Finance and growth: time series evidence on causality*

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Abstract

This paper re-examines the empirical relationship between financial and economic development while (i) taking into account their dynamics and (ii) differentiating between stock market and banking sector development. We study the cointegration and causality between finance and growth for 26 countries. Our time series analysis suggests that the evidence in support of a finance-led growth is weak once we take into account the dynamics of financial and economic development. We show that causality patterns depend on whether countries' financial development stems from the stock market or the banking sector. Stock market development tends to cause growth, while a reverse or bi-directional causality is present between banking sector development and output growth. We also bring evidence that causality patterns differ between market-based and bank-based economies suggesting that financial structure influences the causal direction between financial and economic development. Our findings indicate that the relation between financial and economic development is likely to be more complex than suggested in earlier studies.

Keywords: economic development, stock market development, banking development, cointegration, causality
JEL codes: C22, E44, O16, G21

1 Introduction

The importance of the relationship between financial development and economic growth is well recognized in the growth and financial literature alike. Economic theory predicts that well-functioning financial intermediaries and markets reduce information asymmetries, facilitate risk sharing and mobilize savings, which leads to a more efficient resource allocation and, thus, may foster long-term growth[1]. A large empirical literature provides evidence that financial development matters for

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[1] Theoretical models that capture the different channels through which financial intermediaries affect real output, have been developed, among others, by Greenwood and Jovanovic (1990), Levine (1991), Bencivenga and Smith

growth. However, there is less consensus as to whether the effect is mainly due to banks, stock markets or both. The "finance-led growth" hypothesis, according to which financial development exerts a positive and causal effect on real output is mainly supported in cross-country studies that focus on *bank* development proxies (see King and Levine, 1993; Levine, Loayza and Beck, 2000; Calderon and Liu, 2003; Christopoulos and Tsionas, 2004; Rioja and Valev, 2004; Loayza and Ranciere, 2006). When *stock* market development is also considered, either the direction of causality becomes more difficult to assess (see Beck and Levine, 2004), or the impact of banking sector development on growth is negative (see Shen and Lee, 2006; Panizza, Arcand and Berkes, 2012).

This study provides new evidence that strengthens the notion that finance and growth co-move in a more complex way than previously thought. For this purpose, we investigate the relationship between economic and financial sector - banking and stock markets - development for 26 advanced and emerging economies during the period 1973-2011. Recent economic theories have stressed how banks and stock markets perform different functions which may exert independent influences on economic development. At the same time, the effectiveness of a particular financial structure depends on a host of country-specific factors such as the legal and contractual environment (Deidda and Fattouh, 2008; Song and Thakor, 2010), informational structure (Boot and Thakor, 1997) and new technologies available (Allen and Gale, 1999). Thus, the relative roles of banks or financial markets in real sector outcomes may differ depending on whether countries' financial architecture is mainly market- or bank-based. To uncover these different causality patterns, we explore the role of finance in economic development for each country in our sample, over time, by employing a framework in which both financial and economic development are treated as endogenous variables.

Our results show that causality patterns indeed differ across countries and, in particular, with the type of financial institution considered. Stock market development generally causes economic development, while the causality between banking sector development and growth goes in the reverse direction or is bi-directional, most of the time. We also show that countries' financial structure influences the causal direction between financial and economic development. We find evidence in favor of a finance-led growth only in market-based economies. This evidence suggests that when one takes into account the time-series properties of economic and financial development, not just the size, but also the structure of the financial sector matters for growth.

These findings complement recent research that shows how the structure of the financial system may impact growth (Fecht, Huang and Martin, 2008; Luintel, Khan, Arestis and Theodoridis, 2008; Ergungor, 2008; Arestis, Luintel and Luintel, 2010; Demirguc-Kunt, Feyen and Levine, 2012). Our approach is, however, different. We show that causality patterns between the development of stock markets and banks, and the real sector are different in economies characterized by a market-based or a bank-based financial system. Our findings suggest that the extensive empirical evidence that finance causes growth is sensitive to the type and dominance of a particular financial institution.

The remainder of this paper is organized as follows. Section 2 reviews theoretical and empirical contributions on this topic. Section 3 presents the variables and data used. Section 4 discusses the cointegration and causality tests employed and presents our main results. Section 5 concludes.

(1991), Greenwood and Smith (1997), Blackburn and Hung (1998).

2 Motivation and previous research

Economists hold different opinions of the role of finance in economic growth and the developed theoretical literature mirrors these divisions. The theoretical underpinnings of this role can be traced back to Schumpeter (1934), who saw financial intermediaries as playing a pivotal role in output growth by channeling savings to the most productive investments. The alternative view is held by Robinson (1952), who argued that financial development simply follows economic growth which is generated elsewhere. Patrick (1966) characterizes these two possible relationships as the supply-leading and demand-following hypotheses. Both of his hypotheses, as well as possible interactions between them, have been further developed by, among others, Greenwood and Jovanovic (1990), Levine (1991), Bencivenga and Smith (1991), Greenwood and Smith (1997), Blackburn and Hung (1998).

A more recent theoretical literature is concerned with analyzing the relative advantages of a bank- or market-based financial system. A key theoretical finding argues that market-based systems behave differently than bank-based ones since the predominance of either banks or financial markets affects economic outcomes through different channels. For example, market-based systems provide better cross-sectional risk sharing (Allen and Gale, 1997), enhance efficiency by not committing to unprofitable projects (Dewatripont and Maskin, 1995) and are better at financing new technologies in the presence of diversity of opinion (Allen and Gale, 1999). Bank-based systems, on the other hand, are more effective in weak legal systems with poor institutional infrastructure (Rajan and Zingales, 1998), when firms are more prone to post-lending moral hazard (Boot and Thakor, 1997), the economy is dominated by smaller firms (Petersen and Rajan, 1995), or at early stages of development (Chakraborty and Ray, 2006). Theoretical models also predict an increasing importance of securities markets at higher levels of financial development (see Dewatripont and Maskin, 1995; Boot and Thakor, 1997; Boyd and Smith, 1998).

These diverse theoretical findings have fueled a large body of empirical research. Cross-sectional and panel studies generally suggest a positive link between finance and growth and mainly address the issue of causality using IV and GMM techniques (see King and Levine, 1993; Levine and Zervos, 1998; Levine et al., 2000; Beck, Levine and Loayza, 2000; Beck and Levine, 2004). Several studies, however, have suggested that these causality patterns, may reflect only one side of the causal link (see Demetriades and Hussein, 1996; Arestis, Demetriades and Luintel, 2001; Christopoulos and Tsionas, 2004; Ang, 2008; Luintel et al., 2008). They argue that by exploring the role of finance in economic development for a specific country, over time, one may reveal causality patterns that cannot be inferred from pooled cross-sectional studies. One of the caveats when pooling countries together in cross-sections is also pointed out by Rioja and Valev (2004) who show that the link between finance and growth depends on the stage of economic development: highly and low developed economies are characterized by a weak link, while for developing countries, finance exerts a stronger influence on growth.

To address these issues of country-specific effects, time series research identifies causality on a country-by-country basis, while accounting for the dynamics and cointegration properties of data (Christopoulos and Tsionas, 2004). Among the first to explore causality in a time series framework were Demetriades and Hussein (1996) and Luintel and Khan (1999) who mainly find a bi-directional relationship between finance and growth in a sample of developing countries. They argue that cross-sectional studies of countries with very different experiences in terms of financial development may well suggest simpler than actual dynamics between finance and growth. Arestis et al. (2001), recognizing the low power of the Johansen cointegration test in small samples, limit their research to five developed nations. Using quarterly data they find different causality patterns and a stronger link between banking development and GDP, as compared to stock market capitalization. Christopoulos and Tsionas (2004) try to overcome the issues of low availability of data over long periods of time using panel cointegration techniques. Their findings are restricted to banking sector development and support a unidirectional causality going from financial depth to growth.

Recent evidence which benefits from the availability of longer time series, in particular with regards to stock market data, has cast some doubts on the stylized positive relationship between financial development and growth. Loayza and Ranciere (2006) find that the long-run positive relationship between financial intermediation and output growth co-exists with a mostly negative short-run relationship. Shen and Lee (2006) also find a negative relationship between bank development and growth, when controlling for the development of stock markets. Panizza et al. (2012) show that the relationship between financial development and economic growth turns negative for high levels of credit to GDP.

Turning to the role that financial architecture might play in the finance-growth nexus, empirical evidence is more sparse. Levine (2002) provides the first comprehensive classification of economies in either bank-based or market-based using several proxies for financial sector development including size, efficiency, liquidity and regulation. His panel data evidence shows no support for the notion that either system is better in promoting growth. Different evidence is brought by Arestis et al. (2001), Tadesse (2002) or Luintel et al. (2008) who stress the relative importance of financial sector architecture in explaining economic growth. More specifically, Luintel et al. (2008) show how, in assessing the role of financial structure on growth, cross-country data cannot be pooled due to significant cross-country heterogeneity. Moreover, Demirguc-Kunt et al. (2012) find that, as economies grow, the marginal increase in economic activity associated with an increase in bank development falls, while the one associated with stock market development rises. Thus, as economies develop, stock markets generate more growth than banking sector development.

The distinction between market-based and bank-based financial systems can also have some direct implications for the patterns of causality between finance and growth. For example, Arestis and Demetriades (1997) argue that bank-based systems are arguably better at solving principal-agent problems and promote longer time horizons and expect causality to be either from finance to growth or bi-directional in this institutional framework. By contrast, market-based systems are more concerned with short-term performance and thus causality, in this case, is expected to be from growth to finance, although a bi-directional relationship cannot be ruled out. Different causality patterns emerge if we consider that banks have a comparative advantage in weaker institutional environments, more prone to moral hazard and with well-collateralized financing, while stock markets are better are financing innovative, higher risk-projects that rely on less tangible inputs. The foregoing arguments imply that the impact of different financial institutions on growth may depend on the level of financial and economic development as well as the predominance of a particular financial architecture.

The setting of our analysis allows us to test these latter hypotheses. First, by looking at both types of intermediaries, we can test whether causality patterns between the two financial sectors and economic development differ. Second, since our sample includes a set of country with relative high levels of stock market development, we can examine whether, indeed the services provided by financial markets tend to contribute more to real outcomes.

3 Data

Consistent with theoretical specifications and previous studies (Demetriades and Hussein, 1996; Levine and Zervos, 1998; Arestis et al., 2001; Beck and Levine, 2004), we define *economic development* as the logarithm of real GDP per capita (GDP). We measure *stock market development* by the logarithm of the *ratio of stock market capitalization to nominal GDP* (STOCK) in line with Rousseau and Wachtel (2000), Arestis et al. (2001), Beck and Levine (2004) and Shen and Lee (2006)[2]. The *development of the banking system* is captured by the logarithm of the *ratio of domestic bank credit to nominal GDP* (CRED). Several other measures of bank development are used in the literature[3]. However, domestic credit is argued to be more robustly link to output growth and is more widely used in recent studies (Arestis et al., 2001; Loayza and Ranciere, 2006; Luintel et al., 2008).

Levine and Zervos (1998), Arestis et al. (2001) and Loayza and Ranciere (2006), among others, have argued that the positive effect of financial sector development on growth might be hindered by the negative impact of its fragility and excess volatility. We control for these aspects using a measure of *stock market volatility* (STOCKVOL) constructed in line with Arestis et al. (2001), as quarterly standard deviation of end-of-weak stock prices[4].

Finally, a measure of the *fragility of the banking sector* (FRAG) is the eight-quarter moving standard deviation of the growth rate of domestic credit to GDP, proposed by Loayza and Ranciere (2006). This measure captures the volatility of the banking sector and its propensity to crises and cycles of booms and busts. Appendix Table A.1 provides additional details on the construction of variables and data sources.

We expand the time series evidence on finance and growth by analyzing a sample of both advanced and developing countries, classified according to their level of capital market development. We follow the 2011 FTSE Global Equity Index Series Country Classification which includes four stages of stock market development. We limit our research to the first two groups, i.e. Developed and Advanced Emerging which yield 35 countries. We further eliminate nine countries due to a lack of sufficiently long time series of data and are left with a sample of 26 countries, out of which 21

[2]Another measure employed to capture stock market development is the turnover ratio which relates the value of the trades of shares to GDP. However, lack of availability of this measure for a sufficient long period of time for all the countries analyzed, limits our research to stock market capitalization as a proxy for stock market development.

[3]These include the ratios of broad money (M2) and stock of liquid liabilities (M3) to GDP as measures of intermediary activity able to capture the notion of financial depth.

[4]To economize on the loss of observation we do not compute the moving standard deviation, but rather the quarter volatility based on weakly returns. It should be noted, however, that the two approaches yield comparable volatility measures.

have developed stock markets[5] and 5 are advanced emerging[6]. The country-by-country approach we employ follows Demetriades and Hussein (1996), Luintel and Khan (1999) and Arestis et al. (2001) who study developing and advanced economies using either annual or quarterly data. Our variables are measured quarterly in line with Arestis et al. (2001) and cover a time span of around 40 years (1973-2011).

The objective of this paper is to understand whether the finance-growth nexus is sensitive to a country's financial architecture. To this end, we employ a comprehensive classification of market- or bank-based economies developed by Levine (2002). Levine (2002) identifies the dominance of a particular type of financial institution in a sample of 48 countries using five measures of size, efficiency, liquidity and regulation for each type of financial institution[7]. This broad cross-country approach permits a consistent treatment of financial system structure, however it may suffer from potential anomalies with some stylized facts. For example, Japan, which has traditionally been characterized as a bank-dominated system, appears as having a more developed stock-market system. This reflects the more rapid development of financial markets, compared to the banking sector in Japan over the 1980-1995 period (see also Allen and Gale, 1995). Nevertheless, to allow for comparison with previous evidence, we follow Levine's (2002) classification and divide our sample in two equally sized groups.

4 Empirical analysis

In this section, we briefly present the econometric methods we use and the results we obtain. The empirical literature on finance and growth builds on three econometric approaches: pure cross-sectional OLS studies, time series estimations and panel data analysis employing GMM (see Ang, 2008; Beck, 2008, for an overview). We employ a country-by-country time series analysis which enables us to take into account country specific conditions and the cointegration properties of data. This also allows us to disentangle causality patterns between different types of financial intermediaries and real output across countries.

4.1 Cointegration between financial and economic development

Time series research on the finance-growth nexus has centered around cointegration (Demetriades and Hussein, 1996; Luintel and Khan, 1999; Arestis et al., 2001; Christopoulos and Tsionas, 2004). Consistent with this literature, we use the Johansen (1988; 1992) maximum likelihood procedures to test for the presence of cointegration in a vector autoregression with n variables integrated of order one, of the form:

$$y_t = b_1 y_{t-1} + b_2 y_{t-2} + ... + b_k y_{t-k} + \Phi D_t + \varepsilon_t. \quad (1)$$

[5] Australia, Austria, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, Singapore, South Korea, Spain, Sweden, Switzerland, UK, USA.

[6] Malaysia, Mexico, South Africa, Thailand, Turkey.

[7] This comprehensive set of measures alleviates concerns that the results we get for each group might be influenced by the endogeneity of the group determination.

The *VAR(k)* in (1) can be rewritten as a vector error correction model:

$$\Delta y_t = \pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + ... + \Gamma_{k-1} \Delta y_{t-(k-1)} + \Phi D_t + \varepsilon_t, \quad (2)$$

where y, in our case, is a vector with the five variables capturing economic development, stock market and banking sector development and stock market and banking sector volatility, y=(GDP STOCK CRED STOCKVOL FRAG)', $\pi = \left(\sum_{i=1}^{k} b_i \right) - I_n$, $\Gamma_i = -(b_{i+1} - ... - b_k)$, (i=1,...,k-1), D_t is a set of deterministic variables such as a constant, trend and dummies, and ε_t is a vector of normally distributed errors with zero mean and constant variance.

We test for cointegration through the rank r of the π matrix using Johansen's (1988) maximum likelihood statistics: the trace statistic $\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} ln(1 - \hat{\lambda}_i)$ and the maximal-eigenvalue statistic: $\lambda_{max}(r, r+1) = -Tln(1 - \hat{\lambda_{r+1}})$, where $\hat{\lambda}$ is the estimated value of the i^{th} ordered eigenvalue of π. We test sequentially for the presence of an increasing number of cointegrating vectors r, in favor of the alternative that there are *r+1* (for λ_{trace}) or more than r (for λ_{max}), until we cannot.

We carry out a number of standard steps prior to testing for cointegration in this framework. These include verifying the integration properties of each variable, setting the optimal number of lags and parameterizing the deterministic component D_t. We refer the reader to Appendix B for a more detailed account of these steps and further robustness checks performed in the cointegration analysis.

Allowing for all these specifications, we test for cointegration. The results are presented in Table 1. For brevity, we present only the trace statistic since the results of the maximum eigenvalue are qualitatively the same. When they differ, however, we put more weight on the trace statistic, which is more robust than the maximal eigenvalue in finite samples (Cheung and Lai, 1993). We find evidence of at least one cointegrating vector in all countries, while two cointegrating vectors are found in 11 of them[8].

For this specific number of cointegrating vectors, the matrix π in equation (2) is written as a product of two full rank matrices $\alpha \cdot \beta$', with the β matrix containing the cointegrating vectors and the coefficients of α representing the speed of adjustment to the equilibrium relationship. The Johansen reduced rank regression procedure only determines how many cointegration vectors span the cointegrating space. In order to identify these cointegrating vectors we need to impose restrictions on the columns of β, to test which variables enter the cointegrating relation. The log-likelihood statistic of these tests is presented in Tables 2 and 3 (LR test) and does not reject the null hypothesis that the imposed restrictions, for each cointegrating relationship in each country, hold in the data[9].

We present the normalized cointegrating vectors in Tables 2 and 3. As mentioned, we split our sample in market-based and bank-based economies for the purpose of emphasizing different causality

[8] We discuss in Appendix B further robustness tests performed in the cases where more cointegrating vectors are found, such as Sweden and Japan.

[9] In order to identify the cointegrating vectors, we need to impose $r^2 + k$, ($k \geq 1$) over-identifying restrictions. In other words, whenever we find evidence of two cointegrating vectors, we impose at least five restrictions on the coefficients of matrix β.

Table 1: Johansen Cointegration Test

Johansen cointegration test for the VAR in equation (2). Variables included in the VAR: logarithm of real GDP per capita (GDP), logarithm of the ratio of stock market capitalization to nominal GDP (STOCK), logarithm of the ratio of domestic credit to nominal GDP (CRED), the quarterly standard deviation of the end-of-week stock market price indexes (STOCKVOL) and the eight quarter moving standard deviation of the growth rate of domestic credit to GDP (FRAG). Lags refers to the number of lags of the VAR model equation (1). LM is the p-value of the LM test of residual autocorrelation under the null of no serial correlation at the specified lag order

Country	Trace statistic under H_0= r					Lags	LM	Sample
	r=0	$r\leq1$	$r\leq2$	$r\leq3$	$r\leq4$			
Developed								
Australia	70.91*	35.79	19.24	6.22	0.85	1	0.23	1973-2011
Austria	89.76**	52.65*	19.16	7.87	2.50	2	0.55	1973-2011
Canada	79.01*	39.29	21.24	9.13	1.94	2	0.74	1973-2011
Denmark	86.50**	40.94	17.40	4.05	0.47	2	0.91	1973-2011
Finland	122.59**	62.13**	24.14	12.25	3.53	1	0.08	1973-2011
France	74.47*	36.17	19.76	8.10	3.86	1	0.12	1980-2011
Germany	99.25**	51.70**	16.07	1.65	0.02	2	0.16	1973-2011
Greece	114.52**	66.84**	27.03	10.47	3.61	1	0.07	1988-2011
Ireland	108.99**	41.78	20.82	5.61	0.16	2	0.33	1973-2011
Italy	100.61**	47.76	18.37	7.30	1.10	1	0.30	1973-2011
Japan	130.86**	58.84**	30.35*	13.03	3.78	1	0.45	1973-2011
Netherlands	103.35**	48.25*	24.92	11.72	4.32*	3	0.56	1973-2011
New Zealand	80.65**	43.58	19.86	7.53	1.49	1	0.23	1988-2011
Norway	87.88*	44.66	18.50	7.79	0.48	2	0.36	1980-2011
Singapore	109.37**	68.73**	31.93*	15.03	2.82	2	0.31	1975-2011
South Korea	75.36*	45.32	20.24	8.96	2.83	2	0.24	1987-2011
Spain	114.84**	53.71*	28.98	11.13	2.07	2	0.14	1987-2011
Sweden	129.64**	78.09**	30.63*	11.61	3.19	1	0.11	1982-2011
Switzerland	150.04 **	46.37	15.17	5.80	1.24	1	0.21	1973-2011
United Kingdom	130.16**	38.92	15.83	5.94	0.50	1	0.77	1965-2011
USA	116.37**	32.94	14.90	6.22	0.11	2	0.14	1973-2011
Advanced Emerging								
Malaysia	73.90*	41.61	19.57	7.06	2.33	2	0.12	1986-2011
Mexico	102.76**	52.43*	15.05	6.55	1.91	1	0.36	1988-2011
South Africa	106.32**	36.25	16.56	5.54	1.70	2	0.52	1973-2011
Thailand	98.13**	45.43	15.54	6.25	1.33	1	0.45	1987-2011
Turkey	119.81**	51.55*	18.91	5.24	0.15	2	0.83	1988-2011

* and ** denotes rejection of the hypothesis at the 5% and 1 % level.
Critical values for the cointegration test are provided by Mackinnon, Haug and Michelis (1999).

patterns between the two financial structures. This split, however, should not lead to any particular differences in the cointegrating relationships we uncover. Still, for consistency, we present the results in two separate tables. We normalize the first cointegrating relationship on GDP to reflect the link between output and one or both measures of financial development. The second cointegrating relationship captures the link between the two measures of financial sector development.

We find a stable long-term relationship between *both* measures of financial development and GDP in 12 of the countries. Stock market development is positively related to GDP in 15 of the countries, while a positive stable relationship between CRED and GDP is present in 16 of the countries. Overall, this evidence is consistent with the cross-country literature and points towards a positive finance-growth nexus.

However, a few exceptions are worthwhile noticing. Bank development appears to be negatively related to GDP in Singapore, while stock market capitalization is negatively related to the level of economic development in South Korea. This evidence is interesting considering the intensive financial liberalization reforms undertaken by both countries. For the sample of bank-based economies, the relationship between bank and economic development is positive in eight of the countries and negative in four: Italy, Mexico, Malaysia and Spain. These findings are in line with Shen and Lee (2006) and Panizza et al. (2012) who also report a negative relationship between banking sector development and economic growth. Deidda (2006) develops a theoretical model in which the effect of the financial sector on growth is negative when the former is too big. In our sample, Italy and Spain have bank development to GDP ratios exceeding 300%. Ang and McKibbin (2007), using only proxies for bank development, find a positive relationship between output and finance for Malaysia. Our results indicate that the sign of the relationship between finance and growth is sensitive to the type of financial sector considered and that it can be affected by the inclusion a second proxy for financial development.

Our framework also allows for testing whether the long-term positive effect of financial intermediaries is hindered by a negative effect due to the volatility that characterizes these sectors. Stock market volatility enters the cointegrating relationship alongside GDP in 16 of the countries and has a negative sign in 12 of them. Banking sector fragility only enters in eight of the cointegrating relationships and is negatively associated with GDP in six of the countries out of which four are bank-based economies. Overall, our findings suggest that the volatility of both sectors may negatively impact real output. This evidence complements Loayza and Ranciere (2006) who study the banking sector fragility only.

4.2 Robustness checks

The Johansen cointegration procedure is prone to falsely reject the null hypothesis of no cointegration in small samples (Reinsel and Ahn, 1992). To ensure the robustness of our results, we perform a cointegration test proposed by Phillips and Hansen (1990) which corrects for finite-sample biases. The fully modified OLS (FMOLS) estimates cointegrating relationships by modifying the traditional OLS coefficients to account for endogeneity and serial correlation in the regressors. FMOLS is asymptotically equivalent to system methods like Johansen (1988), while it is less sensitive to lag lengths and performs better in small samples (Phillips and Hansen, 1990).

FMOLS estimators are presented in the Appendix Tables C.1 and C.2. Using FMOLS we identify the same stable long-term relationships as with the Johansen procedure and test for cointegration by examining the stationarity of the error term obtained. We test for a unit root in the residuals of the estimated equations using the ADF and KPSS procedures. The results confirm the stationarity of the residuals and, hence, of the estimated relationships[10].

Overall, the results of the two estimation methods are consistent and show the same positive cointegrating relationship between GDP and the proxies for financial development. Compared to the Johansen procedure, FMOLS gives qualitatively unchanged results. The coefficients are of the same magnitude but statistically not always equal. In a few cases, FMOLS coefficients are not significant where the Johansen coefficients were (South Korea, Italy and Spain). This may be caused by the fact that the FMOLS procedure assumes that the variables on the right hand-side of the equation, hence the proxies for financial development, are exogenous. This might not be the case. For this reason we stress the importance of a simultaneous framework that allows for testing different feedback relationships. However, we estimate the FMOLS relationships using GDP as the explained variable just to allow for a consistent comparison with the Johansen normalized cointegration vectors. We proceed in testing if, in fact, financial development is exogenous to the level of GDP.

4.3 Causality between financial and economic development

We test for a causal link between finance and growth in a simultaneous equation framework which allows us to uncover not only unidirectional causality, but also any potential bidirectional causality in which there is a feedback relationship between finance and economic development[11]. Time series evidence on causality between finance and growth generally focuses on long-term causal links (Luintel and Khan, 1999; Arestis et al., 2001). However, short-term dynamics may also be important, as pointed out by recent evidence (see Loayza and Ranciere, 2006). In order to uncover the potential complex dynamics behind our variables of interest we perform a wide breadth of causality tests.

We test first for weak exogeneity. In the vector error correction model in (2), the equation determining ΔGDP_t when considering, for example, one cointegrating relationship and two lags, is written as:

$$\begin{aligned}\Delta GDP_t \quad &= \quad \alpha_{11} ECT_{t-1} + \gamma_{11}\Delta GDP_{t-1} + \gamma_{12}\Delta STOCK_{t-1} + \gamma_{13}\Delta CRED_{t-1} \\ &\quad + \gamma_{14}\Delta STOCKVOL_{t-1} + \gamma_{15}\Delta FRAG_{t-1} + \varepsilon_{1t}, \end{aligned} \tag{3}$$

where $ECT_{t-1} = \beta_{11}GDP_{t-1} + \beta_{12}STOCK_{t-1} + \beta_{13}CRED_{t-1} + \beta_{14}STOCKVOL_{t-1} + \beta_{15}FRAG_{t-1}$ is the error correction term, i.e. the cointegration relationship between the variables. A test of the null hypothesis $H_0 : \alpha_{11} = 0$ is a test of weak exogeneity since a non-rejection of the null means the lags of the other variables do not enter in the equation determining GDP, i.e. GDP is exogenous to the system (Harris, 1995).

[10]For brevity, the results are not presented here but are available upon request.

[11]Christopoulos and Tsionas (2004) use a different approach to test for a bi-directional causality with a FMOLS framework by regressing both economic growth and financial development on each other. In their study a unidirectional causality from financial depth to growth is found for a sample of developing countries.

Table 2: Cointegrating Vectors: Market-Based Economies

Normalized cointegrating relationships based on the number of cointegration vectors in Table 1. Classification of market-based economies is taken from Levine (2002). Variables included in the VAR: logarithm of real GDP per capita (GDP), logarithm of the ratio of stock market capitalization to nominal GDP (STOCK), logarithm of the ratio of domestic credit to nominal GDP (CRED), the quarterly standard deviation of the end-of-week stock market price indexes (STOCKVOL) and the eight quarter moving standard deviation of the growth rate of domestic credit to GDP (FRAG).

Country	First cointegrating relationship	Second cointegrating relationship	LR test
Australia	$C_1 = GDP - \underset{[-8.21]}{0.29}\, STOCK - \underset{[-6.97]}{0.49}\, STOCKVOL$		0.99
Canada	$C_1 = GDP - \underset{[-5.57]}{0.60}\, CRED - \underset{[6.29]}{0.72} STOCKVOL$		0.28
Ireland	$C_1 = GDP - \underset{[-13.40]}{0.39}\, STOCK - \underset{[-6.94]}{0.32}\, CRED + \underset{[7.64]}{0.40} STOCKVOL$		0.64
Japan	$C_1 = GDP - \underset{[-14.24]}{0.91}\, STOCK - \underset{[-5.03]}{0.92}\, CRED + \underset{[9.25]}{1.58} STOCKVOL$	$C_2 = STOCK + \underset{[2.74]}{0.12} FRAG - \underset{[-10.21]}{2.05}\, STOCKVOL$	0.23
Netherlands	$C_1 = GDP - \underset{[-7.00]}{0.04}\, STOCK - \underset{[-33.59]}{0.42}\, CRED$	$C_2 = CRED + \underset{[2.70]}{3.95} STOCK + \underset{[1.46]}{2.25} FRAG - \underset{[-6.03]}{19.10} STOCKVOL$	0.59
New Zealand	$C_1 = GDP - \underset{[-4.98]}{0.29}\, CRED + \underset{[6.67]}{0.20} STOCKVOL$		0.25
Singapore	$C_1 = GDP - \underset{[-9.17]}{1.40}\, STOCK + \underset{[5.71]}{1.57} CRED$	$C_2 = STOCK - \underset{[-6.50]}{2.30}\, CRED + \underset{[6.65]}{2.01} STOCKVOL$	0.59
South Korea	$C_1 = GDP + \underset{[2.87]}{0.29} STOCK - \underset{[-4.57]}{0.92}\, CRED + \underset{[4.76]}{0.60} FRAG$		0.26
Sweden	$C_1 = GDP - \underset{[-18.99]}{0.09}\, STOCK - \underset{[-16.99]}{0.23}\, CRED$	$C_2 = STOCK + \underset{[2.09]}{3.13} FRAG - \underset{[-7.38]}{18.11} STOCKVOL$	0.48
Switzerland	$C_1 = GDP - \underset{[-2.60]}{0.15}\, STOCK - \underset{[-2.24]}{0.76}\, CRED + \underset{[11.51]}{1.09}\, STOCKVOL$		0.60
Thailand	$C_1 = GDP - \underset{[-3.03]}{1.06}\, CRED + \underset{[8.09]}{1.49} STOCKVOL$		0.36
United Kingdom	$C_1 = GDP - \underset{[-3.01]}{0.33}\, STOCK + \underset{[2.42]}{0.26} FRAG - \underset{[-10.80]}{1.87}\, STOCKVOL$		0.45
USA	$C_1 = GDP - \underset{[-12.92]}{0.34}\, STOCK - \underset{[-4.23]}{0.19}\, FRAG + \underset{[9.74]}{0.56} STOCKVOL$		0.17

LR test is the p-value of the log-likelihood test under the null: $H_0{:}\beta_{ij}{=}0$, i.e. that restrictions on the variables entering each cointegrating vector are binding.
Constant terms are included in the cointegrating relationships, but not reported.
t-statistics in [ ].

Table 3: Cointegrating Vectors: Bank-Based Economies

Normalized cointegrating relationships based on the number of cointegration vectors in Table 1. Classification of bank-based economies is taken from Levine (2002). Variables included in the VAR: logarithm of real GDP per capita (GDP), logarithm of the ratio of stock market capitalization to nominal GDP (STOCK), logarithm of the ratio of domestic credit to nominal GDP (CRED), the quarterly standard deviation of the end-of-week stock market price indexes (STOCKVOL) and the eight quarter moving standard deviation of the growth rate of domestic credit to GDP (FRAG).

Country	First cointegrating relationship	Second cointegrating relationship	LR test
Austria	$C_1 = GDP - \underset{[-3.71]}{8.20}\,CRED + \underset{[3.23]}{253.34}FRAG$	$C_2 = STOCK + \underset{[3.34]}{8.55}CRED - \underset{[-5.98]}{72.10}STOCKVOL$	0.49
Denmark	$C_1 = GDP - \underset{[-9.37]}{0.13}\,STOCK - \underset{[-2.44]}{0.06}\,CRED + \underset{[6.75]}{0.19}STOCKVOL$		0.80
France	$C_1 = GDP - \underset{[-5.35]}{0.54}\,STOCK + \underset{[5.93]}{2.02}FRAG - \underset{[-3.06]}{0.70}\,STOCKVOL$		0.73
Finland	$C_1 = GDP - \underset{[-11.62]}{0.33}\,STOCK - \underset{[-3.04]}{0.30}\,CRED + \underset{[4.54]}{0.20}STOCKVOL$	$C_2 = CRED - \underset{[-5.74]}{0.37}\,STOCKVOL + \underset{[10.55]}{0.97}\,FRAG$	0.98
Germany	$C_1 = GDP - \underset{[-7.65]}{1.93}\,CRED + \underset{[6.99]}{1.80}STOCKVOL$	$C_2 = CRED - \underset{[-7.52]}{0.31}\,STOCK - \underset{[-5.01]}{0.74}\,STOCKVOL$	0.05
Greece	$C_1 = GDP - \underset{[-3.55]}{0.98}\,CRED + \underset{[6.42]}{0.79}FRAG$	$C_2 = CRED - \underset{[-9.82]}{0.73}\,STOCK$	0.16
Italy	$C_1 = GDP + \underset{[2.19]}{4.83}CRED + \underset{[4.27]}{7.70}STOCKVOL$		0.61
Malaysia	$C_1 = GDP - \underset{[-6.16]}{0.66}\,STOCK + \underset{[4.34]}{1.55}CRED + \underset{[4.02]}{0.27}FRAG$		0.64
Mexico	$C_1 = GDP - \underset{[-6.50]}{0.06}\,STOCK + \underset{[11.31]}{0.78}\,CRED$	$C_2 = CRED - \underset{[-2.66]}{0.13}\,STOCK - \underset{[-8.53]}{0.70}\,STOCKVOL$	0.79
Norway	$C_1 = GDP - \underset{[-4.29]}{0.74}\,CRED + \underset{[8.26]}{0.84}STOCKVOL$		0.49
Spain	$C_1 = GDP - \underset{[-5.07]}{0.19}\,STOCK + \underset{[2.38]}{0.10}CRED$	$C_2 = CRED + \underset{[4.12]}{1.26}STOCK - \underset{[-6.99]}{1.59}\,STOCKVOL$	0.60
Turkey	$C_1 = GDP - \underset{[-11.62]}{1.95}\,CRED - \underset{[-7.57]}{0.77}\,FRAG$	$C_2 = CRED - \underset{[-4.75]}{0.30}\,STOCK + \underset{[8.32]}{0.77}STOCKVOL$	0.49
South Africa	$C_1 = GDP - \underset{[-4.11]}{1.17}\,CRED + \underset{[8.77]}{0.94}STOCKVOL + \underset{[6.17]}{0.60}stepdum^*$		0.41

LR test is the p-value of the log-likelihood test under the null: H_0:β_{ij}=0, i.e. that restrictions on the variables entering each cointegrating vector are binding.
* We introduce a step dummy in the deterministic component D_t in (2) in the case of South Africa. This takes the value 0 until 1990Q4 and 1 afterwards and is added to taken into account a sharp increase in the registered population figure in 1991, which causes a shift in the level of GDP/capita. Step dummies are restricted to lie in the cointegrating space and appear as variables in the cointegrating relationship (Hendry and Juselius, 2001).
Constant terms are included in the cointegrating relationships, but not reported.
t-statistics in [ ].

Rejection of the null hypothesis means there is evidence of long run causality going from the variables in the ECT to GDP. Toda and Phillips (1993) propose testing weak exogeneity as a joint test on both the α and β coefficients. We follow this approach and impose restrictions on the β coefficients to identify the cointegrating relationships as well as on the α coefficients to test whether the variables in the cointegrating vectors also enter each of the error-correction equation. Thus, a test of long-run causality going from STOCK to GDP is a joint test $H_0 : \beta_{12} = \alpha_{11} = 0$. Rejection of the null hypothesis implies that there is a causal link going from stock market capitalization to GDP in the long run. However, long-run causality does not mean causality in the Granger sense since it does not take into account the short-run dynamics. Therefore, we perform a second causality test: a short-run Granger non-causality test on the γ coefficients in equation (3). In this case, a test of short-run causality going from stock market capitalization to GDP is a test of the null hypothesis: $H_0 : \gamma_{12} = 0$.

The third causality test we perform is a stronger notion of exogeneity which involves testing the joint hypothesis of short-run and long-run causality (Charemza and Deadman, 1992). Hence the null hypothesis is $H_0 : \gamma_{12} = \alpha_{11} = 0$. The rejection of the null hypothesis implies an overall causality from STOCK to GDP without distinguishing between long-term and short-term causality.

All previous tests are based on likelihood ratios that follow a χ^2 distribution as long as all the parameters of the equation can be rearranged as coefficients of I(0) variables at the same time (Sims, Stock and Watson, 1990). However, rearranging all the parameters as coefficients of I(0) variables assumes the cointegration rank has been accurately estimated. Toda and Yamamoto (1995) derive a causality test which does not require any prior knowledge of the order of cointegration of the variables. Their methodology proposes testing for causality in the level VAR equation, by fitting an augmented *VAR(p+d)* to the data, where d is the order of integration of the variables in the VAR with p lags. Toda and Yamamoto (1995) show that tests on the coefficients of the first p lags of such a model have standard asymptotic inferences which are assured by the additional lags added.

Our fourth causality test is the Toda and Yamamoto (1995) test on the augmented level VAR in equation (1) by one lag, since our variables are I(1). The equation determining GDP, for example, in a VAR(2) becomes:

$$\begin{aligned} GDP_t &= b_{11}^{(1)} GDP_{t-1} + b_{12}^{(1)} STOCK_{t-1} + b_{13}^{(1)} CRED_{t-1} + b_{14}^{(1)} STOCKVOL_{t-1} + b_{15}^{(1)} FRAG_{t-1} \\ &\quad + b_{11}^{(2)} GDP_{t-2} + b_{12}^{(2)} STOCK_{t-2} + b_{13}^{(12)} CRED_{t-2} + b_{14}^{(2)} STOCKVOL_{t-2} + b_{15}^{(2)} FRAG_{t-2} \\ &\quad + b_{11}^{(3)} GDP_{t-3} + b_{12}^{(3)} STOCK_{t-3} + b_{13}^{(3)} CRED_{t-3} + b_{14}^{(3)} STOCKVOL_{t-3} \\ &\quad + b_{15}^{(3)} FRAG_{t-3} + \varepsilon_{1t}. \end{aligned} \tag{4}$$

Toda and Yamamoto (1995) show that a F-test with the null that the first two lags of STOCK are zero: $H_0 : b_{12}^{(1)} = b_{12}^{(2)} = 0$ is asymptotically distributed as $\chi^2(2)$. Again, rejection of the null hypothesis points to causality going from STOCK to GDP, in the Granger sense.

All the causality tests performed are presented in Appendix Tables D.1 and D.2[12]. Given that the four tests capture different types of causality, results are not always consistent among them. We discuss causality if at least two of the tests are significant at a 5% level. The summary of all the causality tests is presented in Tables 4 and 5.

[12]We report only the causality tests between GDP and our proxies for financial development, since the other variables are not the main focus of our study.

For the sample of 13 market-based economies in Table 4, we find evidence of a causal link going from stock market capitalization to GDP in four of the countries, while a bi-directional relationship is found in other four. Reverse causality is present in New Zealand, Singapore, South Korea. Weak evidence of reverse causality is also present in UK which is consistent with Arestis et al. (2001). Our findings confirm Rioja and Valev's (2004) result of weak causality for advanced economies if we look at the across country results for some of the most advanced nations in our sample, i.e. US, UK, France, Italy and Germany, all of which present weak causality links [13].

The relationship between banking sector development and GDP in the sample of market-based countries is rather mixed and weak, at best. We find evidence of *both* financial sectors causing GDP in only two countries: Ireland and Japan. Overall, for the sample of market-based economies, the most compelling evidence points to a strong causal link between stock market development and GDP. However, causality patterns are mixed and country specific and support both a bi-directional link as well as unidirectional causality.

Turning now to the sample of bank-based economies, we present the results in Table 4. Here, we find an even clearer evidence that STOCK causes GDP in six of the 13 countries. Moreover, a bi-directional relationship between the two is found in other three countries: Greece, Norway and Turkey. The only evidence of reverse causality from GDP to both measures of financial development is seen in Malaysia. This result is in line with Ang and McKibbin (2007) who also use a time series approach and study just the experience of Malaysia.

While the relationship between stock markets and economic development appears to be consistent in the two types of economies, the causal link between CRED and GDP points to a clearer evidence of bi-directional and reverse causality in the case of bank-based economies. Thus, GDP is found to cause long-run bank development in Austria, Germany, Norway and Malaysia, while a bi-directional relationship is found in seven other countries. There is no causal link going from CRED to GDP in the sample of bank-based economies.

The results summarized above reflect both a long and short-term causal link. We also tested explicitly for short-term causality since recent empirical evidence has been concerned with the short-run effect that financial development might have on output growth. Results presented in Appendix Tables D.1 and D.2 point to a weak short-run causal link. In market-based economies, there is some evidence of a positive short-run causality from stock market capitalization to GDP. However, in bank-based economies we find some evidence of negative short-run causality going from GDP to bank development. These results are consistent with Christopoulos and Tsionas (2004) for a sample of developing countries and only partially supportive of the negative short-run causality found by Loayza and Ranciere (2006).

[13] The weak causality links between banking system development and GDP in the US and UK is also documented in Arestis et al. (2001). Despite the large financial sector in these two countries, there results may not be surprising. Our measure of banking sector development captures traditional intermediation activities which enhance growth by contributing to an efficient allocation of resources. However, the recent growth of the financial sector, especially in developed countries, has mainly been driven by non-intermediation activities, which have been found to have less impact on economic growth (see Beck, Degryse and Kneer, 2013).

Table 4: Causality patterns in market-based economies

Country	GDP→CRED	CRED→GDP	GDP→STOCK	STOCK→GDP	GDP↔ CRED	GDP↔ STOCK
Australia						**
Canada	*			**		
Ireland		*		**		
Japan		**		*		
Netherlands					**	**
New Zealand			**			
Singapore	*		**			
South Korea			*			
Sweden				**	**	
Switzerland						**
Thailand						
UK			*			
USA						**

Tables present the summary of the four causality tests shown in Appendix Tables D.1 and D.2.
"→"/"↔ " symbolizes a unidirectional/bidirectional causality.
*/** represent a weak/strong evidence of causality depending on the number of tests that support the evidence and the statistical level of significance.
GDP is the log of real GDP/capita, STOCK is the log of the ratio of stock market capitalization to nominal GDP, CRED is the log of the ratio of domestic credit to nominal GDP.

Table 5: Causality patterns in bank-based economies

Country	GDP→CRED	CRED→GDP	GDP→STOCK	STOCK→GDP	GDP↔ CRED	GDP↔ STOCK
Austria	**		**			
Denmark				**	**	
Finland				**	*	
France				*		
Germany	*			*		
Greece					*	**
Italy					*	
Malaysia	*		*			
Mexico				**	*	
Norway	**					**
Spain				**	*	
South Africa	**					
Turkey					**	**

Tables present the summary of the four causality tests shown in Appendix Tables D.1 and D.2.
"→"/"↔ " symbolizes a unidirectional/bidirectional causality.
*/** represent a weak/strong evidence of causality depending on the number of tests that support the evidence and the statistical level of significance.
GDP is the log of real GDP/capita, STOCK is the log of the ratio of stock market capitalization to nominal GDP, CRED is the log of the ratio of domestic credit to nominal GDP.

Our results contribute to the finance-growth literature in several ways. The first notable implication of our findings is that countries experience rather different causality patterns in the finance-growth nexus and that these differences mainly stem from the type of financial institution considered. While previous works such as Demetriades and Hussein (1996) or Luintel et al. (2008) have also stressed the significant cross-country heterogeneity in the causal link between finance and growth, we show here how this link depends on the type of financial institution. At the same time, most time series research focuses solely on banking sector proxies in developing countries (see, for example, Ang and McKibbin, 2007; Christopoulos and Tsionas, 2004; Luintel and Khan, 1999; Demetriades and Hussein, 1996). We look at countries with relatively high levels of development and find that a causal relationship from finance to growth is mainly supported when financial development comes from stock markets. Several theoretical models echo our results by pointing out how stock markets contribute more to economic growth at higher levels of financial development (see Dewatripont and Maskin, 1995; Boot and Thakor, 1997; Boyd and Smith, 1998). For example, in Boot and Thakor (1997) markets improve real sector decisions and outcomes through the feedback from market prices, and the value of this market information is higher in economies characterized by better institutions and less prone to moral hazard, i.e. at higher levels of development.

Second, since we find very little evidence that both measures of financial development cause GDP, our results suggest that the finance-led growth hypothesis requires modification. In particular, given that our sample includes a time period in which the financial sector has developed intensively, results point towards a change in the finance-growth nexus at higher levels of financial development. For example, Rousseau and Wachtel (1998) document a strong causality from finance to growth before the 1930's for five industrialized economies: US, UK, Canada, Norway and Sweden. We show that, at higher levels of financial development, this strong causality seems to vanish if we look at the results for UK and US or is bidirectional, at most, if we consider Canada, Norway and Sweden. A theoretical intuition for this weakening effect is provided in Deidda (2006). He shows how high levels of financial development might be inefficient because a "very big" financial sector consumes real resources which offsets its contribution to economic growth.

Lastly, our findings complement recent evidence which suggests that financial structure matters, since we uncover different causality patterns among market and bank-based economies. A supply-leading hypothesis is more supported in market-based economies. At the same time, evidence points towards a stronger reverse causality between domestic bank credit and GDP in bank-based societies. One channel through which market-based financial systems may matter more for growth is through the funding of more innovative, young companies. Brown, Fazzari and Petersen (2009) bring microevidence that the boom in research and development spending seen in the US during the 1990s was mainly funded through equity finance. Similarly, Brown, Martinsson and Petersen (2012) highlight the importance of stock market development for European firms' R&D investments. Given the undeniable role of R&D investments in endogenous growth models, stock markets may be an important driver of growth, especially at higher levels of development. An alternative explanation provided in Fecht et al. (2008), is that market-oriented financial systems might yield more growth because capital markets tend to promote more investment in productive assets than banks which are more concerned with intertemporal risk sharing. While our findings do not shed light on the particular channels through which market-based financial systems might contribute to higher growth, they provide empirical support to an increasing role of stock markets. Indeed, our results suggest that, at higher levels of development, stock market development plays a causal role in the growth of economies, while the banking sector does not.

5 Conclusions

The growing importance of financial institutions over the past decades has fueled a large body of research over its effects on economic development. Despite the fact that the finance-growth nexus has been extensively analyzed, recent evidence and events have challenged many of the stylized facts derived during the 1990s.

This paper contributes to the finance-growth literature by presenting evidence that causality patterns between finance and growth differ depending on whether financial development stems from the banking sector or stock markets.

We study the time series properties of economic and financial development and find that the finance-led growth hypothesis derived from cross-country studies is weakened and sometimes reversed. Financial development, measured by both the development of the banking sector and stock markets, determines GDP in only two of the countries in our sample. Thus, our time-series country-by-country approach draws caution to the broad-brush picture of causality obtained from cross-country regressions.

We examine the causality of the finance-growth nexus using several econometric tests to ensure that our findings do not critically hinge on methodological choices. We find that stock market development exerts a stronger causal influence on economic development: stock market capitalization causes GDP in ten of the countries. By contrast, the relationship between banking sector development and GDP is bi-directional most of the time, with evidence of reverse causality in eight of the countries. Luintel and Khan (1999), Shan, Morris and Sun (2001) and Calderon and Liu (2003) also find a bi-directional causality between banking sector development and growth for a sample of developing countries. We look at countries with relatively advanced capital markets and show that the impact of banking sector development is less strong at high levels of stock market development.

Our study also adds to the recent evidence (Luintel et al., 2008; Demirguc-Kunt et al., 2012) that the structure of the financial sector may matter in explaining the finance-growth nexus. We find that causality patterns differ in market-based versus bank-based economies. In economies dominated by banks, we find stronger evidence of reverse and bi-directional causality between GDP and bank development as compared to market-based systems. In market-based economies, evidence points towards a more robust link between financial and economic development, both measures of financial intermediation entering the cointegrating relationship in eight of the 13 countries. Moreover, consistent with Rioja and Valev (2004), our evidence supports the view of a weakening finance-growth link for developing countries. Causality patterns in the most developed countries in our sample are weak, at best. Thus, we show that the leading role that financial intermediation has played in industrialized countries (see Rousseau and Wachtel, 1998) appears to vanish when we consider a period in which the financial sector has developed extensively.

Our results confirm the need to reassess the causal link between the financial sector and economic growth; the general notion that finance causes growth may no longer be empirically valid when recent data is employed and both types of financial sectors are considered. Further empirical research may be directed towards disentangling the mechanisms through which the two different types of financial institutions affect the real sector. Beck, Demirguc-Kunt, Laeven and Levine (2008) make a first step in this direction by showing how the development of the financial sector has a disproportionate positive effect on small firms. Research along these lines might lead to the formulation of financial sector policies that shape its development in directions which bring a positive contribution to economic growth.

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Appendix

A Definitions and sources of variables

Table A.1: Definitions and sources of variables

Variable	**Definition and construction**	**Source**
Real GDP* (GDP)	Logarithm of real GDP per capita (seasonally adjusted)	Authors' calculation based on nominal GDP data extracted from IMF-IFS Database, CPI and population data obtained from Datastream
Stock Market Capitalization (STOCK)	Logarithm of the ratio of stock market value to nominal GDP	Stock market value was obtained from Datastream (code: TOTMK...(MV))
Domestic Bank Credit (CRED)	Logarithm of the ratio of domestic bank credit to nominal GDP	Domestic bank credit was obtained from IMF-IFS Database (line 32-Domestic claims)**
Stock market volatility (STOCKVOL)	Logarithm of quarterly standard deviation of stock market returns	Authors' calculation based on end-of-week stock prices returns (code: TOTMK...(PI))
Bank fragility (FRAG)	Logarithm of an eight-quarter moving standard deviation of the growth rate of domestic bank credit to nominal GDP	Authors' calculation

*GDP data is seasonally adjusted, either from source or by the authors using the U.S. Department of Commerce quarterly seasonal adjustment method, X-12.

**Domestic credit to the private sector (line 32d in the IMF IFS database) is often used in other research, however due to lack of sufficiently long time series for this variable, we employ a more aggregate measure, domestic claims (line 32) which includes net claims on Government and as well as the private sector.

B Johansen Cointegration

In this appendix, we discuss some of the caveats that the Johansen cointegration method faces in empirical applications and detail the steps we carry out prior to testing cointegration in this framework.

First, we test the integration properties of each variable using the Augmented Dickey-Fuller (ADF) procedure. The null hypothesis of a unit root, in the presence of an intercept, cannot be rejected for the main variables capturing economic and financial development: GDP, CRED, STOCK. For the variables capturing stock market volatility and bank fragility the null hypothesis is sometimes rejected, thus suggesting the stationarity of these variables. We re-test for stationarity allowing for different number of lags and using the procedure proposed by Kwiatkowski, Phillips, Schmidt and Shin (1992) (KPSS). The evidence of stationarity is less consistent, however still present in some cases. For brevity, the results are not reported here, but can be obtained from the authors. All series are I(0) in the first difference.

Second, we parameterize the deterministic component D_t in equation (1). We allow for an unrestricted constant in the VAR which accounts for linear trends in the level data, but not for a trend in the cointegrating relationship. This unrestricted constant can be decomposed to allow for both linear trends in the data generating process and a non-zero intercept in the cointegrating vectors (Hendry and Juselius, 2001). Our data is best represented by this specification since the log variables are trending over time, while we expect to find stable cointegrating relations. D_t also includes unrestricted (innovational) dummies added to whiten the residuals. Following Hendry and Juselius (2001), we detect outliers larger that $\pm 3\hat{\sigma}$, for which we introduce unrestricted impulse dummies[14]. The introduction of impulse dummies leaves the asymptotic distributions of the cointegration model unaffected (Bohn Nielsen, 2004), while ignored innovational dummies have only minor consequences for small sample inferences of the cointegration rank (Doornik, 1998).

Next, since the Johansen method has been shown to be sensitive to the lag length, we determine the proper number of lags using the Akaike (1974) and Schwarz (1978) information criteria. Charemza and Deadman (1992) argue that the lag length ought to be set such that the VAR residuals are free of autocorrelation, even if this implies relatively long lags. We follow both approaches to estimate the optimal lag length. However, if the information criteria suggest a lag length for which autocorrelation is still present, we set the number of lags such that the VECM residuals are uncorrelated, as the Johansen method proposes (see Hendry and Juselius, 2001). As a robustness checks, we re-test for the number of cointegrating vectors when different lag lengths are allowed. Generally, results are qualitatively the same. Some exceptions are worthwhile noting. For example, in Table 1 in case of Sweden and Japan, when we allow for one lag, the null hypothesis of two cointegrating vectors is rejected in favor of the alternative of at least three. For these two cases, the Akaike (1974) or Schwarz (1978) information criteria suggest one lag, for which the LM-statistic shows no serial correlation in the residuals. However, the number of cointegrating vectors under one lag is not stable, since the recursively estimated third eigenvalue does not appear different from zero and the third cointegrating vector does not appear stationary. Thus, we retest for cointegration using two lags in the VAR and find evidence of only two cointegrating vectors. Since the Johansen cointegration test is more sensitive to under-parametrization than to over-parametrization of the lag length, we allow for two cointegrating vectors in both countries. Similar robustness tests have been performed in the case of The Netherlands and Singapore, where the cointegrating rank is also sensitive to the lag specification: only two cointegrating vectors are found in both countries when we allow for one lag.

[14]The list of impulse dummies introduced for each country is not presented here, but can be obtained from the authors.

C Fully modified OLS

Appendix Table C.1: FMOLS estimates: Market-Based Economies

The estimated system is: $x_t = \gamma z_t + u_{1t}$; $z_t = z_{t-1} + u_{2t}$, where x_t is the normalized variable, GDP in the first cointegrating relationship and STOCK\CRED in the second and z_t is a vector of the other variables. The fully modified OLS estimate of γ is: $\gamma_{FMOLS} = \left(\sum_{t=1}^{T} z_t^2\right)^{-1}\left[\left(\sum_{t=1}^{T} x_t^{+} z_t\right) - T\hat{\delta^{+}}\right]$, where $x_t^{+} = x_t - \hat{\omega}_{12}\hat{\omega}_{22}^{-1}\Delta z_t$, $\hat{\delta}^{+}$ is the bias correction term: $\hat{\delta}^{+} = \hat{\Lambda}\begin{bmatrix} 1 \\ -\hat{\omega}_{22}^{-1}\hat{\omega}_{21} \end{bmatrix}$, $\hat{\Lambda} = \sum_{k=0}^{\infty} E\left(u_{20}u_k^{'}\right)$ and the long-run variance is $\Omega = \{\omega_{i,j}\}_{i,j=1,2}$ (see Banerjee, 1993).

Country	First cointegrating relationship					Second cointegrating relationship				
	GDP	STOCK	CRED	STOCKVOL	FRAG	GDP	STOCK	CRED	STOCKVOL	FRAG
Australia	1	-0.23		-0.03						
		(0.00)		(0.09)						
Canada	1		-0.49	-0.03						
			(0.00)	(0.27)						
Ireland	1	-0.27	-0.43	0.10						
		(0.00)	(0.00)	(0.01)						
Japan	1	-0.10	-1.04	-0.05			1		-0.86	0.26
		(0.00)	(0.00)	(0.14)					(0.00)	(0.07)
Netherlands	1	-0.05	-0.41				-0.30	1	- 0.24	0.01
		(0.00)	(0.00)				(0.00)		(0.01)	(0.94)
New Zealand	1		-0.47	0.07						
			(0.00)	(0.00)						
Singapore	1	-0.86	0.04				1	-1.37	0.34	
		(0.00)	(0.75)					(0.00)	(0.03)	
South Korea	1	-0.02	-0.67		0.20					
		(0.69)	(0.00)		(0.00)					
Sweden	1	-0.09	-0.23				1		-0.58	0.85
		(0.00)	(0.00)						(0.00)	(0.20)
Switzerland	1	-0.04	-0.39	-0.01						
		(0.00)	(0.00)	(0.37)						
Thailand	1		-0.58	0.27						
			(0.01)	(0.02)						
UK	1	-0.35		-0.14	0.02					
		(0.00)		(0.01)	(0.63)					
USA	1	-0.30		0.03	-0.01					
		(0.00)		(0.26)	(0.91)					

p-values in ( )

Appendix Table C.2: FMOLS estimates: Bank-based economies

The estimated system is: x_t=γz_t+ u_{1t}; z_t= z_{t-1}+ u_{2t}, where x_t is the normalized variable, GDP in the first cointegrating relationship and STOCK\CRED in the second and z_t is a vector of the other variables. The fully modified OLS estimate of γ is: $\gamma_{FMOLS} = \left(\sum_{t=1}^{T} z_t^2\right)^{-1}\left[\left(\sum_{t=1}^{T} x_t^+ z_t\right) - T\hat{\delta^+}\right]$, where $x_t^+ = x_t - \hat{\omega}_{12}\hat{\omega}_{22}^{-1}\Delta z_t$, $\hat{\delta}^+$ is the bias correction term: $\hat{\delta}^+ = \hat{\Lambda}\begin{bmatrix} 1 \\ -\hat{\omega}_{22}^{-1}\hat{\omega}_{21} \end{bmatrix}$, $\hat{\Lambda} = \sum_{k=0}^{\infty} E\left(u_{20}u_k^{'}\right)$ and the long-run variance is Ω=$\{\omega_{i,j}\}_{i,j=1,2}$ (see Banerjee, 1993).

Country	First cointegrating relationship					Second cointegrating relationship				
	GDP	STOCK	CRED	STOCKVOL	FRAG	GDP	STOCK	CRED	STOCKVOL	FRAG
Austria	1		-0.81		-3.27		1	-4.52	-4.26	
			(0.00)		(0.33)			(0.00)	(0.00)	
Denmark	1	-0.12	-0.07	0.03						
		(0.00)	(0.00)	(0.05)						
Finland	1	-0.27	-0.50	-0.03				1	0.02	0.49
		(0.00)	(0.00)	(0.28)					(0.70)	(0.00)
France	1	-0.11		-0.01	0.01					
		(0.00)		(0.37)	(0.88)					
Germany	1		-1.19	-0.01			0.25	1	-0.01	
			(0.00)	(0.83)			(0.00)		(0.71)	
Greece	1		-0.04		0.02		-0.16	1		
			(0.73)		(0.73)		(0.00)			
Italy	1		-0.77	0.10						
			(0.00)	(0.06)						
Malaysia	1	-0.44	0.20		0.13					
		(0.00)	(0.42)		(0.01)					
Mexico	1	-0.08	0.58				- 0.01	1	-0.15	
		(0.00)	(0.00)				(0.73)		(0.00)	
Norway	1		-0.94	0.22						
			(0.00)	(0.00)						
Spain	1	-0.22	-0.15				-0.35	1	-0.07	
		(0.00)	(0.00)				(0.00)		(0.55)	
South Africa	1		-0.54	0.02						
			(0.00)	(0.30)						
Turkey	1		-0.92		-0.28		-0.38	1	0.37	
			(0.00)		(0.05)		(0.00)		(0.00)	

p-values in ( ).

D Causality tests

Appendix Table D.1: Causality tests: Market-Based Economies

Country	AU	CA	IE	JP	NL	NZ	SG	KR	SE	CH	TH	GB	US
GDP→ CRED													
WEX	1.76	6.13**	0.01	0.03	35.77***	2.36	12.4**	3.21*	22.79***	0.20	0.49	3.02*	1.08
SRG	0.75	0.01	2.24	0.22	0.37	0.03	1.87	0.18	0.05	0.26	0.05	0.08	1.31
STE	2.46	6.13**	2.39	0.29	37.46***	2.38	13.15***	3.47	23.91***	0.67	0.66	3.02	3.40
T&Y	0.08	0.92	0.57	0.08	9.57**	0.03	3.45	0.21	6.11**	0.09	9.74	0.22	2.40
CRED→ GDP													
WEX	-	0.01	35.04***	12.38***	7.91**	1.97	1.44	0.02	7.42***	4.62**	0.71	1.39	-
SRG	0.14	0.42	0.71	2.03	4.65**	0.01	0.09	0.03	0.06	0.57	0.17	0.79	0.44
STE	-	0.43	36.81***	17.48***	8.19**	2.01	1.57	0.06	7.53**	5.34*	1.12	0.79	-
T&Y	0.28	0.65	1.92	4.13**	5.55	0.18	4.04	0.01	1.2	0.1	2.57	1.28	4.11
GDP→ STOCK													
WEX	9.41***	0.13	0.01	0.06	9.25***	6.85***	9.19***	7.47***	0.64	12.20***	0.86	8.25***	15.44***
SRG	1.3	1.23	0.01	2.71*	5.34**	3.13*	17.81***	1.00	2.20	1.92	0.46	0.18	1.18
STE	10.89***	1.36	1.5	2.71	11.33***	9.61***	23.79***	8.22**	3.35	18.99***	1.08	9.03**	15.45***
T&Y	3.12*	0.08	3.13	0.01	3.75	0.98	16.13***	2.78*	2.44	0.68	4.57	0.87	2.53
STOCK→ GDP													
WEX	1.7	-	35.04***	18.46***	7.91**	-	1.44	0.04	9.62***	4.62**	-	1.39	7.73***
SRG	5.37**	6.53**	0.72	0.14	4.08**	0.86	0.06	3.05*	1.18	0.33	0.28	0.46	8.41***
STE	7.48**	-	37.94***	21.82***	22.72***	0.86	1.43	3.22	15.71***	7.67**	-	2.28	20.94***
T&Y	9.01***	10.16***	6.43**	2.41	15.85***	3.01*	1.17	3.86**	7.84***	0.45	0.01	1.66	16.01***

Table presents the log-likelihood statistics of the causality tests distributed $\chi^2(1)$ for the statistics that are not underlined, $\chi^2(2)$ for the statistics underlined with one line and $\chi^2(3)$ for the statistics underlined with two lines.
GDP is the log of real GDP/capita, STOCK is the log of the ratio of stock market capitalization to nominal GDP, CRED is the log of the ratio of domestic credit to nominal GDP.
WEX is the weak exogeneity test under the null: $H_0 : \alpha_{ij} = \beta_{ij} = 0$
SRG is the short-run Granger causality test under the null: $H_0 : \Gamma^p_{ij} = 0$, distributed $\chi^2(1)$.
STE is the strong exogeneity test under the null: $H_0 : \Gamma^p_{ij} = \alpha_{ij} = 0$.
T&Y is the Toda & Yamamoto(1995) causality test for level VARs.
*/**/*** represent significance at 10%/5%/1% level.

Appendix Table D.2: Causality tests: Bank-Based Economies

Country	AT	DK	FI	FR	DE	GR	IT	NO	SP	MY	MX	ZA	TR
GDP→ CRED													
WEX	10.46***	5.45**	17.68***	1.21	5.23**	0.01	0.31	2.27	0.81	6.39**	4.99**	8.75***	47.00***
SRG	6.11***	0.12	0.08	0.75	0.43	4.43**	7.21**	3.32*	4.48**	1.28	2.53	0.19	0.79
STE	13.60***	13.72***	1.62	2.46	5.54*	4.69*	7.21**	6.82**	4.51	6.52**	9.16**	8.76**	47.79***
T&Y	4.89*	11.26***	0.01	2.61	3.58	2.04	0.06	6.90**	2.12	0.2	0.05	5.91**	4.72*
CRED→ GDP													
WEX	4.44	17.22***	21.60***	-	3.35	27.02***	6.27**	2.6	24.01***	0.80	6.00**	0.39	77.57***
SRG	0.03	0.28	0.15	1.29	2.49	1.88	4.54**	1.64	2.63	0.18	1.02	0.74	24.43***
STE	4.83	17.41***	15.27***	-	5.16	27.85***	12.47***	3.74	25.58***	1.11	11.19**	1.13	86.30***
T&Y	0.13	1.38	0.09	1.35	5.16*	1.7	5.01**	6.15**	0.39	0.83	5.95**	0.18	10.79**
GDP→ STOCK													
WEX	1.34	0.08	0.32	3.56*	0.06	11.03***	1.79	2.91*	0.13	7.44***	0.24	3.05*	12.83***
SRG	8.68***	0.12	3.28*	0.01	0.31	0.21	1.07	4.38**	0.03	5.42**	1.98	1.22	0.03
STE	8.92***	0.22	4.53	3.78	0.39	11.16***	2.37	6.19**	0.24	9.87***	2.04	3.72	12.86***
T&Y	5.97*	0.45	1.59	0.1	0.61	0.77	1.02	7.02**	0.35	1.33	0.88	0.97	1.61
STOCK→ GDP													
WEX	1.37	17.22***	20.14***	5.18**	3.34*	23.81***	-	-	24.01***	0.80	6.00**	-	5.72**
SRG	2.22	3.65*	1.67	0.82	1.27	16.13***	0.25	4.89**	0.25	0.85	3.41*	0.08	0.01
STE	4.38	28.46***	24.40***	6.19**	6.86**	41.00***	-	-	31.19***	1.77	13.60***	-	6.12**
T&Y	2.44	13.72***	10.56***	0.03	5.12*	25.43***	0.01	6.14**	6.32**	1.61	5.43**	2.11	1.56

Table presents the log-likelihood statistics for the causality tests distributed $\chi^2(1)$ for the statistics that are not underlined, $\chi^2(2)$ for the statistics underlined with one line and $\chi^2(3)$ for the statistics underlined with two lines.

GDP is the log of real GDP/capita, STOCK is the log of the ratio of stock market capitalization to nominal GDP, CRED is the log of the ratio of domestic credit to nominal GDP.

WEX is the weak exogeneity test under the null: $H_0 : \alpha_{ij} = \beta_{ij} = 0$.

SRG is the short-run Granger causality test under the null: $H_0 : \Gamma^p_{ij} = 0$, distributed $\chi^2(1)$.

STE is the strong exogeneity test under the null: $H_0 : \Gamma^p_{ij} = \alpha_{ij} = 0$.

T&Y is the Toda & Yamamoto(1995) causality test for level VARs.

*/**/*** represent significance at 10%/5%/1% level.