)	8.640* (0.90)	8.171* (0.00)	−0.016 (−1.783)
ΔSMD	3.799** (0.02)	2.169 (0.52)	–	1.251 (0.89)	1.874 (0.56)	−0.014 (−0.69)
ΔINF	16.56* (0.00)	10.53* (0.00)	36.7* (0.00)	–	9.634* (0.00)	−0.347* (−4.32)
ΔRIR	6.032* (0.10)	3.251** (0.10)	7.88* (0.00)	2.131 (0.78)	–	−0.003 (−0.012)
Sample 3: All G-20 countries						
ΔGDP	–	30.11* (0.00)	14.85* (0.00)	11.65* (0.00)	11.23* (0.00)	−0.50* (−4.356)
ΔBMD	12.9* (0.00)	–	14.22* (0.00)	2.272 (0.00)	7.68* (0.00)	−0.03 (−1.19)
ΔSMD	11.91* (0.00)	1.72 (0.00)	–	2.153 (0.00)	7.049* (0.00)	−0.15* (−3.12)
ΔINF	4.65** (0.00)	15.71* (0.00)	38.8* (0.00)	–	6.889* (0.00)	−0.07* (−4.2)
ΔRIR	5.24** (0.00)	11.8* (0.00)	13.62* (0.00)	12.61* (0.00)	–	−0.01 (−0.15)

Notes: GDP: Per capita economic growth; BMD: Bond market development index; SMD: Stock market development index; INF: Inflation rate; RIR: Real interest rate; and ECT_{-1}: lagged error-correction term; The study uses the Akaike information criterion (AIC) and Schwarz information criterion (SIC) to determine the optimum lag length. Like the standard information criteria, a smaller AIC (or SIC) indicates a better fit of the model to the data; values in square brackets indicate probabilities for *F* statistics, while those in parentheses are *t* statistics; *and **indicate that the parameter estimates are significant at the 1% and 5% levels, respectively

Source: Authors' calculations

The empirical results equally allow us to infer that if there is any deviation from the long-run equilibrium relationship between the chosen economic variables, then the rate of inflation is found to respond to correct this deviation.

Similarly, when $\Delta BMD/\Delta SMD$ serves as the dependent variables, the lagged error-correction term (ECT_{-1}) is statistically significant but only in the sample of the G-20 developed countries. In this case, we can infer that both *BMD* and *SMD* tend to converge to their long-run equilibrium path in response to changes in their regressors (*GDP*/*INF*/*RIR*). The significance of the ECT_{-1} coefficient in the $\Delta BMD/\Delta SMD$ equation in Sample 1 confirms the existence of a long-run equilibrium between bond market development (or stock market development) and its determinants, which are the other variables. In this case, the return to equilibrium occurs at different rates: 2 per cent and 3 per cent, respectively.

The lagged error-correction terms in the ΔRIR equations in Table VII are not statistically significant in any of the three samples. Hence, the real interest rate shows no evidence of correcting any deviations to the long-run equilibrium.

6.2 Short-run causality

In contrast to the fairly uniform long-run Granger causality results, our study reveals a divergent set of short-run causality results between the five variables. These results are summarized in Table VIII and are presented below.

6.2.1 Sample 1: G-20 developed countries. It shows the existence of bidirectional causality between bond market development and economic growth [*BMD <=> GDP*], stock market development and economic growth [*SMD <=> GDP*], inflation rate and economic growth [*INF <=> GDP*], real interest rate and economic growth [*RIR <=> GDP*], bond market development and stock market development [*BMD <=> SMD*], bond market development and real interest rate [*BMD <=> RIR*] and stock market development and real interest rate [*SMD <=> RIR*]. Additionally, we find unidirectional causality from the inflation rate to the bond market development [*INF => BMD]*, from stock market

Table VIII. The summary of short-run granger causality between bond market development, stock market development, economic growth, inflation rate, and real interest rate in the G-20 countries

Causal relationships tested in the model	Direction of relationships observed in the G-20 developed countries	Direction of relationships observed in the G-20 developing countries	Direction of relationships observed in the G-20 countries as a whole
BMD vs GDP	BMD <=> GDP	BMD <=> GDP	BMD <=> GDP
SMD vs GDP	SMD <=> GDP	SMD <=> GDP	SMD <=> GDP
INF vs GDP	INF <=> GDP	INF <= >GDP	INF <=> GDP
RIR vs GDP	RIR <=> GDP	RIR <=> GDP	RIR <=> GDP
SMD vs BMD	SMD <=> BMD	SMD => BMD	SMD => BMD
INF vs BMD	INF => BMD	INF <=> BMD	INF <= BMD
RIR vs BMD	RIR <=> BMD	RIR <=> BMD	RIR <=> BMD
INF vs SMD	INF <= SMD	INF <= SMD	INF <= SMD
RIR vs SMD	RIR <=> SMD	RIR <= SMD	RIR <=> SMD
RIR vs INF	RIR <= INF	RIR => INF	RIR <=> INF

Notes: GDP: Per capita economic growth; BMD: Bond market development index; SMD: Stock market development index; INF: Inflation rate; and RIR: Real interest rate; =>/<=: unidirectional causality; and <=>: Bidirectional causality
Source: Authors' tabulations

development to inflation rate [*INF* <= S*MD]*, and from the inflation rate to the real interest rate [*INF* => *RIR*].

6.2.2 Sample 2: G-20 developing countries. It shows the existence of bidirectional causality between the bond market development and the economic growth [*BMD* <=> *GDP*], stock market development and economic growth [*SMD* <=> *GDP*], inflation rate and economic growth [*INF* <=> *GDP*], real interest rate and economic growth [*RIR* <=> *GDP*], and bond market development and real interest rate [*BMD* <=> *RIR*]. Additionally, we find unidirectional causality from stock market development to bond market development [*BMD* <= *SMD*], from stock market development to real interest rate [*SMD* => *RIR*], from bond market development to inflation rate [*INF* <= *BMD]*, from stock market development to inflation rate [*INF* <= S*MD]* and from real interest rate to inflation rate [*INF* <= *RIR*].

6.2.3 Sample 3: all G-20 countries. It shows the existence of bidirectional causality between bond market development and economic growth [*BMD* <=> *GDP*], stock market development and economic growth [*SMD* <=> *GDP*], inflation rate and economic growth [*INF* <=> *GDP*], real interest rate and economic growth [*RIR* <=> *GDP*], bond market development and real interest rate [*BMD* <=> *RIR*], stock market development and real interest rate [*SMD* <=> *RIR*] and real interest rate and inflation rate [*INF* <=> *RIR].* Moreover, we find unidirectional causality from stock market development to bond market development [*BMD* <= *SMD*], from bond market development to inflation rate [*INF* <= *BMD*], and from stock market development to inflation rate [*INF* <= *SMD*].

6.3 Innovation accounting

Finally, we use innovation accounting to assess the nature of responses to perturbations of the different variables in the system of equations. Towards this end, we use generalized impulse response functions (*GIRFs*). The use of *GIRFs* is to trace the effect of a one-off shock to one of the innovations on the current and future values of the endogenous variables. The key consequence of the *GIRFs* is that the responses are invariant to any re-ordering of the variables in the VECM and, as orthogonality is not imposed, it allows for meaningful interpretation of the initial impact response of each variable to shocks in any other variables.

Figures 2, 3 and 4 show the *GIRFs* of the three panel VAR[11] models pertaining to our Samples 1-3. Our discussion of the impulse response functions centers on the responses of economic growth, bond market development, stock market development, inflation rate and real interest rate to their own and other shocks. In particular, the *GIRFs* indicate how long and to what extent bond market development, stock market development, and the other two macroeconomic determinants react to changes in the economic growth in the panel of the G-20 countries.

The significance of the impulse response is largely determined using confidence bands. Figures 2-4 display the *GIRFs* of the five vector error correction models. The shaded area in these figures represents the confidence bands. When the horizontal curves in the *GIRFs* fall between the confidence bands, the impulse responses are statistically significant. In other words, the null hypothesis of "no effects of a particular shock" on the specific variable cannot be rejected. Our discussion of the impulse response functions mainly centers on the responses of economic growth, bond market development, stock market development, inflation rate and real interest rate to their own and other shocks. For comparative analysis, we report the *GIRFs* to one-standard-error confidence bands (roughly equal to 95 per cent confidence bands) and the responses are very similar to those which we obtained using Cholesky one standard innovation.

In sum, Figure 2 shows the responses of all the variables to a one standard deviation shock in other variables. In each case, the stock market activity variable is found to display

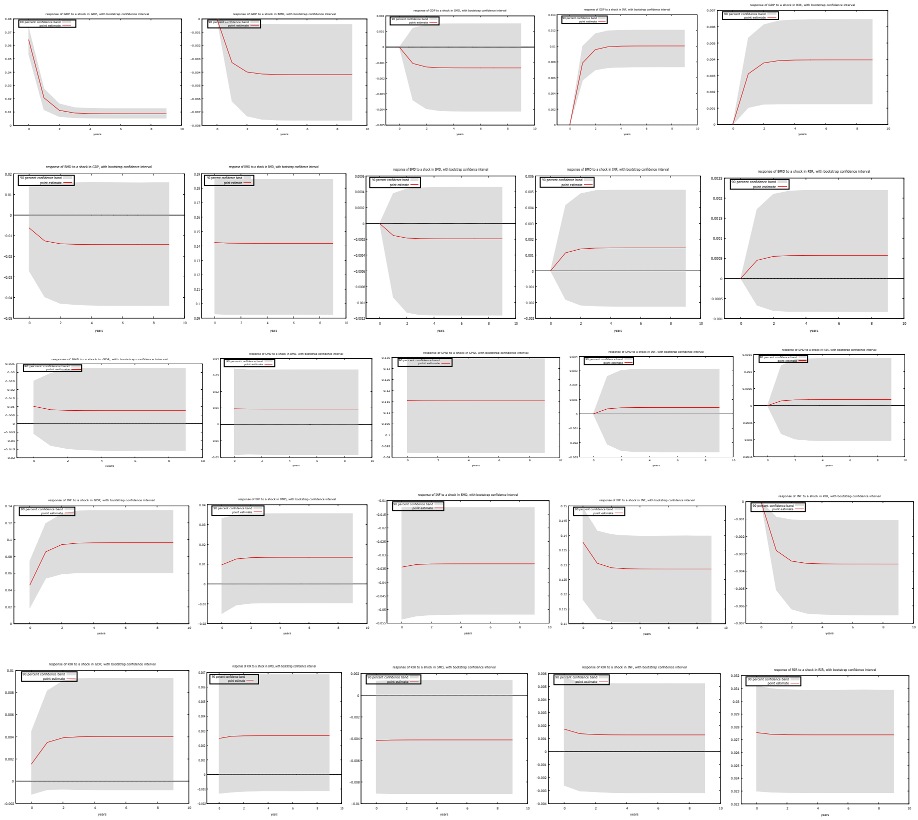
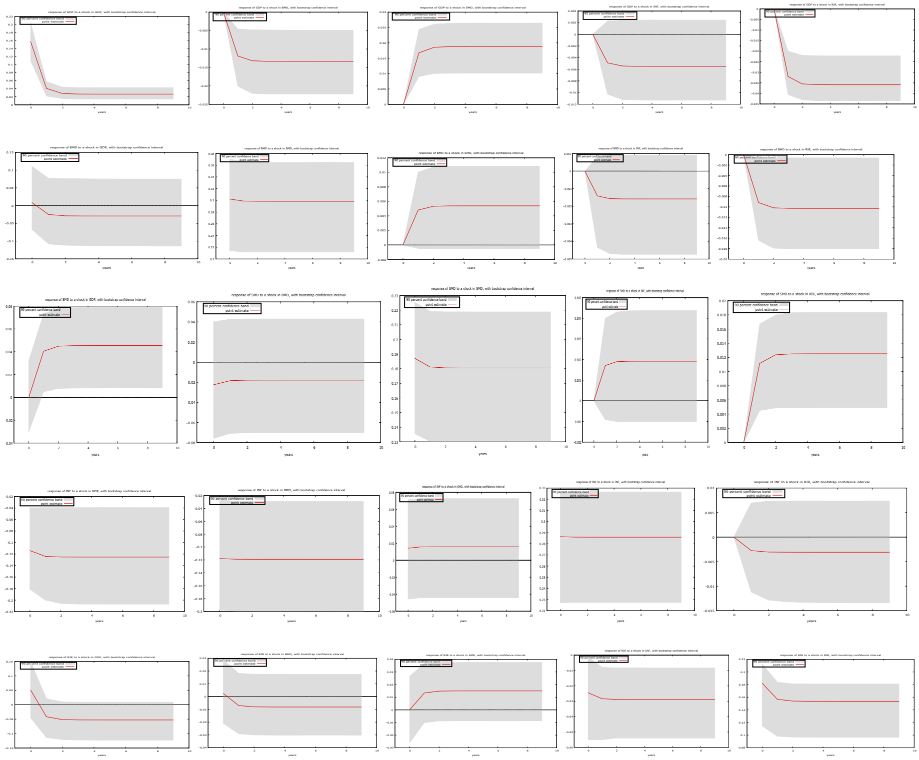


Figure 2.
Plot of generalized impulse response functions for the G-20 developed countries (Sample 1)

Notes: GDP: Per capita economic growth rate; BMD: Composite index of bond market development; SMD: Composite index of stock market development; INF: Inflation rate; RIR: Real interest rate
Source: Authors' calculation

an initial cyclical response to an exogenous shock, albeit in varying degrees. However, the responses of all of the variables to exogenous shocks stabilize in around five years. In Figures 3 and 4, the responses of all variables to an exogenous shock are found to be highly similar, thereby signifying that for the three different measures of stock market depth, the responses of variables are no different.

Some other features of these results, though not reported, deserve mention. First, we performed diagnostic checks in our three panel *VAR* models using our three samples. These included the autocorrelation Lagrange multiplier (LM) test, the normality test, and the White heteroskedasticity test. Second, we conducted a sensitivity analysis by using individual bond market indicators (*PUB*, *PRB* and *INB*) instead, keeping other variables the same. There was no substantial change in our earlier findings.



Notes: GDP: Per capita economic growth rate; BMD: Composite index of bond market development; SMD: Composite index of stock market development; INF: Inflation rate; RIR: Real interest rate
Source: Authors' calculation

Figure 3.
Plot of generalized impulse response functions for the G-20 developing countries (Sample 2)

7. Conclusion and policy implications

In this paper, we have examined the Granger causal relationships between bond market development, stock market development and economic growth in the presence of two additional macroeconomic covariates: inflation rate and real interest rate. Using panel data of the G-20 countries from 1991 to 2016, we found that both bond market development and stock market development are cointegrated with economic growth, inflation rate, and real interest rate. The panel Granger causality test further confirms that, among other things, bond market development, stock market development, economic growth, inflation rate, and real interest rate Granger cause economic growth in the long run. However, our short-run Granger causality results revealed a wide range of short-run adjustment dynamics between these five variables, including the possibility of feedback between them in several instances.

These results demonstrate that studies on economic growth that do not consider bond market development, stock market development, inflation rate, and real interest rate will offer potentially biased results. The partial findings would not only suffer the downside consequences of a missing-variable bias but would also distort and mislead policymakers. If

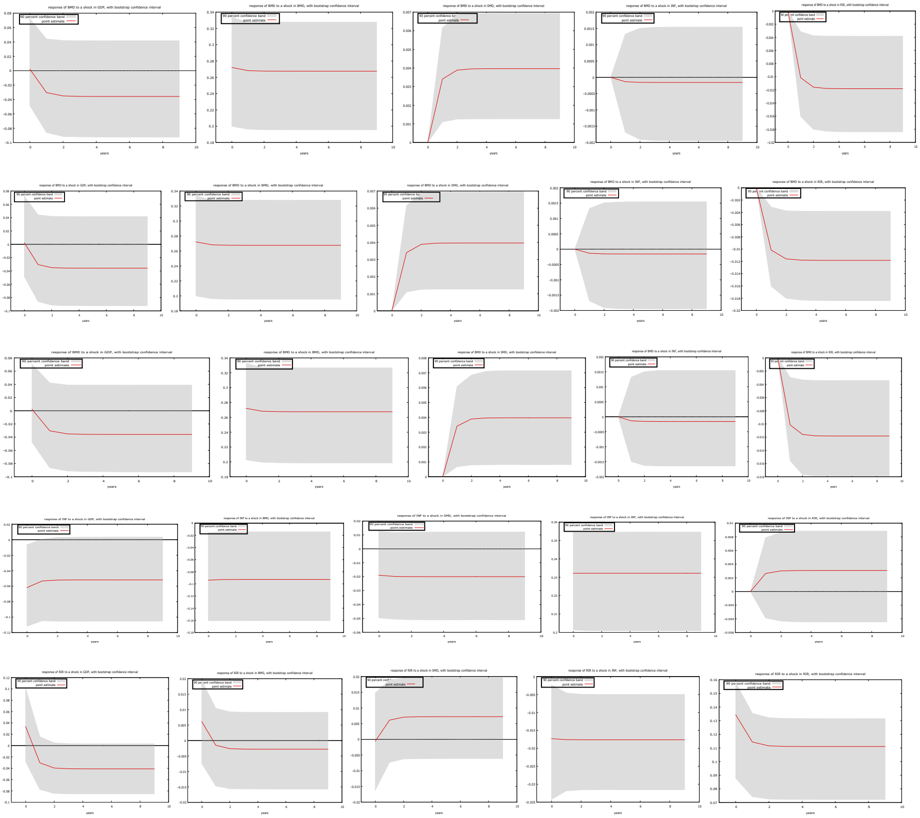


Figure 4.
Plot of generalized impulse response functions for the G-20 countries combined (Sample 3)

Notes: GDP: Per capita economic growth rate; BMD: Composite index of bond market development; SMD: Composite index of stock market development; INF: Inflation rate; RIR: Real interest rate
Source: Authors' calculation

policymakers intend to stimulate economic growth, then they should consider the *co-development* of financial markets, meaning fostering simultaneous development in both the bond market and the stock market. Clearly, the bond market and stock market development are drivers of economic growth; both developments complement each other and positively impact on macroeconomic stability.

In sum, by establishing the linkages between bond market development, stock market development, economic growth and other macroeconomic covariates, we show that the G-20 countries wishing to sustain economic growth, in the long run, should focus attention on developing their financial markets as well as maintaining macroeconomic stability in terms of interest rate and inflation rate. Moreover, the governments of these countries should strive to develop their economies, which will, in turn, lead to an improved bond market, stock market and further macroeconomic stability. These measures will have a virtuous influence on the overall development of financial markets and overall economic development of the country in general.

Notes

1. Financial development means the factors, policies and institutions that lead to effective financial intermediation and markets, as well as deep and broad access to capital and financial services (IMF, 2005).
2. Although different economists assign different degrees of importance to financial development, its contribution in economic growth can be theoretically postulated and has been supported by considerable empirical evidence (Law and Singh, 2014; Menyah *et al.*, 2014; Ngare *et al.*, 2014; Herwartz and Walle, 2014; Samargandi *et al.*, 2014; Pradhan *et al.*, 2013a).
3. Bond market development represents the intensity of public, private and international bond markets. The research on this area remains limited in comparison with banks and stock markets (see, for instance, Mu *et al.*, 2013; Sharma, 2001).
4. A Granger causality test reports on both short- and long-run effects and hence is of special interest to policymakers (Marques *et al.*, 2013).
5. Financial development includes both bond and stock market developments in our paper but is taken differently in most papers to include development in the stock market, the bond market or even the banking sector.
6. In the standard finance literature, both bond markets and stock markets developments are usually well interconnected with near-concomitant changes in the interest rate and inflation rate (Lee and Hsieh, 2014; Rahman and Mustafa, 1997).
7. The G-20 consists of 19 member countries plus the European Union (EU), which is represented by the President of the European Council and by the European Central Bank. Thus, although we look at the G-20, within this group of important industrialized and developing economies, we observe only 19 member nations, which are used for our analysis. The inclusion of the EU, the twentieth member, would have meant double-counting France, Germany, Italy and the UK.
8. The data were obtained from the *World Development Indicators* and *Financial Development and Structure Dataset*, both published by the World Bank. The period of our study is chosen based on data availability.
9. The estimation of *VECM* follows the structure of Holtz-Eakin *et al.* (1988) and Arellano and Bond (1991).
10. The estimation of VECM follows the procedures set out in Holtz-Eakin *et al.* (1988) and Arellano and Bond (1991).
11. VAR denotes vector autoregressive.

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Appendix 1. Profile of the G-20 economies

	Macroeconomic variables							
Countries	POP	INC (PPP)	INC (Nominal)	PINC (PPP)	PINC (Nominal)	TT	HDI	Type of country
Argentina	4.36	874.1	545.1	20047	12503	142.4	0.827	Developing
Australia	2.43	1187.3	1259.0	48899	51850	496.7	0.939	Developed
Brazil	20.6	3141.3	1798.6	15242	8727	484.6	0.754	Developing
Canada	3.62	1682.4	1529.2	46437	42210	947.2	0.920	Developed
China	138.3	21291.8	11218.3	15399	8113	4201.0	0.738	Developing
France	6.46	2733.7	2463.2	42314	38128	1212.3	0.897	Developed
Germany	8.27	3980.3	3466.6	48111	41902	2866.6	0.926	Developed
India	130.9	8662.4	2256.4	6616	1723	850.6	0.624	Developing
Indonesia	25.9	3032.1	932.4	11720	3604	346.1	0.689	Developing
Italy	6.07	2234.5	1850.7	36833	30507	948.6	0.887	Developed
Japan	12.7	5237.8	4938.6	41275	38917	1522.4	0.903	Developed
South Korea	5.12	1934.0	1411.2	37740	27539	1170.9	0.901	Developed
Mexico	12.2	2315.7	1046.0	18938	8555	813.5	0.762	Developing
Russian Federation	14.3	3799.7	1280.7	26490	8929	844.2	0.804	Developing
Saudi Arabia	3.17	1750.9	639.6	55158	20150	521.6	0.847	Developing
South Africa	5.59	739.4	294.1	13225	5261	200.1	0.666	Developing
Turkey	7.98	1988.3	857.4	24912	10743	417.0	0.767	Developing
UK	6.56	2785.6	2629.2	42481	40096	1189.4	0.909	Developed
USA	32.3	18569.1	18569.1	57436	57436	3944.0	0.920	Developed
European Union	50.9	20008.1	16408.4	39317	32244	4485.0	0.876	–

Notes: POP is population; INC is gross domestic product; PINC is per capita gross domestic product; PPP is purchasing power parity; TT is total trade; and HDI is human development index; POP figures are in tens of millions; HDI figure is in number; and other figures are in billions of US dollars; The G-20 "developing countries" may also be termed "emerging countries"
Source: *World Development Indicators*, the World Bank. All figures are for 2016, except for TT, which is for 2014

Table AI. The macroeconomic profile of the G-20 economies

Appendix 2. Principal component analysis

Table AII. Summary of PCA-related information for composite index of bond market development

PCs	Eigen value	Proportion	Cumulative
Part one: Eigen analysis of correlation matrix			
1	1.5327	0.5109	0.5109
2	0.9496	0.3165	0.8274
3	0.5177	0.1726	1.0000
Part two: Eigen vectors (component loadings)			
Variables	PC1	PC2	PC3
PUB	0.669	0.256	0.698
PRB	0.681	0.167	−0.713
INB	0.299	−0.952	0.063

Notes: PCs denote principal components; variables are defined in Table II; *PUB* is public sector bonds, *PRB* is private sector bonds and *INB* is international bonds

Table AIII. Summary of PCA-related information for composite index of stock market development

PCs	Eigen Value	Proportion	Cumulative
Part one: Eigen analysis of correlation matrix			
1	5.5684	0.6075	0.6075
2	1.2150	0.3334	0.9409
3	0.1287	0.0591	1.0000
Part two: Eigen vectors (component loadings)			
Variables	PC1	PC2	PC3
MAC	0.187	0.786	0.589
TRA	0.590	0.389	0.707
TUR	0.785	0.480	0.392

Notes: PCs denote principal components; variables are defined in Table II; *MAC* is market capitalization, *TRA* is traded stocks and *TUR* is turnover ratio
Source: Authors' calculation

The principal component analysis (*PCA*) transforms the data into new variables (i.e. the principal components: *PCs*) that are not correlated. It is a special case of the more general method of factor analysis. The approach entails several steps: construction of a data matrix, creation of standardized variables, calculation of a correlation matrix, determination of eigen values (to rank principal components) and eigenvectors, selection of *PCs* (based on stopping rules), and interpretation of the results (Hosseini and Kaneko, 2011). The aim is to construct, from a set of variables X_j's ($j = 1, 2, \ldots$, n), new variables (P_i) called "principal components," which are linear combinations of the X's. This can be presented like this:

$$\begin{aligned} P_1 &= a_{11}X_1 + \ldots \ldots \ldots \ldots + a_{1n}{}^{1n}X_n \\ &\vdots \\ P_m &= a_{m1}X_1 + \ldots\ldots\ldots + a_{mn}X_n \end{aligned} \quad (2.1)$$

where $P = [P_1, P_2, \ldots, P_m]$ are principal components; $A = [a_{ij}]$ for $i = (1, 2, \ldots, m)$; and $j = (1, 2, \ldots, n)$ are component loadings; and $X = [X_1, X_2, \ldots, X_n]$ are original variables. The component loadings are the weights showing the variance contribution of principal components to variables. Because the principal components are selected orthogonal to each other, a_{ij} weights are proportional to the correlation coefficients between the variables and the principal components.

The first principal component (P_1) is determined as the linear combination of $X_1, X_2, \ldots, X_n$ provided that the variance contribution is at a maximum. The second principal component (P_2), independent from the first principal component, is determined to provide a maximum contribution to the total variance remaining after the variance that is explained by the first principal component. Analogously, the third and the other principal components are determined to provide the maximum contribution to the remaining variance and are independent of each other. The aim here is to determine a_{ij} coefficients providing the linear combinations of variables based on the specified conditions.

It is important to note that the method of principal components could be applied by using the original values of the X_j's, by their deviations from their means, or by the standardized variables. This study adopts the latter procedure, as it is assumed to be more general and can be applied to variables measured in different units. It is important to note that the values of the principal components will be different depending on the way in which the variables are used (original values, deviations, or standardized values). The coefficients *a*'s, called loadings, are chosen in such a way that the constructed principal components satisfy two conditions:

(1) Principal components are uncorrelated (orthogonal).

(2) The first principal component P_1 absorbs and accounts for the maximum possible proportion of total variation in the set of all *X*'s.

Furthermore, the principal component absorbs the maximum of the remaining variation in the *X*'s (after allowing for the variation accounted for by the first principal component) and so on. There are different rules to define a high magnitude, known as stopping rules. Here, "variance-explained" criteria are implemented, based on the rule of keeping enough principal components to account for 90 per cent of the variation (Pradhan *et al.*, 2014a, 2014b, 2014c).

The following equation is used to construct *BMD* and *SMD*, our composite indices for bond markets development and stock markets development:

$$BMD = \sum_{i=1}^{3} a_{ij} \frac{X_{ij}}{Sd(X_i)} \tag{2.2}$$

where *BMD* is our composite index of bond markets development, *Sd* is standard deviation, X_{ij} is *i*th variable in the *j*th year; and a_{ij} is factor load as derived by *PCA*. Similarly, a composite index for stock markets development (*SMD*) is calculated. However, as is clear from the text, the indicators for *BMD* and *SMD* are completely different (see Table II for definitions).

The variables included in the construction of *BMD* are public sector bonds, private sector bonds and international bonds. On the contrary, the variables included in the construction of *SMD* are market capitalization, traded stocks, and turnover ratio. Tables AII and AIII present the statistical values from the principal component analysis for *BMD* and *SMD*, respectively.