

# **Openness, growth and convergence clubs : a threshold regression approach**

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## Abstract :

This paper aims at investigating the trade-and-growth link by applying a new econometric methodology. We apply the threshold test developed by Hansen [2000] to standard growth regressions in order to capture a non-linear effect of trade on growth. Amongst all the threshold variables tested, trade policy indexes are the variables that best sort out the sample. In the end, the threshold test splits up the sample into two different groups: the club of "open" countries and the "closed" one. Three main results may be shown. The convergence phenomenon is more accurate in the open club than in the close one. A robust link between human capital accumulation and growth is only estimated with the group of "open" countries. The relationship between trade and growth is very diverse. For the "open" club, trade indexes coefficients have the expected signs but are non significant. By contrast, as far as the "closed" club is concerned, we have estimated a significant relationship but the coefficients have the opposite sign. This means that for countries with already low barriers to trade, an increase in openness degree is not growth increasing, whereas for high level trade barriers countries this is growth reducing.

# 1- Introduction

Is openness to trade growth promoting ? Can the East-Asian growth "miracle" be explained by the trade policy of these countries? By contrast, are the bad results in growth of some South-American countries due to their protectionist trade policy in the last decades ? All these issues refer to the trade-and-growth link. The dynamic gains from trade still raise controversy from a theoretical point of view, even in the new growth theory (Grossman & Helpman [1991])<sup>1</sup>.

In earlier empirical studies, a positive robust link is always estimated (e.g. Dollar [1992], Edwards [1992]). Recent research has questioned the robustness of the relationship. A debate is now taking place between academics who put in doubt the existence of this robust link (e.g. Rodriguez & Rodrick [2000]) and those who do not so (e.g. Srinivasan & Bhagwati [1999]). The most often cited reference of a clear positive effect of trade on growth is the well-known Sachs & Warner [1995] findings. However, Harrison & Hanson [1999] have shown that the Sachs-Warner trade index is not a good measure of a country's openness to trade. Rodriguez & Rodrick [2000] confirm Harrison-Hanson findings and extend the criticism to other trade openness proxies.

Baldwin & Sbergami [2000] argue that the fragility of the trade and growth results may be explained by the imposition of a linear relationship. They consider ten different proxies of a country's trade openness. With a linear specification, only 3 of the 10 trade indicators are significant in a growth regression. Once non-linearity is imposed, then 7 out of the 10 proxies have a significant impact on growth.

Allowing for non-linearity does have a huge empirical impact on the trade and growth issue. The goal of this paper is to apply a new econometric methodology in the trade-and-growth link in order to investigate the effects of the non-linearity. We shall apply the recent threshold regression method developed by Hansen [2000] to standard growth regressions, in order to capture a non-linear effect of trade on growth. The threshold model allows to split up the sample into different groups and construct convergence clubs. To our knowledge, this is the first paper that intends to construct convergence clubs in growth empirics with Hansen's test.

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<sup>1</sup> See Baldwin [1992] and Scandizzo [1999] for a survey of this literature.

We estimate cross-country growth regressions à la Barro with five different proxies of a country's openness to trade. The null of linearity has always been rejected in favour of the threshold regression. Amongst all the threshold variables tested, trade policy indexes are the variables that best sort out the sample. In the end, whatever the trade indicator used, the threshold test splits up the sample into two different groups: the club of "open" countries and the "closed" ones. Three main findings may be exhibited. The convergence phenomenon is more acute in the open club than in the "closed" one. A robust link between human capital accumulation and growth is only estimated with the group of "open" countries. Lastly, the relationship between trade and growth is very diverse. For the "open" club, trade indexes coefficients have the expected signs but are non significant. By contrast, as far as the "closed" club is concerned, we have estimated a significant relationship but the coefficients have the opposite sign. This means that for countries with already low barriers to trade, an increase in the degree of openness is not growth increasing, whereas for high level trade barriers countries, this is in fact growth reducing.

The rest of this paper is organized as follows. The next section presents the theoretical arguments which postulate for a non-linear relationship between trade and growth. Section 3 describes Hansen's threshold model and his test of non-linearity. Section 4 applies the testing approach to evaluate the different convergence clubs. Section 5 estimates the growth regressions for each convergence club. Section 6 contains concluding remarks.

## **2-Non-linearity in the trade-and-growth link : a brief review**

By contrast to empirical studies, non-linearity is a very usual feature in imperfect competition trade models<sup>2</sup>. As new growth theories are built on imperfect competition and increasing returns, it seems obvious to find a non-linear link between trade and growth. Rivera-Batiz & Romer [1991] show a U-shaped relationship between an ad valorem tariffs and the endogenous growth rate.

Baldwin & Sbergami [2000] develop a simple two country Romerian growth model in order to highlight the channels of transmission between trade liberalisation and growth. Three types of import barriers are introduced : an ad valorem tariff, a specific per unit tariff and an

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<sup>2</sup> Brander & Krugman [1983] for example develop a model where a marginal decrease in trade protection for high barriers countries is welfare reducing, whereas a marginal increase is welfare improving for low barriers countries.

frictional iceberg barrier. They show that the changes in the frictional barrier are growth neutral. These findings come from the mill-pricing feature of monopolist competition. A change in the frictional barrier increases consumer price, but leaves producer prices unaffected. As operating profits are unchanged, there is no incentive to invest in the R&D sector which is the engine of growth in the model. The specific tariff does have an impact on growth due to a tariff-revenue effect. If the tariff revenue is returned lump sum to consumers, then operating profits are modified. As a matter of fact, profits are a fraction of total consumers expenditures which ultimately depend on consumers' income. As the returned tariff revenue changes income, it also promotes growth. Baldwin & Sbergami [2000] demonstrate that the specific tariff and growth relationship is a bell-shaped curve of the Laffer type. For low level of tariffs, an increase in the protection rate raises the growth rate. At last, the ad valorem tariff will also have a non-monotonic effect on growth as in Rivera-Batiz & Romer model. Firms local and foreign market shares are modified by a symmetric tariff. A raise in domestic protection has two effects : firstly an increase in the local market share (and consequently the profit earned in the local market), and secondly a decrease in the foreign market share (and then the profit earned in the foreign market). When the tariff is low, the export market is an important component of the domestic growth rate. If the protection rate goes up, then the second negative effect dominates, and the growth rate is reduced. By contrast, with a high tariff level this second effect is negligible, and the growth rate will increase.

Next to the previous non-monotonic effects, one may find other sources of non-linearity in the trade and growth link. First of all, one may think of the link between openness and international knowledge spillovers. Van Elkan [1996] and Barro & Sala-I-Martin [1997] show that technological diffusion may foster long term growth rate in developing countries which allow them to catch-up with the per capita income of developed countries. Coe & Helpman [1995] show empirical evidence that technological diffusion passes mainly through trade. Hence, openness to trade become a key component in a country convergence mechanism (see Ben-david [1993] for empirical evidence). According to Sachs & Warner [1995], trade should be the only determinant of the catching-up. However, as claimed by Baldwin & Sbergami [2000], openness should affect knowledge spillovers in a non-linear fashion, because the benefits from technological diffusion are likely to be subject to diminishing returns.

The second source of non-linearity concerns the introduction in recent papers of new geographical elements in the endogenous growth apparatus. In this kind of model, the well-known agglomeration effects will change the growth rate (Baldwin & Forslid [1999]).

Asymmetric protection shifts industrial production from the foreign country to the domestic one. This fosters agglomeration in the domestic economy. If learning spillovers are at least partly national in scope, then investment in the R&D sector will increase which, as a result, boosts the growth rate.

### 3-The econometric testing procedure

In this paper, we apply the test advocated by Hansen [2000] to assess the null hypothesis of a linear regression against a threshold regression (TR) analysis. The TR model is given by :

$$(1) \quad y_t = \beta_1' x_t + u_t \quad q_t \leq \gamma$$

$$(2) \quad y_t = \beta_2' x_t + u_t \quad q_t > \gamma$$

where  $y_t$  and  $q_t$  are the observation of the dependent variable and the threshold variable respectively, and  $x_t$  is a  $p \times 1$  vector of independent variables. The threshold variable is used to split up the sample into two groups which are called "regimes". The threshold variable may be part of the  $x_t$ . The random variable  $u_t$  is a regression error. The model allows the regression parameters to differ depending on the value of  $q$ . The model (1)-(2) can be written in a single equation form with the introduction of the dummy variable  $d_t = I(q_t \leq \gamma)$  where  $I(\cdot)$  denotes the indicator function. If we set the variable  $x_t(\gamma) = x_t d_t(\gamma)$ , then Eqs (1)-(2) are equal to

$$(3) \quad y_t = \beta' x_t + \theta x_t(\gamma) + u_t$$

where  $\beta = \beta_2$ . Eqs(3) allows all regression parameters to differ between the two regimes. Hansen [2000] develops an algorithm based on a sequential OLS estimation which searches over all values  $\gamma = q_{-}\{t\} \quad t=1, \dots, T$ . The procedure also provides estimates of  $\beta$  and  $\theta$ . The null hypothesis of linearity against a threshold specification can be expressed as :

$$(4) \quad H_0 : \beta_1 = \beta_2$$

Yet, running this test is not obvious as the threshold value  $\gamma$  is not identified under the null of no threshold effect. Hansen [2000] proposes an heteroskedasticity-consistent F-test

bootstrap procedure to test the null of linearity. Since the threshold value  $\gamma$  is not identified under the null, the p-values are computed by a fixed bootstrap method. The independent variables  $x_{\{t\}}$  are supposed to be fixed, and the dependent variable is generated by a bootstrap from the distribution  $N(0, \hat{u}_t)$  where  $\hat{u}_t$  is the OLS residual from the estimated threshold model. Hansen [2000] shows this procedure yields asymptotically correct p-values. If the null hypothesis of linearity (4) is rejected, one can split up the original sample according to the estimated threshold value  $\gamma$  and then perform the same analysis on each subsamples. This procedure can be carried out until the null is no longer rejected in order to construct more than two regimes.

## 4-Are they convergence clubs ?

### 4.1 Regression Model and Data

The empirics on the openness and growth link rely on growth regressions à la Barro (e.g. Wacziarg [1998], Frankel & Romer [1999]). Our starting point, is then the conditional convergence regression suggested by Barro & Sala-i-Martin [1992] and Mankiw, Romer & Weil [1992]. This regresses per capita GDP growth on the initial level of GDP per capita in order to take into account the convergence phenomenon and on a vector of independent variables which represents the level of the steady state towards which the country is converging. These independent variables are the investment ratio, the initial level of human capital and the population growth rate. We add to these variables a proxy for trade in order to study the impact of openness on growth. The specification is :

$$(5) \quad ((\ln(Y_{i2000}) - \ln(Y_{i1960}))/T) = \beta_0 + \beta_1 \ln(Y_{i1960}) + \beta_2 \ln(\text{Invest}) + \beta_3 \ln(\text{Human}_{1960}) \\ + \beta_4 \ln(n+g+\delta) + \beta_5 \text{Trade} + u +$$

where for each country  $i$  :

$\ln(Y_{it})$  is the log of GDP per capita in year  $t$

$\ln(\text{Invest})$  is the log of investment to GDP ratio

$\ln(\text{Human}_{1960})$  is the log of the average schooling years in the total population over 25 in 1960

$n$  is the average population growth rate and  $g+\delta=0.05$  according to Mankiw, Romer & Weil [1992].

As cross-country data are employed, growth rates (GDP per capita and population) and the investment ratio are measured as the period average (1960-2000). Data are taken from Summers & Heston's [1991] Penn World Tables Mark 6.1. The human capital and trade variables are from the Barro-Lee database.

The choice of a trade proxy is more difficult, because there is not a good measure of a country's openness. Many measures have been proposed in the empirical literature, but none have won a clear dominance because these ones are only weakly correlated between each other (see Pritchett [1996] for a statistical comparison of the different trade indicators). Harrison [1996], Wacziarg [1998], Edwards [1998], Rodrick & Rodriguez [1999], Frankel & Romer [2000] have applied different measures in the empirical growth trade literature. The results are mixed. A significant effect of openness on growth depends on which indicator is used. In front of the difficulties in defining satisfactory summary trade indexes, Edwards suggest that *researchers should move away from this area, and should instead concentrate on determining whether econometric results are robust to alternative indexes* (Edwards [1998, p.386]). Hence, recent papers run growth regressions with different trade proxies (see e.g. Baldwin & Sbergami [2000]). This is the task adopted in the paper.

We implement five different measures of a nation's openness to trade. Most of these are taken from the Barro-Lee dataset. OWTI is the own-imported-weighted-tariffs on intermediate inputs and capital goods, OWQI equals the average number on quantitative restriction imposed on intermediate inputs and capital goods, FREETAR represents an index of tariffs restrictions imposed on imports. TIR is the trade intensity ratio which means imports plus exports to GDP ratio. This index is the average period ratio (1960-2000) and is from PWT Mark 6.1. Lastly, RESIDUALS is an adjusted trade intensity ratio as suggested by Leamer [1988]. Namely, this is the gap between actual trade ratio and the one predicted by a linear regression, the explanatory variables of which are : the 1960 initial level of GDP per capita, the average period (1960-2000) population and the area of the country. A large positive value for residuals means that the country is more open than the average country, once economic and geographic factors are controlled. Even if this variable is somewhat difficult to interpret, we follow Leamer [1988] and Baldwin & Sbergami [2000] by supposing that if the only omitted variable is the trade policy, then residuals can be considered as an index of country's openness<sup>3</sup>.

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<sup>3</sup> For further details on the estimation of this variable and for comparisons with others measures of country's openness to trade, see Serranito [2001]

### 4.1.1 Empirical Results

Table 1 shows the results of standard OLS growth regressions (5) using the different proxies for openness<sup>4</sup>. Note that the variables OWTI, OWQI and FREETAR are constructed as increasing when countries become more closed, so they should have a negative impact on growth. The results confirm the well known results concerning growth empirics, for example Temple [1999]. All the significant coefficients have the expected sign. Initial GDP is significant and negative in all regressions, which means that there is a phenomenon of conditional convergence. Investment ratio and population growth rate (GRPOP) are always significant and as expected are respectively positive and negative. Initial human capital is always positive, but significant in only two of the five regressions.

With regards to the trade index, the coefficients have the correct sign, positive for the openness measures (TRI, RESIDUALS) and negative for the closed-ness ones. The most striking point comes from the fact that none measure of trade is significant at usual level of confidence. Such a result is in contrast with recent papers such as Harrison [1996], Edwards [1998] or Harrison & Hanson [1999] which find a robust relationship between trade and growth for at least few proxies for trade openness. As Baldwin & Sbergami [2000] have pointed out, one may explain the lack of link between growth and trade by the fact that a linear specification between the two variables has been imposed. In the next section, we shall relax this hypothesis in order to evaluate the impact of trade on growth.

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<sup>4</sup> The t-statistics here and in all other tables are based on the procedure of White [1980].

Table 1 : Standard Linear Growth regressions with

	TRI	RESIDUALS	OWTI	OWQI	FREETAR
Constant	4.741* (1.707)	5.580*** (2.420)	5.797*** (2.419)	4.683*** (1.787)	5.580*** (2.396)
GDP60	-0.956*** (-2.867)	-0.981*** (-2.999)	-1.011*** (-2.659)	-0.960*** (-2.436)	-0.981*** (-2.602)
INVEST	1.505*** (4.314)	1.526*** (4.571)	1.363*** (4.269)	1.819*** (4.353)	1.382*** (4.122)
HUMAN60	0.449** (2.147)	0.464** (2.282)	0.287 (1.205)	0.307 (1.266)	0.262 (1.132)
GRPOP	-0.737*** (-3.476)	-0.759*** (-3.780)	-0.726*** (-2.721)	-0.729*** (-3.093)	-0.879*** (-3.569)
TRADE	0.178 (0.685)	0.038 (0.100)	-0.275 (-1.412)	-0.047 (-0.433)	-0.165 (-0.783)
R <sup>2</sup>	0.463	0.460	0.460	0.456	0.438
Sample size	83	83	72	70	70

\*\*\*, \*\* and \* variable is significant at the 1, 5 and 10% level

## 4.2 Testing for a threshold effect

Recent theories of growth have suggested that real income per capita of countries may display convergence clubs, i.e. a tendency for groups of countries to cluster around a small number of poles of attraction (see Galor [1996] for a survey). Since the pioneer work of Durlauf & Johnson [1995], there is now growing literature aiming at testing and estimating convergence clubs. Durlauf & Johnson [1995] use regression-tree analysis to cluster countries based on two threshold variables : initial level of GDP per capita and initial level of human capital. With the same method, Ghosh & Wolf [1998] choose the investment ratio. Applying recursive Chow tests, Berthelemy & Varoudakis [1995] pick out initial human capital and initial level of financial development to pool countries into different groups. Desdoigts [1998] use a non-parametric method to find a set of social-economic characteristics to sort units into groups, and Canova [2001] use initial GDP per capita to sort the countries. According to Sachs & Warner [1995], convergence clubs are exclusively explained by their own constructed openness variable.

As can be seen from this brief survey, there is not yet a variable which have won dominance in sorting the countries into convergence clubs. Hence, we have decided not to impose a priori a variable as the threshold variable. We have to select the threshold variable amongst all the possible ones and then verify that there is indeed evidence for a threshold

effect in growth regressions. We apply the Hansen's test described above with 10000 bootstrap replication in order to compute the p-values of the F-test statistics.

The F-tests of the null of no threshold are reported in Table 2. The striking point of our results is that the linearity hypothesis is strongly rejected in favour of a threshold regression. For all variables, but initial human capital level, the null of no threshold is significantly rejected at the usual level of confidence. Our results do not confirm the theoretical model of Azariadis & Dranzen [1990] where convergence clubs can be explained by initial human capital if there is non-convexities in human capital accumulation. Whatever the trade index used, the threshold specification is always accepted if the threshold variables are initial GDP per capita or the investment ratio. The threshold model is accepted in 4 out of the 5 cases with the population growth rate as the threshold variable.

As far as trade variables are concerned, the results are unambiguous. The linearity hypothesis is rejected with a significant level less than 1% for all trade proxies. We confirm then the results of Baldwin & Sbergani [2000]. Non-linearity is an important characteristic in the openness and growth link. Our preliminary results of a lack of relationship between trade and growth can be explained by the linear specification imposed.

Table 2 :F-tests of null of no threshold ( $H_0:\beta_1=\beta_2$ )

	TRI	RESIDUALS	OWTI	OWQI	FREETAR
GDP60	3.559* (0.054)	3.587* (0.053)	4.750*** (0.008)	4.341** (0.017)	4.501** (0.013)
INVEST	3.900** (0.030)	4.014** (0.025)	4.576** (0.013)	4.947*** (0.006)	4.211** (0.021)
HUMAN60	2.759 (0.180)	2.744 (0.186)	2.560 (0.256)	2.857 (0.174)	2.508 (0.265)
GRPOP	3.617** (0.048)	2.957 (0.137)	6.129*** (0.0003)	4.976*** (0.005)	5.909*** (0.0004)
TRADE	4.070** (0.021)	4.122** (0.021)	5.525*** (0.001)	5.007*** (0.005)	6.389*** (0.0004)

Bootstrap p-values are given in brackets

\*\*\*, \*\*, \* The null of no threshold is rejected at 1,5 an 10%

### **4.3 Composition of the convergence clubs**

Once the threshold model have been established, we have now to select the threshold variable. There is no test to select a variable. We follow Hansen [2000] who advocate to choose the variable that minimizes the p-value. From Table 2, it can be seen that in 4 out of 5

cases, the variable that have the lowest p-value is the trade index. This suggests that there might be a sample split according to trade variables.

Figures 1 to 5 (see Appendix 1) display graphs of the F-test statistics as a function of the threshold in trade proxies. The estimated value of the threshold ( $\gamma$ ) is given by the maximum of this graph. The asymptotic 95% value is also plotted (the straight line), so we can read off the asymptotic 95% confident interval for  $\gamma$ . The estimated threshold value equals 93.81% for the trade intensity ratio. There are 13 countries above and 70 below this threshold (see appendix 2). Most countries belonging to the first club have trade ratio above 100% (like Hong Kong, Singapore, Barbados, Botswana, ...). The selection of this club may be due to the fact that they form a set of "anomalous" countries which can be considered as outliers in the growth regression<sup>5</sup>.

For the RESIDUALS index, the estimated threshold is -0.1622. This value splits the sample in two groups. The first club is composed of 28 countries with large negative values of residuals, mainly South-American and African countries. OECD countries like Spain, the United-States or Japan belong to this club. This is at odds with the fact that OECD countries are considered as open. The second club has a sample size of 55 countries and is composed of other OECD countries, Asian economies and a few African countries.

The estimated threshold as regard the OWTI index equals 0.103. Two groups of 29 and 44 countries are sorted out. The first one with low tariffs ( $OWTI < 0.103$ ) are composed mainly with all OECD countries and the Asian NIEs. The second club of high-tariffs countries regroups South-American and African countries.

With the OWQI index, there is no more a clear difference between OECD countries and the rest of the world. The estimated threshold of 0.112 splits up the sample into a group of 41 countries with low quantitative restriction and a group of 32 countries with high restriction to trade. Interestingly some European countries like for example Germany, the Netherlands, Switzerland and also the United-States are part of the high quantitative restriction group. This means that for OECD countries, the major difference in their trade policy rely on quantitative restriction and not on tariffs. This is due to the GATT rounds during the period which the main goal was to reduce tariffs.

Lastly, the estimated threshold for the FREETAR index equals 0.019. Two groups are sorted out of 26 and 45 countries respectively. The two groups are very similar to the ones obtained with the OWTI index as the threshold variable. In the first one, one may find all

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<sup>5</sup> The average trade intensity ratio for this group of countries is 128% !

OECD countries and the Asian countries, whereas the second one is composed of South-American and African countries.

#### **4.3.1-Tests of a second threshold in dataset**

In this section we shall test, if there is more than one threshold in the growth regressions. For that purpose, as advocated by Hansen [2000], for each trade index we fix  $\gamma$  at the value estimated and split the sample according to the trade proxies values. Then we perform again the threshold test on each subsample. Some recent papers have argued that human capital accumulation and openness must exhibit some complementarities (see Keller [1996] for a theoretical model and Berthelemy, Dessus & Varoudakis [1997] and Serranito [2001] for empirical evidences). So, initial human capital is used as the threshold variable at this stage<sup>6</sup>

In every subsample, but one the null of linearity is accepted at the 1% level of confident. These results show that there is reasonable evidence for only a two-regime specification. The null of linearity is rejected when the TRI variable is used as the threshold variable for the subsample of 70 countries. The F-test equals to 3.073 and the bootstrapped p-value is estimated at 0.0321. According to Figure 6, the threshold estimate is evaluated at 1.26 (i.e. 3.51 average schooling years). This threshold value splits the subsample of 70 countries into two groups. The first one is composed of 31 countries with a high level of initial human capital and the second one is made up of 39 countries with a low level of human capital. The high human capital group consists mainly of the OECD and Asian countries. Again, one may find in the other group South-American and African countries.

## **5- Estimation of the different convergence clubs**

We now turn to the OLS estimation of the growth regression for each convergence clubs. We estimate the threshold model with the whole sample, but now the explanatory variables are the previous independent variables times dummy variables representing each convergence club. This allows to increase the number of degrees of freedom and hence improves the quality of the estimation (Berthelemey & Varoudakis [1996]).

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<sup>6</sup> The threshold test can be applied only in subsamples where the number of countries is fairly important.

Results are reported in Table 3 to 5 for each trade indicator. Note that the  $R^2$  of each regression has significantly increased when the global convergence hypothesis is given up in favour of the local one : on average the  $R^2$  increases from 0.46 to 0.65.

Conclusions are quite similar with TRI, OWTI, OWQI and FREETAR variables<sup>7</sup>. Coefficient estimates are very different between the "open country group" and the "closed" one. The two groups share the same results only for investment ratio variable. In both cases, the investment ratio has the positive expected sign and is significant at the usual level of confident<sup>8</sup>. Interestingly, if the coefficient of initial GDP per capita is negative as expected in both groups , it is systematically higher in the open group. Furthermore, while initial GDP is highly significant in the open group (at the 1% level), it is only weakly significant in the closed one (at the 10% level). If the OWQI variable is used as the trade index, then the initial par capita GDP is no longer significant in the closed group. What this indicates is that the convergence phenomenon is quite different for countries that have high levels of trade barriers, than it is for countries that have low level ones. There is a strong movement of (conditional) convergence for "open" nations with a high estimated speed of convergence (11% on average), whereas for more "closed" nations the convergence movement is either much slower (7,5% on average) or null.

This result is close to the one developed by Sachs & Warner [1995]. One should note however that the Sachs & Warner's argument is slightly different from the conditional convergence hypothesis. It may be stated as follows : only countries that are classified by them as open display a strong movement of catching-up (i.e. unconditional convergence in the Barro & Sala-i-Martin [1992] terminology). We were unable to reproduce this result. We have tested for unconditional convergence on each convergence clubs, in all cases but one the null of a catching-up process is rejected<sup>9</sup>. The catching-up hypothesis is only accepted at the 10% level in the high level human capital club when the openness index is the trade intensity ratio. So, trade policy is not a sufficient condition to explain catching-up as Sachs & Warner claim, but only a necessary one.

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<sup>7</sup> As far as the TRI variable is concerned, we only comment the results of the second and third convergence club (i.e. TRI<93.81%). By misuse of language in order to simplify the comments, we shall name the high level human capital club as the "open group" because countries belonging to it are part of OECD and Asian countries. So, the composition of this group is very close to the one found in the low tariffs or freetar groups.

<sup>8</sup> An exception is the high quantitative restriction group, since the investment ratio plays no role in explaining GDP per capita growth.

<sup>9</sup> The results are not reported but are available upon request.

Human capital accumulation has a diverse effect on both groups. On average, the initial human capital level has a positive and significant effect on growth for low levels of trade barriers countries, and no effect for high levels of trade barriers<sup>10</sup>. Concerning the population growth rate, we find the opposite result. The GRPOP coefficient is negative and significant (at the 1% level) for "closed" nations and has no impact on growth for "open" countries.

Lastly, we turn to the central point of the paper, namely the non-linear impact of trade on growth. The importance of allowing a threshold effect in the trade-and-growth link comes out clearly in Table 3 to 5. In the previous section, where the link has been imposed to be linear, there was no robust relationship between trade and growth. By contrast, with the threshold regression trade is found to affect growth. In the "open" club, the trade indexes have the expected sign (positive for openness indicators and negative for closed-ness measures), but coefficient estimates are non significant. Hence for this group of countries there is indeed no link between trade and growth. By contrast, in the "closed" group, there is a significant link between trade and growth. However, the coefficients have the opposite sign : for this group the more a country is closed, the higher the growth rate it has. We confirm then the preliminary results of Baldwin & Sbergami [2000] which indicates that the trade-and-growth link is quite different for nations that have high levels of trade barriers than it is for nations with low levels of barriers. These empirical results are conform to the new international trade models with imperfect competition and increasing returns which exhibit a non-monotonic relation between trade and growth.

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<sup>10</sup> If openness is measured by the trade intensity ratio, then the human capital variable is never significant in both groups.

Table 3 : Growth Regression Estimation with the TRI Index

	TRI ≥ 93.81	TRI ≤ 93.81 and HUMAN ≥ 3.51	TRI ≤ 93.81 and HUMAN ≤ 3.51
Constant	-7.247 (-0.993)	7.423*** (2.717)	8.615*** (3.343)
GDP60	0.319 (0.416)	-1.513*** (-4.325)	-0.602* (-1.755)
INVEST	0.724 (0.454)	2.339*** (5.113)	0.920*** (3.026)
HUMAN60	1.031* (1.792)	0.416 (0.871)	0.261 (1.071)
GRPOP	1.249** (2.230)	-0.509*** (-3.729)	-1.483*** (-3.947)
TRADE	0.951 (0.677)	0.096 (0.270)	-1.045*** (-3.581)
R <sup>2</sup>	0.685		
Sample Size	83		

Table 4 Growth Regression Estimation with the RESIDUALS and OWQI Indexes

	RESIDUALS		OWQI	
	RESID ≤ -0.162	RESID ≥ -0.162	OWQI ≤ -0.162	OWQI ≥ -0.162
Constant	10.151*** (6.694)	1.633 (0.643)	5.831* (1.895)	6.706** (2.554)
GDP60	-1.224*** (-4.224)	-0.691* (-1.930)	-1.470*** (-3.791)	-0.492 (-1.265)
INVEST	0.825*** (3.324)	1.947*** (5.530)	2.722*** (7.995)	0.324 (0.877)
HUMAN60	0.496*** (3.079)	0.226 (0.266)	0.657*** (2.753)	-0.014 (-0.041)
GRPOP	-0.943*** (-4.812)	-0.622** (-2.391)	-0.561 (-0.821)	-2.06*** (-5.549)
TRADE	1.041* (1.883)	2.323*** (3.567)	0.002 (0.011)	0.438** (2.121)
R <sup>2</sup>	0.599		0.641	
Sample Size	83		70	

Table 5 Growth Regression Estimation with the OWTI and FREETAR Indexes

	OWTI		FREETAR	
	OWTI $\leq$ 0.103	RESID $\geq$ 0.103	FREETAR $\leq$ 0.019	FREETAR $\geq$ 0.019
Constant	14.286*** (6.877)	4.407** (2.093)	13.433*** (5.64)	7.441*** (4.068)
GDP60	-2.215*** (-7.786)	-0.645* (-1.916)	-2.157*** (-7.571)	-0.647*** (-2.237)
INVEST	1.84** (6.535)	1.516*** (4.163)	1.753*** (7.586)	1.354*** (3.030)
HUMAN60	0.991*** (2.808)	-0.031 (-0.158)	1.170*** (3.179)	0.009 (0.050)
GRPOP	-0.15 (0.918)	-1.302*** (-2.38)	-0.26 (-1.212)	-1.43*** (-4.328)
TRADE	-0.166 (-1.043)	0.55** (1.940)	-0.172 (-0.908)	1.027*** (3.223)
R <sup>2</sup>	0.646		0.662	
Sample Size	72		70	

## 6- Conclusion

This paper aims at investigating the trade-and-growth link by applying a new econometric methodology. According to Baldwin & Sbergami [2000], there is both theoretical and empirical evidences for not considering a linear relationship between trade and growth. We apply the threshold test developed by Hansen [2000] to standard growth regressions in order to capture a non-linear effect of trade on growth. We used five different proxies of a country's openness to trade.

We did not impose a threshold variable a priori, but instead we have tested the null of linearity against a threshold specification with all independent variables of the growth regression. The null of linearity has always been rejected in favour of the threshold regression with all variables but one, namely the initial human capital. Amongst all the threshold variables tested, trade policy indexes are the variables that best sort out the sample. In the end, whatever the trade indicator used, the threshold test splits up the sample into two different groups: the club of "open" countries and the "closed" one. We may exhibit three main results :

- The convergence phenomenon is more acute in the open club than in the closed one.
- A robust link between human capital accumulation and growth is only estimated with the group of "open" countries.

- The relationship between trade and growth is very diverse For the "open" club, trade indexes coefficients have the expected signs but are non significant. By contrast, as far as the "closed" club is concerned, we have estimated a significant relationship but the coefficients have the opposite sign. This means that for countries with already low barriers to trade, an increase in openness degree is not growth improving, whereas for high level trade barriers countries this is growth reducing.

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# APPENDIX 1 : F-test graph for a detecting the threshold value

In this appendix we report the graph of the F-test for testing the null of linearity against a threshold specification.

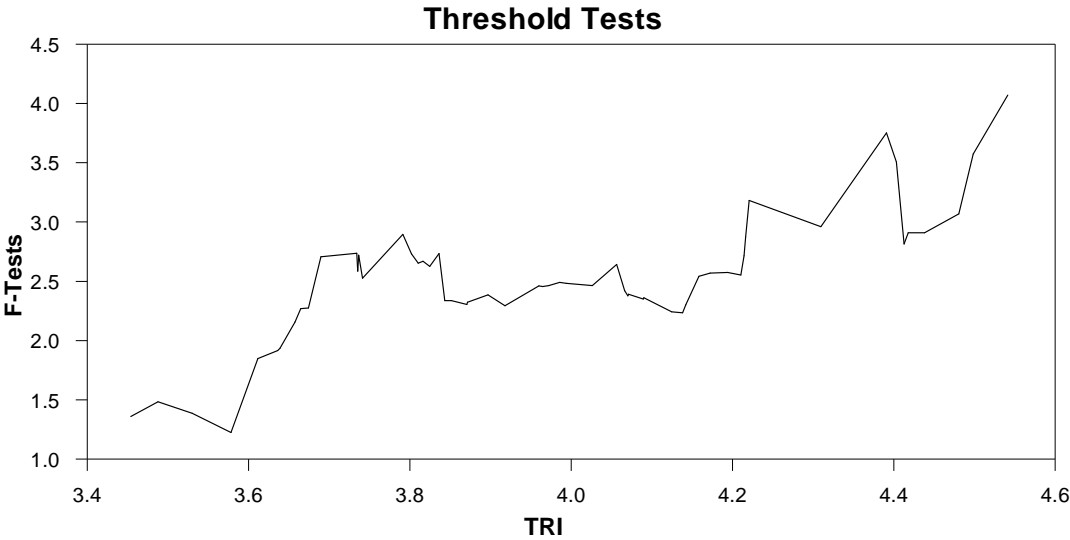


Fig 1 : Log(TRI) as the threshold value

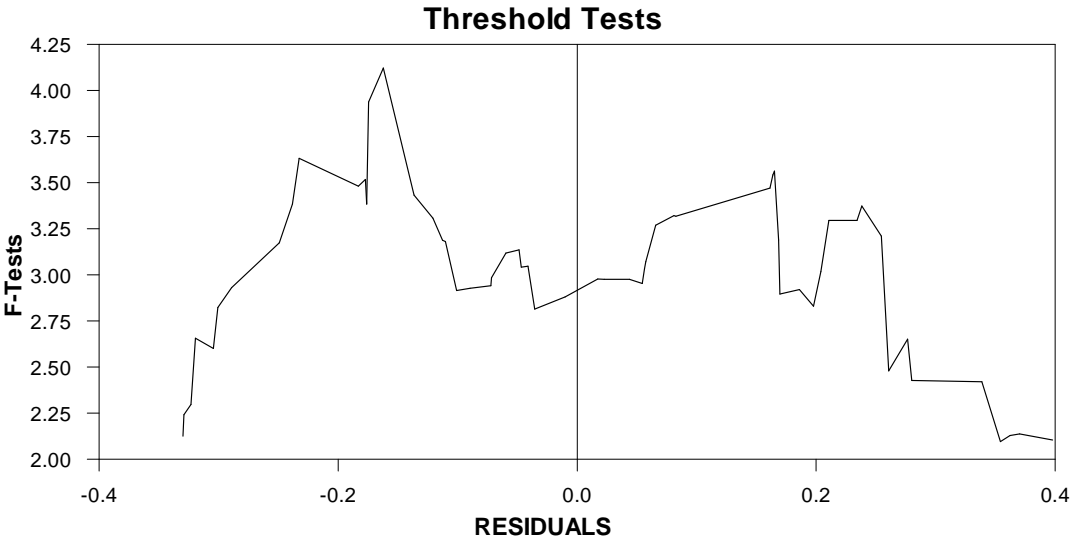


Fig2 :residuals as the threshold value

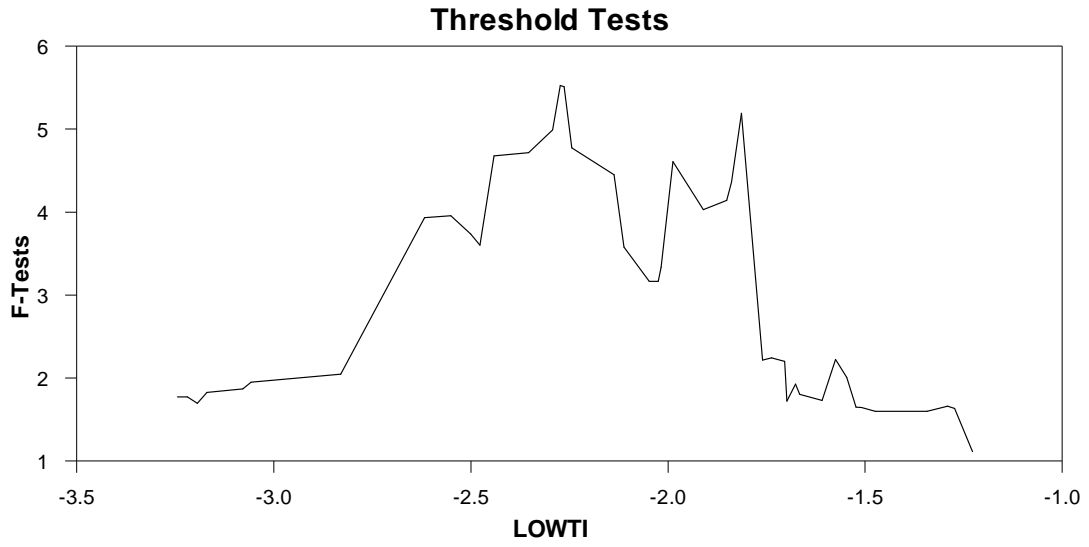


Fig3 : Log(OWTI ) as the threshold variable

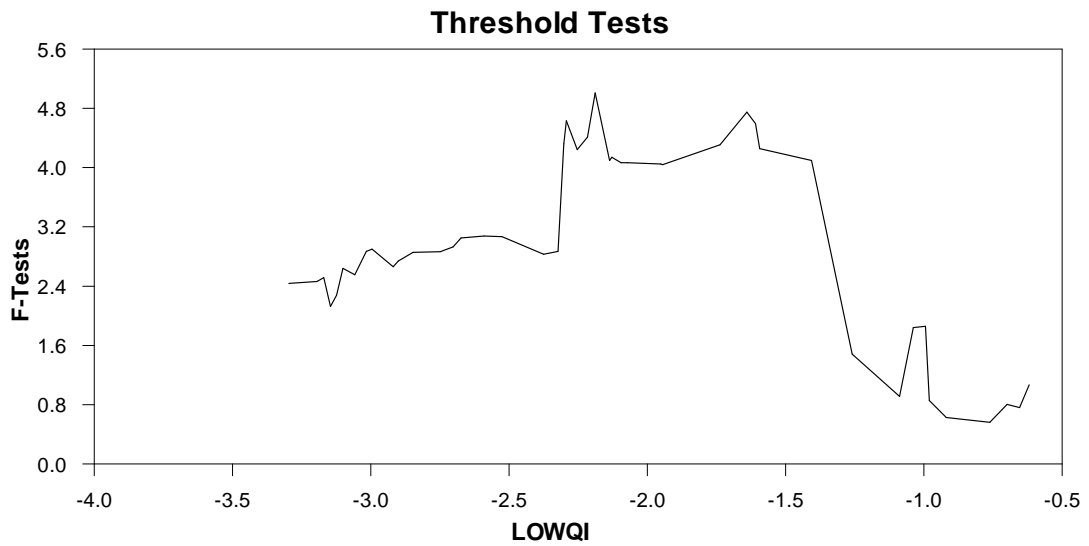


Fig4 : Log(OWQI) as the threshold variable

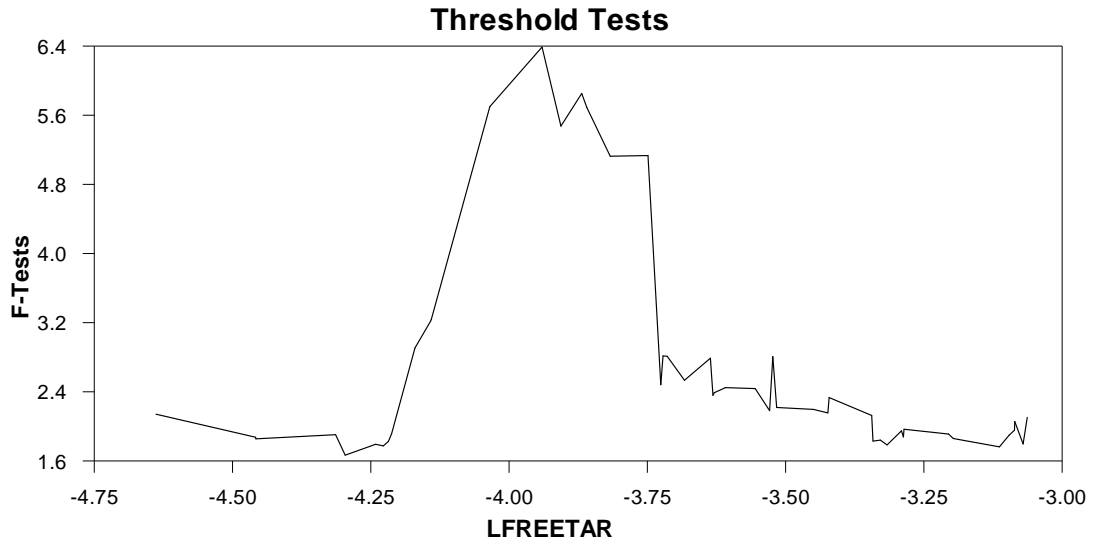


Fig 5 :  $\log(\text{FREETAR})$  as the threshold value

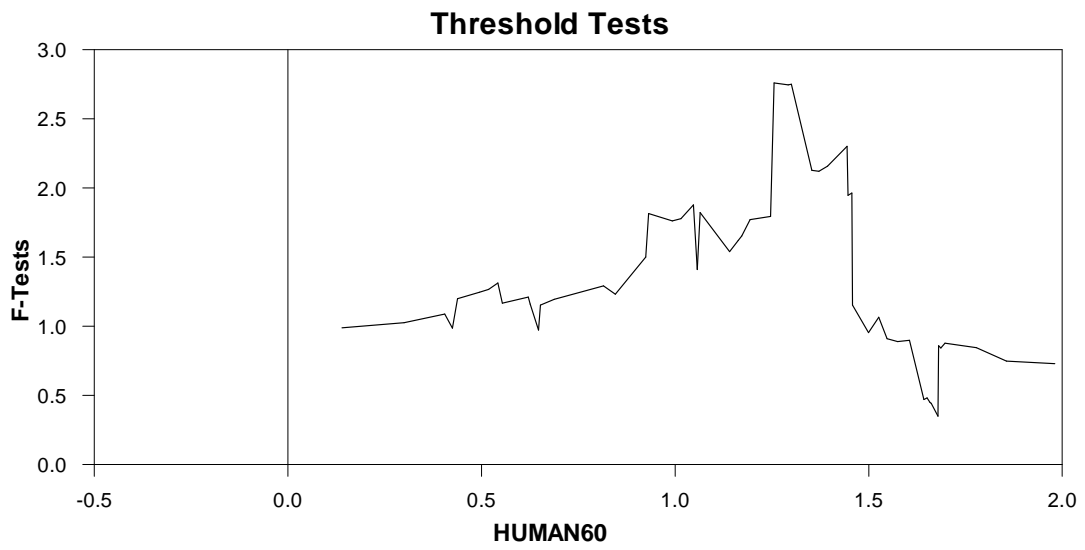


Fig 6 : Test of a second threshold in  $\text{TRI} < 93.81$  subsample