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Financial Development and Macroeconomic Volatility

By YONG MA and KE SONG*

Abstract

Using cross-country panel data over the period 1996-2012, this paper examines the impact of financial development on macroeconomic volatility using GMM estimators. In contrast to the linear relationship identified in many previous studies, we present robust evidence suggesting that the effect of financial development on macroeconomic volatility is nonlinear and U-shaped. We also investigate the potential differences between developed and developing countries. The results of the paper add new evidence and shed interesting insights into the recent debate on the role of finance in macroeconomic fluctuations.

Keywords: financial development, macroeconomic volatility, nonlinear relationship

JEL classification numbers: E32, E44, O11

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1 Introduction

One of the major conclusions of financial economics is that financial development is essential not only for fostering economic growth, but also for smoothing economic volatility (e.g., Acemoglu and Zilibotti, 1997; Braun and Larrain, 2005; Raddatz, 2006). After three decades of financial development worldwide, however, the 2008 global financial crisis has brought to the fore once again the role of finance in macroeconomic fluctuations. In particular, the impact of financial development on macroeconomic volatility needs to be re-examined, keeping in mind that an overdeveloped financial system may a hindrance to economic stability rather than a servant to it.

The results of existing studies on the relationship between financial development and macroeconomic volatility are mixed. For example, Loayza and Raddatz (2007) find evidence that financial development is helpful in reducing the impact of external shocks on the economy. In the study of Aghion et al. (2010), financial development can reduce the volatility of investment and growth by alleviating the liquidity constraints on firms and facilitate long-term investment. Dabla-Norris and Srivisal (2013) present evidence that more developed financial systems are helpful in mitigating the negative effects of real external shocks on macroeconomic volatility. Similar results are also reported in Manganelli and Popov (2015). At the same time, however, there are also studies considering financial development as a source of economic volatility. For example, Smaghi (2010) argues that financial systems in many advanced countries may have grown too large as compared with the needs of the real economy, which was an important factor behind the 2008 global financial crisis. Shleifer and Vishny (2010) find that financial development can lead to increased risk-taking behavior within the financial sector, which complicates economies and increase risks. Quadrini (2011) and Brunnermeier et al. (2012) show that procyclicality of the financial system amplifies shocks and leads to higher economic volatility. Similar conclusions are also obtained in Levchenko et al.

(2009), Wagner (2010), and Huang et al. (2014).

Despite the emergence of a growing body of literature, as discussed above, how financial development may affect macroeconomic volatility is still not well understood. Against this background, we attempt to present some new evidence on this issue by using cross-country data of 68 countries over the period 1996-2012. The main contributions of this paper can be summarized as follows. First, based on panel data model using GMM estimators, we present new evidence on the relationship between financial development and macroeconomic volatility. In contrast to the majority of the traditional literature that has assumed a linear relationship between financial development and macroeconomic volatility, we explore whether there exist nonlinearities in this relationship. Our results provide solid evidence that there is a U-shaped relationship between financial development and macroeconomic volatility. While this result is generally consistent with the nonlinear effects of financial development on the real economy in the previous literature, it also deviates from these studies in that the threshold value associated with the U-shaped relationship is estimated to be higher than those reported in the previous studies (e.g., Easterly et al., 2000; Dabla-Norris and Srivisal, 2013). In addition, previous studies on the effects of finance on economic volatility have been overwhelmingly focused on output (growth) volatility, leaving a gap for the understanding of the price (inflation) volatility effects of financial development. In this regard, our paper also extends the literature by showing that similar conclusions can also be drawn for the impact of financial development on inflation volatility.

Second, our paper differs from the previous studies in estimation strategy. To smooth out the cyclical effects of macroeconomic and financial variables, the traditional approach is to estimate the model using non-overlapping time-averaged variables (e.g., Beck and Levine, 2004; Arcand et al., 2012). However, there are evidences showing that non-overlapping time-averaged variables are not valid instruments in panel data models when the reverse-causation problem arises due to time-aggregation (see Ericsson et al., 2001; Ahmed, 1998). In addition, the use of non-overlapping multi-year averages also leads to a significant reduction of observations that can be used for estimation[1], which may impair the parameter identification of the model. For these reasons, we choose to use overlapping time-averaged variables in our estimation instead of non-overlapping ones. This also helps us to have a more complete understanding of the relationship between finance and macroeconomic volatility in that both the short-term and long-term effects of financial development on macroeconomic volatility are examined.

Third, our paper also features extensive sensitivity tests to ensure that the U-shaped relationship between financial development and macroeconomic volatility does not arise because of overlooked factors. First, we control for a variety of institutional variables such as corruption, rule of law, regulatory quality, political stability, and government effectiveness. Second, we try different proxies for the both the dependent and core explanatory variables. Third, we replicate the analysis by varying data frequencies to account for potential cyclical effects. Fourth, we test the existence of threshold nonlinearities for financial development using the estimation strategy introduced by Hansen (1999). Finally, we divide the sample countries into developed and developing countries and re-estimate the regressions to see whether there are differences across different groups of countries. None of these tests changes our main findings, giving additional credibility to the results of the paper.

The rest of the paper is organized as follows. Section 2 describes the data and discusses the methodology. Section 3 presents the empirical findings. Section 4 extends the analysis by probing into the potential differences between developed and developing countries. Section 5 concludes and discusses some policy implications.

2 Methodology and data

[1] In our case, approximately 80% of the observations are lost due to time-aggregation if we use the non-overlapping 5-year averages.

2.1 Data and variables

To estimate the model, we use data from 68 countries over the period 1996-2012, where the countries and time span included are determined by data availability. The sample countries are listed in Table A1 in the Appendix. All macroeconomic variables and financial development variables used in our analysis are collected from the *World Development Indicators* (WDI), while institutional variables are sourced from the *World Bank's Worldwide Governance Indicators* (WGI). In what follows, we briefly discuss the specific variables used as proxies for the main variables of interest in the regression analysis.

Macroeconomic volatility variables. The main variables used to proxy macroeconomic volatility are output volatility and aggregate price volatility, denoted by the 5-year rolling window standard deviations of real GDP growth rate (*VGDP*) and the 5-year rolling window standard deviations of inflation rate (*VINF*), respectively. By calculating volatility at the 5-year frequency rather than over decades we reduce the chances of identifying spurious volatility associated with mean shifts. Meanwhile, calculating volatility at the 5-year frequency also reduces the risk associated with short window lengths in confusing breaks with persistent shocks around a stable mean. In addition to output and inflation volatility, we also consider other frequently cited measures of macroeconomic volatility in robustness tests, such as volatility of real GDP per capita growth rate (*VGDPP*), volatility of national disposable income per capita growth rate (*VDIP*), and volatility of final consumption expenditure growth rate (*VCON*).

Financial development variables. Our main measure of financial development is private sector credit to GDP ratio (*FD*), which refers to financial resources provided to the private sector by financial corporations. More specifically, it is the ratio to GDP of the credit issued to the private sectors by banks and other financial intermediaries, excluding credit issued to government, state-owned enterprises and other non-private sectors. As stressed by Levine et al. (2000), unlike other measures of financial development that have been used in the empirical literature, such as M2 to GDP ratio, the private sector credit to GDP ratio is more than a simple measure of size or financial depth. It measures the most important activity of the financial intermediary sector and has a significant impact on the economy (Levine et al., 2000; Beck et al., 2000). In the robustness analysis, however, we also use the M2 to GDP ratio (*M2*) as an alternative measure of financial development.

Control variables. As is standard in the literature, we also include a variety of control variables that may affect macroeconomic volatility. First, we control for macroeconomic conditions of an economy using GDP growth rate (*Growth*), inflation rate (*Inflation*), capital formation (*Capita*l), and financial openness (*Open*). We also control for the effects of institutions using a variety of institutional variables that are widely used in the literature. Specifically, we use five indicators that could largely capture the differences in institutional quality across different countries: (1) Political stability (*Stability*), measured by the likelihood that a government will be destabilized by unconstitutional or violent means; (2) Government effectiveness (*Government*), measured by the quality of public services and the quality of policy formulation; (3) Regulatory quality (*Regulation*), measured by the ability of a government to provide sound policies and regulations; (4) Rule of law (*Law*), measured by the extent to which agents have confidence in and abide by the rules of society, including the quality of property rights, the police and the courts, and the risk of crime; (5) Control of corruption (*Corruption*), measured by the extent to which public power is exercised for private gain, including both petty and grand forms of corruption as well as elite "capture" of the state. All these five indicators are sourced from the World Bank's *Worldwide Governance Indicators* (WGI) and constructed such that higher scores correspond to better outcomes. Finally, to control for the effects of financial crises that a large number of countries experienced during the sample period, we also include a crisis dummy which takes the value 1 if country i at time t experiences a financial crisis, and zero otherwise. Data for the episodes of financial crises are sourced from Laeven and Valencia

(2013).

A more detailed description of the variables used in our analysis is presented in Table A2 in the Appendix. Table 1 reports the summary statistics of the data.

Table1 Summary statistics

Variable	Definition	Obs.	Mean	Std. Dev.	Min	Max
VGDP	Volatility of real GDP growth rate	1156	0.018	0.011	0.002	0.096
VINF	Volatility of inflation rate	1156	0.083	0.499	0.001	9.771
VGDPP	Volatility of real GDP per capita growth rate	1156	0.015	0.010	0.001	0.080
VCON	Volatility of final consumption expenditure growth rate	1156	0.024	0.031	0.001	0.351
VDIP	Volatility of national disposable income per capita growth rate	1156	0.001	0.001	0.000	0.010
FD	Private sector credit/GDP	1156	0.689	0.583	0.016	3.051
FD^2	Quadratic term of private sector credit/GDP	1156	0.814	1.195	0.000	9.308
M2	M2/GDP	1156	0.802	0.788	0.099	6.699
$M2^2$	Quadratic term of M2/GDP	1156	1.263	4.109	0.010	44.874
Growth	Real GDP growth rate	1156	0.036	0.033	-0.131	0.263
Inflation	Inflation rate	1156	0.059	0.097	-0.238	1.380
Capital	Gross capital formation/GDP	1156	0.221	0.074	-0.024	1.527
Open	Financial openness	1156	0.755	1.548	-1.864	2.439
Crisis	Crisis dummy	1156	0.065	0.246	0	1
Stability	Political stability	1156	0.108	0.870	-2.386	1.663
Government	Government effectiveness	1156	0.367	1.033	-1.605	2.431
Regulation	Regulatory quality	1156	0.407	0.895	-1.616	2.247
Law	Rule of law	1156	0.291	1.024	-1.708	2.003
Corruption	Control of corruption	1156	0.353	1.104	-1.488	2.586

2.2 Model and estimation methodology

To examine the impact of financial development on macroeconomic volatility, we estimate the following dynamic panel data model:

$$V_{i,t} = c + \alpha V_{i,t-1} + \beta FD_{i,t} + \gamma FD_{i,t}^2 + \theta Z_{i,t} + \varphi_i + \mu_t + \varepsilon_{i,t} \quad (1)$$

where $V_{i,t}$ is a measure of macroeconomic volatility; $FD_{i,t}$ is a measure of financial development; $FD_{i,t}^2$ is the quadratic term of $FD_{i,t}$, which captures the potential nonlinear effect of financial development on macroeconomic volatility; $Z_{i,t}$ is a vector of control variables that likely impact macroeconomic volatility; φ_i and μ_t are the unobservable country- and time-specific effects, respectively; $\varepsilon_{i,t}$ is the error term.

There are two main challenges in estimating the dynamic panel data model given by Eq. (1). The first one is that the unobserved country-specific effects that are typically present in dynamic panel data models cannot be addressed by the conventional methods. The second one arises from the endogeneity problem that the explanatory variables in Eq. (1) might be jointly endogenous with the dependent variable. Thus, the potential biases due to reverse or simultaneous causation must be controlled. These problems can be addressed by using the first-differenced generalized method of moments (GMM) estimator proposed by Arellano and Bond (1991). To understand the first-differenced GMM estimator, we can rewrite Eq. (1) in GMM's general form:

$$y_{i,t} = \alpha y_{i,t-1} + \beta' X_{i,t} + \eta_i + \varepsilon_{i,t} \quad (2)$$

where $y_{i,t}$ denotes our volatility variables and $X_{i,t}$ is a matrix of the financial development variables and other control variables, η_i denotes the country-specific effects, and $\varepsilon_{i,t}$ is the error term. To get rid of the country-specific effects η_i, which is correlated with $y_{i,t-1}$ and could lead to inconsistent within-group estimators, we take first differences of Eq. (2) and get:

$$y_{i,t} - y_{i,t-1} = \alpha(y_{i,t-1} - y_{i,t-2}) + \beta'(X_{i,t} - X_{i,t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \qquad (3)$$

It can be seen from Eq. (3) that, after doing the first difference, the new error term could be related with the new and lagged dependent variables. Then the instruments are used to eliminate the endogeneity of the regressors. The GMM estimators also use levels equations to reduce the finite sample bias and improve the precision.

The major problem with the first-differenced GMM estimator is that it may fail to exploit all of the available moment conditions. To overcome this problem, Arellano and Bover (1995) suggest using the system GMM estimator, where the first-differenced variables are used as instruments in the level regression while the lagged level variables are used as instruments in the first-differenced regression. As shown in Blundell and Bond (1998), the system GMM estimator is more precise and efficient than the first-differenced GMM estimator.[2]

Another frequently encountered problem in GMM estimation is that the instrument counts tends to grow exponentially with the number of time periods or explanatory variables. To address the problem of instrument proliferation, we use the following two approaches suggested by Roodman (2009). First, to reduce the instrument count, typically only one or two lags are used as instruments. Second, we combine the instruments into smaller sets by collapsing the blocks in the instrument matrix.

Finally, to determine the overall validity of the instruments, the Sargan test of over-identifying restrictions suggested by Arellano and Bond (1991) is used. The null hypothesis is that there is no correlation between the residuals and the instrumental variables. Another specification test is the second-order serial correlation test (i.e., AR(2) test) with the null hypothesis that there is no second-order serial correlation in the errors. To ensure adequate model specification, both the null hypotheses of the Sargan test and the AR(2) test should not be rejected.

[2] For robustness, however, both the first-differenced GMM estimates and the system GMM estimates are reported in our analysis.

3 Empirical results

3.1 Stylized facts

Before proceeding to the econometric analysis, it might be useful to look at some stylized facts on the relationship between financial development and macroeconomic volatility. To this end, we begin with two simple scatter diagrams constructed using sample data for the finance-volatility nexus. In Fig. 1, the scatter diagram on the left hand side shows the relationship between financial development and output volatility while the one on the right shows the relationship between financial development and inflation volatility.

From Fig. 1 we can see that, the relationship between financial development and macroeconomic volatility, no matter measured by output volatility or inflation volatility, is clearly not monotonic. More specifically, at low levels of financial development, an increase in financial development seems to be negatively associated with output and inflation volatility. However, there seems to be a point, roughly located within the interval 1.2–1.5, after which the negative relationship between financial development and macroeconomic volatility becomes positive. The intuition behind these observed stylized facts is that there is likely a U-shaped relationship between financial development and macroeconomic volatility.

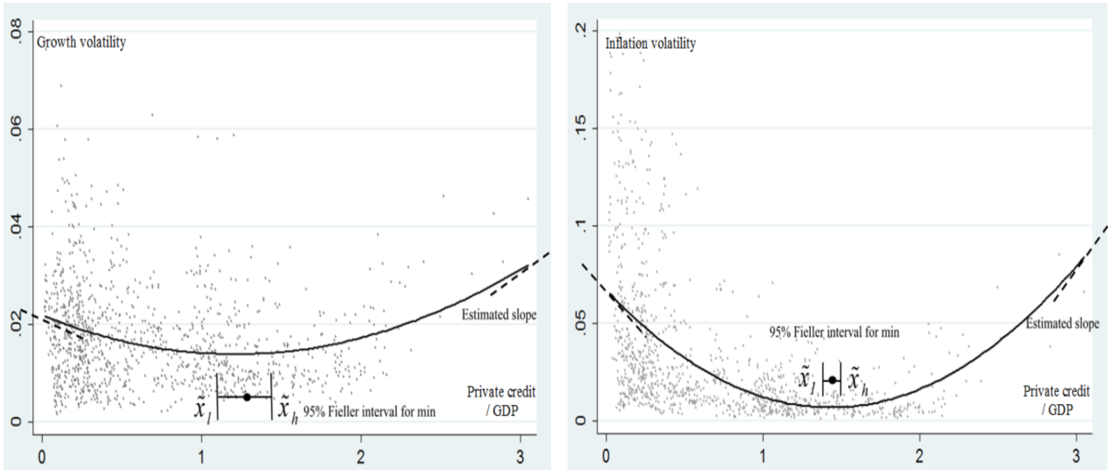

Fig. 1. Financial development and macroeconomic volatility.

Notes: In this figure, the scatter diagram on the left shows the relationship between financial development (measured by private credit to GDP ratio) and output volatility (calculated as the standard deviations of real GDP growth rate), while the scatter diagram on the right shows the relationship between financial development and inflati0n volatility (calculated as the standard deviations of inflation rate). The quadratic relationships as well as the associated confidence interval and the two lower bounds in Figure 1 are calculated using the appropriate U test proposed by Lind and Mehlum (2010). For country sample and sources, see data appendix.

To give a more clear illustration of the likely U-shaped relationship between financial development and macroeconomic volatility, we now proceed to use the appropriate U test proposed by Lind and Mehlum (2010), which gives the exact necessary and sufficient conditions for the identification of a U shape in finite samples. The results of the test statistics from the appropriate U test as well as the derived Fieller interval are reported in Table 2. With the appropriate U test, again, we can see that there does exist a nonlinear and U-shaped relationship between financial development and macroeconomic volatility.

Table 2 The appropriate U test for the relationship between financial development and macroeconomic volatility

Dependent variable: Growth volatility		
Private credit to GDP (X_i)	$\hat{\beta} =$	-0.013 (0.002)***
Private credit to GDP (X_i^2)	$\hat{\gamma} =$	0.005 (0.001)***
Slope at X_l	$\hat{\beta} + 2\hat{\gamma}X_l =$	-0.013 [0.000]***
Slope at X_h	$\hat{\beta} + 2\hat{\gamma}X_h =$	0.020 [0.000]***
Appropriate U test		5.99 [0.000]***
Extreme point	$-\hat{\beta}/(2\hat{\gamma}) =$	1.212
95% confidence interval, Fieller method		[1.119,1.344]
Dependent variable: Inflation volatility		
Private credit to GDP (X_i)	$\hat{\beta} =$	-0.084 (0.005)***
Private credit to GDP (X_i^2)	$\hat{\gamma} =$	0.029 (0.002)***
Slope at X_l	$\hat{\beta} + 2\hat{\gamma}X_l =$	-0.083 [0.000]***
Slope at X_h	$\hat{\beta} + 2\hat{\gamma}X_h =$	0.095 [0.000]***
Appropriate U test		13.07 [0.000]***
Extreme point	$-\hat{\beta}/(2\hat{\gamma}) =$	1.432
95% confidence interval, Fieller method		[1.385,1.486]

Notes: (1) This table reports the test of the U-shaped relationship between financial development and macroeconomic volatility (output and inflation volatility) using the appropriate U test proposed by Lind and Mehlum (2010); (2) Robust standard errors in parentheses and P-values in square brackets; (3) ***, ** and * denote significances at the 1, 5, and 10% levels.

3.2 Regression results

In the previous subsection we have provided some preliminary results on the relationship between financial development and macroeconomic volatility. However, this evidence is intuitive, but not adequately convincing. To get a more precise sense of this relationship, we now turn to present evidence from more formal econometric (regression) analysis.

The baseline regression results for Eq. (1) are shown in Table 3, where two major volatility variables (i.e., output volatility and inflation volatility) are used as the proxies for macroeconomic volatility (dependent variable) and the private sector credit to GDP ratio is used as the proxy for financial development (core explanatory variable). In our baseline analysis, both the first-differenced and system GMM estimation results are reported in Table 3, denoted as DIF-GMM and SYS-GMM respectively. From the diagnostic results in Table 3, we can see that all regressions are estimated appropriately. Specifically, both the Sargan test of identifying restrictions and the AR(2) test cannot be rejected in all regressions, suggesting that the instruments used are valid and there is no evidence of second-order serial correlation in the estimation.

Table 3 Financial development and macroeconomic volatility: baseline results

Dependent variable: Output volatility (*VGDP*)			Dependent variable: Inflation volatility (*VINF*)		
	(1)	(2)		(3)	(4)
	DIF-GMM	SYS-GMM		DIF-GMM	SYS-GMM
L.VGDP	0.623***	0.595***	*L.VINF*	0.648***	0.605***
	(9.27)	(12.31)		(4.69)	(9.12)
FD	-0.025***	-0.028***	*FD*	-0.445***	-0.439***
	(-2.86)	(-8.72)		(-7.53)	(-3.49)
FD^2	0.009***	0.010***	FD^2	0.162***	0.159***
	(7.94)	(9.16)		(4.36)	(6.83)
Growth	-0.006***	-0.012***	*Growth*	-0.041*	-0.026**
	(-2.59)	(-6.82)		(-1.89)	(-2.27)
Inflation	0.011**	0.010***	*Inflation*	0.047*	0.043***
	(2.13)	(8.74)		(1.87)	(2.96)
Capital	-0.002***	-0.005***	*Capital*	-0.003*	-0.008**
	(-2.84)	(-3.27)		(-1.89)	(2.12)
Open	-0.001***	-0.002***	*Open*	-0.001	-0.005
	(-3.06)	(-5.48)		(-1.09)	(-1.20)
Crisis	0.011**	0.012***	*Crisis*	0.112***	0.098***
	(2.09)	(7.62)		(3.57)	(3.93)
Stability	-0.004**	-0.006***	*Stability*	-0.009**	-0.010**
	(-2.23)	(-3.05)		(-2.39)	(-2.21)
Government	-0.007	-0.004	*Government*	-0.122	-0.046
	(-1.01)	(-1.38)		(-0.66)	(-1.04)
Regulation	-0.004*	-0.005*	*Regulation*	-0.057*	-0.061**
	(-1.78)	(-1.92)		(-1.81)	(-2.19)
Law	-0.009**	-0.010**	*Law*	-0.108**	-0.149**
	(-2.40)	(-2.32)		(-2.17)	(-2.46)
Corruption	-0.002**	-0.002***	*Corruption*	-0.091**	-0.043***
	(-2.43)	(-3.95)		(-2.33)	(-3.31)
Constant	0.017***	0.020***	*Constant*	0.026*	0.029**
	(6.05)	(8.28)		(1.76)	(2.49)
AR(1) Test	0.002	0.001	AR(1) Test	0.003	0.002
AR(2) Test	0.382	0.356	AR(2) Test	0.279	0.435
Sargan Test	0.471	0.396	Sargan Test	0.489	0.372
Observations	1088	1088	Observations	1088	1088
N	68	68	N	68	68

Notes: (1) *, ** and *** indicate that the coefficients are significant at the level of 10%, 5% and 1%, respectively; (2) *L.VGDP* and *L.VINF* is the lagged dependent variable of output and inflation, respectively; (3) Values in parentheses are z-statistics; (4) The p-values of first-order correlation test, second-order serial correlation test and overidentification test are shown in AR(1) Test, AR(2) Test and Sargan Test, respectively.

Let us first focus on the left section of Table 3, where we report the estimation results for the relationship between financial development and output volatility. As can be seen from regressions (1) and (2), for both the first-differenced and system GMM estimators, the level term of financial development (*FD*) is estimated to be negatively correlated with output volatility at the 1 percent significance level, while its quadratic term (FD^2) is estimated to be positively correlated with output volatility at the 1 percent significance level. This result strongly suggests that the relationship between financial development and output volatility is nonlinear and U-shaped. That is, there exists a turning point after which the negative impact of financial development on output volatility becomes positive. As for the threshold level of financial development, we can use the estimated coefficients to compute an estimate of the threshold value for the U-shaped relationship. To be more specific, by calculating the partial derivative of output volatility with respect to the financial development variable, it is easy to see that the threshold level of financial development is located around 1.4, which means that the dampening effect of financial development on output volatility will vanish and actually become positive after the private sector credit to GDP ratio exceeds 140%.

Similar results are obtained for the impact of financial development on inflation volatility, as shown in the right section of Table 3. Two main results emerge from regressions (3) and (4). First, the coefficients on financial development (*FD*) and its quadratic term are estimated to be negative and positive respectively, both of which are significant at the 1% significance level. Second, the threshold level of financial development is calculated to be 1.37 under the first-differenced GMM estimation (regression (3)) and 1.38 under the system GMM estimation (regression (4)), both of which are very close to the threshold levels found in the financial development-output volatility nexus. Taken together, the results in Table 3 suggest that there is a significant U-shaped relationship between financial development and macroeconomic volatility, where financial development is helpful in reducing economic volatility only up to a certain level (about 140% as measured by private sector credit to GDP ratio), after which it would become a drag on economic stability.

The above findings are generally consistent with the literature that reported a non-linear impact of finance on economic volatility (e.g., Easterly et al., 2000; Dabla-Norris and Srivisal, 2013). However, compared with the results in the previous literature, our estimates of the threshold level of financial development turn out to be higher in magnitude. For instance, the threshold level of financial development (measured by private sector credit to GDP ratio) for the financial development-output volatility nexus was found to be around 100% in the study of Easterly et al. (2000). Similar results are also reported in Dabla-Norris and Srivisal (2013), where financial depth starts to exert a positive effect on investment and consumption volatility after it reaches 100 percent of GDP. The differences between the estimation results are probably due to differences in data and methods. However, considering that our study uses a large panel of countries with longer periods and conducts extensive sensitivity tests to ensure the robustness of the results (see the next section), it is quite likely that the threshold level of financial development for the finance-volatility nexus is higher than previously estimated.

Another thing worth mentioning is that some interesting results will emerge if we link our findings to a broad literature concerning the role of finance in economic performance. In particular, a large body of literature has documented an inverted U-shaped relation between financial development and economic growth, where the threshold level of financial development (private sector credit to GDP ratio) is usually estimated to be around or below 100% (e.g., Arcand et al., 2012; Cecchetti and Kharroubi, 2012). Recall that our estimate of the threshold value of financial development for the relationship between financial development and economic volatility is around 140%. The interesting point here is that the threshold value of financial development turns out to be remarkably higher for the finance-volatility nexus than that for the finance-growth nexus, implying an asymmetric effect of financial development on economic growth and volatility. From a policy perspective, this suggests that after the positive effect of financial development on economic growth reaches the threshold level, it might still be desirable to promote financial development for the purpose of economic stability. In this regard, the optimal choice of financial development strategy also depends on the policy makers' preference for growth versus their preference for stability.

Now we turn to discuss some of the results from the control variables. The coefficients on GDP growth rate (*Growth*) and gross capital formation (*Capital*) are found to be significantly negative in all equations, suggesting that higher economic growth or capital formation is conducive to smoothing macroeconomic volatility. In contrast, the coefficient on inflation rate (*Inflation*) is estimated significantly positive, implying that macroeconomic volatility tends to be amplified in a high inflation environment. Financial openness (*Open*) has a significantly negative impact on output volatility, but its impact on inflation volatility is insignificant. As expected, the coefficient on financial crisis (*Crisis*) is significantly positive in all equations, implying that macroeconomic volatility tends to be higher in crisis periods. As for the institutional variables, we find that greater political stability, higher regulatory quality, better rule of law, and more effective control of corruption lead to lower output and inflation volatility. Among the five institutional variables, government effectiveness (*Government*) is the only one that is statistically insignificant, but still has the expected negative sign. Taken together, these results suggest that countries with low institutional quality tend to suffer from more macroeconomic volatility.

3.3 Robustness checks

In this section we conduct various robustness checks to check the sensitivity of our results to alternative proxy variables, different data frequencies and alternative modelling strategies. As mentioned earlier, the system GMM estimator is generally considered to be more precise and efficient than the first-differenced GMM estimator. Therefore, for the sake of simplicity, we only report the system GMM estimates in this section.

3.3.1 Alternative proxy variables

First, additional robustness checks are carried out using alternative measures of the dependent variable. Specifically, we use three alternative proxies for macroeconomic volatility, including volatility of real GDP per capita growth rate (*VGDPP*), volatility of national disposable income per capita growth rate (*VDIP*) and the volatility of final consumption expenditure growth rate (*VCON*). The results obtained by using these alternative proxies are presented in Table 4.

Table 4 Robustness to alternative measures of macroeconomic volatility

Dependent variable:	*VGDPP*	*VDIP*	*VCON*
	(1)	(2)	(3)
Lagged dep.var.	0.528***	0.710***	0.644***
	(10.23)	(11.26)	(8.79)
FD	-0.031***	-0.050***	-0.122**
	(-6.27)	(-3.13)	(-2.06)
FD^2	0.011***	0.018**	0.045**
	(5.88)	(2.02)	(2.17)
Growth	-0.006**	-0.002***	-0.039**
	(-2.19)	(-3.18)	(-2.43)
Inflation	0.009***	0.011**	0.002*
	(3.56)	(2.16)	(1.88)
Capital	-0.017***	-0.005***	-0.003*
	(-4.22)	(-3.25)	(-1.84)
Open	-0.001**	-0.001	-0.003***
	(-2.12)	(-0.18)	(-2.59)
Crisis	0.012***	0.009***	0.005***
	(6.29)	(4.28)	(2.64)
Stability	-0.004**	-0.001*	-0.003**
	(-2.29)	(-1.82)	(-2.38)
Government	-0.005	-0.002	-0.004
	(-1.06)	(-0.68)	(-0.19)
Regulation	-0.008*	-0.002*	-0.036**
	(-1.82)	(-1.79)	(-2.35)
Law	-0.012**	-0.009**	-0.017*
	(-2.05)	(-2.13)	(-1.79)
Corruption	-0.002*	-0.004**	-0.006*
	(-1.76)	(-2.23)	(-1.83)
Constant	0.023***	0.004***	0.016***
	(9.45)	(8.32)	(3.49)
AR(1) Test	0.002	0.000	0.001
AR(2) Test	0.324	0.226	0.416
Sargan Test	0.597	0.351	0.525
Observations	1088	1088	1088
N	68	68	68

Notes: (1) *, ** and *** indicate that the coefficients are significant at the level of 10%, 5% and 1%, respectively; (2) Values in parentheses are z-statistics; (3) The p-values of first-order correlation test, second-order serial correlation test and overidentification test are shown in AR(1) Test, AR(2) Test and Sargan Test, respectively.

From Table 4 we can see that, consistent with the baseline results, the coefficients on the level and quadratic terms of financial development are all statistically significant with the expected sign, indicating that the U-shaped relationship between financial development and macroeconomic volatility remains robust to different measures of macroeconomic volatility. As for the threshold level, by computing the partial derivative of each dependent variable with respect to financial development (*FD*), we can see that the associated threshold values are 141%, 139% and 136%, respectively. Again, these results suggest that the dampening effect of financial development on macroeconomic volatility is likely to reverse after the private sector credit to GDP ratio exceeds 140%.

After checking the robustness of our results to alternative proxies of macroeconomic volatility, we now proceeds to see whether our results is also robust to another frequently used proxy variable for financial development: the M2/GDP ratio. The results are reported in Table 5. From Table 5 we can that, for all of the five measures of macroeconomic volatility, the U-shaped relationship between financial development and macroeconomic volatility remains unchanged when the M2/GDP ratio is used as a proxy for financial development. Comparing the results in Table 5 with those in Table 4, it is evident that the threshold level of the M2/GDP ratio is higher than that of the private credit/GDP ratio. This is not surprising because most of the sample countries typically have a higher M2/GDP ratio than the private credit/GDP ratio during the observation period.

Table 5 Robustness to alternative measure of financial development (M2/GDP)

Dependent variable:	*VGDP*	*VINF*	*VGDPP*	*VDIP*	*VCON*
	(1)	(2)	(3)	(4)	(5)
Lagged dep.var.	0.630***	0.609***	0.556***	0.724***	0.662***
	(10.87)	(9.35)	(11.34)	(12.20)	(8.56)
M2	-0.026***	-0.609***	-0.014***	-0.037***	-0.008***
	(-3.19)	(-3.68)	(-4.62)	(-3.49)	(-2.92)
$M2^2$	0.007***	0.132***	0.003***	0.009***	0.002***
	(4.25)	(3.97)	(3.66)	(4.71)	(2.99)
Growth	-0.010***	-0.029**	-0.004**	-0.003**	-0.041***
	(-2.89)	(-2.18)	(-2.47)	(-2.05)	(-4.24)
Inflation	0.009**	0.049**	0.008*	0.009**	0.003***
	(2.09)	(2.24)	(1.81)	(2.01)	(2.93)
Capital	-0.008***	-0.410**	-0.019***	-0.005**	-0.006*
	(-4.63)	(-2.34)	(-6.15)	(-2.23)	(-1.80)
Open	-0.001***	-0.007	-0.002**	-0.001	-0.003*
	(-3.46)	(-1.28)	(-2.30)	(-0.16)	(-1.89)
Crisis	0.010***	0.094**	0.013**	0.007***	0.003***
	(2.98)	(2.16)	(2.32)	(5.52)	(3.71)
Stability	-0.007**	-0.009**	-0.005**	-0.000*	-0.002**
	(-2.03)	(-2.18)	(-2.43)	(-1.85)	(-2.13)
Government	-0.003	-0.039	-0.006	-0.001	-0.006
	(-1.09)	(-1.42)	(-1.20)	(-0.56)	(-0.52)
Regulation	-0.006*	-0.068**	-0.009**	-0.001*	-0.039*
	(-1.87)	(-2.08)	(-2.11)	(-1.83)	(-1.92)
Law	-0.011**	-0.137*	-0.016***	-0.009**	-0.015**
	(-2.42)	(-1.81)	(-3.06)	(-2.18)	(-2.27)
Corruption	-0.003*	-0.041*	-0.003**	-0.004*	-0.005**
	(-1.89)	(-1.95)	(-2.23)	(-1.87)	(-2.19)
Constant	0.012**	0.079	0.012***	0.005**	0.026***
	(2.15)	(0.77)	(3.48)	(2.21)	(3.02)
AR(1) Test	0.001	0.002	0.001	0.001	0.002
AR(2) Test	0.393	0.528	0.284	0.502	0.478
Sargan Test	0.342	0.430	0.467	0.289	0.341
Observations	1088	1088	1088	1088	1088
N	68	68	68	68	68

Notes: (1) *, ** and *** indicate that the coefficients are significant at the level of 10%, 5% and 1%, respectively; (2) Values in parentheses are z-statistics; (3) The p-values of first-order correlation test, second-order serial correlation test and overidentification test are shown in AR(1) Test, AR(2) Test and Sargan Test, respectively.

Finally, considering that both the private credit/GDP ratio and the M2/GDP ratio do not take into account the complex multidimensional nature of financial development, we also use the composite index recently created by Svirydzenka (2016) as an alternative measure of financial development for robustness.[3] The results are reported in Table 6. From Table 6 we can see that the coefficients on the level and quadratic terms of financial development are all statistically significant with the same signs as before, suggesting that the U-shaped relationship between financial development and macroeconomic volatility still holds when we use a more broad-based financial development indicator that captures the multidimensional nature of financial development.

[3] This composite index of financial development is constructed by aggregating nine indices that summarize how developed financial institutions and financial markets are in terms of their depth, access, and efficiency. For technical details, please refer to Svirydzenka (2016). The data sets are available at http://www.nber.org/data/international-finance/#findev.

Table 6 Robustness to alternative measure of financial development (composite financial development index constructed by Svirydzenka (2016))

Dependent variable:	*VGDP*	*VINF*	*VGDPP*	*VDIP*	*VCON*
	(1)	(2)	(3)	(4)	(5)
Lagged dep.var.	0.796***	0.667***	0.709***	0.826***	0.680***
	(15.67)	(14.91)	(15.22)	(16.87)	(12.52)
FD	-0.056**	-4.767**	-0.024**	-0.002**	-0.093***
	(-2.34)	(-2.42)	(-2.13)	(-2.10)	(-3.18)
FD^2	0.049**	3.517**	0.023**	0.002**	0.046***
	(2.22)	(2.27)	(2.20)	(1.99)	(3.75)
Growth	-0.013***	-0.024**	-0.006**	-0.004**	-0.052***
	(-2.97)	(-2.02)	(-2.15)	(-2.01)	(-4.38)
Inflation	0.013**	0.056**	0.010*	0.012**	0.003***
	(2.20)	(1.99)	(1.83)	(2.17)	(2.87)
Capital	-0.007***	-0.472**	-0.017***	-0.004**	-0.008**
	(-4.38)	(-2.26)	(-5.38)	(-2.15)	(-1.97)
Open	-0.002**	-0.007	-0.002*	-0.003	-0.005*
	(-2.05)	(-1.36)	(-1.83)	(-1.16)	(-1.85)
Crisis	0.008***	0.087**	0.011**	0.009***	0.003***
	(3.19)	(2.20)	(2.12)	(5.18)	(3.62)
Stability	-0.008**	-0.012**	-0.006**	-0.001*	-0.003***
	(-2.07)	(-2.05)	(-2.14)	(-1.86)	(-3.29)
Government	-0.006	-0.043	-0.005	-0.002	-0.004
	(-1.28)	(-1.51)	(-1.06)	(-0.45)	(-0.85)
Regulation	-0.009**	-0.071*	-0.011**	-0.001*	-0.035*
	(-2.09)	(-1.88)	(-2.22)	(-1.86)	(-1.90)
Law	-0.015**	-0.140*	-0.019***	-0.008**	-0.017**
	(-2.34)	(-1.80)	(-3.15)	(-2.02)	(-2.19)
Corruption	-0.002*	-0.039*	-0.005**	-0.003*	-0.006*
	(-1.86)	(-1.92)	(-2.10)	(-1.82)	(-1.89)
Constant	-0.007	1.081*	0.007**	0.001**	0.026**
	(-1.60)	(1.76)	(2.55)	(2.29)	(2.24)
AR(1) Test	0.002	0.004	0.001	0.003	0.003
AR(2) Test	0.540	0.415	0.367	0.418	0.531
Sargan Test	0.452	0.593	0.486	0.309	0.426
Observations	1088	1088	1088	1088	1088
N	68	68	68	68	68

Notes: (1) *, ** and *** indicate that the coefficients are significant at the level of 10%, 5% and 1%, respectively; (2) Values in parentheses are z-statistics; (3) The p-values of first-order correlation test, second-order serial correlation test and overidentification test are shown in AR(1) Test, AR(2) Test and Sargan Test, respectively.

3.3.2 Varying the data frequency

In our baseline analysis, the volatility of macroeconomic and financial variables is calculated over a five-year window. To check the robustness of our results to different data frequencies, we also consider a shorter window length of three years and a longer window length of eight years. The use of a three-year window has the benefit of generating more observations and capturing the short-term effects of financial development on macroeconomic volatility. In contrast, the use of an eight-year window would be more effective in capturing the long-term effects. The regression results with the two window lengths are reported in Table 7.

Table 7 Robustness to alternative data frequency

Dependent variable: Output volatility (*VGDP*)			Dependent variable: Inflation volatility (*VINF*)		
	(1)	(2)		(3)	(4)
	3-year window	8-year window		3-year window	8-year window
L.VGDP	0.587***	0.656***	*L.VINF*	0.597***	0.679***
	(11.92)	(13.18)		(9.59)	(10.35)
FD	-0.022***	-0.030***	*FD*	-0.404***	-0.528***
	(-6.32)	(-10.59)		(-2.89)	(-6.67)
FD^2	0.008***	0.011***	FD^2	0.146***	0.196***
	(5.37)	(12.35)		(3.88)	(9.42)
Growth	-0.015***	-0.010**	*Growth*	-0.029***	-0.022**
	(-3.69)	(-2.02)		(-3.53)	(-2.18)
Inflation	0.017**	0.010*	*Inflation*	0.049***	0.040***
	(2.03)	(1.84)		(3.89)	(4.62)
Capital	-0.004*	-0.005**	*Capital*	-0.005**	-0.007*
	(-1.83)	(-2.21)		(2.25)	(1.82)
Open	-0.002**	-0.004***	*Open*	-0.006	-0.009
	(-2.18)	(-4.35)		(-1.08)	(-1.35)
Crisis	0.012***	0.010***	*Crisis*	0.099***	0.085**
	(6.84)	(4.42)		(3.97)	(2.16)
Stability	-0.005**	-0.008***	*Stability*	-0.009**	-0.012**
	(-2.13)	(-2.92)		(-2.17)	(-2.09)
Government	-0.005	-0.003	*Government*	-0.051	-0.036
	(-0.59)	(-0.78)		(-0.47)	(-0.88)
Regulation	-0.007**	-0.005*	*Regulation*	-0.075**	-0.059**
	(-2.12)	(-1.90)		(-2.33)	(-1.99)
Law	-0.008*	-0.013**	*Law*	-0.118*	-0.162**
	(-1.86)	(-2.36)		(-1.83)	(-2.46)
Corruption	-0.001**	-0.004**	*Corruption*	-0.038**	-0.056*
	(-1.85)	(-2.27)		(-2.19)	(-1.89)
Constant	0.015*	0.024	*Constant*	0.011**	0.023
	(1.78)	(1.31)		(2.04)	(0.49)
AR(1) Test	0.002	0.001	AR(1) Test	0.003	0.002
AR(2) Test	0.478	0.332	AR(2) Test	0.462	0.375
Sargan Test	0.387	0.385	Sargan Test	0.412	0.386
Observations	1224	884	Observations	1224	884
N	68	68	N	68	68

Notes: (1) *, ** and *** indicate that the coefficients are significant at the level of 10%, 5% and 1%, respectively; (2) *L.VGDP* and *L.VINF* is the lagged dependent variable of output and inflation, respectively; (3) Values in parentheses are z-statistics; (4) The p-values of first-order correlation test, second-order serial correlation test and overidentification test are shown in AR(1) Test, AR(2) Test and Sargan Test, respectively.

As Table 7 shows, the U-shaped relationship between financial development and macroeconomic volatility still holds true for both of the two window lengths, suggesting that our results is robust to different data frequencies. In fact, the coefficients on our main variables of interest (i.e., financial development and its quadratic term) turn out to be more significant in the case of the eight-year window regressions, implying that the nonlinear and U-shaped effects of financial development on macroeconomic volatility would be more evident over longer horizons.

3.3.3 Alternative modelling strategy

To further assess the presence of threshold nonlinearities in the finance-volatility nexus, it would be helpful to use the threshold regression model proposed by Hansen (1999) as a robustness check. Unlike using a square term to capture the nonlinear effects of finance on macroeconomic volatility, the modelling strategy proposed by Hansen (1999) allows the relationship between financial development and macroeconomic volatility to be piecewise linear, with the level of financial development acting as a regime-switching trigger. Specifically, the following model is used to test the presence of threshold nonlinearities in the finance-volatility nexus:

$$V_{it} = \mu_i + \beta_1 FD_{it} I(FD_{it} \le \gamma) + \beta_2 FD_{it} I(FD_{it} > \gamma) + \alpha Z_{it} + \varepsilon_{it} \quad (4)$$

where μ_i denotes the individual-specific fixed effect, financial development (FD) is the threshold variable and γ is the threshold value to be estimated. $I(\cdot)$ is an indicator function, which takes value 1 if the hypothesis in the parenthesis is valid and 0 otherwise. From Eq. (4) we can see that the effect of financial development on macroeconomic volatility is divided into two regimes depending on whether the threshold variable (FD) is lower or higher than the threshold value γ. These two regimes are then distinguished by the differing regression coefficients, β_1 and β_2. Z_{it} is the vector of control variables defined as before. $\varepsilon_{it} \sim iid(0, \delta^2)$ is the error term.

The estimation results obtained by using the above threshold regression model are presented in Table 8. From Table 8 we can see that the test for the significance of the threshold effect, as indicated by the F statistic proposed by Hansen (1999), is highly significant in all equations in Table 8, confirming the existence of threshold nonlinearities in the finance-volatility nexus. Quantitatively speaking, the threshold values of financial development for the five volatility variables (i.e., *VGDP*, *VINF*, *VGDPP*, *VDIP* and *VCON*) are estimated to be 138%, 140%, 1.43%, 141% and 136%, respectively, which are very close to the threshold values obtained in the previous analysis. In addition, we also find that for all of the five regressions in Table 8, the coefficient β_1 is estimated to be significantly negative while β_2 is estimated to be significantly positive, suggesting that financial development is conducive to reducing macroeconomic volatility only if it is below the threshold value; after that, the reverse will be true. Overall, these results are largely consistent with our previous findings.

Table 8 Robustness to alternative modelling strategy: threshold regression model

Dependent variable:	*VGDP*	*VINF*	*VGDPP*	*VDIP*	*VCON*
	(1)	(2)	(3)	(4)	(5)
Threshold Estimates					
λ	1.383	1.402	1.426	1.408	1.361
Impact of Finance					
β_1	-0.027***	-0.086***	-0.024***	-0.011**	-0.039**
	(0.008)	(0.021)	(0.008)	(0.005)	(0.017)
β_2	0.031**	0.051**	0.029***	0.013**	0.042*
	(0.014)	(0.026)	(0.014)	(0.006)	(0.023)
Control variables					
Growth	-0.013**	-0.035*	-0.004**	-0.003***	-0.028**
	(0.006)	(0.019)	(0.002)	(0.001)	(0.012)
Inflation	0.009**	0.052**	0.007**	0.008**	0.003***
	(0.004)	(0.026)	(0.003)	(0.004)	(0.001)
Capital	-0.008**	-0.026*	-0.017**	-0.004***	-0.011*
	(0.004)	(0.014)	(0.008)	(0.001)	(0.006)
Open	-0.002**	-0.005	-0.003***	-0.000	-0.002**
	(0.001)	(0.009)	(0.001)	(0.001)	(0.001)
Crisis	0.015***	0.072*	0.010***	0.007**	0.003***
	(0.004)	(0.039)	(0.003)	(0.003)	(0.000)
Stability	-0.006**	-0.009*	-0.005**	-0.002**	-0.001***
	(0.003)	(0.005)	(0.002)	(0.001)	(0.000)
Government	-0.004	-0.041	-0.004	-0.001	-0.006
	(0.003)	(0.028)	(0.003)	(0.001)	(0.004)
Regulation	-0.005**	-0.089**	-0.004**	-0.001***	-0.028*
	(0.002)	(0.045)	(0.002)	(0.000)	(0.015)
Law	-0.015*	-0.143**	-0.011*	-0.009**	-0.013*
	(0.008)	(0.067)	(0.006)	(0.004)	(0.007)
Corruption	-0.002**	-0.046*	-0.002**	-0.003***	-0.009*
	(0.001)	(0.025)	(0.001)	(0.001)	(0.005)
Test for threshold effect					
F	26.612**	34.503***	18.159***	31.925***	8.908***
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Observations	1156	1156	1156	1156	1156
N	68	68	68	68	68

Notes: (1) *, ** and *** indicate that the coefficients are significant at the level of 10%, 5% and 1%, respectively; (2) Values in parentheses are standard errors, except for the F test, which are p-values.

4 Further discussion: Is there a difference between developed and developing countries?

Having established that there is a threshold level at which financial development switches from smoothing economic volatility to exacerbating it, we now turn to the influence of the stages of economic development on the finance-volatility nexus. Put another way, we investigate whether there is a difference in the finance-volatility nexus between developed and developing countries. To this end, first we classify the sample countries into developed and developing countries according to the World Bank's classification of countries (see Table A1 in the Appendix). Then we construct a dummy variable (*D*) that takes value 1 if a country belongs to the developed group and 0 otherwise.

After the dummy variable is constructed, to test whether the impact of financial development on macroeconomic volatility in developed countries differ from that of the developing ones, we include interaction terms for the dummy variable and the financial development variables in the regression. That is, Eq. (1) is now transformed into:

$$V_{i,t} = c + \alpha V_{i,t-1} + \beta FD_{i,t} + \gamma FD_{i,t}^2 + \phi D \times FD_{i,t} + \lambda D \times FD_{i,t}^2 + \theta Z_{i,t} + \varphi_i + \mu_t + \varepsilon_{i,t} \quad (5)$$

where *D* denotes the dummy variable as specified above; all other variables in Eq. (5) are the same as before. The parameters on the interaction terms are our main interest, which capture the difference in the effect of financial development on macroeconomic volatility in developed countries compared with developing countries.

The regression results for Eq. (5) are reported in Table 9. Two striking facts emerge from this table. First, the U-shaped relationship between financial development and macroeconomic volatility remains unchanged after we take into account the potential differences between developed and developing countries, giving additional credibility to the main conclusion of our paper. Second, the coefficients on the two interaction terms are statistically significant in all regressions, suggesting that there are indeed differences in the effect of financial development on macroeconomic volatility between developed and developing countries. In particular, the threshold levels of financial development are estimated to be higher in developed countries than those found in developing countries. To see this more clearly, we can calculate respectively the threshold value for developed and developing countries. Recall that the dummy variable (*D*) takes value 1 for developed countries and 0 for developing countries. Thus, the threshold level of financial development for the developed countries can be calculated as $T_{developed} = -\frac{\beta + \phi}{2\gamma + \lambda}$ while that for the developing countries can be calculated as $T_{developing} = -\frac{\beta}{2\gamma}$. Using the estimated coefficients in regressions (1)-(5) in Table 9, it can be easily calculated that, for developed countries, the threshold levels of financial development with respect to the five volatility variables (i.e., *VGDP*, *VINF*, *VGDPP*, *VDIP*, *VCON*) are 150%, 157%, 144%, 146% and 145%, respectively; while for developed countries, the corresponding threshold levels are 109%, 108%, 113%, 107% and 108%, respectively. This result, however, is not surprising, as most developed countries typically have a higher level of financial development than developing countries.

Table 9 The difference between developed and developing countries

Dependent variable:	*VGDP*	*VINF*	*VGDPP*	*VDIP*	*VCON*
	(1)	(2)	(3)	(4)	(5)
Lagged dep.var.	0.648***	0.639***	0.574***	0.703***	0.691***
	(10.36)	(9.92)	(10.49)	(14.25)	(7.99)
FD	-0.024***	-0.420***	-0.034***	-0.045***	-0.134***
	(-3.64)	(-7.99)	(-10.13)	(-3.96)	(-4.87)
FD^2	0.011***	0.194***	0.015***	0.021***	0.062***
	(3.92)	(6.19)	(4.08)	(5.15)	(3.63)
$D\times FD$	0.003***	0.019***	0.008***	0.007***	0.015***
	(3.61)	(19.22)	(5.18)	(3.84)	(5.67)
$D\times FD^2$	-0.004***	-0.066***	-0.006***	-0.008***	-0.021***
	(-2.95)	(-17.60)	(-4.39)	(-6.43)	(-4.98)
Growth	-0.009***	-0.024**	-0.006***	-0.002***	-0.039***
	(-3.82)	(-2.03)	(-3.88)	(-4.25)	(-7.16)
Inflation	0.007**	0.044***	0.009**	0.011*	0.002***
	(2.09)	(3.34)	(2.06)	(1.89)	(5.05)
Capital	-0.006**	-0.039***	-0.019**	-0.005**	-0.008*
	(-2.08)	(-3.49)	(-2.19)	(-2.17)	(-1.79)
Open	-0.002***	-0.008	-0.002**	-0.001	-0.002**
	(-6.39)	(-1.15)	(-2.42)	(-0.55)	(-2.12)
Crisis	0.011***	0.085**	0.015***	0.006**	0.005***
	(4.35)	(2.01)	(3.03)	(2.24)	(4.31)
Stability	-0.009**	-0.008**	-0.004**	-0.001*	-0.002**
	(-2.17)	(-2.02)	(-2.36)	(-1.84)	(-2.29)
Government	-0.002	-0.035	-0.007	-0.002	-0.003
	(-0.63)	(-0.75)	(-0.89)	(-0.24)	(-0.16)
Regulation	-0.006**	-0.072**	-0.006***	-0.000**	-0.032**
	(-2.08)	(-2.42)	(-3.06)	(-2.13)	(-2.04)
Law	-0.012*	-0.139**	-0.013***	-0.009**	-0.011*
	(-1.91)	(-2.08)	(-3.03)	(-2.43)	(-1.77)
Corruption	-0.003*	-0.050**	-0.003*	-0.002**	-0.006*
	(-1.87)	(-1.99)	(-1.84)	(-2.01)	(-1.77)
Constant	0.014***	0.071*	0.034***	0.004**	0.013***
	(3.79)	(1.86)	(3.13)	(2.02)	(3.59)
AR(1) Test	0.001	0.001	0.002	0.000	0.001
AR(2) Test	0.458	0.395	0.267	0.357	0.384
Sargan Test	0.425	0.368	0.292	0.335	0.276
Observations	1088	1088	1088	1088	1088
N	68	68	68	68	68

Notes: (1) *, ** and *** indicate that the coefficients are significant at the level of 10%, 5% and 1%, respectively; (2) Values in parentheses are z-statistics; (3) The p-values of first-order correlation test, second-order serial correlation test and overidentification test are shown in AR(1) Test, AR(2) Test and Sargan Test, respectively.

Another interesting result worth mentioning is that the coefficients on the interaction terms turn out to be much more significant in the inflation volatility regression than those in other regressions. This suggest that, compared with the volatility effects of financial development on real variables such as output, income and consumption, the volatility effects of financial development on price (inflation) seem to be more pronounced in developed countries. Note also that the threshold level after which the dampening effect of financial development on inflation volatility vanishes is much higher in developed countries (157%) than that in developing countries (108%). One possible reason for this distinct effect of financial development on inflation in developed countries may be that central banks in developed countries typically exhibit higher preference towards inflation stability and thus pursue more rigorous anti-inflation policies to make inflation under control. In this context, the threshold level after which finance starts to have a magnifying effect on inflation volatility may come at a much later time in developed countries than in developing countries.

5 Concluding remarks

In this paper, we investigate the nonlinear effect of financial development on macroeconomic volatility using cross-country panel data over the period 1996–2012. We find that financial development has a significant U-shaped effect on macroeconomic volatility. That is, financial development is helpful for smoothing economic volatility only up to a threshold level, after which further growth of the financial system can be a drag on economic stability. This result is found to be robust to alternative proxy variables, different data frequencies, and alternative modelling strategies. Further, we also find that the U-shaped effect of financial development on inflation volatility tends to be more pronounced in developed countries than in developing countries.

Although the main focus of this paper is not to examine the underlying causes for the U-shaped relationship between financial development and economic volatility, we put forward several possible explanations, as suggested by the relevant literature. First, the financial system may become inefficiently large compared to the size of the domestic economy, which may extract excessive information rents and result in a misallocation of labour (Philippon, 2010; Bolton et al., 2011; Cecchetti and Kharroubi, 2012). Second, the presence of a large and overcomplicated financial system may increase financial fragility that leads to economic instability and crises (Rajan, 2005; Gennaioli et al., 2012). Third, financial development may be helpful for economies that are catching up to the productivity frontier, but has very limited or no obvious effect for economies that are close to the frontier (Aghion et al., 2005).

The main findings of the paper, together with the experience of the 2008 financial crisis, lead us to conclude that there is a pressing need to reassess the role of finance in the economy. In particular, more finance is not always better. From a policy perspective, as the financial sector can grow too big and pose risks to economic instability, policymakers should adopt appropriate measures to maintain a proper size of the financial system. According our estimation, financial development measured by private credit to GDP ratio should not exceed 140%. Finally, our results also suggest that institutional quality matters for economic stability. In this regard, to achieve better economic stability, policy reforms should also strive for greater political stability, higher regulatory quality, better rule of law, and more effective control of corruption.

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Appendix

Table A1 Countries included in the sample

Developed countries	Austria, Australia, Britain, Canada, Chile, Greece, Cyprus, Denmark, France, Finland, Germany, Italy, Japan, Korea, Luxembourg, Malta, Netherlands, New Zealand, Portugal, Singapore, Spain, Sweden, Switzerland, United States, Uruguay
Developing countries	Bangladesh, Belize, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Cameroon, China, Colombia, Congo, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Gabon, Gambia, Guatemala, Honduras, Hungary, Indonesia, Jordan, Kenya, Lesotho, Madagascar, Malaysia, Mali, Mauritius, Morocco, Mexico, Peru, Philippines, South Africa, Sierra Leone, Senegal, Sri Lanka, Swaziland, Thailand, Togo, Turkey, Venezuela, Zambia

Note: The sample countries are classified into developed and developing countries according to the World Bank's classification of countries.

Table A2 Definitions and sources of variables

Variable	Definition	Source
VGDP	Standard deviations of real GDP growth rate	Authors' calculation
VINF	Standard deviations of inflation rate	Authors' calculation
VGDPP	Standard deviations of real GDP per capita growth rate	Authors' calculation
VCON	Standard deviations of final consumption expenditure growth rate	Authors' calculation
VDIP	Standard deviations of national disposable income per capita growth rate	Authors' calculation
FD	Private sector credit to GDP ratio	WDI*
FD^2	Square of private sector credit to GDP ratio	Authors' calculation
M2	Money and quasi money (M2) to GDP ratio (M2/GDP)	WDI
$M2^2$	Square of M2/GDP	Authors' calculation
Growth	Annual growth rate of real GDP	WDI
Inflation	Annual percentage change in the GDP deflator	WDI
Capital	Gross capital formation to GDP ratio	WDI
Open	KAOPEN index constructed by Chinn and Ito	Chinn-Ito website**
Crisis	Crisis dummy that takes the value 1 if there is a crisis and the value 0 otherwise	Laeven and Valencia (2013)
Stability	Political stability index constructed by WGI, with a larger score indicating greater political stability	WGI***
Government	Government effectiveness index constructed by WGI, with a larger score indicating higher government effectiveness	WGI
Regulation	Regulatory quality index constructed by WGI, with a larger score indicating higher regulatory quality	WGI
Law	Rule of law index constructed by WGI, with a larger score indicating better law and order	WGI
Corruption	Corruption control index constructed by WGI, with a larger score indicating better control of corruption	WGI

Notes: (1) * WDI denotes the World Bank's *World Development Indicators* database; (2) ** Data are available at the Chinn-Ito index website (http://web.pdx.edu/~ito/Chinn-Ito_website.htm); (3) *** WGI denotes the World Bank's *Worldwide Governance Indicators*.