Trade as a Threshold Variable for Multiple Regimes

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Abstract. This paper employs the data-sorting method developed by Hansen (2000) which allows the data to endogenously select regimes using different variables. It is shown that openness, as measured by the trade share to GDP, is a threshold variable that can cluster middle-income countries into two distinct regimes that obey different statistical models. Our result suggests that openness may not be as crucial in the growth process of low and high-income countries but it is instrumental in identifying middle-income countries into high and low-growth groups.

Keywords: Endogenous splitting; Threshold variables; Openness; Growth

JEL classification: C13; C21; O47

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"... we can use measures of foreign trade and openness to help explain the clustering of middle-income economies into high-growth and low-growth groups."

Costas Azariadis (1996)

1. Introduction

The relationship between openness and growth is at the center of lively discussions amongst economist. On the one hand, recent work by Sachs and Warner (1995), Edwards (1998) and Frankel and Romer (1999), just to name a few, assigns an important role of trade and openness to economic growth. On the other hand, there exists a fair amount of scepticism about this relationship, both on theoretical and empirical grounds, as summarized in Rodríguez and Rodrik (2000).

Some evidence in favor of a positive openness-growth relationship is obtained by plotting the cross-country average annual growth rate of trade volume against the average annual growth rate of per capita GDP from 1960 to 1993. The relationship that emerges is clearly positive indicating that a component of the growth performance of many economies maybe associated with an increase in trade intensity. However, for the same time period, the trade intensity in many rapidly growing countries, like Japan, has been declining. Moreover, the majority of sub-Sahara African countries have exhibited trade intensity increases while having virtually no growth. This evidence suggests that the relationship between openness and growth is far from simple.

This paper examines an alternative way by which openness maybe influencing economic performance. Following Durlauf and Johnson (1995) (DJ) and more recently Hansen (2000) we employ a data-sorting method which allows the data to endogenously select regimes using different variables. We show that openness, as measured by the ratio of trade volume to GDP, is a threshold variable that can cluster middle-income countries into two regimes that obey different statistical models. This finding is in favor of theoretical models in which trade and openness is a plausible source of multiple equilibria such as Trejos (1992), Azariadis (1996, pp.464-465) and Trejos and Ferreira (2000).

2. Estimation

In this section we follow Hansen (2000) to search for multiple regimes in the data by using, in addition to initial per capita output (y_{1960}) and initial literacy rate (LIT), trade share (TS) as a possible threshold variable. The advantage of Hansen's methodology over the regression-tree methodology used in DJ is that it is based on an asymptotic distribution theory. Unlike the regression-tree approach, Hansen's method can test the statistical significance of regimes selected by the data.[1]

In line with most empirical growth literature, we consider the following regression equation:

$$\log y_{i,1985} - \log y_{i,1960} = a_0 + a_1 \log y_{i,1960} + a_2 \log s_{ik} + a_3 \log s_{ih} + a_4 \log(n_i + g + \delta) + \varepsilon_i, \quad (1)$$

where y_i is per capita GDP for country i, s_k is physical capital investment (investment share to GDP), s_h is human capital investment (secondary-school enrollment of working-age population), n is population growth, $g + \delta = 0.05$ as in Mankiw, Romer, Weil (1992), and ε is a random error term.

The country-sample (96 countries) and data (real GDP, working-age population, average share of real investment, secondary-school enrolment rates and adult literacy rates) are from DJ.[2] Data on trade share defined as the ratio of imports plus exports to real GDP in 1985, are from PWT-5.6 (series, OPEN).[3]

Since Hansen's theory allows for one threshold for each threshold variable, we proceed by selecting among the three threshold variables (y_{1960}, LIT, TS) by employing the heteroskedasticity-consistent Lagrange Multiplier test for a threshold obtained in Hansen (1996). Our first round of threshold model selection obtains the following p-values: 0.270 for trade share, 0.168 for literacy rate and 0.080 for initial per capita output. These results indicate that there maybe a sample split based on initial per capita output. As shown in Hansen (2000), the threshold value occurs at \$863 and the asymptotic 95% confidence set is [\$594, \$1794]. This threshold value divides our entire sample of 96 countries into a low-income group with 18 countries and a high-income group with 78 countries.

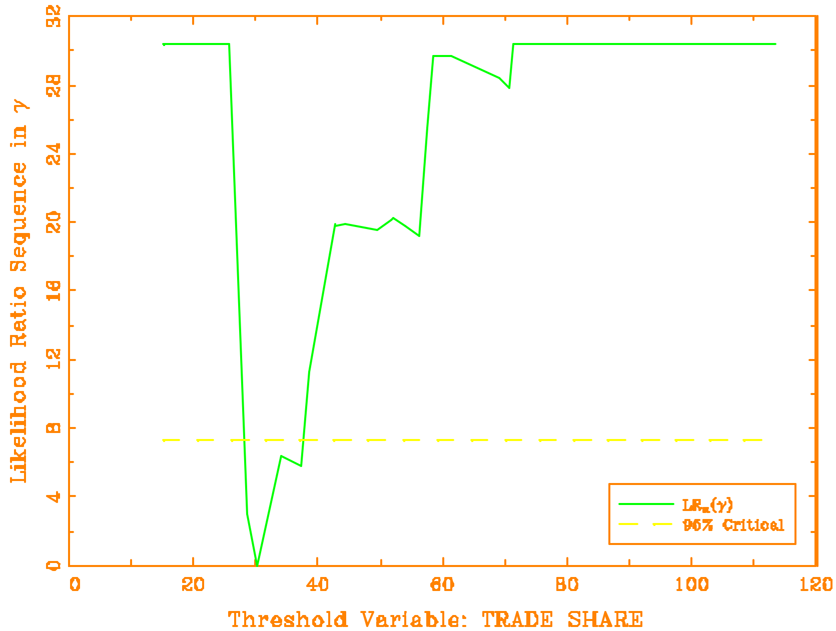
Our second round of threshold model selection involves the 78 countries with per capital output above \$863 and obtains the following p-values for our three threshold variables: 0.552 for trade share, 0.055 for literacy rate and 0.146 for per capita output. These results indicate a possible sample split based on literacy rate. The threshold value occurs at 45% and the asymptotic 95% confidence set is [19%, 57%]. The literacy-rate threshold variable splits the high-income subsample

[1] For a detailed discussion on the statistical theory for threshold estimation in the regression context, see Hansen (2000).

[2] With the exception of the adult literacy rates that are from the World Bank's *World Report*, all of the data used in DJ are from the Real National Accounts constructed by Summers and Heston (1988).

[3] Trade share in our country sample varies dramatically from 13.16% in Burma to 318.07% in Singapore. The data and programs used in this paper are available by the author upon request.

Figure 1: Threshold Variable Confidence Interval



of 78 countries into two further groups; the low-literacy group with 30 countries and the high-literacy group with 48 countries.

In the third round, we obtain our key finding. In this round we try spliting the high-income-low-literacy subsample with 30 countries (income above \$863 and literacy rate below 45%). The p-values obtained from the three alternative threshold models are, 0.033 for trade share, 0.121 for literacy rate and 0.105 for initial per capita output, indicating that there may be a sample split based on trade share. Figure 1 presents the normalized likelihood ratio sequence $LR_n^*(\gamma)$ statistic as a function of the trade share. The least-squares estimate γ is the value that minimizes the function $LR_n^*(\gamma)$ which occurs at $\hat{\gamma} = 30.27\%$. The asymptotic 95% critical value (7.35) is shown by the dotted line and where it crosses $LR_n^*(\gamma)$ displays the confidence set $[28.53\%, 37.23\%]$. This threshold divides our subsample of 30 countries into a high-income-low-literacy-low-trade group with 8 countries and a high-income-low-literacy-high-trade group with 22 countries. Notice that our third splitting is the most significant (at the 3.3% level) indicating strong evidence in favor of trade share as a threshold variable among middle-income countries.

We have tried to further split the high-income-high-literacy rate group of 48 countries but none

Table 1: Four Regimes Obtained by Hansen's Threshold Regression Estimation

Regime 1:	$y_{i,1960} \leq \$863$	(18 countries)
Regime 2:	$y_{i,1960} > \$863$; $LIT_{i,1960} \leq 45\%$; $TS_{i,1985} \leq 30.27$	(8 countries)
Regime 3:	$y_{i,1960} > \$863$; $LIT_{i,1960} \leq 45\%$; $TS_{i,1985} > 30.27$	(22 countries)
Regime 4:	$y_{i,1960} > \$863$; $LIT_{i,1960} > 45\%$	(48 countries)

Notes: LIT denotes literacy rate and TS denotes trade share.

of the bootstrap test statistics were significant and therefore no further splitting was possible with the existing threshold variables. We have also checked the robustness of these three variables (y_{1960}, LIT, TS) by examining a list of other possible threshold variables suggested in the theoretical literature of multiple equilibria and growth; these include corruption (data from Mauro 1995), inflation, and political instability (data from Sachs and Warner 1995). None of the bootstrap test statistics for these variables were statistically significant at any round of the selection process.

Table 1 illustrates the four regimes whereas Table 2 presents the countries in each regime determined by our threshold estimation. The countries in each regime compare well with those identified by the regression-tree approach in DJ (1995 p.374). Like DJ we obtain four regimes, however these regimes are identified with different threshold variables. Our main difference is twofold: first their regimes 3 and 4 are clustered into our Regime 4; that is we do not obtain a statistically significant threshold for splitting the high-income-high-literacy rate countries using per capita output. Second, their Regime 2 is, in our work, divided into two regimes (Regime 2 and Regime 3) based on the countries' trade share.

Next, we turn our attention to the estimation of equation (1) for the four regimes. Table 3 presents estimates for each regime in the unrestricted and restricted models.[4] The heterogeneity of the coefficient estimates across regimes is evident. Starting with the unrestricted model, point estimates on initial income level ($\log y_{1960}$) vary from -0.657 and significant at the 1% level for Regime 1, to 0.652 and significant at the 5% level for Regime 2. The coefficient estimate on physical capital investment ($\log s_k$) is 0.099 but insignificant for Regime 3, and 0.834 and highly significant for Regime 4. Finally, estimated coefficients on human capital investment ($\log s_h$) range from 0.018 but insignificant for Regime 1 to 0.589 and highly significant for Regime 3.

[4]The restricted model imposes the constraint that the coefficient on $\log(n_i + g + \delta)$ is equal in magnitude and opposite in sign to the sum of the coefficients on $\log s_{ik}$ and $\log s_{ih}$.

Table 2: Country Classification in Four Regimes

	Regime 1	Regime 2	Regime 3	Regime 4	
1	B. Faso	Bolivia	Algeria	Argentina	Mexico
2	Bangladesh	Ghana	Angola	Australia	N. Zealand
3	Burma	Guatemala	Benin	Austria	Netherlands
4	Burundi	India	Cameroon	Belgium	Nicaragua
5	C. Afri. Rep.	Mozambique	Chad	Brazil	Norway
6	Ethiopia	Nigeria	Congo	Canada	Panama
7	Liberia	Somalia	Egypt	Chile	Paraguay
8	Malawi	Sudan	Haiti	Colombia	Peru
9	Mali		Honduras	Costa Rica	Philippines
10	Mauritania		I. Coast	Denmark	Portugal
11	Nepal		Indonesia	Dom. Rep.	S. Africa
12	Niger		Jordan	Ecuador	S. Korea
13	Rwanda		Kenya	El Salvador	Singapore
14	Sierra Leone		Morocco	Finland	Spain
15	Tanzania		Pakistan	France	Sri Lanka
16	Togo		Papua N. G	Greece	Sweden
17	Uganda		Senegal	Hong Kong	Switzerland
18	Zaire		Syria	Ireland	Thailand
19			Tunisia	Israel	Tri & Tobago
20			Turkey	Italy	U.K.
21			Zambia	Jamaica	U.S.A.
22			Zimbabwe	Japan	Uruguay
23				Madagascar	Venezuela
24				Malaysia	W. Germany

Disparity in coefficient estimates across regimes in the restricted model is as large as in the unrestricted model. The estimated share of physical capital α, varies from 0.06 but insignificant for Regime 3 to 0.413 and highly significant for Regime 1. Human capital shares are substantially different across regimes too, ranging from 0.014 but insignificant for Regime 1 to 0.349 and highly significant for Regime 3.[5]

Heterogeneity of coefficient estimates is particularly striking between Regime 2 and Regime 3 (both in the unrestricted and restricted regressions) which are clustered according to the trade threshold variable. This reinforces our finding that more open middle-income economies obey a

[5]Computing the shares of labor input across regimes obtains: 0.802 for Regime 1, 0.617 for Regime 2, 0.591 for Regime 3, and 0.553 for Regime 4. This results is consistent (even though not as strong in magnitude) with DJ's observation that labor shares decline with economic development. In a recent paper, Duffy and Papageorgiou (2000) have used panel data techniques to estimate a two-factor Constant Elasticity of Substitution (CES) aggregate production function specification for a cross-section of 82 countries over a period of 28 years. They find that the elasticity of substitution and therefore the capital share is increasing with economic development, which is consistent with the declining labor shares across regimes obtained here.

Table 3: Cross-Country Regressions for the Four Regimes

Specification	Regime 1	Regime 2	Regime 3	Regime 4
Unrestricted				
Constant	4.312**	−8.584	3.979**	4.310***
	(1.627)	(5.736)	(1.874)	(0.965)
$\log y_{1960}$	−0.657***	0.652**	−0.395**	−0.395***
	(0.218)	(0.204)	(0.147)	(0.061)
$\log s_k$	0.228***	0.603	0.099	0.834***
	(0.072)	(0.280)	(0.190)	(0.139)
$\log s_h$	0.018	0.027	0.589***	0.095
	(0.097)	(0.143)	(0.101)	(0.135)
$\log(n+g+\delta)$	−0.295	−2.063	−0.598	−0.418
	(0.337)	(1.775)	(0.462)	(0.270)
s.e.e.	0.368	0.230	0.254	0.289
Adj. R^2	0.36	0.32	0.69	0.54
Restricted				
Constant	4.434***	−4.094**	3.719***	3.221***
	(1.558)	(1.195)	(1.065)	(0.562)
Implied α	0.184***	0.324***	0.060	0.413***
	(0.053)	(0.113)	(0.108)	(0.061)
Implied β	0.014	0.059	0.349***	0.034
	(0.077)	(0.059)	(0.072)	(0.076)
s.e.e.	0.220	0.204	0.247	0.291
Adj. R^2	0.41	0.46	0.71	0.53
Obs.	18	8	22	48

Notes: α and β are the shares of physical and human capital respectively. Standard errors are given in parentheses. The standard errors for α and β were recovered using standard approximation methods for testing nonlinear functions of parameters. White's heteroskedasticity correction was used. *** Significantly different from 0 at the 1% level. ** Significantly different from 0 at the 5% level. * Significantly different from 0 at the 10% level.

model that is significantly different from that in more closed middle-income economies.

It is well-known in the literature that cross-country level regressions, such as ours, maybe subject to a list of econometric problems; two potentially serious problems are the omitted-variables error and the endogeneity error. DJ (pp.371-372, Table III) examined the possibility of omitted-variables error showing that evidence of multiple regimes is robust to the addition of a set of 13 control variables. Since our threshold estimation includes trade shares, there are legitimate concerns about potential endogeneity problems between trade and growth. Put differently, it maybe that income affects the level of openness and not the reverse. Frankel and Romer (1999) show that correcting for endogeneity problems by using instruments obtained from geographical components of countries, yields a stronger positive effect of trade on economic growth.

3. Conclusion

This paper proposes an alternative way by which openness maybe affecting growth. It is shown that openness, as measured by the trade share to GDP, is a threshold variable that can cluster middle-income countries into two distinct regimes that obey different statistical models. Our result suggests that openness may not be as crucial in the growth process of high and low-income countries but it is instrumental in clustering middle-income countries into high and low-growth groups. Our finding is consistent with, and provides evidence in favor of a small but growing class of theoretical papers that view openness as a potential source of multiple equilibria. In a more general sense, our finding is in agreement with Durlauf and Johnson (1995), Liu and Stengos (1999) and Durlauf (2001) in that the constant coefficient linear model assumptions made in standard growth regressions are not supported by the data.

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