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Financial structure on growth and volatility☆

Chih-Chuan Yeh [a], Ho-Chuan (River) Huang [b,*], Pei-Chien Lin [c]

[a] Department of Finance, Overseas Chinese University, Taiwan, ROC
[b] Department of Banking and Finance, Tamkang University, Taiwan, ROC
[c] Department of Industrial Economics, Tamkang University, Taiwan ROC

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ABSTRACT

By applying the pooled mean group estimator to a large panel up to 40 countries over the 1960–2009 period, this study finds that financial structure is significantly cointegrated to both economic growth and its volatility. In particular, the relationship is positive in nature, suggesting that more market-based countries enjoy faster economic growth but suffer more from economic fluctuations in the long run. Accordingly, in sharp contrast to the existing evidences, we conclude that the architecture of an economy's financial system matters for real sector performance. Moreover, the findings are robust to a variety of sensitivity checks, including the problem of endogeneity, the use of different financial structure (and growth volatility) indicators, the inclusion of extra growth (volatility) determinants, and the control of cross-sectional dependence in the panel data.
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1. Introduction

This study empirically re-assesses the long-debated issue that whether the financial architecture of a country exerts any discernible effect on economic growth, and also offers additional fresh evidence on the potential influences of financial structure on the volatility of growth rates. Arguably, the existing theories generally emphasize specific features of banks and markets and often provide contrasting, even conflicting, predictions concerning the possible impacts of financial structure, measured by the mix of financial markets and intermediaries operating in a country, on economic growth. On one hand, the advocates of bank-based financial systems assert that banking sectors are better at fostering economic performance through their relative skills in (i) producing information and improving capital allocation and corporate governance, (ii) ameliorating risk and enhancing investment efficiency, and (iii) mobilizing capital to take advantage of economies of scale, e.g., Levine (2002, p. 399). On the other hand, the proponents of market-oriented financial systems stress the growth-improving role of well-functioning stock markets by (i) promoting higher motive to research firms as it is much simpler to profit from this information in a large, liquid market, (ii) enhancing better corporate governance, and (iii) facilitating richer risk management, e.g., Levine (2002, p. 400).[1] Apparently, there is hardly any consensus at the theoretical front, and the relative merits of bank-oriented versus market-oriented financial systems remain an empirical issue.

To evaluate the precise relationship between financial structure and economic growth, earlier empirical works often concentrate on Japan and Germany as bank-based systems and the United Kingdom and the United States as market-based systems. However, as argued in Levine (2002), it is unlikely to reach general conclusions about the growth effects of bank-based and market-based financial architecture based on only four economies, particularly those four countries that share very comparable long-run growth patterns. In order to provide international evidence on the role of financial structure on growth, Levine (2002) constructs a large data set for 48 countries that encompasses wide-ranging national experiences. By averaging the time-series data for each country over the 1980–1995 period, i.e., one observation per country, Levine (2002) employs cross-sectional analysis to assess four competing theories of financial structure, namely, the bank-based view, the market-based view, the financial-services view, and the law

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* Corresponding author at: Department of Banking and Finance, Tamkang University, #151, Yingzhuan Rd., Danshui Dist., New Taipei City 25137, Taiwan, ROC.
E-mail address: river@mail.tku.edu.tw (H.-C.(R.) Huang).

[1] Moreover, other hybrid views suggest that banks and stock markets are important for growth under different conditions. Boyd and Smith (1998) argue that, while banks play an important role in promoting growth in the early stages of economic development, stock markets are more beneficial for growth as economic development advances. Similarly, Rajan and Zingales (1998a) declare that bank-based systems have a comparative advantage in countries with weak legal institutions but, as the contractual environments become stronger, the economies will benefit more from getting more market-oriented.

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and finance view. By minimizing the significance of the bank-based versus market-based debate, the financial-services view highlights that the key issue is the overall financial services themselves that are provided by the financial systems are by far the most relevant, whether they are provided by banks or markets is of second-order importance. Moreover, as a notable and special case of the financial-services view, the law and finance view emphasizes that a well-operating legal system facilitates the functions of both banks and markets and thereby stimulates economic growth.

The empirical results of Levine (2002) are demonstrative in that, while the cross sectional data strongly support both the financial-services and the law and finance views, there is no evidence in favor of either the bank-based or the market-based perspective. Notably, the findings are robust to a variety of sensitivities checks that utilizes alternative indicators of financial structure, distinct data sets, and different econometric approaches. As such, the paper's primary conclusion is that classifying economies by their financial architecture is unlikely to be an effective way in explaining cross-country differences in long-run economic growth. In addition, Beck and Levine (2002) employ the Rajan and Zingales' (1998b) empirical specification to a large panel of 42 countries and 36 industries to investigate the association between financial structure and both industry growth and new establishments. Again, the results indicate that distinguishing whether a country is bank-based or market-based does not improve our understanding of the industrial growth patterns and the formation of new establishments. Furthermore, they find that the structure of the financial system does not help the efficiency of capital allocation across countries.[2] Another related paper by Demirgüç-Kunt and Maksimovic (2002) uses firm-level data to demonstrate that the difference in the organization of financial systems is not significantly related to the ability of firms' access to obtain external financing and is, therefore, not a robust predictor for economic growth.

In sharp contrast, there are also studies documenting that financial structure exerts a statistically significant and economically important effect on economic growth. For instance, Tadesse (2002) examines the relative performance of bank-oriented versus market-oriented systems differs among countries with alternative level of financial development and with diverging size distribution of firms. The results from using industry-level data of a panel of 36 countries reveal that banks outperform (underperform) markets among less (more) financially developed economies, and countries dominated by smaller (larger) firms grow faster in bank (market)-based financial systems. Thus, financial structure matters for real sector performance. In addition, Pinno and Serletis (2007) apply a standard Bayesian classification (mixture) approach to the data set of Levine (2002), and find evidence in support that economic growth benefits more from bank-based (market-based) financial systems in developing (developed) countries. Similarly, Luintel et al. (2008) and Arestis et al. (2010) uncover significant heterogeneity in cross-country parameters and adjustment dynamics and suggest the use of (mainly) time series approaches in analyzing the role of financial structure in economic performance. Their outcome indicates that the structure of financial systems significantly explains real per capita *output* level for the majority of sample countries under investigation.

In fact, the findings of Luintel et al. (2008) and Arestis et al. (2010) are not inconsistent with that of Levine (2002), since they are actually analyzing the effect of financial structure on the level of economic development (proxied by the logarithm of real GDP per capita) while Levine (2002) is assessing the impact of financial structure on economic growth (proxied by the first difference of the logarithm of real GDP per capita). While financial structure is associated with higher level of real per capita GDP, it does not necessarily imply that growth is faster as well. As a complement to the existing empirical evidences, this study first relies upon a panel data of 40 countries over the 1960–2009 period and a (pooled) mean group estimator to explore the long-run linkage among *growth*, financial structure, and other conditioning variables. On balance, the results indicate that there is an equilibrium relation between economic growth and financial architecture, along with other growth determinants. In particular, the financial structure–growth nexus is statistically significant and positive in nature, suggesting that economic growth is faster in more market-based countries. Furthermore, we proceed to assess whether financial structure plays any important role in determining the extent of growth volatility.[3] Overall, the panel results show that, after controlling for growth volatility determinants, there exists a significantly positive link between growth volatility and financial structure. In sum, we provide strong evidence in supporting to notion that financial structure not only matters for growth but also for growth volatility as well.

The paper is organized as follows. Section 2 discusses the empirical strategy. Section 3 describes the data sources. Section 4 analyzes the empirical results. Section 5 concludes the paper.

2. Empirical model

In a recent influential paper, Levine (2002) constructs a broad cross-country dataset for 48 countries to examine the comparable growth effect of market- and bank-based financial systems. In particular, most of the analyses involve pure cross-sectional analyses with one observation (averaged over the 1980–1995 period) per country. In contrast, we rely upon a large panel data set to explore not only the long-run effect of financial structure on economic growth, but also the possible long-term influence of financial structure on the volatility of growth rates. To do so, we will employ the pooled mean group (PMG) estimator, proposed by Pesaran et al. (1999), to obtain consistent estimates of financial structure (along with other growth or volatility determinants) variables. In a panel data structure, suppose that the long-run equilibrium association between the dependent variable y and the explanatory variable x (among which, a measure of financial structure) can be characterized as,

$$y_{it} = \theta_{0i} + \theta'_i x_{it} + \epsilon_{it} \tag{1}$$

where y_{it} is either the growth rate of real per capita gross domestic product or its corresponding volatility measure for country i in year t, and the vector x_{it} contains mainly an indicator of financial structure, along with other covariates. The coefficient of major interest is θ_i, which measures the long-run effect of x_{it} on y_{it}.

As suggested in Pesaran et al. (1999), Eq. (1) can be embedded into an autoregressive distributed lag (ARDL) model to allow for rich dynamics in the manner that the dependent variable y_{it} adapts to changes in the explanatory variables x_{it}, if any. The ARDL $(p,q,\cdots,q)$ model, i.e., the dependent and independent variables enter the right-hand side with lags of order $p, q, \cdots, q$, respectively, can be written as,

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij} x_{i,t-j} + \mu_i + \epsilon_{it} \tag{2}$$

where μ_i represents the country-specific effects.

[2] In the same line, Ndikumana (2005) also concludes that financial structure per se exert no independent effect on domestic investment in that it does not increase the response of investment to changes in output (per capita GDP), after controlling for the level of financial development and other determinants of investment.

[3] The recent literature points out that understanding growth volatility is important because growth stability, by itself, is an important policy objective (Mishkin, 2009), countries with higher growth volatility tend to have lower economic growth (Ramey and Ramey, 1995), larger growth volatility is associated with worsened income distribution (Breen and García-Peñalosa, 2005), and higher macroeconomic volatility shifts the Phillips curve outwards and generates more output and employment costs (Benigno and Ricci, 2011).

For estimation purpose, Eq. (2) can be further re-parameterized in a panel data error correction model as,

$$\Delta y_{it} = \phi_i\left[y_{i,t-1} - \theta'_i x_{i,t}\right] + \sum_{j=1}^{p-1}\lambda^*_{ij}\Delta y_{i,t-j} + \sum_{j=0}^{q-1}\delta^{*'}_{ij}\Delta x_{i,t-j} + \mu_i + \epsilon_{it} \tag{3}$$

where $\phi_i = -\left(1-\sum_{j=1}^{p}\lambda_{ij}\right)$, $\theta_i = -\beta_i/\phi_i$, $\beta_i = \sum_{j=0}^{q}\delta_{ij}$,

$$\lambda^*_{ij} = -\sum_{m=j+1}^{p}\lambda_{im}, j = 1, 2, \cdots, p-1$$

and

$$\delta^*_{ij} = -\sum_{m=j+1}^{q}\delta_{im}, j = 1, 2, \cdots, q-1.$$

Notice that the coefficient ϕ_i measures the error-correcting speed of adjustment. If growth (or, volatility) and financial structure variable along with other controlling variables are cointegrated, it is expected that ϕ_i has a significantly negative value so that the variables show a return to the long-run equilibrium. In other words, finding of a significantly negative estimate on ϕ_i can be regarded as evidence in favor of a long-run cointegrated relationship among all the variables.[4]

Eq. (3) can be estimated by a number of alternative estimation methods that differ on the extent to which they allow for parameter heterogeneity across countries. At one extreme, the conventional pooled (OLS) estimator imposes fully homogeneous coefficients in the model in a way that requires all slope and intercept parameters to be identical for each country.[5] At the other extreme, the mean group (MG) estimator of Pesaran and Smith (1995) permits completely heterogeneous parameters in the model (imposing no cross-country coefficient restriction) which can be estimated on a country-by-country basis. As long as N and T are large enough, the mean of long-run coefficients across countries can be consistently estimated by the unweighted average of the individual country parameter estimates. Somewhere between these two extremes, the pooled mean group estimator restricts the long-run slope coefficients to be equal across countries but permits the short-term coefficients and regression intercepts to be country specific. For brevity, we refer the interested readers to the more detailed description of those approaches in Pesaran et al. (1999).

3. Data description

For estimation purpose, we follow Loayza and Ranciere (2006) to include only countries with at least 25 consecutive annual observations in all variables to meet the requirements on the time series dimension of the data by using the PMG or MG procedures. [6] As a consequence, the full sample consists of a panel of annual observations for 40 developed and developing countries over the period 1960–2009.

In order to test whether or not financial structure matters for growth and its volatility, we need a measure of financial structure. Since, arguably, there is no widely accepted indicator of a bank-based or market-based financial system, we follow Levine (2002) to adopt three alternative aggregate indicators of financial system structure by focusing on measures of the relative activity, size, and efficiency of banking systems and stock markets. The first and primary one, i.e., `FS-Activity`, is a measure of the activity of stock markets relative to that of banks. In particular, the activity of stock markets is assessed by the total value traded ratio, i.e., the value of domestic equities traded on domestic exchanges divided by GDP; and the activity of banks is appraised by the private credit ratio, i.e., is the claims on the private sector by deposit money banks divided by GDP. Accordingly, `FS-Activity` is defined as the logarithm of the total value traded ratio divided by the private credit ratio. The second one, i.e., `FS-Size`, is an indicator of the size of stock markets comparable to that of banks. Specifically, the size of the stock markets is measured by the market capitalization ratio, i.e., the ratio of listed shares to GDP; and the size of bank is, again, represented by the private credit ratio. As a result, `FS-Size` is equal to the logarithm of the market capitalization ratio divided by the private credit ratio. The third one, i.e., `FS-Efficiency`, is an index of the efficiency of stock markets relative to that of banks. Precisely, the efficiency of stock markets is again measured by the total value traded ratio and the efficiency of the banking system is measured by the overhead costs. Large overhead costs may reflect inefficiencies in the banking system. Thus, `FS-Efficiency` is defined as the logarithm of the total value traded ratio times overhead costs.[7] All the data are taken from Beck et al. (2000, 2010). Table 1 displays the list of countries in the sample, and reports the mean values of three alternative financial structure indicators over the 1960–2009 period. In all cases, larger values of `FS-Activity`, `FS-Size` and `FS-Efficiency` represent a more market-based financial system.

Two major dependent variables are separately considered, i.e., the growth rate and its corresponding volatility. The growth rate, i.e., `Growth`, is calculated as the annual growth rate of real per capita GDP. Since volatility is unobservable, it is obtained from growth variables using several alternative approaches. Firstly, in a nonparametric manner, we follow Arize et al. (2000) to employ a time-varying measure of growth volatility to account for periods of low and high growth volatility. In particular, the growth volatility is calculated as the 5-year moving-sample standard deviations of the growth rates and is denoted as $\mathtt{MG}_{it}$. Yet, Pritchett (2000) argues that the standard deviation of growth rates may not be a satisfactory proxy for the level of output volatility experienced by a country under some circumstances. Accordingly, by first calculating the changes in the growth rates, Pritchett (2000) proposes to measure the growth volatility by the five-year average of the absolute values of the changes in the rate of growth, which is denoted by $\mathtt{ADG}_{it}$. Our third and primary volatility index, following Breen and García-Peñalosa (2005), is the five-year moving standard deviation of the absolute values of the changes in the rate of growth, denoted as $\mathtt{MGD}_{it}$. In contrast to the nonparametric measures of growth volatility, we will also follow the parametric approaches of Byrne and Davis (2005a, 2005b) by estimating a GARCH-type model and collect the (square root of) fitted conditional variances as a parametric proxy of growth volatility. Particularly, we consider two popular alternatives, i.e., a GARCH (generalized autoregressive conditional heteroskedasticity) model, and an EGARCH (exponential GARCH) model. After fitting each model for all countries and taking square root of the fitted conditional variances,

[4] In fact, as argued in Pesaran et al. (1999), the PMG approach does not require pre-tests of panel unit root, and can be readily applied to stationary as well as nonstationary variables.

[5] The dynamic fixed effects (DFE) estimator constrains all the slope coefficients to be the same across countries, but allows for distinct country intercepts.

[6] The reason for us to use 25 consecutive observations, rather than 20 as in Loayza and Ranciere (2006), is that we use 5-year moving standard deviations to construct the growth volatility. By doing so, we lose 5 time series observations for each country, resulting in 20 available observations as in Loayza and Ranciere (2006).

[7] The indicator of `FS-Efficiency` is conceptually measured by a ratio but practically expressed in a product term. According to Levine (2002), `FS-Efficiency` is a measure of the efficiency of stock markets relative to that of banks. For that purpose, the total value traded ratio (hereafter TVTR) is used to measure the efficiency of stock markets for it reflects the liquidity of the domestic stock market. On the other hand, the *overhead costs* (hereafter OC) is employed to measure the degree of efficiency in the banking sector, which equals the overhead costs of the banking system relative to banking system assets. It should be noted that large overhead costs may reflect "inefficiencies" in the banking system. As such one can use the reciprocal of the overhead cost, i.e., 1/OC, to represent the efficiency of the banking sector. In this manner, we can measure the relative efficiency of stock market to the banking system as TVTR/(1/OC), which mathematically turns out to be TVTR $\times$ OC.

Table 1
Financial structure indicators for 40 countries.

Country	FS-Activity	FS-Size	FS-Efficiency
Argentina	−1.6517	0.1758	−5.8541
Australia	−0.4699	0.0642	−4.1977
Austria	−2.5103	−1.6620	−5.9936
Belgium	−1.5985	−0.2205	−5.7255
Canada	−0.7151	−0.0938	−4.4767
Colombia	−3.7267	−1.1406	−6.9605
Cote d'Ivoire	−4.5844	−0.5308	−8.7003
Denmark	−0.9814	−0.4278	−4.5955
Egypt	−2.3510	−0.4734	−7.3915
Finland	−0.6167	−0.0295	−5.2822
France	−0.8899	−0.4635	−4.4556
Greece	−2.9791	−1.0852	−5.7834
India	−0.8530	−0.4583	−4.7234
Indonesia	−3.3910	−1.6939	−5.9118
Israel	−1.0757	−0.3625	−4.9326
Italy	−1.1368	−0.8397	−4.8379
Jamaica	−2.3625	0.8284	−6.2889
Japan	−1.0188	−0.5664	−4.9019
Jordan	−1.7250	0.1461	−5.2367
Korea, Republic of	−0.5946	−0.7555	−3.8485
Malaysia	−1.2752	0.1615	−4.5685
Mexico	−1.4011	−0.1557	−5.1375
Netherlands	−0.3995	−0.2761	−4.4778
New Zealand	−2.0978	−0.9847	−5.5819
Nigeria	−4.7154	−0.4336	−7.9309
Norway	−1.1226	−0.6921	−4.9355
Pakistan	−1.1496	−0.8579	−5.0893
Peru	−1.5635	0.4057	−5.9677
Philippines	−1.8007	−0.1715	−5.5202
Portugal	−4.4141	−2.3113	−5.9721
South Africa	−0.6472	0.9947	−3.9760
Spain	−0.6610	−0.6292	−4.3138
Sri Lanka	−2.9965	−0.4908	−7.0948
Sweden	−0.0594	0.3158	−3.6332
Thailand	−1.8226	−1.3181	−4.9750
Trinidad & Tobago	−2.9388	0.1856	−7.0568
Tunisia	−4.0624	−1.6208	−8.1202
Turkey	−1.3428	−0.6589	−4.7400
United States	0.8198	0.7286	−2.8974
Venezuela	−3.7811	−0.9825	−7.3925

FS-Activity is defined as the logarithm of the total value traded ratio divided by the private credit ratio, FS-Size is equal to the logarithm of the market capitalization ratio divided by the private credit ratio, and FS-Efficiency equals the logarithm of the total value traded ratio times overhead costs.

we can obtain measures of growth volatility HG, and HEG, respectively. More details about the GARCH models are shown in the Appendix A.

Finally, we also control for several determinants of growth and volatility. The conditioning information set contains the (initial) level of GDP per capita, population, inflation rate, government spending as ratio to GDP, and trade openness (the sum of import and export as a share of GDP). All the conditioning covariates are specified in natural logarithmic form.[8] Except for the government spending as ratio to GDP, which is taken from Penn World Table 7.0, the other explanatory variables are all taken from World Development Indicators. Table 2 reports the simple correlation matrix for the main variables. Some messages emerge. First, the correlation between growth and volatility is ambiguous in sign and significance. Second, there are positive and significant correlations among alternative volatility indicators, suggesting that those distinct volatility measures are closely related. Third, alternative financial structure measures are positively and significantly correlated, indicating that these three structure measures capture similar aspect of the bank-based and market-based financial system. Fourth, while there seems to exist a (significantly) positive association between growth and alternative measure of financial structure, the correlations among different indicators of growth volatility and financial structure are mostly negative and significant.

4. Empirical results

4.1. Financial structure and growth

Table 3 summarizes the results on specification tests and the estimation of the long-run parameters linking per capita GDP growth, initial level of GDP per capita, and financial structure. In panel A, we consider a benchmark specification by estimating an ARDL (1,1,1) model. In order to mitigate the potential endogeneity problem (of financial structure), we replace the financial structure variable with a lagged term in Panel B, and augments the lag order for all variables (dependent as well as independent) to (3,3,3) in Panel C. As suggested in Pesaran (1997, pp. 183–184), once the order of the ARDL model is appropriately augmented, the ARDL approach continues to be applicable even if financial structure variable is endogenous, irrespective of whether it is I(1) or not. Our main focus is on the results from using the PMG estimator, considering its gains in consistency as well as efficiency over other panel error-correction counterparts when the restriction on the homogeneity of long run parameters is appropriate. For comparison purpose, the MG estimates are also presented.

First, notice that all the joint Hausman-type test statistics are small, and insignificantly different from zero according to the corresponding *p*-values. Thus, the null hypothesis of homogeneous long-run parameters cannot be rejected, indicating that the PMG estimates are preferable to the MG counterparts. Moreover, we also find that pooling considerably sharpens the estimates; the standard errors of the PMG estimates are much smaller than those of MG estimates. Second, the existence of a long-run relationship among growth, financial structure along with other growth determinants requires that the coefficient of the error correction model to be negative and not lower than −2 (that is, within the unit circle).[9] In this respect, we report the estimates for the pooled (averaged) error correction coefficient along with its corresponding standard error. Without exception, all the coefficients fall within the dynamically stable range in both the cases of the PMG and MG estimators. Third, regarding the estimated parameters, our analysis focuses on those obtained by the PMG estimator. In Panel A, the growth rate of GDP per capita is negatively related to initial income in the long run, suggesting that initially poorer countries grow faster so that, in the long run, they can catch up with the richer economies, and vice versa. Most importantly for our purposes, the estimate of financial structure is 0.3640 with a standard error being 0.0654. Obviously, the coefficient is significantly positive at any conventional levels, and suggests that more market-based financial systems are associated with higher growth rates in the long run. Noticeably, our key finding from long-run panel data model is in sharp contrast to the cross-sectional results of Levine (2002), Beck and Levine (2002), and Demirgüç-Kunt and Maksimovic (2002), to name a few.

To check if our finding is sensitive to the possible endogeneity problem of financial structure, i.e., the contemporaneous feedback running from growth to financial structure, we experiment with two extra empirical strategies. We first use the lagged, instead of the current, financial structure variable and present the empirical results in Panel B. Then, we follow Pesaran's (1997) suggestion to augment the order of lags of the ARDL specification to (3,3,3) and summarize the estimation

[8] The inflation rate is specified as ln(1 + inflation / 100) since some of the values are negative.

[9] The sign and the magnitude of the error correction coefficient displays the short term adjustment process. If the value of the estimated coefficient lies between 0 and −1, then the dependent variable monotonically converge to its long run equilibrium track in relation to variations in exogenous forcing variables, and the greater the magnitude of the error term coefficient, the greater the response (or speed of adjustment) of the dependent variable to the corresponding error correction terms. If the value is between −1 and −2, then the error correction term will produce dampened fluctuation in the dependent variable about its equilibrium route (Alam and Quazi, 2003). A value smaller than −2 will cause the dependent variable to diverge.

Table 2
Correlations of growth, volatility and financial structure.

	Growth	MDG	HG	HEG	MG	ADG	FS		
							Activity	Size	Efficiency
Growth	1.0000								
MDG	−0.0110	1.0000							
HG	0.0594***	0.5727***	1.0000						
HEG	0.0456**	0.4952***	0.7539***	1.0000					
MG	−0.0413*	0.8658***	0.6086***	0.5467***	1.0000				
ADG	0.0076	0.8716***	0.6066***	0.5323***	0.9041***	1.0000			
FS-Activity	0.1248***	−0.2231***	−0.2041***	−0.1619***	−0.2035***	−0.2327***	1.0000		
FS-Size	0.0722**	−0.0073	0.0683**	0.0452	0.0154	0.0079	0.7301***	1.0000	
FS-Efficiency	0.0270	−0.2237***	−0.2561***	−0.2357***	−0.2253***	−0.2579***	0.9321***	0.4364**	1.0000

The variable 'Growth' is the real per capita GDP growth rate. MDG is the five-year moving standard deviation of the absolute values of the changes in the rate of growth, HG and HEG are the square root of the fitted conditional variances estimated from the GARCH and EGARCH model,respectively, MG is the 5-year moving-sample standard deviations of the growth rates, and ADG is the five-year average of the absolute values of the changes in the rate of growth. FS-Activity is defined as the logarithm of the total value traded ratio divided by the private credit ratio, FS-Size is equal to the logarithm of the market capitalization ratio divided by the private credit ratio, and FS-Efficiency equals the logarithm of the total value traded ratio times overhead costs. The superscripts ***, ** and * denote significant at 1%, 5% and 10% levels, respectively.

Table 3
Financial structure on growth — simple information set.

	Panel A			Panel B			Panel C		
	PMG	MG	Joint H-stat.	PMG	MG	Joint H-stat.	PMG	MG	Joint H-stat.
Error correction coefficient									
ϕ	−1.1759***	−1.1294***		−1.1108***	−1.0947***		−1.2881***	−1.4418***	
	(0.1482)	(0.2178)		(0.1703)	(0.2303)		(0.1936)	(0.2528)	
Long-run coefficients									
Initial per capita GDP (log)	−3.0443***	4.1490	1.11	−2.3879***	−5.4657***	2.07	−3.5517***	2.4469	2.29
	(0.5006)	(10.2594)	[0.57]	(0.4995)	(1.9722)	[0.35]	(0.4926)	(3.2543)	[0.32]
FS-Activity	0.3640***	0.1715					0.3762***	−0.3363	
	(0.0654)	(0.6200)					(0.0577)	(0.5259)	
FS-Activity (lagged)				0.2370***	0.3900				
				(0.0601)	(0.2492)				
No. countries	40			40			40		
No. obs.	987			954			907		

The dependent variable is the growth rate of real per capita GDP, i.e., Growth. In Panel A, the ARDL lag order is assumed to be (1,1,1). Compared to Panel A, Panel B uses the lagged, rather than the current, FS-Size as the main explanatory variable, while Panel C postulates the ARDL lag order to be (3,3,3). The standard errors are reported in parenthesis and p-value is reported in bracket. The superscripts ***, ** and * indicate significant at 1%, 5% and 10% levels, respectively.

outcome in Panel C. By concentrating on the PMG approach, the additional estimation results are both qualitatively and quantitatively similar to those displayed in Panel A. In particular, the signs and statistical significances of the estimated coefficients remain unchanged. The coefficients on the initial GDP per capita continue to be negative and statistically significant at 1% level, supporting the convergence hypothesis. In addition, the long-term estimates on the financial structure are positive and highly significant, lending further support to the view that market-based financial system is better for promoting long-run economic growth than the bank-based counterpart.

To further check whether our primary result is driven by the use of a particular measure of financial structure, we follow Levine (2002) to re-estimate the ARDL (1,1,1) model with two alternative financial structure indicators, i.e., FS-Size and FS-Efficiency. The results are displayed in Panels A and B of Table 4, respectively. As shown, the joint Hausman test statistics continue to be statistically insignificant and suggest that the PMG estimators are more favorable. Moreover, the statistically significant and negative error correction terms indicate that there exists a long-run cointegrating relationship among growth, initial income and financial structure, irrespective of which financial structure measure is considered. Moreover, we find that the long-run estimates of FS-Size and FS-Efficiency are not only positive but also statistically significant at 1% level, meaning that faster growth is associated with more market-oriented financial systems. Thus, our key finding is robust to the use of alternative indicators of financial structure. Note that the estimated long-run coefficients of financial structure are much larger in magnitude compared to those found in Table 3.

In addition, we proceed to verify if these results are sensitive to model specification, and offer additional supportive empirical evidence in Table 5. Particularly, we account for additional explanatory variables of growth in Panel A, and take into account the possible cross sectional dependence among countries in Panel B. Again, it is found that the restriction on the homogeneity of long-run parameters is adequate and the PMG estimates are preferable. Furthermore, the existence of a long-run equilibrium linkage among variables is confirmed by the significantly negative estimates for error correction terms. By focusing on the long-run PMG estimates, in Panel A, we continue to find that financial structure exerts a significantly positive effect on growth, even controlling for other potential growth determinants such as population, inflation, government spending, and trade openness. Moreover, in Panel B, the empirical evidence confirms the hypothesis that more well-functioning markets enhance economic growth, after potential cross-sectional dependence being considered. In both panels, the financial structure indicator enters the growth regression in a positive and significant way. On balance, those supplementary findings lend additional strong support to the market-based view regarding the impact of financial structure on economic growth.[10]

Finally, we test two hybrid hypotheses regarding the relative merits of bank-based versus market-based systems along the dimensions

[10] We also substitute FS-Size and FS-Efficiency for FS-Activity in the model, and obtain very similar outcomes. This further substantiates the robustness of our findings. Nevertheless, to conserve some space, we do not tabulate these results here. Interested readers can obtain these results upon request.

Table 4
Alternative financial structure indicators on growth.

	Panel A			Panel B		
	PMG	MG	Joint H-statistic	PMG	MG	Joint H-statistic
Error correction coefficient						
ϕ	−1.1592***	−1.1754***		−1.1421***	−1.1721***	
	(0.1442)	(0.2129)		(0.1290)	(0.2260)	
Long-run coefficients						
Initial per capita GDP (log)	−2.0117***	−4.2596**	1.51	−8.4364***	−7.0148	0.77
	(0.3841)	(1.9027)	[0.47]	(1.2596)	(4.5756)	[0.68]
`FS-Size`	0.5359***	1.0385**				
	(0.1028)	(0.4316)				
`FS-Efficiency`				0.6892***	0.9686	
				(0.1121)	(0.7557)	
No. countries	40			39		
No. obs.	965			721		

The dependent variable is the growth rate of real per capita GDP, i.e., `Growth`. The ARDL lag order is selected to be (1,1, 1). The main proxy for financial structure is `FS-Size` and `FS-Efficiency`, respectively. The standard errors are reported in parenthesis and p-value is reported in bracket. The superscripts ***, ** and * indicate significant at 1%, 5% and 10% levels, respectively.

Table 5
Financial structure on growth — full information set.

	Panel A			Panel B		
	PMG	MG	Joint H-statistic	PMG	MG	Joint H-statistic
Error correction coefficient						
ϕ	−1.0173***	−1.0934***		−1.1063***	−1.2182***	
	(0.0975)	(0.1630)		(0.0752)	(0.0758)	
Long-run coefficients						
Initial per capita GDP (log)	−5.7346***	−65.9799	1.87	−4.2824***	−29.5454***	2.44
	(0.6860)	(43.7583)	[0.93]	(0.7839)	(9.1236)	[0.87]
`FS-Activity`	0.3995***	−0.6450		0.4438***	0.6307	
	(0.0640)	(0.7077)		(0.0756)	(0.6511)	
Population (log)	1.4121	220.4022		3.3435***	161.5361	
	(1.1825)	(222.6239)		(1.0288)	(118.1001)	
1 + inflation / 100 (log)	−4.6810***	−21.1510		−3.3694***	−9.1115	
	(1.2111)	(13.5701)		(0.8854)	(6.5227)	
Government spending/GDP (log)	−2.8633***	−31.9510*		0.3034	−13.0318**	
	(0.8062)	(18.2712)		(0.7066)	(6.0143)	
Trade/GDP (log)	2.6386***	9.2967		0.5261	−15.2439	
	(0.5417)	(11.0427)		(0.5337)	(15.0092)	
No. countries	40			40		
No. obs.	985			985		

The dependent variable is the growth rate of real per capita GDP, i.e., `Growth`. The ARDL lag order is selected to be (1,⋯,1). In Panel B, all variables are de-meaned so as to control for cross-sectional dependence. The standard errors are reported in parenthesis and p-value is reported in bracket. The superscripts ***, ** and * indicate significant at 1%, 5% and 10% levels, respectively.

of economic development and legal systems. According to Boyd and Smith (1998), bank-based systems are more important in promoting growth in early stages of economic development, and then countries benefit more from becoming more market-based in later stages of economic development. Thus, we include an interaction between financial structure and a proxy for economic development (measured by the real per capita GDP) into an otherwise standard growth regression. A positive and significant coefficient on the interaction term is taken as evidence in favor of the proposition. Panel A of Table 6 reports the results. While the financial structure variable still exerts a significant positive impact on growth, its interaction with the economic development variable has a significant but negative coefficient estimate, which is in contrast to those of Levine (2002). As a result, our result provides evidence that market-based system is more important in promoting growth in early stage of economic development, which is not quite consistent with the theoretical prediction of Boyd and Smith (1998).

In addition, according to Rajan and Zingales (1998a), banks have a comparative advantage in countries with weak legal systems, and stock markets play a leading role in enhancing growth only as their legal system capabilities strengthen. Similarly, we also contain an interaction between financial structure and an index of legal system development (an index of the extent to which the country follows the rule of law).[11] Again, if the conjecture is correct, we would expect to see a significantly positive parameter on the interaction term. The outcome is summarized in Panel B of Table 6. It is readily seen that the PMG estimates on financial structure and its interaction with rule of law are significantly negative and positive, respectively. The positive and statistically significant estimation of the coefficient for the interaction term is in contrast to those of Levine (2002), who concludes no such positive growth effect of the interaction between financial structure and legal system.[12] As such, our empirical evidence substantiates the postulation that bank-based (market-based) system is more important in country with weak (strong) legal system to promote growth, thereby supporting the theoretical hypothesis proposed by Rajan and Zingales (1998a).

[11] The source of 'rule of law' data is from La Porta et al. (1998), as scale from zero to 10, with lower scores for less tradition for law and order.
[12] Furthermore, regressions with alternative indicators of financial structure, e.g., `FS-Size` and `FS-Efficiency` also provide very similar results. Nevertheless, to conserve some space, we do not tabulate these results here. Interested readers can obtain these results upon request.

Table 6
Financial structure on growth — economic development and legal systems.

	Panel A			Panel B		
	PMG	MG	Joint H-statistic	PMG	MG	Joint H-statistic
Error correction coefficient						
ϕ	-1.0847^{***}	-1.2090^{***}		-0.9289^{***}	-1.0892^{***}	
	(0.0914)	(0.1463)		(0.1019)	(0.1763)	
Long-run coefficients						
Initial per capita GDP (log)	-3.9923^{***}	-9.2360	2.37	-7.7986^{***}	-60.9966	1.10
	(0.5494)	(10.2954)	[0.94]	(0.8750)	(47.5490)	[0.98]
`FS-Activity`	3.3788^{***}	-2.4070		-0.3584^{**}		
	(0.5684)	(14.5629)		(0.1694)		
`FS-Activity` × economic development	-0.3072^{***}	0.2912				
	(0.0576)	(1.5737)				
`FS-Activity` × rule of law				0.0853^{***}	-0.0315	
				(0.0205)	(0.1170)	
Population (log)	0.6248	5.9390		6.3562^{***}	256.4736	
	(1.0140)	(28.0796)		(1.5804)	(245.1857)	
1 + inflation / 100 (log)	-1.7325^{***}	-9.0478		-8.3490^{***}	-13.6471	
	(0.4423)	(12.0847)		(1.8682)	(12.5878)	
Government spending/GDP (log)	-1.8386^{***}	-7.2320		-3.0152^{***}	-24.4624	
	(0.7008)	(9.4705)		(0.8819)	(18.1406)	
Trade/GDP (log)	0.8043^{*}	-6.2006		3.1371^{***}	0.7862	
	(0.4585)	(8.5048)		(0.5797)	(3.3934)	
No. countries	40			36		
No. obs.	985			902		

The dependent variable is the growth rate of real per capita GDP, i.e., `Growth`. The ARDL lag order is selected to be (1,⋯,1). The level of `Economic Development` is proxied by the (log of) per capita GDP, and the `Rule of Law` is an index of the degree to which the country follows the rule of law. The standard errors are reported in parenthesis and p-value is reported in bracket. The superscripts ***, ** and * indicate significant at 1%, 5% and 10% levels, respectively.

4.2. Financial structure and growth volatility

As discussed earlier, lower growth volatility is one of the primary objects of macroeconomic policy, is associated with higher economic growth, and is accompanied with more equal distribution of income. Thus, its importance and determinants deserve further analysis. While there are many studies assessing the influence of financial structure on economic growth, to the best of our knowledge, no available work has been done in exploring the role of financial structure played in the determinant of growth volatility. As such, this paper offers the first empirical examination to assess whether bank-based or market-based financial system is better in reducing the volatility of growth rates. The following analysis is based on the 40 country panel over the 1960–2009 period. For simplicity, we choose the ARDL lag structure for each country to be (1,⋯,1) throughout, except in the case of augmenting the lags to mitigate the potential problem of endogeneity in the financial structure variable.

Table 7 presents the basic results of the effects of financial structure (`FS-Activity`) on our main growth volatility indicator (`MDG`). According to the Hausman test statistics and error correction estimates, we will focus on the long-run PMG estimation results in each Panel. In Panel A, we find that (initial) per capita GDP is negatively and significantly related to growth volatility. This finding is consistent with the view of Koren and Tenreyro (2007), who argue that the GDP growth is less volatile in rich countries than in poor ones. Of particular interest is that coefficient of the financial structure variable. Note that the estimate is positive and statistically significant at 1% level, indicating that a more market-based (bank-based) system is likely to be associated with higher (lower) growth volatility. Combined with the finding in the previous section, our preliminary

Table 7
Financial structure on growth volatility — simple information set.

	Panel A			Panel B			Panel C		
	PMG	MG	Joint H-stat.	PMG	MG	Joint H-stat.	PMG	MG	Joint H-stat.
Error correction coefficient									
ϕ	-0.4024^{***}	-0.5076^{***}		-0.3791^{***}	-0.4771^{***}		-0.5598^{***}	-0.7651^{***}	
	(0.0388)	(0.0470)		(0.0441)	(0.0531)		(0.0973)	(0.1407)	
Long-run coefficients									
Initial per capita GDP (log)	-1.1908^{***}	-1.2063	0.50	-1.0566^{***}	-6.6549	2.86	-1.0552^{***}	-15.8982	0.77
	(0.3235)	(2.1538)	[0.78]	(0.3363)	(4.2655)	[0.24]	(0.2125)	(16.6028)	[0.68]
`FS-Activity`	0.2242^{***}	0.0781					0.2024^{***}	1.7108	
	(0.0446)	(0.2306)					(0.0257)	(1.5024)	
`FS-Activity` (lagged)				0.2395^{***}	-1.0734				
				(0.0573)	(1.0564)				
No. countries	40			40			40		
No. obs.	987			954			874		

The dependent variable is the growth volatility, i.e., `MDG`. In Panel A, the ARDL lag order is assumed to be (1,1,1). Compared to Panel A, Panel B uses the lagged, rather than the current, `FS-Size` as the main explanatory variable, while Panel C postulates the ARDL lag order to be (3,3,3). The standard errors are reported in parenthesis and p-value is reported in bracket. The superscripts ***, ** and * indicate significant at 1%, 5% and 10% levels, respectively.

Table 8
Alternative financial structure indicators on growth volatility.

	Panel A:			Panel B:		
	PMG	MG	Joint H-statistic	PMG	MG	Joint H-statistic
Error correction coefficient						
ϕ	−0.4010***	−0.5276***		−0.4715***	−0.6462***	
	(0.0474)	(0.0551)		(0.0467)	(0.0633)	
Long-run coefficients						
Initial per capita GDP (log)	−0.4708*	27.4072	1.03	−1.1256***	−4.2619	0.75
	(0.2858)	(27.6559)	[0.60]	(0.3692)	(3.0351)	[0.69]
FS-Size	0.2518***	−13.0435				
	(0.0788)	(12.7470)				
FS-Efficiency				0.1768***	0.4750	
				(0.0426)	(0.8749)	
No. countries	40			39		
No. obs.	965			721		

The dependent variable is the growth volatility, i.e., MDG. The ARDL lag order is selected to be (1,1,1). The main proxy for financial structure is FS-Size and FS-Efficiency, respectively. The standard errors are reported in parenthesis and p-value is reported in bracket. The superscripts ***, ** and * indicate significant at 1%, 5% and 10% levels, respectively.

conclusion is that, while market-oriented financial system promotes economic growth in a more effective way than the bank-oriented counterpart, it seems to induce higher growth volatility as well.

By further utilizing alternative empirical strategies such as the use of lagged financial structure variable and the augmented ARDL model with lags up to 3 for all variables, Panels B and C in Table 7 provide results that are robust to the potential problem of endogeneity. The sign and the significance of the (lagged) financial structure variable remain qualitatively and quantitatively similar to those reported in Panel A. Apparently, the additional findings continue to support the hypothesis that volatility of growth rates is higher in economies with more market-based financial system. But why market-oriented financial system will enhance growth volatility? One possible explanation for this outcome is that, as argued by Boot and Thakor (1997), banks-as coordinated coalitions of investors-are better than uncoordinated markets at monitoring firms and reducing post-lending moral hazard (asset substitution). In stock markets, investors can inexpensively sell their shares, so that they have fewer incentives to exert rigorous corporate control. Under this circumstance, the more importance of the stock market may imply less monitoring on firm's performance after lending and thus generating more unpredicted outcomes in production and hence inducing more volatility in economic growth.

Furthermore, we consider if the key finding is robust to the uses of alternative measures of financial structure. Specifically, instead of using FS-Size, we rely upon the relative activity (FS-Size) and efficiency (FS-Efficiency) aspects of stock markets over banks to proxy a country's financial structure. The testing and estimation results are displayed in Panels A and B of Table 8, respectively. Again, the Hausman test statistics are small in magnitude and insignificantly different from 0, indicating that the homogeneity restriction cannot be rejected, and the PMG estimator is more favorable for its consistency and efficiency over the MG counterpart. The (pooled) error correction coefficients continue to be significantly negative, and within the unit circle, suggesting that there exists a long-run cointegrating relationship between growth volatility and financial structure. Most importantly, the relation is positive in nature and statistically significant at any conventional level. Thus, the finding that larger growth volatility is linked to more market-based financial system is unlikely to be caused by the use of a particular indicator of financial structure.

Besides, it is well recognized that growth volatility is unobservable in nature and has to be estimated in practice. Whether or not our principal finding is sensitive to the employment of the main volatility proxy, i.e., MDG, remains an open question. To address this concern, we construct a variety of growth volatility measures such as HG, HEG, MG, and ADG. By utilizing these alternative indicators of volatility as the dependent variable separately, the respective PMG and MG estimates are summarized in Table 9. In all cases, the Hausman tests fail to reject the null hypothesis of long-run parameters homogeneity and, thus, indicate the superiority of the PMG estimator. Moreover, the pooled error correction coefficients continue to be significantly negative and within the unit circle, revealing that a long-run equilibrium relationship among growth volatility, economic development (proxied by the initial real per capita GDP), and financial structure. In particular, Panels A and B of Table 9 offer results by using conditional variances

Table 9
Alternative growth volatility indicators.

	PMG	MG	Joint H-statistic
Panel A: HG			
Error correction coefficient			
ϕ	−0.6280***	−0.7989***	
	(0.0783)	(0.0931)	
Long-run coefficients			
Initial per capita GDP (log)	−0.1086***	0.3086	0.53
	(0.0257)	(0.4466)	[0.77]
FS-Activity	0.0243***	−0.0029	
	(0.0064)	(0.0662)	
Panel B: HEG			
Error correction coefficient			
ϕ	−0.8519***	−0.9881***	
	(0.1171)	(0.1248)	
Long-run coefficients			
Initial per capita GDP (log)	0.0234	0.3418	0.31
	(0.0989)	(0.6868)	[0.86]
FS-Activity	0.0238*	−0.0712	
	(0.0123)	(0.1645)	
Panel C: MG			
Error correction coefficient			
ϕ	−0.4575***	−0.6650***	
	(0.0507)	(0.0668)	
Long-run coefficients			
Initial per capita GDP (log)	0.0019	0.3547	0.04
	(0.3382)	(1.8872)	[0.98]
FS-Activity	0.1378***	0.0934	
	(0.0533)	(0.1967)	
Panel D: ADG			
Error correction coefficient			
ϕ	−0.3172***	−0.4382***	
	(0.0399)	(0.0485)	
Long-run coefficients			
Initial per capita GDP (log)	−0.9140***	8.7617	1.09
	(0.2544)	(10.1459)	[0.58]
FS-Activity	0.2738***	−1.8307	
	(0.0422)	(2.0382)	

The dependent variable is the growth volatility proxied by HG, HEG, MG, and ADG, respectively. The ARDL lag order is selected to be (1,1,1). The standard errors are reported in parenthesis and p-value is reported in bracket. The superscripts ***, ** and * indicate significant at 1%, 5% and 10% levels, respectively.

Table 10
Financial structure on growth volatility — full information set.

	Panel A:			Panel B:		
	PMG	MG	Joint H-Statistic	PMG	MG	Joint H-Statistic
Error correction coefficient						
ϕ	-0.5028^{***}	-0.8673^{***}		-0.3248^{***}	-0.7657^{***}	
	(0.0634)	(0.0994)		(0.0438)	(0.1059)	
Long-run coefficients						
Initial per capita GDP (log)	-1.6319^{***}	−8.9003	2.68	0.4216	−0.9131	2.85
	(0.3356)	(11.7735)	[0.85]	(0.8101)	(4.1734)	[0.83]
FS-Activity	0.2611^{***}	−0.4655		0.2720^{***}	−2.2106	
	(0.0421)	(0.4363)		(0.0747)	(1.6084)	
Population (log)	−0.5701	20.4872		-4.3384^{***}	279.4995	
	(0.8893)	(17.5935)		(1.2432)	(329.9569)	
1 + inflation / 100 (log)	1.3714^{***}	0.1382		1.0678^{***}	−27.3532	
	(0.4815)	(16.3069)		(0.2703)	(23.6012)	
Government spending/GDP (log)	0.1787	−2.0271		-0.9445^{*}	−3.0447	
	(0.5240)	(7.1050)		(0.5085)	(6.7677)	
Trade/GDP (log)	0.3149	−3.0026		−0.1716	9.9971	
	(0.2932)	(2.7401)		(0.4368)	(7.6048)	
No. countries	40			40		
No. obs.	985			985		

The dependent variable is the growth volatility, i.e., MDG. The ARDL lag order is selected to be (1,…,1). In Panel B, all variables are de-meaned so as to control for cross-sectional dependence. The standard errors are reported in parenthesis and p-value is reported in bracket. The superscripts ***, ** and * indicate significant at 1%, 5% and 10% levels, respectively.

(taken square root) derived from the parametric GARCH (HG) and exponential GARCH (HEG) models to proxy for growth volatility. As indicated, the use of distinct growth volatility measures does not alter our previous findings. The PMG coefficients on the financial structure are both positive, and statistically significant at 10% level or less. Accordingly, the evidence is once more supportive of the notion that the more market-based the financial system, the higher the growth volatility. Besides, two additional nonparametric indicators of growth volatility (MG and ADG) are further employed to assess the linkage between growth volatility and financial structure. Notably, the PMG estimates of financial structure in Panels C and D of Table 9 provide overwhelming and consistent evidence justifying the view that market-based, compared to bank-based, financial systems tend to lead to more unstable growth path in the long run.[13]

Before entirely embracing the results of Tables 7 to 9, it is necessary to test their robustness to the inclusion of other explanatory variables. In addition to the original (initial) per capita GDP and financial structure variables, as in Section 3, we contain the same additional controlling variables such as population, inflation, government spending, and trade openness, to avoid or mitigate possible omitted variables problem. Panel A of Table 10 presents the results. The estimation outcome is qualitatively similar to that in Table 7. Of particular importance, the sign and, even, magnitude of the financial structure coefficient remain virtually unchanged (positive), and its statistical significance continues to be at the 1% level. Therefore, our earlier findings are robust to the addition of other explanatory variables. Furthermore, Panel B of Table 10 reports estimation results using de-meaned variables to control for potential cross-sectional dependence in the panel data. Most relevant to our purpose, the PMG coefficient estimate of financial structure is still a significant explanatory variable of growth volatility across the panel. Similar positive effects of financial structure on growth volatility can also be found when we replace FS-Activity with FS-Size and FS-Efficiency. As such, consistent with our previous findings, the impact of financial structure on growth volatility is positive, indicating that the volatility of growth rates is higher in the more market-based economies.

5. Conclusion

This paper re-investigates a long-debated issue on the relative merits of bank-based versus market-based financial system being better for promoting long-run economic growth, and provides fresh evidences with respect to effect of financial structure on growth volatility as well. By relying on a large panel of 40 countries in the 1960–2009 period, the Hausman test statistics imply that the restriction on the homogeneity of long-run parameters cannot be rejected in every case. Moreover, the negative and statistically significant error correction coefficients signify that there exists a long-run cointegrating (equilibrium) relationship among growth (volatility) and financial structure, along with other covariates.

Most importantly, our implementation of the PMG estimator to the ARDL model provides the following observations. Firstly, in sharp contrast to the conclusion of existing (cross-sectional) studies, our panel data results offer strong and consistent support to the market-based view of financial system. In particular, we find that long-run economic growth is faster in countries with more market-oriented financial system. Secondly, in addition to the growth effect, we also examine if financial structure matters for the determination of growth volatility in a country. Notably, the PMG estimates reveal that the long-run relationship between financial structure and growth volatility is statistically significant and positive. Thus, the novel findings suggest that, while the market-based financial system is better enhancing economic growth, it's done at the cost of higher growth volatility. Finally, a variety of sensitivity checks indicate that our unique results are robust to the problem of endogeneity, the use of alternative financial structure (and growth volatility) proxies, the inclusion of additional growth (volatility) determinants, and the control of cross-sectional dependence in the panel data.

Appendix A

Basically, a standard GARCH model consists of a mean equation and a variance equation. Specifically, for each country *i*, we fit an ARMA (p,q)

[13] Similar conclusion can also be drawn from the outcome when we substitute FS-Size for FS-Activity. However, when we use FS-Efficiency to examine the effect of financial structure on the varies definitions of volatility, the estimates are neither consistent in signs nor in levels of statistical significance. As stated in page 408 of Levine (2002), many readers may question the accuracy of this efficiency index, as such we would be more cautious about the results from FS-Efficiency.

(autoregressive moving average) model for the mean equation of the growth rate (g),[14]

$$g_t = a_0 + \sum_{j=1}^{p} a_j g_{t-j} + \sum_{j'=1}^{q} b_{j'} \epsilon_{t-j'} \quad (4)$$

where ϵ_t is a white noise. The optimal lags for p and q are made possible by the minimum lags chosen according to either AIC or BIC criteria. In addition, to allow for conditional heteroskedasticity, we assume,

$${}_t|\Omega_{t-1} = h_t^{\frac{1}{2}} \eta_t$$

where Ω_{t-1} denotes information set up to time $t-1$, h_t represents the conditional variance at time t, and $\eta_t \sim NID(0,1)$.

As mentioned, two alternative GARCH models will be fitted in order to obtain the conditional heteroskedasticity h_t. The first one is the GARCH(1,1) specification proposed by Bollerslev (1986),[15]

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta h_{t-1}. \quad (5)$$

The second one is the exponential GARCH model introduced by Nelson (1991). One particular feature of the EGARCH model is that it allows for asymmetric responses of positive and negative shocks. The EGARCH(1,1) specification for the conditional variance function can be written as,

$$\ln(h_t) = \alpha_0 + \alpha_1 \left| \frac{\epsilon_{t-1}}{\sqrt{h_{t-1}}} \right| + \alpha_1 \frac{\epsilon_{t-1}}{\sqrt{h_{t-1}}} + \beta \ln(h_{t-1}). \quad (6)$$

After fitting Eq. (4) along with Eqs. (5) and (6) for each country and period, and taking square root of the fitted conditional variances, we can obtain measures of growth volatility denoted by HG and HEG, respectively.

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[14] For notational simplicity, the subscript i for the country is omitted.

[15] It is straightforward to extend to a more general GARCH (p^*,q^*) specification.