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Abstract

A sizeable literature suggests that financial sector development could be an important enabler of the growth benefits of trade openness. We provide a comprehensive analysis of how financial development can affect the relationship between trade openness and growth using a dynamic panel threshold model and an extensive dataset for a large sample of countries for the 1970-2015 period. We find that there is a financial development threshold in which trade openness has a positive and significant effect on economic growth. We also find that when splitting the sample into industrialized and non-industrialized countries, the financial development threshold that enables the growth benefits of trade is higher in the former group of countries than in the latter. This finding is consistent with the fact that the export composition of industrialized countries is tilted towards more capital-intensive finance-constrained goods.

JEL Classification: F43, O41, C33

Key words: Trade openness, growth, threshold model, panel data.

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1 Introduction

A key issue in economic growth is whether or not trade openness has significant growth effects and how these effects are best enabled. In theory, there are many channels through which trade openness can have positive effects on growth. For instance, it has been argued that openness generates important gains from comparative advantage, disseminates knowledge and technologies, facilitates technology transfer, increases market size, and reduces rent-seeking activities (Grossman and Helpman, 1991; Jones and Romer, 2010; Young, 1991, among others). These effects should, in turn, be reflected in stronger economic growth as resource allocation improves and the frontier of production expands. Trade openness, however, could also be detrimental to growth, particularly when a country specializes in extractive and non-innovative sectors (Matsuyama, 1992; Chang *et al.*, 2009, among others).

The empirical evidence of a strong and robust link between trade openness and growth is, unsurprisingly, mixed. On the one hand, cross-country and panel data studies have found that trade has a positive effect on growth (Dollar, 1992; Edwards, 1998; Frankel and Romer, 1999; Lee *et al.*, 2004; Wacziarg and Welch, 2008, among others). Some of these studies, however, have been criticized for their use of faulty methodologies, inadequate trade openness measures, and lack of robust results (Rodríguez and Rodrik, 2001; Rodríguez, 2007). On the other hand, other studies have reported evidence that trade openness in itself might not be enough to deliver strong economic growth and that the trade and growth relationship might even be nonlinear (Ulaşan, 2015; Chang *et al.*, 2009). Openness seems to be more effective when complemented by competitiveness-boosting factors.

This latter result suggests that enabling the growth benefits of trade might require the presence of certain institutions, which themselves are a source of comparative advantage (Nunn and Trefler, 2014). One such institution is financial markets. Financial markets are key as they facilitate the interplay between saving and investment decisions, and thus economic growth. These markets are, however, fraught with imperfections, asymmetric information, and other problems. The extent of these imperfections affects economic outcomes. The development of financial markets and associated institutions would be reflected in better saving-investment allocation and better growth performance (McKinnon, 1973; Levine, 2005).

The empirical literature has not conclusively established the existence of a robust financial development and growth relationship. Several cross-country and panel data studies have found that financial development has a positive effect on economic growth (Levine *et al.*, 2000; Levine, 2005, among others). However, more recent studies have uncovered vanishing (Rousseau and Watchel, 2011) and even detrimental growth effects of excessive financial development (Arcand *et al.*, 2015). This latter finding suggests that some countries might have encouraged the development of excessively large financial sectors. Other studies have used microdata to provide evidence that countries with more developed financial sectors have higher production levels in the externally financed sector (Rajan and Zingales, 1998).

In this paper, we examine whether financial sector development affects the openness and economic growth nexus. This is an extremely topical issue, especially given the pushback against trade openness and the recent introduction of tariffs in some countries, which have made global trade relations increasingly problematic. In addition, important questions about the soundness of developing large financial markets –and the sense that there is too much finance in some countries– have been raised. While we do not address these issues directly, we do examine how financial sector development can strengthen the openness and growth relationship. Are there some threshold levels of financial development that an economy needs to enable the growth benefits from openness? Are these thresholds different across country groups?

There are many ways in which financial development could affect the trade openness and growth nexus. First, financial development can itself be a source of comparative advantage. More developed financial sectors tend to be of most benefit to those industries that require external financing in greater proportion, and affect a country's trade structure (Rajan and Zingales, 1998; Kletzer and Bardhan, 1987; Beck, 2002, among others). Beck (2002), for instance, reports evidence that countries with more developed financial sectors have a comparative advantage in manufacturing, as the financing of the considerable fixed costs faced by this sector is cheaper in such countries.

Second, financial development, insofar as it mitigates the distortive effects of financial frictions, can positively affect productivity and tilt trade composition towards capital-intensive industries. Thus, sectors vulnerable to financial frictions, like the large-scale manufacturing sector, respond positively to the development of a country's financial markets (Buera *et al.*, 2011). This could lead to a restructuring of a country's trade composition away from labor-intensive industries and towards capital-intensive industries (Leibovici, 2018), including the large-scale manufacturing and high-tech sectors. There is some evidence that a country's export composition matters for economic growth (Hausmann *et al.*, 2007).

Third, as trade openness increases a country's exposure to world market fluctuations, a more developed financial system functions as an insurance mechanism against external risks, facilitating greater trade openness (Kim *et al.*, 2010). To the extent that asset markets allow for well-diversified incomes across a country's population, protectionist lobbying efforts would be reduced (Feeney and Hillman, 2004). Empirical evidence about the complementarity between asset development and trade liberalization is reported in Svaleryd and Vlachos (2002), and Feeney and Hillman (2004).

Fourth, the benefits of trade liberalization are often affected by the depth of a country's financial sector. This is the case because in a world with financial frictions and shallow financial markets, credit constrained firms operate at sub-optimal levels and are not able to take advantage of trade openness (Kohn *et al.*, 2017). In this situation, only the non-credit constrained firms would export, and the deepening of financial markets would increase both the number of exporting firms and total exports (Chaney, 2016).

In sum, we have discussed many channels through which financial sector development could affect the trade openness and growth relationship. Most of these channels are enablers of the growth benefits of international trade. They also explain differences in export composition across countries and across time.

To examine how financial development affects the trade openness and growth relationship, we utilize a dynamic panel threshold model for a large sample of countries for the period 1970-2015. This method allows us to separate the observations into discrete groups based on their financial development, and then estimate the different growth effects of trade openness among these groups within a unified framework (Hansen, 1999, 2000; Ramírez-Rondán, 2015).

We find evidence of a single financial development threshold in which trade openness has a positive and significant effect on growth. Importantly, this financial development threshold (27.3 percent of GDP) is not especially high, and more than 70 percent of the countries in the sample exceeded it in 2011-15. When the sample is split into industrialized and non-industrialized countries, we find that the financial development threshold for the former (38.4 percent of GDP) is greater than that of the latter (27.4 percent). This partly reflects differences in these countries' trade composition, as industrialized economies export more capital-intensive credit-dependent goods than non-industrialized economies.

Our paper is related to Chang *et al.* (2009), who examine a set of wide-ranging reforms, including in the financial sector, that could help a country benefit from trade openness. Their findings, based on a dynamic panel model with interactions, suggest that financial development has a positive and increasing effect on the trade and growth relationship. These findings are at odds with the recent literature, which has reported that financial development in excess of 80-100 percent of GDP is detrimental to growth

(Arcand *et al.*, 2015). In contrast, our use of a dynamic panel threshold model allows us to identify a financial development threshold beyond which the trade and growth relationship become significant. The estimated thresholds are well below the financial sector levels deemed excessive. Moreover, when conducting a horse race between models, we find that the dynamic panel threshold model is superior to the dynamic panel model with interactions.

The remainder of this paper is organized as follows. In Section 2 we discuss our empirical methodology, including the specification of the model and estimation methods. In Section 3 we present our main empirical results–testing for the existence of a threshold, inference of the threshold estimate, regression results, and discussion. In Section 4 we present a battery of robustness tests on the threshold location, additional control variables, and comparison with other nonlinear specifications. Finally, in Section 5 we conclude.

2 Data and methodology

2.1 Specification

The standard dynamic panel growth regression model takes the form

$$y_{it} - y_{it-1} = \mu_i + \kappa y_{it-1} + \beta x_{it-1} + \theta' Z_{it-1} + \epsilon_{it}, \tag{1}$$

where y_{it} is log of real gross domestic product (GDP) per capita, $y_{it} - y_{it-1}$ is the GDP per capita growth rate; μ_i is an unobserved country-fixed effect; x_{it} is a measure of trade openness; Z_{it} is a set of control variables; ϵ_{it} is the error term; i indexes countries; and t indexes time periods (quinquenniums). β, κ and θ are parameters to be estimated. Note that y_{it-1} on the right hand side takes into account the transitional convergence effect as predicted by the neoclassical growth theory, and is the dynamic feature of the model.

In order to assess whether or not financial development affects the trade openness and economic growth relationship, we estimate the following dynamic growth regression with a threshold variable:

$$y_{it} - y_{it-1} = \mu_i + \kappa y_{it-1} + \beta_1 x_{it-1} 1(q_{it-1} \leq \gamma) + \beta_2 x_{it-1} 1(q_{it-1} > \gamma) + \theta' Z_{it-1} + \epsilon_{it}, \tag{2}$$

where q_{it} is a country's financial development level; and $1(.)$ is an indicator variable which takes the value of 1 if financial development is greater than a threshold, and of 0 otherwise. γ is the financial development threshold parameter to be estimated. In this specification the effects of trade openness on growth depend on the financial development regime.

Note that q_{it-1}, x_{it-1} and Z_{it-1} are lagged variables with respect to the dependent variable, making them internal instruments. This is to avoid endogeneity problems that arise from an existing correlation between either the control variables or the threshold variable and the error term. Such problems are common in economic growth models, since there is a contemporary double causality between growth and its determinants.

2.2 Control variables

Numerous economic and institutional variables can be posited as determinants of economic growth. However, following the empirical economic growth review of Loayza *et al.* (2005) and given data availability we consider the following growth determinants: transitional convergence, structural policies, institutions, stabilization policies, and external conditions (world trends).

First, the relationship between initial per capita GDP and growth rates is an important implication of the neoclassical growth theory; that is, a country´s growth performance depends on its initial position. That literature states that, *ceteris paribus*, backward countries with a low capital-output ratio may grow faster than rich ones due to the decreasing return to factors of production. To control for this possibility, we include the initial level of per capita GDP as one of the regressors.

Second, we include a country´s level of financial development as another regressor, because it facilitates the saving and investment decisions. Financial markets also allows for risk diversification through the negotiation of financial instruments that enable identification of profitable investment projects and mobilize savings on them (Loayza *et al.*, 2005). We use the ratio of domestic private credit to GDP to measure the degree of financial depth.

We also consider three other structural factors: (i) human capital plays a key role in exploiting the inflow of technological knowledge and utilizing the new physical capital ushered in by trade liberalization, so we use a human capital index from the Penn World Table; (ii) public infrastructure affects growth by entering directly as production function input, by improving total factor productivity, and by encouraging private investment; and (iii) government efficiency and quality foster economic growth; Mauro (1995) states that greater control of corruption increases economic growth, so we consider an average of four indicators reported in the *International Country Risk Guide* (ICRG) as a proxy for institutions.

Lastly, stabilization policies contribute to economic growth, since they reduce uncertainty, encourage firm investment and let economic agents focus on productive activities (Loayza *et al.*, 2005). For this reason, we use three variables as proxies of the stabilization capability of countries: (i) price instability; (ii) output instability; and (iii) the occurrence of systemic banking crises. In addition, we account for other global conditions that could impact GDP growth by including time dummies or world GDP growth in the estimation.

2.3 Data

Our period of study spans from 1970 to 2015 for a sample of 80 countries. Table 1 shows constructions and definitions of the variables used in the estimation analysis, including the trade openness measure to be used.[1] Summary statistics of the variables involved in the estimation analysis are given in Table 2, and Table 3 shows pairwise correlations among the variables included in the estimation analysis; the initial GDP per capita is highly correlated with the structural variables and institution, which reveals that richer countries show better fundamentals.

2.4 Threshold regression model

Threshold regression models divide individual observations into classes based on the value of an observed variable, and have been widely used in time series analysis. Hansen (1999) extends these models to a balanced panel data context –mainly by introducing econometric techniques using least squares (LS) estimation methods. As the growth models are dynamic, we use the econometric techniques developed by Ramírez-Rondán (2015), who proposes maximum likelihood (ML) estimation for a dynamic panel threshold model using a first difference transformation. In this context, the first GDP per capita of each quinquennium represents the transitional dynamics.

We divide the observations into two regimes depending on whether the threshold variable q_{it} is smaller or larger than the threshold parameter γ. The regimes are distinguished by differing regression slopes, β_1 and β_2. For the identification of these coefficients, the elements of q_{it-1} must not be time-invariant. The error ϵ_{it} is assumed to be independent and identically distributed (iid) with mean zero and finite variance.

[1] This structure-adjusted measure of trade intensity was proposed by Pritchett (1996) to avoid attributing to trade policy what is merely the result of structural country characteristics, like area or landlockedness, and has been widely used in the growth literature; see for example Blyde and Fernández-Arias (2005), Loayza *et al.* (2005), Chang *et al.* (2009) or Aghion *et al.* (2009).

Table 1: Variables

Variable	Definition	Source
GDP per capita growth	Log difference of real GDP per capita.	World Development Indicators.
Initial GDP per capita	Initial value of ratio of total GDP to total population. GDP is in 2010 US$. In logs.	World Development Indicators.
Human capital	Human capital index, based on years of schooling and returns to education. In logs.	Penn World Table.
Financial depth	Ratio of domestic credit claims on private sector to GDP. In logs.	World Development Indicators.
Public infrastructure	Fixed and mobile telephone lines per 100 habitants. In logs.	World Development Indicators.
Institutions	Average of four indicators: bureaucracy quality, prevalence of law and order, absence of corruption, and accountability of public officials.	International Country Risk Group (ICRG).
Trade openness	Residual of a regression of the log of the ratio of exports and imports to GDP, on the logs of area and population, and dummies for oil exporting and for landlocked countries.	World Development Indicators, the observatory of economic complexity, and CIA.
Price instability	Deviation of annual % change in consumer price index (CPI) from 4%.	World Development Indicators.
Output instability	Standard deviation of GDP per capita growth.	World Development Indicators.
Systemic banking crises	Frequency of years under banking crisis.	Chang *et al.* (2009) and Laeven and Valencia (2018).
External conditions	World GDP per capita growth.	World Development Indicators.

The static and dynamic estimations of model (2) involves three steps: estimation, inference and testing.

Threshold and slope estimations

In the static methodology, one can eliminate the country-specific effect by removing country-specific means. Let $\Delta y_{it} \equiv y_{it} - y_{it-1}$, $\beta' = (\beta_1, \beta_2)'$ and assuming for simplicity that there are no control variables; thus, the within transformation of model (2) is

$$\Delta y_{it}^{+} = \kappa y_{it-1}^{+} + \beta' x_{it-1}^{+}(\gamma) + \epsilon_{it}^{+}, \tag{3}$$

where we define $\Delta y_{it}^{+} \equiv \Delta y_{it} - T^{-1}\sum_{t=1}^{T} \Delta y_{it}$, $y_{it-1}^{+} = y_{it-1} - T^{-1}\sum_{t=1}^{T} y_{it-1}$, $\epsilon_{it}^{+} \equiv$

Table 2: Summary statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Growth per capita growth (%)	720	1.858	2.692	-10.457	15.839
Initial GDP per capita, in logs	720	8.375	1.545	5.431	11.561
Human capital, in logs	720	0.715	0.341	0.009	1.314
Financial depth, in logs	720	3.439	0.922	-0.192	5.396
Output instability	720	2.918	2.367	0.074	21.621
Institutions	720	3.520	1.446	0.5	6.0
Systemic banking crises	720	0.080	0.204	0.0	1.0
Public infrastructure, in logs	720	2.243	2.242	-3.416	5.295
Trade openness, in logs	720	0.044	0.440	-1.410	1.504
External conditions (%)	720	1.528	0.490	0.606	2.081
Price instability, in logs	720	2.594	0.898	0.013	8.783

Table 3: Correlations

Variable	GDP growth per capita	Initial GDP per capita	Human capital	Financial depth	Output instability
Initial GDP per capita	0.060				
Human capital	0.156	0.829			
Financial depth	0.212	0.706	0.658		
Output instability	-0.253	-0.198	-0.360	-0.269	
Institutions	0.163	0.790	0.710	0.659	-0.289
Systemic banking crises	-0.295	0.060	0.051	0.017	0.112
Fixed and mobile lines	0.191	0.724	0.814	0.617	-0.361
Trade openness	0.188	0.159	0.230	0.267	-0.065
World GDP growth	0.163	-0.022	-0.052	-0.031	0.010
Price instability	-0.259	-0.232	-0.250	-0.423	0.252
Variable	**Institutions**	**Systemic banking crises**	**Public infrastructure**	**Trade openness**	**World GDP growth**
Systemic banking crises	0.029				
Fixed and mobile lines	0.592	-0.025			
Trade openness	0.129	-0.045	0.323		
World GDP growth	-0.020	-0.189	-0.041	-0.025	
Price instability	-0.310	0.180	-0.367	-0.353	-0.096

$\epsilon_{it} - T^{-1}\sum_{t=1}^{T}\epsilon_{it}$ and

$$x^{+}_{it-1}(\gamma) \equiv \begin{pmatrix} x_{it-1}1(q_{it} \leq \gamma) - \frac{1}{T}\sum_{t=1}^{T} x_{it-1}1(q_{it} \leq \gamma) \\ x_{it-1}1(q_{it} > \gamma) - \frac{1}{T}\sum_{t=1}^{T} x_{it-1}1(q_{it} > \gamma) \end{pmatrix}.$$

For any given γ, the slope coefficients κ and β can be estimated by ordinary least squares (LS), and then the regression residuals are

$$\widehat{\epsilon}^{+}_{it}(\gamma) = \Delta y^{+}_{it} - \widehat{\kappa} y^{+}_{it-1} - \widehat{\beta}(\gamma)' x^{+}_{it-1}(\gamma), \tag{4}$$

and the sum of squared errors to be minimized is

$$S(\gamma) = \sum_{i=1}^{n} \sum_{t=1}^{T} \widehat{\epsilon}_{it}^{+}(\gamma)^2. \tag{5}$$

The criterion function (5) is not smooth, so conventional gradient algorithms are not suitable for its minimization. Hansen (1999, 2000) recommends estimation of the threshold by using a grid search over the threshold variable space. That is, construct an evenly spaced grid on the empirical support of the threshold variable q_{it}, and minimizes the concentrated sum of squared errors (5). Finally, once $\widehat{\gamma}$ is obtained, the slope coefficient estimate is $\widehat{\beta} = \widehat{\beta}(\widehat{\gamma})$; and note that $\widehat{\beta}(\widehat{\gamma}) = (\widehat{\beta}_1(\widehat{\gamma}), \widehat{\beta}_2(\widehat{\gamma}))'$.

As regards the dynamic methodology, we cannot consider a fixed effects transformation for the dynamic threshold model since it could introduce a correlation between the transformed regressors and the transformed error term in the model, thus leading to inconsistency of the slope parameter. This is addressed by taking a first difference transformation of model (2) to eliminate the individual specific effect. We then have:

$$\begin{aligned} y_{it} - y_{it-1} - (y_{it-1} - y_{it-2}) = \kappa(y_{it-1} - y_{it-2}) + \beta_1(x_{it-1}1(q_{it-1} \leq \gamma) - \\ x_{it-2}1(q_{it-2} \leq \gamma)) + \beta_2(x_{it-1}1(q_{it-1} > \gamma) - x_{it-2}1(q_{it-2} > \gamma)) + \epsilon_{it} - \epsilon_{it-1}. \end{aligned} \tag{6}$$

Let $\Delta^2 y_{it} \equiv y_{it} - y_{it-1} - (y_{it-1} - y_{it-2})$, $\Delta y_{it-1} \equiv y_{it-1} - y_{it-2}$, $\Delta x^*_{it-1} \equiv x_{it-1}1(q_{it-1} \leq \gamma) - x_{it-2}1(q_{it-2} \leq \gamma)$, $\Delta x^+_{it-1} \equiv x_{it-1}1(q_{it-1} > \gamma) - x_{it-2}1(q_{it-2} > \gamma)$, and $\Delta\epsilon_{it} \equiv \epsilon_{it} - \epsilon_{it-1}$, then equation (6) becomes:

$$\Delta^2 y_{it} = \kappa \Delta y_{it-1} + \beta_1 \Delta x^*_{it-1}(\gamma) + \beta_2 \Delta x^+_{it-1}(\gamma) + \Delta\epsilon_{it}. \tag{7}$$

The ML estimation of the dynamic panel linear model depends on the initial condition, which is key to establishing the consistency of the estimates (see Hsiao *et al.*, 2002). Thus, by assuming that the process has started from a finite period in the past, such that the expected changes in the initial endowments are the same across all individuals, that model specification in the first period is given by $\Delta^2 y_{i1} = \delta + v_{i1}$, were δ is an auxiliary external parameter. Further, we assume exogeneity of x_{it-1}, homoscedasticity across regimes, and by construction, $E(v_{i1}|x_i) = 0$, where $x_i = (x_{i0}, x_{i1}, ..., x_{iT})'$, and $Ev_{i1}^2 = \sigma_v^2$.

Let $\Delta^2 y_i = (\Delta^2 y_{i1}, \Delta^2 y_{i2}, ..., \Delta^2 y_{iT})'$ and $\Delta\epsilon_i = (v_{i1}, \Delta\epsilon_{i2}, ..., \Delta\epsilon_{iT})'$, and also define $\omega = \sigma_v^2/\sigma_\epsilon^2$. Thus, under the assumption that ϵ_{it} is independent normal, the joint probability distribution function of $\Delta^2 y_i$ is equivalent to (in logarithm):

$$lnL(\delta,\beta,\kappa,\gamma,\sigma^2_\epsilon,\omega) = -\frac{nT}{2}ln(2\pi) - \frac{n}{2}ln|\Omega| - \frac{1}{2}\sum_{i=1}^{n}\Delta\epsilon(\delta,\beta,\kappa,\gamma)'\Omega^{-1}\epsilon(\delta,\beta,\kappa,\gamma), \quad (8)$$

where Ω is defined in Hsiao *et al.* (2002). The criterion function (8) is well defined, and depends on a fixed number of parameters. Then, the ML estimators of $\widehat{\delta}$, $\widehat{\beta}$, $\widehat{\kappa}$, $\widehat{\gamma}$, $\widehat{\sigma}^2_\epsilon$ and $\widehat{\omega}$ are the values that maximize $lnL(\delta,\beta,\kappa,\gamma,\sigma^2_\epsilon,\omega)$.

Hence, the algorithm for estimation has the following procedure:[2] (i) for a given value of γ on the grid of the threshold variable, the criterion (8) is smooth; so we can calculate $\widehat{\delta}(\gamma)$, $\widehat{\beta}(\gamma)$, $\widehat{\kappa}(\gamma)$, $\widehat{\sigma}^2_\epsilon(\gamma)$ and $\widehat{\omega}(\gamma)$ by maximizing that function; (ii) by plugging those previous estimates in (8), it only depends on γ; and since the function is not smooth in γ, we find $\widehat{\gamma}$ on the grid of the threshold variable which yields the highest value of the likelihood function; and finally, we set $\widehat{\beta}_1 = \widehat{\beta}_1(\widehat{\gamma})$ and $\widehat{\beta}_2 = \widehat{\beta}_2(\widehat{\gamma})$.

Asymptotic confidence intervals

When there is a threshold effect ($\beta_1 \neq \beta_2$), Hansen (2000) has shown that threshold estimate, $\widehat{\gamma}$, is consistent for γ_0 (the true value of γ) and that the asymptotic distribution is non standard. Hansen (1999) argues that the best ways to form confidence intervals for the threshold is to form the no rejection region using the likelihood ratio statistic for test on $\widehat{\gamma}$. To test hypothesis H_0: $\gamma = \gamma_0$, the likelihood ratio test is to reject for large values of $LR(\gamma_0)$ where

$$LR(\gamma) = n(T-1)\frac{S(\gamma) - S(\widehat{\gamma})}{S(\widehat{\gamma})}, \quad (9)$$

where $S(\gamma)$ is defined in (5) in the static methodology, while in the dynamic case $S(\gamma) = \sum_{i=1}^{n}\Delta\widehat{\epsilon}_i(\gamma)'\Omega^{-1}\Delta\widehat{\epsilon}_i(\gamma)$ is the minimum distance estimator, which converges in distribution as $n \to \infty$ to a random variable ξ with distribution function $P(\xi \leq z) = (1 - exp(-z/2))^2$.

Then, the asymptotic distribution of the likelihood ratio statistic is non-standard, yet free of nuisance parameters (Hansen, 2000). Since the asymptotic distribution is pivotal, we use it to form valid asymptotic confidence intervals. Furthermore, the distribution function ξ has the inverse

$$c(\alpha) = -2ln(1 - \sqrt{1-\alpha}), \quad (10)$$

[2]For further details on the estimation see Ramírez-Rondán (2015).

where α is the significance level. The "no-rejection region" of confidence level $1-\alpha$ is the set of values of γ such that $LR(\gamma) \le c(\alpha)$. This is easiest to find by plotting $LR(\gamma)$ against γ and drawing a flat line at $c(\alpha)$.

Test for existence of threshold effects

It is important to determinate whether the threshold effect is statistically significant. The hypothesis of no threshold effects in (2) can be represented by the linear constraint $H_0 : \beta_1 = \beta_2$. Under the null hypothesis, H_0, the threshold γ is not identified, so classical tests have non-standard distributions. Hansen (2000) suggested a bootstrap to simulate the asymptotic distribution of the likelihood ratio test for this kind of models, so that the p-values constructed from the bootstrap procedure are asymptotically valid.

Under the null hypothesis of no threshold, the model (1) without control variables is

$$\Delta y_{it} = \mu_i + \kappa y_{it-1} + \beta_1 x_{it-1} + \epsilon_{it}, \tag{11}$$

after the within and first difference transformations are made in order to eliminate μ_i, we get

$$\Delta y_{it}^{+} = \kappa y_{it-1}^{+} + \beta_1 x_{it-1}^{+} + \epsilon_{it}^{+}, \tag{12}$$

and

$$\Delta^2 y_{it} = \kappa \Delta y_{it-1} + \beta_1 \Delta x_{it-1} + \Delta\epsilon_{it}, \tag{13}$$

where $x_{it-1}^{+} \equiv x_{it-1} - T^{-1}\sum_{t=1}^{T} x_{it-1}$ and $\Delta x_{it-1} = x_{it-1} - x_{it-2}$. The parameter β_1 is estimated by LS or ML, yielding estimates $\widehat{\beta}_1$, residuals $\widehat{\epsilon}_{it}$ and let $S_0 = \sum_{i=1}^{n}\sum_{t=1}^{T} \widehat{\epsilon}_{it}^{+2}$ the sum of squared residuals and $S_0 = \sum_{i=1}^{n} \Delta\widehat{\epsilon}_{it}' \Omega^{-1} \Delta\widehat{\epsilon}_{it}$ the minimum distance estimator of the linear model in the static and dynamic methodologies, respectively. The likelihood ratio test of H_0 is based on

$$F = n(T-1)\frac{S_0 - S(\widehat{\gamma})}{S(\widehat{\gamma})}; \tag{14}$$

thus, the null hypothesis is rejected if the percentage of draws for which the simulated statistic exceeds the actual value is less than some critical value.

3 Estimation and inference results

3.1 Linear model results

Table 4 provides the results of a linear model with two estimation methodologies. In the full sample, trade openness has a significant positive effect on growth under the maximum likelihood (ML) estimation, but not under the least squares (LS) estimation. Although the effect on economic growth seems to be inconclusive, when we split the sample into industrialized and non-industrialized countries we find that this positive and highly strong effect only occurs in industrialized countries, and that there are no effects in non-industrialized countries in either estimator.

As suggested by the theory, trade openness seems to have a differentiated effect on economic growth. We also find that financial development plays an enabling role on that effect –and indeed, we find that it consistently has a statistically significant effect on growth across estimators and samples. While there is no evidence that financial development has a direct effect on growth, it has an important indirect effect throughout trade openness.

3.2 Threshold effects

The first step is to test for the existence of a threshold effect in the relationship between GDP growth and trade openness using the F test of equation (14). This also involves estimating equation (2) and computing the residual sum of squares for the financial depth threshold. We conduct the test for the existence of threshold effects using a sample of 80 countries over nine five-year average periods between 1970 and 2015.[3]

The test for existence of threshold effects is shown in Table 5. The null hypothesis of no threshold effect against single threshold can be rejected at least at the 95 per cent significance level. The test statistics F for the single threshold are 23.057 and 18.711 with their corresponding bootstrap p-value of 0.005 and 0.042 for the static and dynamic methodologies, respectively. This indicates that the test for a single threshold is highly significant;[4] thus, we conclude that there is strong evidence for threshold effects of financial depth in the trade and growth relationship.

[3] These are the results when considering the full sample. The rejection of the null hypothesis also holds when considering other sub samples and different sets of control variables.

[4] We also perform a test in which we allow two thresholds, but we find that the test is not statistically significant.

Table 4: Estimation results of the linear model

Dependent variable: GDP per capita growth	Full sample		Industrialized countries		Non-industrialized countries	
	LS	ML	LS	ML	LS	ML
Trade openness	0.622	1.371	4.056	3.475	0.437	0.757
Structure-adjusted trade volume/GDP, in logs	(0.459)	(0.386)	(0.893)	(0.781)	(0.529)	(0.433)
	[0.528]	[0.466]	[0.753]	[0.961]	[0.570]	[0.568]
Financial depth	-0.217	-0.460	-0.163	-0.071	-0.03	-0.120
Domestic credit to private sector/GDP, in logs	(0.257)	(0.225)	(0.356)	(0.295)	(0.315)	(0.267)
	[0.251]	[0.216]	[0.299]	[0.344]	[0.290]	[0.260]
Transitional convergence	-4.628	-3.817	-4.184	-2.701	-4.547	-4.009
Initial GDP per capita, in logs	(0.492)	(0.391)	(1.020)	(0.903)	(0.576)	(0.443)
	[0.616]	[0.411]	[1.250]	[0.863]	[0.678]	[0.550]
Human capital	1.173	0.705	-5.689	-9.381	1.580	1.550
Index based on schooling and returns, in logs	(1.494)	(1.234)	(3.982)	(3.381)	(1.694)	(1.326)
	[1.429]	[1.293]	[4.489]	[3.70]	[1.473]	[1.40]
Public infrastructure	0.704	0.488	-0.730	-0.868	0.730	0.559
Fixed and mobile lines per 100 people, in logs	(0.173)	(0.117)	(0.535)	(0.462)	(0.195)	(0.125)
	[0.167]	[0.095]	[0.517]	[0.278]	[0.173]	[0.108]
Institutions	0.532	0.607	1.046	0.984	0.402	0.466
Average of 4 ICRG indicators	(0.190)	(0.168)	(0.363)	(0.321)	(0.224)	(0.186)
	[0.176]	[0.174]	[0.399]	[0.360]	[0.193]	[0.185]
Output instability	0.098	0.079	-0.053	-0.123	0.082	0.079
Std. Dev of GDP per capita growth	(0.044)	(0.041)	(0.107)	(0.082)	(0.051)	(0.045)
	[0.046]	[0.065]	[0.107]	[0.107]	[0.048]	[0.067]
Price instability	-0.290	-0.261	-2.066	-2.021	-0.191	-0.223
CPI growth	(0.143)	(0.131)	(0.396)	(0.366)	(0.164)	(0.142)
	[0.155]	[0.155]	[0.360]	[0.590]	[0.158]	[0.156]
Systemic banking crises	0.053	-0.133	0.932	0.553	0.109	0.177
Frequency of years under crisis: 0-1	(0.471)	(0.415)	(0.581)	(0.454)	(0.578)	(0.519)
	[0.389]	[0.492]	[0.402]	[0.718]	[0.447]	[0.578]
External conditions	-0.321	-0.302	-1.188	-1.255	0.027	0.048
World GDP growth	(0.164)	(0.155)	(0.176)	(0.164)	(0.213)	(0.189)
	[0.144]	[0.218]	[0.164]	[0.336]	[0.183]	[0.233]
Number of countries	80	80	21	21	59	59
Number of periods, five year average	9	9	9	9	9	9
Time period	1971-2015	1971-2015	1971-2015	1971-2015	1971-2015	1971-2015
R-squared	0.242	-	0.602	-	0.231	-
Negative log-likelihood	-	1403	-	236	-	1015

Notes: LS stands for (ordinary) least squares, and ML stands for maximum likelihood. Homoscedastic and heteroskedastic standard errors in parentheses and brackets, respectively.

3.3 Threshold estimate and its confidence interval

The second step is to compute the confidence intervals. The point estimate of the threshold and their asymptotic 90%, 95%, and 99% confidence intervals are reported in Table 6. The two categories of countries and periods indicated by the point estimate are those with "low financial depth" and "high financial depth". Moreover, the asymptotic confidence intervals for the threshold are very tight, indicating low uncertainty regarding the nature of this division.

More information about the estimated threshold can be obtained by plotting the concentrated likelihood ratio function $LR(\gamma)$ of the estimate (see Figure 1). This

Table 5: Tests for threshold effects

	Threshold estimate (%)	Test F	Bootstrap p-value	Critical values
Static methodology	27.429	23.057	0.005	13.708[1/] 15.658[2/] 21.306[3/]
Dynamic methodology	27.338	18.711	0.042	13.802[1/] 17.557[2/] 24.816[3/]

Note: 1/, 2/ and 3/ critical values at 10%, 5% and 1%, respectively. We used 1000 bootstrap replications for the test.

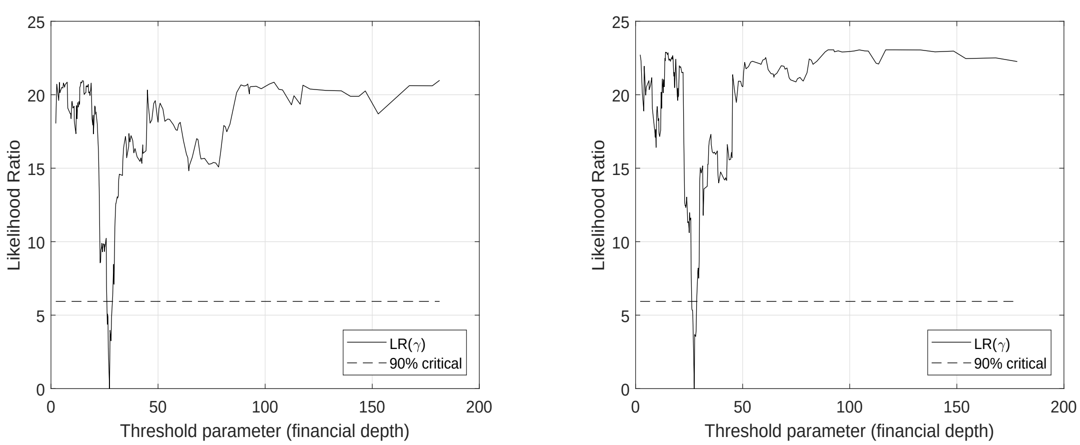
Table 6: Asymptotic confidence interval in threshold model

	Threshold	90% confidence interval	95% confidence interval	99% confidence interval
Static methodology	27.429	[26.306 ; 28.516]	[26.193 ; 28.516]	[25.939 ; 29.720]
Dynamic methodology	27.338	[26.183 ; 28.507]	[25.924 ; 29.457]	[22.925 ; 29.720]

function is minimized at zero in the estimated threshold $\widehat{\gamma} = 27.429$ and $\widehat{\gamma} = 27.338$, corresponding to the static and dynamic methodologies with high precision and little uncertainty, since the confidence interval, the set of values below the dotted line, is very small.

Figure 1: Confidence interval construction for threshold

(a) LS estimation (a) ML estimation



3.4 Slope estimation results

When considering a threshold model for the full sample (see Table 7) the effect of trade openness on growth becomes differentiated between two regimes: countries with "low financial depth" –less than 27%– gain nothing from trade openness, while those with "high financial depth" benefit greatly from increased openness.[5] Therefore, it can be concluded that there are two country regimes, and that trade openness has a different effect on growth for each according to financial depth level. The empirical literature supports these findings, as a poor level of financial development would not let domestic firms and economic sectors with scale economies to benefit from the potential lower costs and higher returns on capital, thus slowing development and growth. Conversely, greater financial depth level boosts economic growth.

To be sure, the marginal effect should not be the same for countries with different income levels and institutional quality. Table 7 also shows the results obtained for industrialized and non-industrialized countries.[6] The results show that the estimated threshold around 38% domestic credit to the financial sector is considerably higher than that for non-industrialized countries (27%). But even though the level of financial development required for commercial openness to have a positive impact on growth is higher for industrialized countries, the marginal effect of trade on growth is also higher when the financial threshold is actually met: the elasticity for non-industrialized countries ranges from 2.7 to 2.8, while in industrialized countries it ranges from 4.4 to 4.8.

One might wonder whether the effect of openness when crossing the threshold in the case of industrialized countries is the same as in the case of non-industrialized countries; thus, we test the significance of the difference between the coefficients.[7] The resulting range of the p-values of this test goes from 0.091 for the LS estimation to 0.095 for the ML estimation; the test favors the alternative hypothesis that the difference in the effects is statistically significant at a p-value less than 0.10. As to the null equality hypothesis of the thresholds of the industrialized and non-industrialized countries, we cannot apply an analogous test since the threshold parameter estimates do not converge to a normal distribution –but it might be expected that such estimates

[5] Note that the null hypothesis of a linear model is rejected in all cases.

[6] See Appendix A for the classification based on United Nations.

[7] As such coefficients come from different independent samples and regressions, we use the following Z test, following the approach of Clogg *et al.* (1995): $Z = (\widehat{\beta}_{2,Ind} - \widehat{\beta}_{2,Nonind})/(SE(\widehat{\beta}_{2,Ind})^2 + SE(\widehat{\beta}_{2,Nonind}))^{0.5}$, where $\widehat{\beta}_{2,Ind}$ and $\widehat{\beta}_{2,Nonind}$ are the coefficients of trade openness once the threshold is met for the industrialized and non-industrialized countries, respectively; and SE stands for the standard error in Table 7; and the test follows a standard normal distribution under the null hypothesis of equality of the two coefficients.

Table 7: Estimation results of the threshold model

Dependent variable: GDP per capita growth	Full sample		Industrialized countries		Non-industrialized countries	
	LS	ML	LS	ML	LS	ML
Financial depth threshold estimate ($\widehat{\gamma}$)	27.429	27.338	38.666	38.413	27.429	27.429
[90% Confidence Interval]	[26.3 ; 28.5]	[26.2 ; 28.3]	[35.2 ; 47.8]	[35.3 ; 46.4]	[26.3 ; 28.4]	[26.4 ; 28.8]
Trade openness (Financial depth $< \widehat{\gamma}$)	-0.253	0.519	1.910	1.057	-0.369	-0.044
Structure-adjusted trade volume/GDP, in logs	(0.493)	(0.424)	(0.907)	(0.955)	(0.555)	(0.460)
	[0.541]	[0.468]	[0.995]	[1.255]	[0.561]	[0.539]
Trade openness (Financial depth $\geq \widehat{\gamma}$)	2.590	3.026	4.822	4.354	2.817	2.710
Structure-adjusted trade volume/GDP, in logs	(0.635)	(0.518)	(0.893)	(0.776)	(0.783)	(0.606)
	[0.713]	[0.615]	[0.758]	[0.995]	[0.872]	[0.860]
Financial depth	-0.203	-0.449	-0.088	0.065	-0.014	-0.085
Domestic credit to private sector/GDP, in logs	(0.252)	(0.222)	(0.344)	(0.284)	(0.308)	(0.262)
	[0.245]	[0.219]	[0.286]	[0.306]	[0.285]	[0.267]
Transitional convergence	-5.275	-4.423	-4.732	-3.402	-5.235	-4.739
Initial GDP per capita, in logs	(0.504)	(0.408)	(0.996)	(0.879)	(0.589)	(0.464)
	[0.579]	[0.447]	[1.172]	[0.862]	[0.621]	[0.560]
Human capital	1.220	0.530	-4.66	-8.365	1.661	1.362
Index based on schooling and returns, in logs	(1.466)	(1.216)	(3.846)	(3.237)	(1.658)	(1.299)
	[1.393]	[1.224]	[4.075]	[3.181]	[1.434]	[1.316]
Public infrastructure	0.684	0.514	-0.938	-1.092	0.70	0.590
Fixed and mobile lines per 100 people, in logs	(0.170)	(0.115)	(0.519)	(0.444)	(0.191)	(0.122)
	[0.163]	[0.091]	[0.499]	[0.321]	[0.168]	[0.103]
Institutions	0.627	0.696	1.235	1.227	0.478	0.542
Average of 4 ICRG indicators	(0.188)	(0.166)	(0.355)	(0.312)	(0.220)	(0.183)
	[0.170]	[0.170]	[0.374]	[0.421]	[0.184]	[0.178]
Output instability	0.094	0.072	-0.073	-0.144	0.076	0.077
Std. Dev of GDP per capita growth	(0.044)	(0.040)	(0.103)	(0.078)	(0.049)	(0.044)
	[0.046]	[0.064]	[0.098]	[0.098]	[0.048]	[0.065]
Price instability	-0.349	-0.297	-2.322	-2.335	-0.264	-0.278
CPI growth	(0.141)	(0.129)	(0.389)	(0.358)	(0.161)	(0.140)
	[0.147]	[0.151]	[0.366]	[0.648]	[0.149]	[0.150]
Systemic banking crises	-0.016	-0.269	0.999	0.594	-0.012	0.076
Frequency of years under crisis: 0-1	(0.462)	(0.410)	(0.560)	(0.433)	(0.566)	(0.508)
	[0.397]	[0.504]	[0.393]	[0.710]	[0.457]	[0.590]
External conditions	-0.361	-0.343	-1.14	-1.202	-0.028	-0.002
World GDP growth	(0.161)	(0.153)	(0.170)	(0.158)	(0.208)	(0.186)
	[0.142]	[0.211]	[0.155]	[0.335]	[0.180]	[0.223]
Test for threshold effects (p-value)	0.005	0.042	0.060	0.095	0.010	0.018
Number of countries	80	80	21	21	59	59
Number of periods, five year average	9	9	9	9	9	9
Time period	1971-2015	1971-2015	1971-2015	1971-2015	1971-2015	1971-2015
R-squared	0.272	-	0.635	-	0.266	-
Negative log-likelihood	-	1393	-	228	-	1003

Notes: LS stands for (ordinary) least squares, and ML stands for maximum likelihood. Homoscedastic and heteroskedastic standard errors in parentheses and brackets, respectively. The test shows the probability value for the null hypothesis of $\widehat{\beta}_1 = \widehat{\beta}_2$. We used 1000 bootstrap replications for the test.

are in fact different, since the confidence intervals of each do not overlap under any of the LS and ML estimations.

Industrialized countries need a more developed financial system because of their trade composition. While non-industrialized countries have a higher share of agricultural materials, raw materials, and raw minerals and generally specialize in low-technology industries, industrialized countries instead have a substantially higher export share of manufactured, high technology, and information and communication technology goods and services. Such sophisticated products –which include aerospace products, ICT goods and services, scientific products and instruments, and electrical machinery– have high capital, technology and R&D intensity.

Goods with a high level of sophistication require more technology and financial instruments to meet the needs of a more demanding industry; indeed, industrialized countries have better financial characteristics than non-industrialized ones in terms of financial institutions (depth, access, efficiency and stability) and financial markets (stock market capitalization, stock market turnover ratio, etc.). And industrialized countries are also associated with better developed infrastructure, higher human capital indexes, and higher quality institutions, making them well-suited to the production of technology-intensive goods.

3.5 Countries in each regime

The percentage of countries corresponding to low financial depth regime in the last quinquennium of the analysis is 30%, as shown in Table 8, indicating that with improvements in their financial sector, these countries can take advantage of international specialization. It should be noted that the classifications of countries in Table 8 are based on the dynamic methodology; the classifications with the static methodology estimates are the same, since the threshold estimates are rather similar for both methodologies.

Nevertheless, throughout the period of 1970-2015, the evolution in the level of financial development has not been the same across all countries: 31.3% remained in the regime of "high" financial depth, 20% stagnated in the "low" regime, and almost all the remaining countries enhanced their financial systems, with six exceptions –Algeria, Argentina, Cameroon, Cote d'Ivoire, Dominican Republic, and Venezuela– originally positioned in the "good" regime by their private credit levels, which have since decreased to the extent that they have not been able to reach the required threshold level for the last 10 or 15 years at least.

These countries have been characterized by political instability, high export vulnerability, dependence on oil exports, or even deep economic recessions. Thus, important preconditions for financial development to flourish –such as a robust institutional context or even trade openness, sufficient bureaucratic quality, and law and order– were absent (Chinn and Ito, 2006).

The fact is that while the financial development level of all industrialized countries has been far beyond its threshold for the last 15 years, in the case of non-industrialized

Table 8: Percentage of countries in each regime by quinquennium

Regime	1971-1975	1976-1980	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015
	Full sample								
Financial depth < 27.338%	57.5%	47.5%	41.3%	46.3%	55.0%	46.3%	43.8%	41.3%	30.0%
Financial depth ≥ 27.338%	42.5%	52.5%	58.8%	53.8%	45.0%	53.8%	56.3%	58.8%	70.0%
	Industrialized countries								
Regime	1971-1975	1976-1980	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015
Financial depth < 38.413%	42.9%	33.3%	33.3%	9.5%	9.5%	9.5%	0.0%	0.0%	0.0%
Financial depth ≥ 38.413%	57.1%	66.7%	66.7%	90.5%	90.5%	90.5%	100.0%	100.0%	100.0%
	Non-industrialized countries								
Regime	1971-1975	1976-1980	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015
Financial depth < 27.429%	74.6%	59.3%	54.2%	62.7%	74.6%	62.7%	59.3%	55.9%	40.7%
Financial depth ≥ 27.429%	25.4%	40.7%	45.8%	37.3%	25.4%	37.3%	40.7%	44.1%	59.3%
	Non-industrialized countries under the industrialized threshold								
Regime	1971-1975	1976-1980	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015
Financial depth < 38.413%	89.8%	79.7%	72.9%	76.3%	76.3%	71.2%	74.6%	67.8%	62.7%
Financial depth ≥ 38.413%	10.2%	20.3%	27.1%	23.7%	23.7%	28.8%	25.4%	32.2%	37.3%

countries, 40.7% of the countries still linger in the regime in which trade openness has a null marginal effect on economic growth (see Table 8). Furthermore, looking at the industrialized countries' threshold for financial development, it can be seen that 60% of the countries do not comply with this requirement as of the last quinquennium in the sample.

3.6 Control variables results

Moving on to control variables, the initial GDP per capita was significant and negative as the neoclassic model predicts. Financial depth as a control variable is not significant, while institutions have a positive effect on GDP growth: a higher institutional quality of government increases GDP growth.[8] Human capital has no additional statistically significant effect on economic growth, and public infrastructure, as measured by fixed and mobile telephones per 100 habitants, has a positive and statistically significant impact on growth.[9]

[8] Similarly, Mauro (1995) finds that improving the control of corruption index in a standard deviation would make the annual growth rate rise by 1.3%.

[9] Note that human capital and public infrastructure have negative effects in the industrialized countries; these unexpected results can be due to the few countries in the subsample, which makes

Controls for stabilization policies in the estimation are output instability, price instability, and the frequency of systemic banking crises. Inflation has a negative and significant impact on GDP growth. This leads to the conclusion that higher macroeconomic instability (approximated by the inflation rate) has a negative effect on the per capita GDP growth rate. Price instability negatively affected growth mainly in the 1980s, during which many countries recorded their highest levels of inflation. As a consequence, this period, characterized by high price instability leading to a reduced output growth rate, was known as "the lost decade".

In the same way, the occurrence of banking crises may be detrimental to GDP growth. The indicator used states that a country is in crisis when significant signs of financial distress in the banking system (major bank runs, losses in the banking system, and/or bank liquidations); and if there are significant banking policy intervention measures in response to significant losses in the banking system (Laeven and Valencia, 2018), the effect on output growth is not significant. Similarly, the five-year average of output instability has no effect on long-term growth.

Finally, the world GDP growth variable as a control of external conditions in the estimation, incorporated as the five-year average of aggregate world GDP growth, has an overall negative impact on economies. The effects are higher in industrialized countries, while there are no effects in non-industrialized ones.

4 Robustness

4.1 Threshold location

Even though the estimated threshold remains robust across methodologies in each subsample, we perform a sensitivity analysis of the threshold estimate; to this end, we estimate the threshold considering a leave-one-out, leave-two-out, and leave-three-out sample. We then analyze how many times these estimates fall within the 90% confidence interval of each sample estimation. This rules out the possibility of outliers in the sample, and evaluates the robustness of our estimates. The results of these tests indicate that the estimated threshold is robust to the changes in the sample, as none of the sub-sample estimates falls out of the confidence interval (see Table 9).

the slope results quite sensitive.

Table 9: Robustness of the threshold estimate

% of threshold estimates that fall in 90% confidence interval			
	Full sample	Industrialized countries	Non-industrialized countries
Static methodology			
Leave one country out	100%	100%	100%
Leave two countries out	100%	94%	100%
Leave three countries out	100%	89%	100%
Dynamic methodology			
Leave one country out	100%	95%	100%
Leave two countries out	100%	88%	100%
Leave three countries out	100%	79%	99%

Note: for the leave two and three countries out tests, we used 200 draws from all possible combinations in each sample.

4.2 Additional control variables

Several other control variables are considered in the empirical economic growth literature; thus, in addition to the baseline specification in Table 10, we also employ the investment to GDP ratio and population growth as additional control variables. These variables also serve as a source of growth through capital and labor in a growth accounting exercise.

In regard to external conditions, the measurement variables used in the literature are international interest rates, international movement in capital flows, oil prices, commodity prices, global uncertainty, among others; in order to capture those external condition movements over the time period, we include time dummy variables instead of world GDP growth.

Table 7 shows the results by including more control variables and, overall, the financial depth threshold estimate and slope trade openness effects are quite robust. Finally, we include other country control variables like terrestrial precipitation, the Chinn-Ito index of financial openness (Chinn and Ito, 2006), and the debt to GDP ratio; but apart from reducing our availability of countries in the sample, such variables turn out to be non-significant in the regressions, so we decided not to include in the robustness exercise.

4.3 Comparison with other nonlinear models

Table 11 provides the results of a linear model with an interaction between financial development and trade openness, like that employed in Chang *et al.* (2009), and Zghidi

Table 10: Estimation results with more control variables

Dependent variable: GDP per capita growth	Full sample				Industrialized countries				Non-industrialized countries			
	LS		ML		LS		ML		LS		ML	
Financial depth Threshold estimate ($\widehat{\gamma}$)	27.429	27.429	27.338	27.338	35.353	38.834	38.413	38.666	27.429	27.429	27.429	27.429
[90% Confidence Interval]	[26.2 ; 28.5]	[26.2 ; 29.5]	[26.2 ; 28.8]	[25.9 ; 29.5]	[35.2 ; 47.8]	[31.1 ; 47.8]	[35.2 ; 46.4]	[34.9 ; 59.4]	[26.3 ; 28.4]	[26.3 ; 28.8]	[26.4 ; 28.8]	[22.9 ; 28.8]
Trade openness (Financial depth < $\widehat{\gamma}$)	-0.265	-0.106	0.520	0.606	1.550	1.644	0.926	1.062	-0.361	-0.395	-0.062	-0.102
Structure-adjusted trade volume/GDP, in logs	(0.489)	(0.599)	(0.420)	(0.411)	(1.116)	(2.704)	(0.957)	(1.022)	(0.553)	(0.817)	(0.457)	(0.441)
	[0.545]	[0.674]	[0.476]	[0.477]	[0.927]	[2.270]	[1.273]	[1.527]	[0.565]	[0.699]	[0.546]	[0.546]
Trade openness (Financial depth ≥ $\widehat{\gamma}$)	2.525	2.382	2.937	2.854	4.568	4.007	4.291	3.854	2.737	2.552	2.643	2.457
Structure-adjusted trade volume/GDP, in logs	(0.631)	(0.774)	(0.514)	(0.509)	(0.880)	(2.229)	(0.778)	(0.838)	(0.782)	(1.140)	(0.608)	(0.581)
	[0.706]	[0.855]	[0.608]	[0.610]	[0.777]	[1.916]	[0.976]	[1.131]	[0.870]	[1.149]	[0.856]	[0.777]
Financial depth	-0.135	0.036	-0.390	-0.178	0.158	0.096	0.147	0.298	0.006	0.397	-0.079	0.318
Domestic credit to private sector/GDP, in logs	(0.251)	(0.315)	(0.221)	(0.221)	(0.349)	(0.818)	(0.289)	(0.297)	(0.308)	(0.470)	(0.260)	(0.261)
	[0.237]	[0.294]	[0.218]	[0.222]	[0.299]	[0.740]	[0.346]	[0.370]	[0.275]	[0.386]	[0.259]	[0.283]
Transitional convergence	-5.393	-5.412	-4.488	-4.564	-4.352	-6.072	-3.194	-4.785	-5.404	-4.900	-4.882	-4.680
Initial GDP per capita, in logs	(0.504)	(0.621)	(0.406)	(0.396)	(0.984)	(2.797)	(0.888)	(1.083)	(0.596)	(0.904)	(0.465)	(0.448)
	[0.548]	[0.661]	[0.438]	[0.463]	[1.075]	[2.737]	[0.947]	[1.273]	[0.592]	[0.757]	[0.549]	[0.591]
Human capital	0.886	-0.659	0.290	-1.243	-8.112	-11.87	-9.297	-12.679	1.478	-1.582	1.226	-2.482
Index based on schooling and returns, in logs	(1.524)	(2.390)	(1.282)	(1.637)	(3.980)	(110)	(3.356)	(3.885)	(1.733)	(3.519)	(1.379)	(1.873)
	[1.530]	[2.249]	[1.438]	[1.429]	[4.137]	[8.989]	[3.069]	[5.121]	[1.581]	[2.847]	[1.554]	[1.647]
Public infrastructure	0.617	0.577	0.438	0.604	-0.606	0.015	-1.028	-0.232	0.635	-0.126	0.520	0.068
Fixed and mobile lines per 100 people, in logs	(0.171)	(0.295)	(0.119)	(0.165)	(0.537)	(1.457)	(0.457)	(0.522)	(0.194)	(0.477)	(0.127)	(0.213)
	[0.171]	[0.267]	[0.101]	[0.139]	[0.509]	[1.228]	[0.266]	[0.50]	[0.177]	[0.428]	[0.114]	[0.177]
Institutions	0.528	0.396	0.607	0.465	1.267	1.109	1.265	1.070	0.412	0.234	0.488	0.303
Average of 4 ICRG indicators	(0.190)	(0.239)	(0.167)	(0.167)	(0.357)	(0.884)	(0.320)	(0.345)	(0.222)	(0.335)	(0.183)	(0.182)
	[0.176]	[0.224]	[0.166]	[0.162]	[0.380]	[0.835]	[0.438]	[0.482]	[0.186]	[0.328]	[0.171]	[0.165]
Demographics	-0.522	-0.536	-0.449	-0.451	-0.805	-0.890	-0.378	-0.460	-0.405	-0.324	-0.371	-0.297
Rate of population growth	(0.209)	(0.257)	(0.177)	(0.175)	(0.320)	(0.741)	(0.278)	(0.276)	(0.250)	(0.372)	(0.213)	(0.208)
	[0.222]	[0.274]	[0.213]	[0.216]	[0.341]	[0.688]	[0.378]	[0.360]	[0.234]	[0.308]	[0.249]	[0.224]
Investment	0.569	0.768	0.608	0.744	0.537	1.024	0.152	0.772	0.512	0.684	0.570	0.771
Gross capital formation, in logs	(0.309)	(0.387)	(0.257)	(0.257)	(0.777)	(1.885)	(0.684)	(0.716)	(0.358)	(0.534)	(0.285)	(0.278)
	[0.304]	[0.414]	[0.286]	[0.279]	[0.765]	[1.702]	[0.783]	[1.003]	[0.325]	[0.415]	[0.318]	[0.30]
Output instability	0.084	0.085	0.065	0.080	-0.082	-0.044	-0.131	-0.019	0.070	0.067	0.071	0.068
Std. Dev of GDP per capita growth	(0.043)	(0.053)	(0.040)	(0.040)	(0.103)	(0.250)	(0.079)	(0.092)	(0.049)	(0.072)	(0.044)	(0.042)
	[0.044]	[0.045]	[0.065]	[0.068]	[0.098]	[0.195]	[0.10]	[0.135]	[0.047]	[0.077]	[0.066]	[0.072]
Price instability	-0.336	-0.204	-0.289	-0.194	-2.079	-1.314	-2.251	-1.354	-0.245	-0.053	-0.258	-0.072
CPI growth	(0.140)	(0.176)	(0.128)	(0.129)	(0.387)	(1.016)	(0.366)	(0.410)	(0.161)	(0.243)	(0.139)	(0.138)
	[0.142]	[0.172]	[0.145]	[0.129]	[0.332]	[0.930]	[0.612]	[0.657]	[0.145]	[0.218]	[0.143]	[0.120]
Systemic banking crises	0.012	-0.07	-0.166	-0.194	1.119	0.839	0.642	0.605	-0.023	-0.081	0.079	-0.026
Frequency of years under crisis: 0-1	(0.460)	(0.565)	(0.408)	(0.404)	(0.556)	(1.295)	(0.434)	(0.439)	(0.566)	(0.832)	(0.506)	(0.490)
	[0.390]	[0.556]	[0.50]	[0.518]	[0.384]	[0.913]	[0.715]	[0.523]	[0.448]	[0.727]	[0.589]	[0.562]
External conditions	-0.395	✓	-0.373	✓	-1.214	✓	-1.195	✓	-0.065	✓	-0.039	✓
World GDP growth	(0.160)		(0.152)		(0.170)		(0.160)		(0.208)		(0.185)	
	[0.142]		[0.218]		[0.153]		[0.333]		[0.179]		[0.235]	
Test for threshold effects (p-value)	0.009	0.020	0.042	0.075	0.080	0.112	0.102	0.107	0.018	0.010	0.024	0.023
Number of countries	80	80	80	80	21	21	21	21	59	59	59	59
Number of periods, five year average	9	9	9	9	9	9	9	9	9	9	9	9
Time period	1970-2015	1970-2015	1970-2015	1970-2015	1970-2015	1970-2015	1970-2015	1970-2015	1970-2015	1970-2015	1970-2015	1970-2015
R-squared	0.286	0.329	-	-	0.651	0.703	-	-	0.275	0.349	-	-
Negative log-likelihood	-	-	1388	1368	-	-	227	217	-	-	1000	977

Notes: LS stands for (ordinary) least squares, and ML stands for maximum likelihood. Homoscedastic and heteroskedastic standard errors in parentheses and brackets, respectively. The test shows the probability value for the null hypothesis of $\widehat{\beta}_1 = \widehat{\beta}_2$. We used 1000 bootstrap replications for the test. The specifications with ✓ include time dummies.

and Abida (2014). These results suggest that the effect of trade openness on growth is different for different values of financial depth, while the unique effect of trade openness is not significant. We can again see a differentiated marginal effect of trade openness on growth when we split the full sample into two sub samples (industrialized and non-industrialized countries).

Table 11: Estimation results of the interaction model

Dependent variable: GDP per capita growth	Full sample		Industrialized countries		Non-industrialized countries	
	LS	ML	LS	ML	LS	ML
Trade openness	-1.635	-0.495	-2.390	-5.991	-1.850	-1.276
Structure-adjusted trade volume/GDP, in logs	(1.008)	(0.852)	(3.096)	(2.550)	(1.166)	(0.969)
	[1.016]	[0.799]	[2.970]	[3.688]	[1.081]	[0.992]
Trade openness*financial depth	0.787	0.625	1.465	2.159	0.839	0.717
	(0.314)	(0.255)	(0.675)	(0.556)	(0.382)	(0.306)
	[0.297]	[0.226]	[0.621]	[0.798]	[0.355]	[0.325]
Financial depth	-0.143	-0.414	-0.197	-0.091	0.066	-0.034
Domestic credit to private sector/GDP, in logs	(0.257)	(0.225)	(0.351)	(0.283)	(0.317)	(0.268)
	[0.255]	[0.220]	[0.295]	[0.317]	[0.299]	[0.268]
Transitional convergence	-5.127	-4.208	-4.426	-3.252	-5.093	-4.506
Initial GDP per capita, in logs	(0.528)	(0.421)	(1.010)	(0.876)	(0.625)	(0.489)
	[0.614]	[0.442]	[1.185]	[0.696]	[0.674]	[0.581]
Human capital	1.305	0.638	-5.679	-8.661	1.737	1.499
Index based on schooling and returns, in logs	(1.487)	(1.228)	(3.920)	(3.244)	(1.687)	(1.318)
	[1.401]	[1.267]	[4.494]	[3.187]	[1.444]	[1.369]
Public infrastructure	0.678	0.498	-0.702	-0.884	0.699	0.569
Fixed and mobile lines per 100 people, in logs	(0.173)	(0.116)	(0.527)	(0.442)	(0.195)	(0.124)
	[0.164]	[0.094]	[0.518]	[0.312]	[0.169]	[0.108]
Institutions	0.609	0.673	1.132	1.106	0.470	0.524
Average of 4 ICRG indicators	(0.192)	(0.169)	(0.360)	(0.309)	(0.225)	(0.187)
	[0.178]	[0.178]	[0.386]	[0.370]	[0.194]	[0.187]
Output instability	0.086	0.067	-0.097	-0.195	0.067	0.067
Std. Dev of GDP per capita growth	(0.044)	(0.041)	(0.107)	(0.080)	(0.051)	(0.045)
	[0.047]	[0.065]	[0.101]	[0.095]	[0.049]	[0.067]
Price instability	-0.326	-0.281	-2.210	-2.251	-0.224	-0.246
CPI growth	(0.143)	(0.130)	(0.395)	(0.356)	(0.164)	(0.142)
	[0.154]	[0.157]	[0.364]	[0.603]	[0.156]	[0.157]
Systemic banking crises	0.006	-0.213	1.047	0.649	0.014	0.102
Frequency of years under crisis: 0-1	(0.468)	(0.414)	(0.575)	(0.435)	(0.577)	(0.517)
	[0.392]	[0.501]	[0.411]	[0.704]	[0.451]	[0.582]
External conditions	-0.318	-0.304	-1.216	-1.285	0.033	0.050
World GDP growth	(0.163)	(0.154)	(0.173)	(0.158)	(0.211)	(0.188)
	[0.143]	[0.217]	[0.162]	[0.347]	[0.182]	[0.231]
Number of countries	80	80	21	21	59	59
Number of periods, five year average	9	9	9	9	9	9
Time period	1971-2015	1971-2015	1971-2015	1971-2015	1971-2015	1971-2015
R-squared	0.252	-	0.618	-	0.241	-
Negative log-likelihood	-	1400	-	229	-	1012

Notes: LS stands for (ordinary) least squares, and ML stands for maximum likelihood. Homoscedastic and heteroskedastic standard errors in parentheses and brackets, respectively.

The panel model with interactions provides further evidence about the nonlinear trade-growth relationship, which varies with a country's level of financial development. That is, the panel model with interacions does not identify a financial development threshold beyond which the trade and growth relationship become significant. In addition, both the R-squared and the negative log-likelihood favor the threshold model against the interaction model; that is, the threshold model fits the data better than the interaction model in the full, industrialized, and non-industrialized samples.

5 Conclusion

In this paper, we examine the implications of financial sector development for the trade openness and growth nexus. We find that financial sector development, from a clearly identifiable threshold, is a key enabler of the growth benefits of trade. This finding is consistent with the recent literature suggesting that the indirect effects of financial development on growth might be as strong as the direct effects, and that these effects are concentrated on trade. We find that these results are robust to changes in specification and to the sequential elimination of three countries from the sample at a time. This finding provides evidence that financial sector development is itself a source of comparative advantage. The use of a dynamic panel regression is justified as it allows us to clearly identify the financial sector development threshold within a tractable framework.

We also find that the financial-sector-threshold enablers of growth benefits from trade are greater for industrialized than for non-industrialized economies. This is consistent with the literature's conjecture that countries that export more capital-intensive and finance-dependent sectors need deeper financial sectors. Importantly, the financial development thresholds we estimate are much lower than the 80-100 percent of GDP thresholds found to be detrimental to economic growth elsewhere in the literature. Furthermore, industrialized economies also gain considerably more once their threshold is met.

Future work should look more closely at the trade composition of trade openness measures and the comparative advantage effects of financial development, given the growing evidence that both the levels and composition of international trade are important for growth. Moreover, an understanding of the extent to which domestic firms are liquidity constrained will be key for any assessment of the benefits and potential of trade openness. The assessment of financial sectors as a source of economic growth needs to recognize that this sector in itself represents a source of comparative advantage.

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A Classification of countries

Table 12: Classification of countries

Industrialized countries	Non-industrialized countries		
Australia	Algeria	Ghana	Paraguay
Austria	Argentina	Guatemala	Peru
Belgium	Bangladesh	Honduras	Philippines
Canada	Bolivia	India	Senegal
Denmark	Botswana	Indonesia	Sierra Leone
Finland	Brazil	Iran, Islamic Rep.	Singapore
France	Burkina Faso	Israel	South Africa
Germany	Cameroon	Jamaica	Sri Lanka
Greece	Chile	Kenya	Sudan
Iceland	China	Korea, Rep.	Thailand
Ireland	Colombia	Madagascar	Togo
Italy	Congo, Dem. Rep.	Malawi	Trinidad and Tobago
Japan	Congo, Rep.	Malaysia	Tunisia
Luxembourg	Costa Rica	Mali	Turkey
Netherlands	Cote d'Ivoire	Mexico	Uruguay
Norway	Dominican Republic	Morocco	Venezuela
Portugal	Ecuador	Nicaragua	Zambia
Spain	Egypt, Arab Rep.	Niger	
Sweden	El Salvador	Nigeria	
United Kingdom	Gabon	Pakistan	
United States	Gambia, The	Panama	

Source: United Nations.