Banking sector development and economic growth developing countries: A bootstrap panel Granger causality analysis

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Abstract The purpose of this paper is to revisit the Granger causal relationship between banking sector development and economic growth for forty developing countries in the period 1970-2012. In order to capture the different aspects of banking sector development, we develop two banking sector development indices and apply the panel bootstrapped approach to Granger causality testing approach properly taking into account cross-sectional dependence and heterogeneity issues. The empirical results show limited support for the supply-leading, demand-following and complementarity hypotheses. Our results also provide evidence as the causal relationship between banking sector development and economic growth exists in twenty five countries.

Keywords Economic growth . Banking sector development . Cross-sectional dependency . Slope heterogeneity . Granger causality Bootstrap

JEL Classification O43 . C22 . C23

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1 Introduction

The banking sector is an integral part of the economy. Hence this sector plays a key role in the wellbeing of the economy. A weak banking sector not only jeopardizes the long-term sustainability of an economy, it can also be a trigger for a financial crisis which can lead to economic crises. The role of banks in an economy has received attention since the 18th century (e.g. Smith, 1776; Bagehot, 1873 and Schumpeter, 1911 and 1934). Generally, the relationship between financial development and economic growth has been widely discussed in the literature since the seminal work Schumpeter (1911). Many studies (King and Levine, 1993a, b; Thornton, 1994; Gregorio and Guidotti, 1995; Berthelemy and Varoudakis, 1996; Greenwood and Bruce, 1997; Greenwood and Smith, 1997; Blackburn and Hung, 1998; Rajan and Zingales, 1998; Beck *et al*. 2000; Kirkpatrick, 2000; Fase and Abma, 2003; Beck and Levine, 2004; Craigwell and *al*. 2001; Ang, 2008a; Fung 2009; Kar *et al*. 2011; Murinde, 2012; Pradhan, 2013; Hsueh *et al*. 2013; Herwartz and Walle, 2014; Uddin *et al*. 2014; Menyah *et al*. 2014) examined the link between financial sector development and economic growth using a number of econometric techniques, such as cross-sectional, time series, panel data, firm level , industry-level and country-level.

The existing literature offers a wide range of perspectives and insights into the issue of the growth – finance nexus, which, however, sometimes report contradicting results. Bagehot (1873) and Hicks (1969) argued that financial system played a critical role in igniting industrialization in England by facilitating the mobilization of capital for "immense works". Schumpeter (1934) emphasized the importance of the banking system in economic growth and highlighted circumstances when banks can actively spur innovation and future growth by identifying and funding productive investments. With the contributions of McKinnon (1973) and Shaw (1973), the relationship between financial development and economic growth has been an important issue of debate, and during the last thirty years this relationship has been extensively studied. Recent empirical studies, however, offers contradictory evidence (Kaminsky and Reinhart, 1999; Deidda and Fattouh, 2002; Khan and Senhadji, 2003; Wachtel, 2003; Favara, 2003; Rousseau and Wachtel, 2011; Arcand *et al*. 2012; Al-Malkawi *et al*. 2012).

In response to the above focus on finance-growth nexus, this paper examines the nexus in the developing countries. In those countries, banks are the most important financial intermediaries and play an important role in bridging savings and investments. According to the results presented in the existing literature, the direction of causality between banking sector development and economic growth still remains divisive. Three different hypotheses have been proposed.

The first view is that banking sector development is supply-leading, in the banking sector development sense that it fosters economic growth by acting as a productive input. This view pioneered by Schumpeter (1911) and confirmed by notable studies such as Thornton (1994), Calderon and Liu (2003), Naceur and Ghazouani (2007) , Ang (2008b), Abu-Bader and Abu-Qarn (2008), Jalil *et al*. (2010), Wu *et al*. (2010), Kar *et al*. (2011), Chaiechi (2012), Bojanic (2012), Hsueh *et al*. (2013) and Menyah *et al*. (2014). The second view is demand-following supported by studies such as Liang and Teng (2006), Ang and McKibbin (2007), Odhiambo (2008), Colombage (2009), Odhiambo (2010), Kar *et al*. (2011), Pradhan *et al*. (2013) which argues that growth leads to banking sector development. The third view is one of the bidirectional causalities. Accordingly, there is a mutual or two-way causal relationship between banking sector development and economic growth. Studies such as those of Ahmed and Ansari (1998), Craigwell *et al*. (2001) Dritsakis and Adamopoulos (2004), Wolde-Rufael (2009), Chow and Fung (2013), Pradhan *et al*. (2013), Pradhan *et al*. (2014).

Consequently, the current verdict on the relationship between banking sector development and economic growth and their causality has remained inconclusive. However, the discussion focuses on measures of banking sector development, which must move literature because most authors only analyze an approach that from the outputs and the same database published by the International Monetary Fund (IMF) and the World Bank. Accordingly, it is logical to find almost the same results. In addition, what might be an adequate banking system at one time or in one social, institutional and economic environment may be outright detrimental at another time or in other environments. In other words, there may be various structural shifts or breaks which further complicate identification of causal relationships.

Conversely to the traditional analysis of the finance-growth relationship, Graff (2001, 2002, and 2005) proposed an alternative approach to the traditional work, to assess the level of banking sector development, for the banking sector Inputs and its impact on economic performance. This new approach is based on Graff resources available for development of the banking system and can be summarized in three indicators: the share of manpower employed in the banking system, the banking system's share in gross domestic product (GDP) and the number of banks and branches per capita.

The economic historians are able to give convincing examples for all possibilities of all causality outlined above. There is, obviously, the need for further research. The paper contributes to the existing literature in four important aspects. First to the best of our knowledge, this is the first study that uses a tow indices of banking sector development refer to the Inputs and Outputs of the banking system. Second, The sample adopted for the dataset is wider than other contributions based on the panel approach and includes forty developing countries[1] from 1970-2012. Third, this study is the first researches used a bootstrap panel Granger causality test to investigate the causal relationship between banking sector development and economic growth. This allows testing for Granger causality on each individual panel member separately by taking into account the possible contemporaneous correlation across countries (Kònya, 2006; Chang *et al*. 2013; Menyah *et al*. 2014). Fourth, we take into consideration cross sectional dependence and country-specific heterogeneity across the forty countries. We hope that this study can bridge the gap in the current literature between banking sector development and economic growth.

The remainder of this paper is structured as follows: Section 2 describes the data and the construction of banking sector development indices used in the empirical analysis. Section 3 presents a brief discussion of the cross-sectional dependence test, the slope heterogeneity test and the bootstrap panel Granger causality test proposed by Kónya (2006). Results are discussed in Section 4. Finally, Section 5 presents the conclusions that we draw from this research.

[1] Developing countries are defined according to their Gross National Income (GNI) per capita per year. Countries with a GNI of US$ 11,905 and less are defined as developing (specified by the World Bank, 2013).

2 Data and the construction of banking sector development indices

We use annual data over the period 1970 to 2012 for forty developing countries. Economic growth is proxied by real GDP per capita. The sample excluding countries that are very small (less than one million), countries with centrally planned economies[2] during the period 1970-2012, countries where oil exports constituted over 20% of GDP in 1995, and countries with civil wars claiming a death toll exceeding 2.5% of the total population during 1970-2012.The exclusion of these countries in the sample is justified by the fact that it is unreasonable to run regressions across countries that are fundamentally different from the usual conditions (Harberger, 1998).

One of the most important issues in assessing the relationship between banking sector development and economic growth is how to obtain a satisfactory empirical measure of banking sector development. An increase in financial instruments and the foundation of these instruments more commonly available in a country is defined as banking sector development. Various measures have been used in the literature to proxy for the "level of banking sector development". The existing literature for the measurement of banking sector development (**BSD**) comprises two different categories. The first category is traditionally based on Outputs on the banking sector. Gregorio and Guidotti (1995), Levine and Zervos (1998), Rousseau and Wachtel (1998), Beck and Levine (2004), Liang and Teng (2006), Naceur and Ghazouani (2007), Abu-Bader and Abu-Qarn (2008), Gries *et al*. (2009), Banos *et al*. (2011), Pradhan *et al*. (2013) discuss different indicators Outputs of banking sector development capturing the size, activity and efficiency of the banking sector. The second category based on Inputs on the banking sector. Graff (2001, 2002 and 2005) a proposing new set of proxies for banking sector development based on the Inputs of the banking system. The construction of the new variable for banking sector development is motivated by the interest in obtaining a reasonably reliable and comparable quantification of the proportion of societal resources devoted to the banking system.

Ang and McKibbin (2007) explains that there is no broad consensus among economists as to which of the proxies of financial development is the best measurement and more so these proxies are highly correlated. Therefore, it is really difficult to have a single measure of financial development that could highlight all the aspects of the financial system (Huang, 2011). The use of principal component analysis (PCA) for the aggregate index of financial development is gaining popularity in growth finance literature to construct a summary index of financial development and other dimensions of financial systems (Ang and McKibbin, 2007; Gries *et al*. 2009; Huang, 2011).

We use the composite indicators for both Outputs and Inputs[3] by using the banking sector indicators above and through PCA. The first component of our index of Outputs banking sector development is Broad money supply: Broad money supply, expressed as a percentage of GDP, is the sum of currency outside banks; demand and term deposits, including foreign currency deposits of resident sectors (other than the central bank); certificates of deposit and commercial paper. The second component is Domestic credit provided by the banking sector: It includes all credit to various sectors on a gross basis, with the exception of credit to the central government. It is expressed as a percentage of gross domestic products. Finally, the third component of our aggregate summary index is Domestic credit to the private sector: This credit, expressed as a percentage of GDP, refers to financial

[2] Centrally planned economies were characterized by the dominance of large enterprises, while SMEs hardly existed.
[3] For details and sources, see the appendix.

resources provided to the private sector, such as through loans, purchases of non-equity securities, trade credits and other accounts receivable that establish a claim for payment. The data are abstracted and transformed from World Development Indicators, published by the World Bank and we use the natural log of these variables in our estimation.

Based on Graff (2001, 2002 and 2005) studies, we employ three indicators to construct the second Input index of banking sector development are discussed below.

The banking system's share in GDP, that is to say, the factor incomes generated in the banking sector, is probably the best indicator. More specifically, the share of the banking system in GDP consists of wages and the labor markets are characterized by the optimality of wages fixed by the market. This is based on equality between wages and marginal productivity of labor. The sector's share is valued at conditions that are very close to what most economists consider appropriate. Following this line of reasoning, the only flaw is to point to the observation that in the real world factor markets are frequently far from resulting in market clearing prices, so that some reservation is called for.

The second indicator is the number of banks and branches per capita, which gives an idea about the degree to which a country's population has access to financial services. Obviously, the validity of this indicator is weakened by differences in the dispersion of a country's population over its territory. In addition to this, technical progress and financial innovations, such as, telephone and Internet banking have made the accessibility of a bank office obsolete for many financial interactions and services. Thus, although this measure indicates a decline in banking sector development in most developed countries in recent years is the result of innovations in the banking sector and thus a sign of progress rather than a decline.

Finally, we refer to the share of manpower employed in the banking system. This measure is questionable because it ignores the productivity levels of those working in the banking system. To address this problem, we suggest a weighting of raw numbers of employees with an internationally comparable labour productivity proxy, mean years of schooling of the population aged 25-65 years (Barro and Lee, 1996), which results in an indicator for 'effective' rather than 'raw' labour. For a first picture, this correction, albeit imperfect, should, at least to some degree, improve the validity of our manpower indicator.

Table 1 presents the results of principal component analysis with the three Outputs and three Inputs measures of **BSD** listed above.

The eigenvalue associated with the first component is significantly larger than one of the two sets of **BSD** indicators (Outputs and Inputs). The first principal component explains approximately 89.2% and 83 % of the standardized variance (a total of 70% of variance explained is generally considered acceptable); the second principal component explains another 8.5% and 13 %, and the last principal component accounts for only 1.3% and 3.9% of the variation (respectively for Outputs and Inputs banking sector development indicators). Clearly, the first principal component is the best two indices of **BSD** in this case. Below, we denote these summary indices of **BSD** as **OBS** for Outputs and **IBS** for Inputs.

Table 1 Banking sector development indices analysis

Outputs Banking Sector (OBS) Development Indicators				
Component	Eigenvalues	Difference	Proportion	Cumulative
Comp 1	2.677	2.392	0.892	0.892
Comp 2	0.285	0.247	0.095	0.987
Comp 3	0.038		0.013	1.000
Inputs Banking Sector (IBS) Indicators				
Component	Eigenvalues	Difference	Proportion	Cumulative
Comp 1	2.489	2,096	0.830	0.830
Comp 2	0.393	0.275	0.131	0.961
Comp 3	0.118		0.039	1.000

3 Econometric Methodology

The empirical analysis in this paper is carried out in two steps. First, as a prerequisite to our Granger causality tests, we carry out tests for cross-section dependence and slope homogeneity. In the second step, based on the results from preliminary analysis, we apply a panel causality test that takes into consideration the issues of cross-section dependence and slope homogeneity (Kònya, 2006). A brief account of the econometric models used is presented below.

Recent advances in panel causality analysis have brought to the fore two basic econometric issues that cannot be ignored in under taking panel Granger causality tests. The first concerns the issue of cross-dependence and the second concerns the issue of heterogeneity across countries. The recent world economic situation has shown that turbulence in a country can easily be transmitted to other countries through international trade and economic and financial integration (Nazilioglu *et al*. 2011). As pointed out by Pesaran (2006) ignoring cross-section dependency leads to substantial bias and size distortions implying that testing for the cross-section dependence is a crucial step in a panel data analysis (Nazilioglu *et al*. 2011; Chu and Chang, 2012; Boubtane *et al*. 2013; Chang *et al*. 2013).

3.1 Cross-section dependence tests

The first step in analyzing panel data Granger causality is testing for cross-sectional dependence. Following Kónya (2006); Kar *et al*. (2011); Boubtane *et al*. (2013); Chang *et al*. (2013) we employ four different cross-sectional dependence test statistics. The first is the Lagrange Multiplier (LM) test developed by Breusch and Pagan (1980) which requires the estimation of the following panel data model:

$$\ln y_{i,t} = \alpha_i + \beta_i \ln x_{i,t} + \varepsilon_{i,t} \qquad for \quad i = 1,2,\ldots\ldots\ldots\ldots, N; t = 1,2,\ldots\ldots\ldots\ldots\ldots\ldots, T \qquad (1)$$

In Eq. (1), $y_{i,t}$ is real GDP per capita, i is the cross-sectional dimension, t is the time dimension, $x_{i,t}$ Is $k \times 1$ vector of explanatory variables (**OBS** or **IBS**), α_i and β_i are the individual intercepts and slope coefficients that are allowed to differ across states. The null hypothesis of no-cross sectional dependence, $H_0 : Cov(\varepsilon_{i,t}, \varepsilon_{j,t}) = 0$, for all t and $i \neq j$ is tested against the alternative hypothesis of cross-sectional dependence, $H_0 : Cov(\varepsilon_{i,t}, \varepsilon_{j,t}) \neq 0$, for at least one pair of $i \neq j$. For testing the null hypothesis, Breusch and Pagan (1980) developed the following LM test:

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \tag{2}$$

In Eq. (2) $\hat{\rho}_{ij}^2$ is the sample estimate of the pair-wise correlation of the residuals from individual ordinary least squares (OLS) estimation of the Eq. (1) for each i. Under the null hypothesis of no cross-sectional dependency with a fixed N (number of cross-sections) and time period $T \to \infty$, the statistic has a chi-square asymptotic distribution with $N(N-1)/2$ degrees of freedom (Greene, 2003, p.350). It is important to note that the LM test is applicable with N relatively small and T sufficiently large. To overcome this problem, Pesaran (2004) proposed the following LM statistic for the cross-section dependency test (the so-called CD_{LM} test)

$$CD_{LM} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T\hat{\rho}_{ij}^2 - 1) \tag{3}$$

Under the null hypothesis of no cross-sectional dependence with $T \to \infty$ and**,** this test statistic has the standard normal distribution. Though CD_{LM} is applicable even for N and T large, it is likely to exhibit substantial size distortions when N is large relative to T. The shortcomings of the LM and the CD_{LM} tests clearly show a need for a cross-sectional dependency test that can be applied with large N and small T. In that respect, Pesaran (2004) proposed the following test for cross-sectional dependence CD:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \tag{4}$$

However, the CD test will lack power in certain situations where the population average pair-wise correlations are zero, but the underlying individual population pair-wise correlations are non-zero (Pesaran *et al*. 2008, p. 106). Furthermore, when the mean of the factor loadings is zero in the cross-sectional dimension, the CD test can not reject the null hypothesis in stationary dynamic (Sarafidis and Robertson, 2009). To address these problems, Pesaran *et al*. (2008) proposes a bias-adjusted test which is a modified version of the LM test that uses the exact mean and variance of the LM statistic. The bias-adjusted LM test is as follows:

$$LM_{adj} = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \frac{(T-K)\hat{\rho}_{ij}^2 - \mu_{Tij}}{\sqrt{v_{Tij}^2}} \tag{5}$$

Where μ_{Tij} and v_{Tij}^2 are respectively the exact mean and variance of $(T-k)\rho_{ij}^2$ provided in Pesaran *et al*. (2008, p.108). Pesaran *et al*. (2008) showed that under the null hypothesis of no cross-sectional dependence with $T \to \infty$ first followed by $N \to \infty$, the statistics LM_{adj} follow an asymptotic standard normal distribution.

3.2 Slope homogeneity tests

Another important point in the bootstrap panel causality approach is testing for cross-country heterogeneity. It does not allow us to capture heterogeneity due to country specific characteristics, if the slope homogeneity is assumed without any empirical evidences (Breitung, 2005; Menyah *et al*. 2014). In addition, Granger (2003) stated that the causality from one variable to another variable by imposing the joint restriction for whole panel is a strong null hypothesis. The null hypothesis of slope homogeneity and the alternative hypothesis of heterogeneity can be described as follows: $H_0 : \beta_i = \beta$**, for all** i, $H_1 : \beta_i \neq \beta_j$, for a nonzero fraction of pair-wise slopes for $i = j$. To test for the null hypothesis, the customary approach is to follow the Wald principle. Accordingly, the test of slope homogeneity is $\beta_i = ... = \beta_N$, where the Wald statistic is asymptotically distributed chi-squared with **N-1** degrees of freedom (Mark *et al*. 2005). Fisher's exact test (F) is valid for cases where the cross section dimension (N) is relatively small and the time dimension (T) of panel is large; the explanatory variables are strictly exogenous; and the error variances are homoscedastic. In order to relax the assumption of homoscedasticity in the **F** test, Swamy (1970) developed the slope homogeneity test to detect cross-sectional heteroscedasticity (Pesaran and Yamagata, 2008). However, Wald and Swamy tests are applicable for panel data models where N is small relative to T. Pesaran and Yamagata (2008) proposed a standardized version of Swamy's test (the so-called $\tilde{\Delta}$ test) for testing slope homogeneity in large panels.

The $\tilde{\Delta}$ test is valid as $(N,T) \to \infty$ without any restrictions on the relative expansion rates of N and T when the error terms are normally distributed. In the $\tilde{\Delta}$ test approach, the first step is to compute the following modified version of the Swamy's test:

$$\tilde{S} = \sum_{i=1}^{N} (\hat{\beta}_i - \tilde{\beta}_{WFE})' \frac{x' M_T - x_i}{\tilde{\sigma}_i^2} (\hat{\beta}_i - \tilde{\beta}_{WFE}) \tag{6}$$

In Eq. (6), $\hat{\beta}_i$ is the estimator from the pooled OLS and $\tilde{\beta}_{WFE}$ is the estimator from the weighted fixed effect pooled estimation of the regression model of Eq. (1); M_T is an identity matrix, and $\tilde{\sigma}_i^2$ is the estimator of σ_i^2. Pesaran and Yamagata (2008) then developed the following standardized dispersion statistic:

$$\tilde{\Delta} = \sqrt{N} \left(\frac{N^{-1}\tilde{S} - K}{\sqrt{2K}} \right) \tag{7}$$

Under the null hypothesis with the condition of $(N,T)\to\infty$, so long as $\sqrt{N}/T\to\infty$ and the error terms are normally distributed, the $\tilde{\Delta}$ test has an asymptotic standard normal distribution. The small sample properties of the $\tilde{\Delta}$ test can be improved under normally distributed errors by using the following bias-adjusted version:

$$\tilde{\Delta}_{adj}=\sqrt{N}\left(\frac{N^{-1}\tilde{S}-E(\tilde{Z}_{i,t})}{\sqrt{\mathrm{var}(\tilde{Z}_{i,t})}}\right) \tag{8}$$

Where the mean is $E(\tilde{Z}_{i,t})=k$ and the variance is $\mathrm{var}(\tilde{Z})=2k\frac{T-k-1}{T}+1$[4].

3.3 Panel Granger non-causality test

The approach proposed by Kònya (2006) was recently used in the analysis of finance-growth nexus. Kar *et al*. (2011) examined the linkages between financial development and economic growth in the MENA countries, Hsueh *et al*. (2013) analyzed the connections between economic growth and financial development in Asian countries. Menyah *et al*. (2014) identify Granger causality between financial development, trade openness and economic growth in African countries. This study is the first that uses a bootstrap panel Granger causality test to investigate the causal relationship between banking sector development and economic growth in developing countries. The tools used for bootstrap panel causality tests are presented below.

The panel causality approach by Kónya (2006) that examine the relation-ship between **Y** and **BSD** can be studied using the following bivariate finite-order vector autoregressive (VAR) model:

$$\begin{cases} y_{i,t}=\alpha_{1,i}+\sum_{s=1}^{ly_1}\beta_{1,i,s}y_{i,t-s}+\sum_{s=1}^{lBSD_1}\gamma_{1,i,s}BSD_{i,t-s}+\varepsilon_{1,i,t} \\ BSD_{i,t}=\alpha_{2,i}+\sum_{s=1}^{ly_2}\beta_{2,i,s}y_{i,t-s}+\sum_{s=1}^{lBSD_2}\gamma_{2,i,s}BSD_{i,t-s}+\varepsilon_{2,i,t} \end{cases} \tag{9}$$

In the equation systems **(9)**, **y** denotes real GDP per capita, **BSD** is the banking sector development indices (**OBS** or **IBS**) obtained through principal component analysis, index i refers to the country $(i=1,\ldots\ldots,N)$, t to the time period $(t=1,\ldots\ldots,T)$, s the lag, ly_1, $lBSD_1$, ly_2 and $lBSD_2$ indicate the lag lengths. The error terms, $\varepsilon_{1,i,t}$ and $\varepsilon_{2,i,t}$ are supposed to be white-noises (i.e. they have zero means, constant variances and are individually serially uncorrelated) that may be correlated with each other for a given country, but not across countries[5].

Since for a given country the two equations in **(9)** contain the same pre-determined, i.e. lagged exogenous and endogenous variables, the OLS estimators of the parameters are consistent and asymptotically efficient. This suggests that the $2N$ equations in the system can be estimated one-by-one, in any preferred order. Then, instead of N **VAR** systems in **(9)**, we can consider the following two sets of equations:

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[4] See Chang, *et al*. (2013).

[5] $\varepsilon_{1,i,t}$ and $\varepsilon_{2,i,t}$ are correlated when there is feedback between BSD and Y , i.e. in the non-reduced form of (1), called structural VAR, y_t depends on BSD_t and/or BSD_t depends on y_t. For a proof see Enders (2004, p. 266).

$$\begin{cases} y_{1,t} = \alpha_{1,1} + \sum_{s=1}^{ly_1} \beta_{1,1,s} y_{1,t-s} + \sum_{s=1}^{lBSD_1} \gamma_{1,1,s} BSD_{1,t-s} + \varepsilon_{1,1,t} \\ y_{2,t} = \alpha_{1,2} + \sum_{s=1}^{ly_1} \beta_{1,2,s} y_{2,t-s} + \sum_{s=1}^{lBSD_1} \gamma_{1,2,s} BSD_{2,t-s} + \varepsilon_{1,2,t} \\ . \\ . \\ y_{N,t} = \alpha_{1,N} + \sum_{s=1}^{ly_1} \beta_{1,N,s} y_{N,t-s} + \sum_{s=1}^{lBSD_1} \gamma_{1,N,s} BSD_{N,t-s} + \varepsilon_{1,N,t} \end{cases} \tag{10}$$

and

$$\begin{cases} BSD_{1,t} = \alpha_{2,1} + \sum_{s=1}^{ly_2} \beta_{2,1,s} y_{1,t-s} + \sum_{s=1}^{lBSD_2} \gamma_{2,1,s} BSD_{1,t-s} + \varepsilon_{2,1,t} \\ BSD_{2,t} = \alpha_{2,2} + \sum_{s=1}^{ly_2} \beta_{2,2,s} y_{2,t-s} + \sum_{s=1}^{lBSD_2} \gamma_{2,2,s} BSD_{2,t-s} + \varepsilon_{2,2,t} \\ . \\ . \\ BSD_{N,t} = \alpha_{2,N} + \sum_{s=1}^{ly_2} \beta_{2,N,s} y_{N,t-s} + \sum_{s=1}^{lBSD_2} \gamma_{2,N,s} BSD_{N,t-s} + \varepsilon_{2,N,t} \end{cases} \tag{11}$$

In this system, each equation has the different predetermined variables. The only possible link among individual regressions is contemporaneous correlation within the systems. Therefore, system (**10**) and (**11**) must be estimated by Seemingly Unrelated Regression (SUR) procedure to take into account contemporaneous correlation within the systems (in presence of contemporaneous correlation the SUR estimator is more efficient than the OLS estimator). Following Kónya (2006), we use country specific bootstrap Wald critical values to implement Granger causality. This procedure[6] has several advantages. Firstly, it does not assume that the panel is homogeneous, so it is possible to test for Granger-causality on each individual panel member separately. However, since contemporaneous correlation is allowed across countries, it makes possible to exploit the extra information provided by the panel data setting. Therefore, country specific bootstrap critical values are generated. Secondly, this approach does not require pretesting for unit roots and cointegration, though it still requires the specification of the lag structure. This is an important feature since the unit-root and cointegration tests in general suffer from low power, and different tests often lead to contradictory outcomes. Thirdly, this panel Granger causality approach allows the researcher to detect for how many and for which members of the panel there exists one-way Granger-causality, two-way Granger-causality or no Granger-causality.

In the equation systems **(10)** and **(11)**, for each country one of four possible bootstrap panel causality hypotheses can be derived. (i) there is one-way Granger causality from **BSD** to y if not all $\gamma_{1,i}$ are zero, but all $\beta_{2,j}$ are zero, (ii) there is one-way Granger causality running

[6] For the details and exposition of the estimation and testing procedures, see Kónya (2006), Kar *et al*. (2011).

from y to **BSD** if all $\gamma_{1,i}$ are zero, but not all $\beta_{2,j}$ are zero, (iii) there is two-way Granger causality between **BSD** and y if neither $\gamma_{1,i}$ nor $\beta_{2,j}$ are zero, and finally (iv) there is no Granger causality between **BSD** and y if all $\gamma_{1,i}$ and $\beta_{2,j}$ are zero (Chang *et al*. 2013).

4 Results and Discussions

As outlined earlier, testing for both cross-sectional dependence and slope homogeneity in the bootstrap panel causality analysis is crucial for selecting the appropriate estimator and for imposing restrictions on causality. Because the countries examined in this work are highly integrated with regard to their economies, it is necessary to consider cross-sectional dependency and slope heterogeneity, and the results for this are shown in Table 2. First, we use four statistics, LM (Breusch and Pagan, 1980), CD_{LM} and CD (Pesaran, 2004) and LM_{adj} (Pesaran *et al*. 2008). It is clear that the null hypothesis of no cross-sectional dependence across the countries is strongly rejected at the conventional significance levels; this implies that the SUR method is more appropriate than the country-by-country OLS estimation. This finding implies that uncertainty shocks occurred in a particular country is transmitted to other countries, due to a high degree of globalization, market integration, and close economic linkages in the countries.

Table 2 also reports the results from the slope homogeneity test developed by Swamy (1970) and Pesaran and Yamagata (2008). The statistics are taken from Swamy (1970), $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ (both taken from Pesaran and Yamagata (2008)), and the null hypothesis is that after conducting the regression analysis of Eq.(1) the slope coefficients of the explanatory variables are the same among all each countries surveyed. The results strongly reject the null hypothesis of homogeneous slope, and support the alternative hypothesis that heterogeneity exists among countries, and thus that individual countries are affected by their own specific characteristics. The rejection of the homogeneous slope hypothesis means that inaccurate outcomes will be obtained if we impose the constraint of slope homogeneity. In this scheme of things, the direction of causal linkages between banking sector development and economic growth in developing countries is rather heterogonous, or in other words, the directional causal linkages between the variables of interest may differ across these countries (Chang *et al*. 2013).

Table 2 Cross-sectional dependence and homogeneous tests

Study	Test Stat	OBS	IBS
Breush and Pangan (1980)	LM	51.346**	40.334**
Pesaran (2004)	CD_{LM}	5.008***	4.445***
	CD	3.412***	3.224***
Pesaran *et al*. (2008)	LM_{adj}	18.115***	20.058***
Swamy (1970)	$\tilde{S}$	30.694***	23.426***
Pesaran and Yamagata (2008)	$\tilde{\Delta}$	5.013***	3.513***
	$\tilde{\Delta}_{adj}$	6.005***	4.319***

Note: *** and ** indicate significance at the 0.01 and 0.05 levels, respectively.

Having established the existence of cross-sectional dependency and heterogeneity across countries we apply the bootstrap panel causality approach developed by Kónya (2006). However, before proceeding to estimation, optimal lag lengths must be determined. Since the results from the causality test may be sensitive to the lag structure, determining the optimal lag length(s) is crucial for the robustness of empirical findings (Chang and Hsieh, 2012).

Again following Kónya (2006) we estimate the system for each possible pair of ly_1, $lBSD_1$, ly_2 and $lBSD_2$ respectively by assuming lags ranging from 1 to 4 and then choose the combinations which minimize the Akaike Information Criterion (AIC_k) (Kónya, 2006) and Schwartz Information Criterion (SC_k)[7] defined as follows:

$$AIC_k = \ln|W| + \frac{2N^2q}{T} \qquad and \qquad SC_k = \ln|W| + \frac{N^2q}{T}\ln(T) \tag{12}$$

Where W stands for estimated residual covariance matrix, N is the number of equations, q is the number of coefficients per equation, T is the sample size, all in system $k = 1,2$. Occasionally, these two criteria select different lag lengths.

The existence of cross-sectional dependence and sectional dependence and heterogeneity across states reject the null hypothesis of slope homogeneity for each of countries, it is justified to use the Bootstrap Panel Granger Causality method in Kónya (2006). For each system of equations the number of lags was chosen according to the AIC_k and SC_k criterion. Additionally, specifications incorporating deterministic trend were taken into account. The results from the bootstrap panel Granger causality[8] analysis are reported in Tables 3 and 4. We discuss our empirical findings for each country and both the banking sector development Indices (Outputs and Inputs) in the following sections.

In Table 3 we show the results from panel causality analysis between **OBS** and economic growth. For Benin, Brazil, Costa Rica, Iran, Jordan, Malawi, South Africa, Tanzania and Thailand there was a unidirectional causality running from **OBS** to economic growth, supporting the supply-leading hypothesis. In contrast, in the case of El Salvador, India, Jamaica, Mexico, Panama, Sri Lanka and Tunisia there was a unidirectional causality running from economic growth to **OBS**, supporting the demand-following hypothesis. In the case of Argentina, Malaysia and Morocco we found support for the feedback hypothesis where there was a bi-directional causality running between **OBS** and economic growth. In the remaining twenty one countries or for more than half of the sample there was no causality running in any direction between **OBS** and economic growth evidence consistent with the neutrality hypothesis.

[7] In order to save space, results from the lag selection procedure are not shown in the paper but are available upon reader's request.

[8] The TSP routine written by László Kónya was used to obtain the results for the panel Granger causality test. We are grateful to László Kónya for sharing his codes.

Table 3 Results for panel causality (BSD indicator)

Countries	H_0 : OBS does not Granger cause GDP				H_0 : GDP does not Granger cause OBS			
	Wald statistics	Bootstrap critical value			Wald statistics	Bootstrap critical value		
		10%	5%	1%		10%	5%	1%
Argentina	**12.905*** **	10.761	15.654	31.971	**59.969***	9.782	14.264	26.378
Benin	**11.005*** **	10.321	15.152	30.125	7.879	10.442	15.123	26.052
Botswana	1.995	9.308	13.743	26.632	11.523	13.743	19.531	34.633
Brazil	**26.748** **	13.637	23.411	75.847	0.632	7.746	10.745	19.998
Burkina Faso	9.792	13.012	18.114	31.459	0.014	12.946	18.005	32.003
Cameroon	5.531	12.640	18.751	34.309	3.525	16.082	23.749	43.531
Central Afr Rep	0.125	8.991	13.072	23.550	0.909	9.073	13.316	24.096
Colombia	7.413	11.414	16.839	33.633	0.744	10.580	13.518	25.081
Costa Rica	**11.324*** **	10.597	15.641	30.545	7.872	10.638	15.526	26.401
Dominican Rep	11.410	11.736	16.851	29.745	5.005	14.409	20.521	38.417
Ecuador	0.521	10.483	15.524	31.183	5.408	17.978	26.069	44.739
Egypt	2.187	10.415	15.524	31.083	2.954	10.423	15.290	27.519
El Salvador	4.774	16.001	10.165	32.822	**47.801***	11.010	15.635	28.611
Guatemala	4.631	14.632	22.636	51.523	5.206	7.317	10.958	20.252
Haïti	0.295	8.103	11.927	20.727	0.003	7.805	11.893	22.114
India	4.874	6.903	9.798	18.884	**9.713** **	5.121	7.201	11.097
Iran	**11.281** **	9.619	14.173	25.952	1.391	11.623	16.954	30.902
Jamaica	0.967	10.086	15.319	28.271	**31.504** **	16.837	23.968	45.295
Jordan	**27.636***	8.962	13.302	23.979	5.305	13.967	19.855	35.971
Kenya	0.063	8.187	11.702	20.835	0.276	9.651	14.397	29. 802
Liberia	0.007	10.908	15.802	27.072	3.673	9.941	14.179	25.413
Malawi	**10.084***	9.463	13.603	24.901	1.047	10.155	14.679	26.267
Malaysia	**13.295*** **	10.641	15.534	31.760	**61.569***	9.452	13.874	26.319
Mali	4.404	11.460	16.166	27.495	1.528	10.197	15.232	26.562
Mexico	2.635	11.016	16.004	31.526	**12.416*** **	9.303	13.286	25.295
Morocco	**13.607*** **	12.076	18.509	33.949	**50.967***	15.298	21.943	38.830
Nepal	4.926	11.371	16.197	28.863	0.174	8.962	12.603	22.605
Panama	3.108	10.853	15.968	31.749	**17.964*** **	15.744	22.975	42.197
Paraguay	5.415	10.299	14.973	27.859	2.416	11.297	16.086	30.968
Peru	0.986	10.439	17.212	39.988	0.765	10.879	15.992	30.028
Philippines	3.511	9.973	14.524	27.959	1.513	16.201	23.202	42.429
Sierra Leone	3.935	9.322	13.590	25.724	0.525	8.379	12.104	22.523
South Africa	**10.202*** **	10.294	15.405	31.196	0.845	9.417	13.518	23.599
Sri Lanka	2.412	13.852	20.522	41.288	**21.501** **	11.934	17.253	31.161
Tanzania	**10.037***	9.417	13.594	24.889	1.041	10.149	14.675	26.245
Thailand	**13.666*** **	10.515	15.977	29.571	12.450	27.498	37.659	66.445
Togo	2.769	10.032	14.374	25.466	0.043	10.548	15.102	27.732
Tunisia	0.991	10.898	16.076	31.381	**17.112*** **	15.783	22.405	39.545
Venezuela	2.990	13.373	19.914	37.321	7.916	13.902	20.009	37.720
Zimbabwe	0.987	8.008	11.638	23.008	0.275	9.854	14.179	25.067

Note: ***,**,* indicate significance at the 0.01, 0.05, 0.1 levels, respectively.

Table 4 presents the results for panel causality analysis between **IBS** and economic growth.

Table 4 Results for panel causality (BSD indicator)

Countries	H_0 : IBS does not Granger cause GDP				H_0 : GDP does not Granger cause IBS			
	Wald statistics	Bootstrap critical value			Wald statistics	Bootstrap critical value		
		10%	5%	1%		10%	5%	1%
Argentina	**16.543****	8.027	11.418	20.721	0.019	8.426	12.543	22.635
Benin	**7.725*****	6.698	9.418	16.685	0.879	10.415	14.587	25.999
Botswana	**19.112*****	7.045	10.154	18.135	0.035	9.558	13.342	24.748
Brazil	0.954	6.787	9.992	16.871	**10.216****	6.529	9.671	17.371
Burkina Faso	3.790	18.109	25.311	42.134	3.432	13.871	20.001	36.621
Cameroon	2.651	9. 098	13.453	25.613	0.647	14.041	21.109	36.887
Central Afr Rep	2.691	9.006	13.246	24.013	0.107	14.013	20.752	38.212
Colombia	**11.987***	9.005	13.573	26.001	8.594	10.645	16.597	29.015
Costa Rica	1.881	12.791	6.942	12.761	3.147	11.434	17.651	34.875
Dominican Rep	4.161	15.037	22.152	40.037	0.601	8.998	12.402	24.312
Ecuador	2.432	13.372	20.642	41.318	**21.079****	11.804	17.255	31.146
Egypt	1.768	11.771	18.896	37.764	**11.561*****	14.013	26.632	40.667
El Salvador	2.507	9.143	11.490	18.703	**32.103*****	9.231	8.681	15.541
Guatemala	1.805	9.983	14.215	27.276	12.765	14.531	20.054	36.081
Haïti	1.876	6.032	8.574	16.632	0.017	8.021	11.560	20.771
India	0.695	8.168	12.014	28.209	**14.975****	10.543	14.124	22.544
Iran	3.301	8.176	11.744	21.869	8.144	13.669	19.318	36.027
Jamaica	2.312	13.676	20.565	41.318	**21.102****	11.897	17.376	31.301
Jordan	3.401	10.756	15.634	30.101	**15.296****	10.298	14.545	26.672
Kenya	0.874	14.605	20.759	38.069	0.307	16.466	23.523	41.187
Liberia	1.537	12.973	20.620	39.765	7.006	9.380	14.378	26.911
Malawi	3.246	5.901	8.724	16.014	0.012	7.597	11.461	20.196
Malaysia	**22.927*****	7.279	10.564	19.154	0.051	10.213	14.698	25.792
Mali	0.007	6.853	9.778	16.987	5.693	12.721	18.059	32.955
Mexico	2.666	9.024	13.088	24.109	0.112	14.018	20.612	38.323
Morocco	**13.637*****	12.096	18.529	33.969	**49.997***	15.402	21.965	38.865
Nepal	3.544	9.598	14.471	28.113	0.932	22.117	30.012	51.969
Panama	**8.011*****	6.957	9.767	17.320	0.911	10.972	15.144	26. 752
Paraguay	1.922	6.736	9.535	15.802	0.073	13.728	18.530	31.813
Peru	0.013	8.269	12.199	22.751	0.091	12.163	17.044	29.720
Philippines	4.033	7.794	11.153	20.799	8.925	13. 015	17.782	30.764
Sierra Leone	1.221	7.182	10.513	18.321	0.371	11.927	16.989	29.555
South Africa	**13.295*****	10.621	15.611	31.849	**61.949***	9.832	13.984	26.278
Sri Lanka	**27.606***	8.942	13.292	23.959	5.295	13.877	19.835	35.941
Tanzania	3.501	10.093	14.614	27.719	1.706	42.703	23.281	42.603
Thailand	2.605	10.917	15.905	31.327	**12.387*****	9.271	13.001	25.208
Togo	**7.402*****	6.297	9.015	16.343	0.865	10.391	14.564	25.981
Tunisia	3.208	10.973	15.999	31.771	**17.944*****	15.724	22.955	42.167
Venezuela	2.412	13.852	20.522	41.291	**21.501****	11.931	17.251	31.162
Zimbabwe	2.182	11.059	17.294	35.040	12.151	14.271	22.022	41.221

Note: ***,**,* indicate significance at the 0.01, 0.05, 0.1 levels, respectively.

Table 4 shows that there was a unidirectional causality running from IBS to economic growth in Argentina, Benin, Botswana, Colombia, Malaysia, Panama, Sri Lanka and Togo where the supply-leading hypothesis was supported. However, the opposite unidirectional causality running from economic growth to banking sector development was detected for Brazil, Ecuador, Egypt, El Salvador, India, Jamaica, Jordan, Thailand, Tunisia and Venezuela where the demand-following hypothesis was supported. In the case of Morocco and South

Africa there was a bi-directional causality running between economic growth and banking sector development implying support for the "complementarity" hypothesis.

For the remaining twenty countries i.e. for half of the sample, the "neutrality" hypothesis is supported as there was no causality in any direction between banking sector development and economic growth. This is in sharp contrast to previous studies.

Some points are worth noting based on the results given above. Firstly, compared to the number of countries considered, Granger non causality in either direction can be rejected relatively rarely for **OBS** and **IBS**. As a result, the study provide no evidence to indicate that banking sector development is the most important determinant of economic growth in each country surveyed, and thus their banking sector development should be attributed to their own specific characteristics. Secondly, the results show that whether the causality from banking sector development to economic growth stands depends on the banking sector development indices (**OBS** or **IBS**) used for each country.

Furthermore, the results of this paper show that, whatever the banking sector development indices (Outputs or Inputs), the causal direction from banking sector development to economic growth is clearer only in Benin than in other countries. The findings support strong evidence on supply-leading hypothesis which implies that banking sector development induces economic growth. On the other hand, for three countries only (El Salvador, India and Tunisia) the findings support strong evidence on demand-following. Finally there is a bi-directional causality running between banking sector development and economic growth in Morocco implying support for the "complementarity" hypothesis.

5 Summary and conclusion

This paper revisited the Granger causal relationship between banking sector development and economic growth for forty countries using a bootstrap panel causality approach that allows for both cross-sectional dependency and for heterogeneity across countries for the period 1970-2012. We developed two banking sector development indices based on three indicators Outputs and three indicators Inputs of banking sector development using principal component analysis.

The empirical results show that the direction of causality between banking sector development and economic growth is sensitive to the choice of indices used Outputs or Inputs of banking sector development. The findings support evidence on the three demand-following, supply leading and complementarity hypotheses.

Some interesting conclusions emerge from this empirical study. First, none of the banking sector development indices causes economic growth in twenty three countries or for almost 57% of the sample (Burkina Faso, Cameroon, Central African Republic, Dominican Rep, Ecuador, Egypt, El Salvador, Guatemala, Haiti, India, Jamaica, Kenya, Liberia, Mali, Mexico, Nepal, Paraguay, Peru, Philippines, Sierra Leone, Tunisia, Venezuela and Zimbabwe). Second, as regards the causality from economic growth to banking sector development, the results show that banking sector development is not sensitive to economic growth in twenty three countries or for almost 57% of the sample (Benin, Botswana, Burkina Faso, Cameroon, Central African Republic, Colombia, Costa Rica, Dominican Rep, Guatemala, Haiti, Iran, Kenya, Liberia, Malawi, Mali, Nepal, Paraguay, Peru, Philippines, Sierra Leone, Tanzania, Togo and Zimbabwe). Third, sixteen countries or for almost 40% of the sample, the "neutrality" hypothesis is supported as there was no causality in any direction between banking sector development and economic growth, i.e. at least 62% of the sample there is a

causal relationship between banking sector development and economic growth (twenty five countries: Argentina, Benin, Botswana, Brazil, Colombia, Costa Rica, Ecuador, Egypt, El Salvador , India, Iran, Jamaica, Jordan, Malawi, Malaysia, Mexico, Morocco, Panama, South Africa, Sri Lanka, Tanzania, Thailand, Togo, Tunisia and Venezuela).

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APPENDIX: DATA AND SOURCES

The banking system's share of GDP is computed from various issues of the UN NATIONAL ACCOUNT STATISTICS, New York, referring to 'finance, insurance and business services'

The number of Banks and branches are counted from the corresponding editions of the BANKERS' ALMANAC AND YEARBOOK, London: Thomas Skinner; labor force data (for normalization) are from ILO and included in the PENN WORLD TABLES

The share of labor employed in the banking system is taken from various issues the ILO YEARBOOK OF LABOUR STATISTICS, Geneva. The corresponding ISIC-2 ('international standard industrial classification of all economic activities', 1968) classification is 'majordivision 8' (financial institutions, insurance, real estate and business services).