The relationship between trade openness and economic growth: Some new insights on the openness measurement issue

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Abstract

In spite of the wave of liberalization undertaken during the last decades, the debate, among economists, on the links and causality between trade openness, growth and income distribution is still open. Empirical results most often suggest that, in the long run, more outward-oriented countries register better economic growth performance. However, this empirical evidence continues to be questioned for at least two main reasons: there are still some discussions and doubts on the way countries' trade openness is measured on the one hand, the debate on the estimation methodology is still open on the other hand. The aim of this paper is to contribute to this debate by proposing a more elaborated way of measuring trade openness taking into account two additional dimensions of countries' integration in world trade: quality and variety. Our results confirm that countries exporting higher quality products grow more rapidly. More importantly, we find an interesting non-linear pattern between the trade dependency ratio and trade in quality, suggesting that trade may impact growth negatively for countries which have specialized in low quality products. A non-linear relationship between exports variety, trade ratio and growth is also found, suggesting that countries exporting a wider range of products will grow more rapidly until a certain threshold in terms of dependency of the economy to trade.

Key words: growth, openness, quality, variety, generalized method of moments, dynamic panel estimation

1 – Introduction

In spite of the wave of liberalizations undertaken during the last 30 years, the debate on the links and causality between trade openness, growth and income distribution is still open (Rodriguez and Rodrik, 2001). Empirical evidence tends to show that in the long run more outward-oriented countries register higher economic growth (e.g., among others, Sachs and Warner, 1995; Edwards, 1998; Frankel and Romer, 1999; Dollar and Kraay, 2004; Lee *et al.*, 2004). More recently, using broader databases and cross-section or panel-data estimations, Freund and Bolaky (2008) and Chang et *al*. (2009) also show that trade openness has a positive impact on income and that this positive relationship is enhanced by complementary policies. According to some authors however (e.g., Rodriguez and Rodrik, 2001) most of this work suffer from, at least, two serious shortcomings that make their results to be questioned: the way trade openness is measured and the retained estimation methods.

Reviewing the existing literature on trade and growth shows that there is not a clear definition of trade openness. For many authors trade openness implicitly refers to trade policy orientation and what they are interested in is to assess the impact of trade policy or trade liberalization on economic growth. For other authors however, trade openness is a more complex notion, covering not only the trade policy orientation of countries but also a set of other domestic policies (such as macroeconomic policies or institutional ones) which altogether make the country more or less outward oriented. In such a case, what the authors are interested in is to measure the impact of global policy orientation on economic growth. Finally, one may adopt an even more global view of trade openness covering not only the policy dimension but also all other non-policy factors that clearly have an impact on trade and on the outward orientation of countries. Factors such as geography and infrastructures, for instance, do affect trade and the outward orientation of countries, whatever their policy orientation is.

Many different measures of trade openness have been proposed and used in empirical analyses of the relationship between openness and growth. They more or less relate to the three alternative definitions of openness mentioned above. In line with the trade policy orientation definition, some authors have retained measures based on trade restrictions/distortions, such as average tariff rates[1], average coverage of quantitative barriers, and frequency of non-tariff barriers or collected tariff ratios (see, e.g., Pritchett, 1996; Harrison, 1996; Edwards, 1998, Yanikkaya, 2003). Obviously, these indicators are very imperfect and partial measures of the

[1] And/or other characteristics of the tariff distribution: tariff dispersion, frequency of tariff picks, etc.

overall restrictions/distortions induced by trade policies. Furthermore, data required to compute such indicators are often available for only a limited set of countries and years.

In terms of the global policy orientation definition, various “qualitative” indices allowing for classifying countries according to their trade and global policy regime have been proposed (see, e.g., the 1987 World Development Report outward orientation index or the openness indices proposed by both Sachs and Warner, 1995, and Wacziarg and Welch, 2003). Such measures unfortunately provide only a very rough classification of countries (from rather closed to rather open). Also many of the data required to construct these indices are available only for a few countries and at one point in time.

Finally, measures based on trade flows, which have been commonly used in empirical analyses, rather relate to the most global definition of trade openness. Trade dependency ratios are the most popular of these measures (see, e.g., Frankel and Romer, 1999; Irwin and Tervio, 2002; Frankel and Rose, 2002; Dollar and Kraay, 2004 and Squalli and Wilson, 2011, for a recent contribution). Their main advantage is that the data required to compute them are available for nearly all countries and over a rather long period. Their main weakness is that they are mainly outcome-based measures, and as such, are the result of very complex interactions between numerous factors so that it is not clear what such measures exactly capture. Another limitation of these trade dependency ratios lies in their endogeneity in growth regressions, which requires specific estimation techniques (such as instrumental variables techniques as in Frankel and Romer, 1999, and Irwin and Tervio, 2002, or identification through heteroskedasticity techniques as in Lee *et al.*, 2004).

This last limitation may in fact be extended to all trade openness measures, and constitutes the second shortcoming in existing empirical evidence that has been pointed out by Rodriguez and Rodrik (2001). As argued by Lee *et al.* (2004), all measures of openness are generally closely linked to the growth rate. Hence, it is likely that all measures of openness are jointly endogenous with economic growth, which may cause biases in estimation resulting from simultaneous or reverse causation. Various methods have been used to remedy this problem and there is still a debate among scientists about which method is the most appropriate (see, e.g., Dollar and Kraay, 2004; and Lee *et al*., 2004).

In this paper, our aim is to contribute to the on-going debate on the growth effect of trade by enriching the most global definition of trade openness. We argue that trade openness is a multidimensional concept that cannot be summarized to a single measure such as the commonly used trade ratio. Thus, following recent developments in growth theory and in international economics, we propose a more elaborated way of measuring trade openness taking into account two additional dimensions of countries' integration in world trade: the quality and the variety of the exported basket. Indeed, according to the existing literature both these factors are likely to affect positively growth, which call for considering them when measuring countries' trade openness in view of examining the relationship between trade and growth.

On the one hand, endogenous growth theory has provided a framework for a positive growth effect of trade through innovation incentives, technology diffusion and knowledge dissemination (see, e.g., Young, 1991; Grossman and Helpman, 1991). Inspired from these theoretical developments, Hausmann *et al*. (2007) proposed an analytical framework linking the type of goods (as defined in terms of productivity level) a country specializes in to its rate of economic growth. In order to test empirically for this relationship, they defined an index aiming at capturing the productivity level (or the quality) of the basket of goods exported by each country. Using various panel data estimators during the period 1962 – 2000, their growth regression showed that countries exporting goods with higher productivity levels (or higher quality goods) have higher growth performances. These results suggest that what countries export matters as regards the growth effect of trade. Hence, our measurement of trade openness should consider this quality dimension as a complement to the trade ratio (or the dependency) dimension.

On the other hand, monopolistic competition trade models with heterogeneous firms and endogenous productivity provide theoretical support for a positive impact of trade openness on growth. Indeed, the theory predicts a productivity improvement in the country due to the exit of less efficient firms after trade liberalization -or a reduction in transport costs for example- (e.g., Melitz, 2003). Furthermore, a higher share of the most productive firms will start exporting, which translates into an increase in the variety of exports. As exporters are more productive on average than domestic firms, an increase in exports variety can be associated to rising country productivity.

Based on this literature, Feenstra and Kee (2008) developed a model allowing to link, across countries and over time, relative export variety to total factor productivity using a GDP function. They tested this relationship on the basis of exports to the US for a panel of 48 countries over the period 1980-2000 using three stage least squares regressions. Their empirical results indicated that there is a positive and significant relationship between export variety and average productivity. Furthermore, computing the gains from trade in the monopolistic competition model of Melitz (2003), Feenstra (2010) shows that countries with a greater export over GDP ratio will experience higher gains in terms of GDP per capita growth, from export variety. Once again, these results suggest that, in addition to the trade dependency ratio, the structure of countries' exports matters regarding the growth effect. Hence, our measurement of trade openness should also consider this variety dimension.

Our empirical application draws on the Barro and Lee (1994)'s model, which has been extended to take into account our set of three indicators of trade openness: trade dependency ratio, quality index and variety index. Barro and Lee (1994) study empirical determinants of growth. They are in line with the endogenous growth theory. Unlike the usual neoclassical growth model for a closed economy (Solow, 1956), endogenous growth models take into account the sources of technological progress (human capital, role of government for instance). Thus, we include some proxies for trade openness in our empirical model as potential sources of technological change.

Estimations are performed on 5-year averaged data over the period 1980-2004 for an unbalanced panel of 158 countries. We use a Generalized Method of Moments (GMM) estimation approach developed for dynamic panel data models in order to deal with the potential endogeneity bias due to omitted variables, simultaneity and measurement error.

Our results confirm that countries more open to trade and exporting higher quality products experience higher growth. More importantly, we point out an interesting pattern of non linearity in the growth effect of the trade ratio: the higher the quality of the export basket of the country, the greater the positive impact of trade on economic growth. In addition, there is a minimum level of export quality under which trade can be detrimental to growth. This non-linear pattern in the trade to growth relationship is found for the whole sample and for various sub-samples of developing countries. It has particularly important implications for developing countries since as they often exhibit low quality export baskets, they are more likely to experience negative trade impact on growth.

From our estimation results we also confirm a non linear relationship between the export variety, the trade ratio and growth. Export variety has often a positive impact on growth per se; but this relationship seems to exist until a certain degree of dependency of the economy on trade. As most developing countries are below this threshold, export diversification appears as an important strategy for them.

The remainder of the article is organized as follows. In the next section, we present the specification of performed growth regressions and the retained econometric methodology. Section 3 reports and discusses empirical results, while section 4 concludes.

2 – Specification of growth regressions and econometric methodology

Inspired from Barro and Lee (1994)'s approach we retain the following specification:

$$\ln\left(\frac{GDP}{pop}\right)_{i,t} = \alpha \ln\left(\frac{GDP}{pop}\right)_{i,t-1} + \beta_1\, education_{i,t-1} + \beta_2 \ln(life)_{i,t-1} + \beta_3\left(\frac{I}{GDP}\right)_{i,t} + \beta_4\left(\frac{X}{GDP}\right)_{i,t} + \mu_i + \gamma_t + \nu_{i,t} \qquad (1)$$

where the dependent variable is the logarithm of GDP per capita of country *i* for period *t*, with *GDP* corresponding to Gross Domestic Product and *pop* to the total population. Explanatory variables are the following. First, the initial level of GDP per capita is included to test for the impact of initial conditions. Countries' endowments in production factors are controlled for using the initial level of human capital investment, which is approximated through the level of education (*education*) and the life expectancy at birth (*life*); and the physical investment as measured by the investment over GDP ratio $\left(\frac{I}{GDP}\right)$ [2]. The effects of education, life expectancy and investment ratio are likely to be positive. Finally, in order to test for the impact of trade on income per capita, we choose as a measure of trade openness the export ratio ($\frac{X}{GDP}$, i.e., exports over GDP), an export quality index $(Quality)$, an export variety index $(Variety)$ and the combined effect of the export ratio with each of these indices. We decided to choose the export ratio instead of the usual trade ratio ($\frac{X+M}{GDP}$, i.e, sum of exports and imports over GDP) in order to keep consistency with the quality and the variety indices which are concerned with growth mechanisms arising from the export side.

Thus, our two alternative specifications are:

[2] Due to the lack of available data, general government final consumption expenditure ratio, black market premium and revolution variables used by Barro and Lee (1994) are not introduced here.

- an extended specification including the export quality index (*Quality*) and its cross impact with the export ratio:

$$\ln\left(\frac{GDP}{pop}\right)_{i,t} = \alpha \ln\left(\frac{GDP}{pop}\right)_{i,t-1} + \beta_1\ education_{i,t-1} + \beta_2 \ln(life)_{i,t-1} + \beta_3\left(\frac{I}{GDP}\right)_{i,t} + \beta_4\left(\frac{X}{GDP}\right)_{i,t} + \beta_5 \ln(Quality)_{i,t} + \beta_6\left(\frac{X}{GDP}\right)_{i,t} * \ln(Quality)_{i,t} + \mu_i + \gamma_t + \nu_{i,t} \quad (2)$$

- an extended specification with the alternative export variety index (*Variety*) and its cross impact with the export ratio:

$$\ln\left(\frac{GDP}{pop}\right)_{i,t} = \alpha \ln\left(\frac{GDP}{pop}\right)_{i,t-1} + \beta_1\ education_{i,t-1} + \beta_2 \ln(Life)_{i,t-1} + \beta_3 \ln\left(\frac{I}{GDP}\right)_{i,t} + \beta_4\left(\frac{X}{GDP}\right)_{i,t} + \beta_5 (Variety)_{i,t} + \beta_6\left(\frac{X}{GDP}\right)_{i,t} * (Variety)_{i,t} + \mu_i + \gamma_t + \nu_{i,t} \quad (3)$$

The model includes time-specific effects (γ_t) accounting for period-specific effects such as productivity changes that are common to all countries or the global effect of US dollar appreciation, country-specific fixed-effects (μ_i) that take into account country-specific features that are constant in time, such as geography, and an error term $(\nu_{i,t})$.

Our empirical estimation is run on an unbalanced panel of 158 countries for the period 1980-2004 using 5-year averaged data (except for initial GDP per capita, education and life expectancy that take the first observation within each period). As most explanatory variables are likely to be jointly endogenous with economic growth while important variables, e.g., the country-specific effects, are not observable and omitted in the estimation, estimating this model by Ordinary Least Squares (OLS) or Within group estimations would potentially lead to biased results. Thus, we use the System-GMM estimator developed for dynamic panel data models (Arellano and Bover, 1995; Blundell and Bond, 1998). The main advantage of this estimator is that it does not require any external instrument to deal with endogeneity.

Within the GMM approach, one may choose the first-differenced estimator, which considers regression equations in first-differences instrumented by lagged levels of explanatory variables. Taking first-differences eliminates country-specific fixed-effects, thus solving the problem of the potential omission of time invariant country specific factors that may influence growth. Nevertheless, the first-differenced GMM estimator (Arellano and Bond, 1991) is not suitable when time series are persistent and the number of time series observations is small, like in the case of empirical growth models where data has to be averaged[3] in order to avoid modelling cyclical dynamics (Bond et al., 2001). Under these conditions, lagged levels of explanatory variables tend to be weak instruments for subsequent first-differences, thus producing biased estimates. Therefore, Arellano and Bover (1995) and Blundell and Bond (1998) suggest to retain the System-GMM approach, which combines - into one system - regression equations in first-differences and in levels, where instruments used for level equations are lagged first-differences of the series.

Hence, departing from this general model:

$$y_{i,t} = \alpha\, y_{i,t-1} + \beta' X_{i,t} + \tau_t + \eta_i + \nu_{i,t} \quad \text{for } i =,\ldots, \text{N and } t =2,\ldots, \text{T} \qquad (4)$$

where

$\varepsilon_{i,t} = \eta_i + \nu_{i,t}$ has the standard error component structure:

$$E[\eta_i] = E[\nu_{i,t}] = E[\eta_i . \nu_{i,t}] = 0 \text{ for } i =,\ldots, \text{N and } t =2,\ldots, \text{T} \qquad (5)$$

y is the dependent variable, X is the vector of explanatory variables, η_i and τ_t denote respectively unobserved country- and time-effects and $\nu_{i,t}$ is the idiosyncratic disturbance term.

We perform the following transformation to remove the unobserved individual effect:

$$y_{i,t} - y_{i,t-1} = \alpha\,(y_{i,t-1} - y_{i,t-2}) + \beta'(X_{i,t} - X_{i,t-1}) + (\tau_t - \tau_{t-1}) + (\nu_{i,t} - \nu_{i,t-1}) \qquad (6)$$

Nevertheless, instead of using a "first-difference transformation" as is usually done, we perform a "forward orthogonal deviation". Thus, instead of subtracting the previous observation from the contemporaneous one, we subtract the average of all future available observations of a variable[4]. This way of dealing with heterogeneity allows us to preserve sample size in our unbalanced panel while still being able to use past values of explanatory variables as instruments (Arellano and Bover, 1995; Roodman, 2006).

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[3] Data is usually averaged over 5 years.

[4] That is, for a variable *w* the transformation will be: $w_{i,t+1} \equiv c_{it}\left(w_{it} - \frac{1}{T_{it}} \sum_{s \rangle t} w_{is} \right)$ where the sum is taken over all available future observations T_{it}, and the scale factor c_{it} is $\sqrt{T_{it}/(T_{it}+1)}$.

Under the assumption of absence of serial correlation in the idiosyncratic disturbance terms on the one hand:

$$\mathrm{E}\left[\nu_{i,t} \, . \, \nu_{i,s}\right] = 0 \text{ for } i = 1, \ldots, \mathrm{N} \text{ and } s \neq t, \qquad (7)$$

that the initial conditions are predetermined on the other hand:

$$\mathrm{E}\left[y_{i,1} \, . \, \nu_{i,t}\right] = 0 \text{ for } i =,\ldots,\mathrm{N} \text{ and } t = 2,\ldots, \mathrm{T}, \qquad (8)$$

the differenced equation (6) can be instrumented by lagged levels of explanatory variables (Arellano and Bond, 1991), using the following $m = 0.5(T-1)(T-2)$ moment conditions:

$$\mathrm{E}\left[y_{i,t-s} \, . \left(\nu_{i,t} - \nu_{i,t-1}\right)\right] = 0 \qquad (9)$$

$$\mathrm{E}\left[X_{i,t-s} \, . \left(\nu_{i,t} - \nu_{i,t-1}\right)\right] = 0 \qquad (10)$$

For t =3,…, T and $s \geq 2$

Furthermore, according to Blundell and Bond (1998), when combining equations (4) to (8) with two additional assumptions:

$$E\left[\eta_i \, . \left(y_{i,2} - y_{i,1}\right)\right] = 0 \qquad (11)$$

$$E\left[\eta_i \, . \left(X_{i,2} - X_{i,1}\right)\right] = 0 \text{ for } i =,\ldots, \mathrm{N} \qquad (12)$$

which are restrictions on the initial conditions of the data generating process[5]; $T-2$ additional moment conditions can be used:

$$\mathrm{E}\left[\varepsilon_{i,t} \, . \left(y_{i,t-1} - y_{i,t-2}\right)\right] = 0 \qquad (13)$$

$$\mathrm{E}\left[\varepsilon_{i,t} \, . \left(X_{i,t-1} - X_{i,t-2}\right)\right] = 0 \text{ for } i =,\ldots, \mathrm{N} \text{ and } t = 3,\ldots, \mathrm{T} \qquad (14)$$

This allows the use of lagged first-differences of the series as instruments for equation in levels, as suggested by Arellano and Bover (1995).

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[5] In our context, assumption (11) means for example that deviations of $y_{i,1}$ from long-run steady-state values must not depend on unobserved fixed-effects, even if the latest can affect the level of steady-state outputs. Bond *et al.* (2001) argue that this assumption may be valid in growth model frameworks, thus allowing us to use the System-GMM estimator in our model.

Thus, System-GMM estimator implies running a GMM procedure on the following system of equations:

$$y_{i,t} - y_{i,t-1} = \alpha\,(y_{i,t-1} - y_{i,t-2}) + \beta'(X_{i,t} - X_{i,t-1}) + (\tau_t - \tau_{t-1}) + (\nu_{i,t} - \nu_{i,t-1}) \qquad (7)$$

and

$$y_{i,t} = \alpha\, y_{i,t-1} + \beta' X_{i,t} + \tau_t + \eta_i + \nu_{i,t} \qquad (16)$$

In order to test for the appropriateness of our retained instruments, we consider two specification tests. The first one is the Hansen test of over-identification for which the null hypothesis is that the chosen instruments are valid. The second one examines whether the idiosyncratic disturbance term $\nu_{i,t}$ is serially correlated. The test is performed on the first-differenced error term (that is, the residual of equation (7)) and the null hypothesis is that the latter is second-order uncorrelated. In both cases, failure to reject the null hypothesis gives support to our retained specification.

3 – Data and results

3.1. Data

To reduce the impact of business cycles, we use a total of five-year averaged data between 1980 and 2004 for an unbalanced panel of 158 countries (Appendix A provides the full list of countries in the sample). Most required data are extracted from the World Bank World Development Indicators (WDI) database, as it is the case for the following variables. The dependent variable is computed using the GDP per capita based on purchasing power parity (expressed in constant 2005 US dollars). The investment ratio is proxied through the gross fixed capital formation in percentage of GDP; the life expectancy at birth is the number of years one is expected to stay alive when birthing; and the education level is measured as the gross secondary school enrolment ratio. The export ratio is computed using GDP as well as values of exports of goods and services in current US dollars.

The export quality index is computed according to the Haussmann *et al*. (2007)'s approach and the variety indicator according to Feenstra and Kee (2008) and Feenstra (2010). They are both computed based on export values in current US dollars extracted from the CEPII international trade database BACI (at a SITC2 disaggregated level). Further details on the definition and computation of these indicators can be found in appendix B. Table 1 summarizes some basic descriptive statistics for all variables used in growth regressions.

Table 1: Descriptive statistics for variables used in the model

Variables	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
GDP per capita (constant 2005 USD)	756	9308.66	11578.08	108.21	94734.24
Education (%)	896	60.14	32.74	2.40	161.74
Life expectancy (years)	1147	64.62	10.21	30.47	81.08
Investment / GDP (%)	709	21.62	7.84	2.53	86.79
Exports / GDP (%)	736	35.22	24.03	2.76	199.12
Export quality (current USD)	756	7808.01	3681.57	1771.54	27594
Export variety (%)	756	66.94	27.02	5.11	1

Source: Authors' calculations

3.2. Empirical results

In this section we examine whether trade openness can be considered as a main determinant of growth. Results of the first regression (1) are reported as a benchmark in Table 2 since they refer to the specification including the export ratio as the single measure of trade openness. The quality and the variety index as additional measures of trade openness are presented in columns (2) and (4) respectively. Results of the regressions including in addition the cross effect of the export ratio with the quality and with the variety index are reported in columns (3) and (5) respectively.

As far as the first specification is concerned, Table 2 indicates that when trade openness is measured by the export ratio only, it does not appear as a significant determinant of growth. In line with Rodriguez and Rodrick (2001), this could be caused by two technical issues ; the first one being the endogeneity of trade as regard to growth and the second one being the way openness to trade is measured. We are confident that our empirical strategy allows us to deal properly with any kind of endogeneity. What we are interested in is then to check if this lack of statistical impact is originating from an ill-specified measure of trade integration.

Interestingly, column (2) shows that when trade openness is measured by both the export ratio and the export quality index, the latter only has a positive and significant impact on GDP per capita growth. This result confirms Hausmann *et al.* (2007)'s result that a higher quality of exports enhances growth.

Finally, column (3) reveals an interesting non-linear pattern between trade openness and growth once the export ratio is crossed with the quality index, as both this variable and the export ratio appear statistically significant. Our estimation results suggest that trade may have a negative impact on growth when countries have specialized in low quality products; trade clearly enhances growth once countries have specialized in high quality products and their export basket exhibits a minimum required level of quality. The corollary is also true, as the higher the quality of the export basket, the greater the impact of the export ratio on growth. More specifically, Table 2 indicates that, all other things being unchanged, one percentage point increase in the export ratio would raise the 5-years average GDP per capita by (-0.057 + 0.006*Ln*Quality*). Hence, a minimum level of quality of the export basket is required (13 360 current USD) for the impact of the export ratio starts to be positive. As indicated by Table 1, this threshold is much higher than the average of the export quality index over the whole sample (7 808 current USD) suggesting that trade is likely to enhance growth only for countries which are used to exhibit high quality of export baskets.

Once we exclude major oil exporting countries from the sample (column (3_o)), [6] results remain similar to those of specification (3), suggesting no specific behaviour for these countries. It is interesting to note that the minimum level of quality of the export basket required for a positive impact of the export ratio on the GDP per capita growth remains unchanged at 13 360 current USD.

Turning now to the variety dimension, specification (4)'s results show that when trade openness is measured by both the export ratio and the export variety index, the latter only has a positive and significant impact on GDP per capita. This result is in line with Feenstra and Kee (2008) and Feenstra (2010) which suggest that a higher variety of exports contributes to enhance growth.

However, the cross effect of the export ratio and the variety index does not appear statistically significant (column 5), while the impact of export variety remains so. Hence our results seem

[6] A country is considered to be a major oil exporting country if on average, over the 1980-2004 period, the value of its oil exports account for more than 2/3 of the value of its total exports (these countries represents 10% of the whole sample). One must underline that results are robust to changing this oil over total exports threshold to 50%.

to suggest that when the variety of exports is considered, there are no complementarities between this and the export ratio; only the variety has a positive impact on growth. Nevertheless, results could be biased by the presence in our sample of oil exporting countries which exhibit particularly low export variety indices and high export ratios.

Indeed, when major oil exporting countries are excluded from the sample (specification (5_o)), one recovers the non-linear impact of trade on growth: the cross effect of the export ratio and the variety index becomes negative and statistically significant, and both the variety index and the trade ratio appear positive and significant. Results indicates that, all other things being unchanged, one percentage point increase in the export ratio would raise the 5-years average GDP per capita by (0.010 - 0.011**Variety*). Hence, a maximum level of variety of the export basket is required (0.90) for the impact of the export ratio to remain positive. Since, as indicated by Table 1, most observations of our sample are below this threshold, we can conclude that the export ratio has nearly always a positive effect on GDP per capita. The corollary would be that the impact of an increase in the export variety on growth is positive until a certain degree of dependency of the economy on exports (the export ratio has to remain below 51%). As indicated by Table 1, this threshold is higher than the average of the export ratio over the whole sample (35.22%).

Regarding control variables, Table 2 shows that initial GDP per capita exhibit an expected positive and close to 1 statistically significant coefficient. Among the main growth determinants considered by Barro and Lee (1994), the investment ratio has an expected positive and significant impact in most of the specifications. In terms of human capital, nor the secondary enrolment ratio nor the life expectancy at birth have a significant impact on GDP per capita growth. This is puzzling but may be due to the fact that these variables have a long term impact on development and not a contemporaneous one. Finally, it should be noted that for all estimations, Hansen and AR(2) specification tests give support to our retained GMM-System estimator. The lagged variables that are chosen appear as good instruments in the present context.

Table 2: Growth regressions results using System-GMM estimator

	Total sample					Without oil	
Ln (GDP/pop) final	(1)	(2)	(3)	(4)	(5)	(3_o)	(5_o)
Ln (GDP/pop) init.	1.089***	0.983***	0.924***	1.022***	1.019***	0.930***	0.993***

	(0.076)	(0.054)	(0.041)	(0.064)	(0.042)	(0.043)	(0.031)
Education	-0.002	-0.001	-9.35e-05	-0.007	-0.000	0.000	-0.000
	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
I/GDP	0.026**	0.010	0.011	0.025**	0.022***	0.0070**	0.002
	(0.012)	(0.007)	(0.007)	(0.01)	(0.007)	(0.003)	(0.004)
Ln (life expec.)	-0.809	-0.512	-0.160	-0.622	-0.678*	-0.174	-0.297
	(0.603)	(0.456)	(0.184)	(0.43)	(0.347)	(0.194)	(0.199)
X/GDP	0.002	0.001	-0.057*	0.000	0.006	-0.038*	0.010**
	(0.003)	(0.001)	(0.032)	(0.001)	(0.005)	(0.022)	(0.004)
Ln (quality)		0.297**	0.117			0.130	
		(0.124)	(0.107)			(0.112)	
X/GDP* Ln (quality)			0.006*			0.004*	
			(0.003)			(0.002)	
Variety				0.299*	0.566*		0.562**
				(0.181)	(0.310)		(0.242)
X/GDP* variety					-0.008		-0.011**
					(0.006)		(0.004)
Constant	2.004	-0.481	0.105		1.778*	0.039	0.819
	(1.764)	(1.287)	(0.829)		(1.069)	(0.964)	(0.688)
Observations	636	636	636	636	636	575	575
Number of panelid	158	158	158	158	158	140	140
AR(2) test p-value	0.144	0.224	0.204	0.12	0.134	0.439	0.532
Hansen test p-value	0.583	0.199	0.172	0.25	0.373	0.229	0.106

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Estimation method: two-step GMM system (Arellando and Bover, 1995; Blundell and Bond, 1998) with Windmeijer (2005) correction and orthogonal deviation.
Weakly exogenous variables used as instruments are education and life expectancy 2nd lag (3rd lag for column (3_o)). and investment, export ratio, export quality and multiplicative interaction terms 3rd lag. Exogenous variables used as instruments are year dummies (Roodman, 2006) for the system; and the predetermined variable initial GDP per capita which is only used for the level equation.
Source: Authors' calculations.

To check the robustness of our results we performed the same regressions on various sub-samples covering different groups of developing countries defined according to the 2005 World Bank classification (Table 3). We work first with the sub-sample of Developing Countries (DC)[7]; and within it, with Low Income Countries (LIC) and Lower Middle Income Countries (LMIC)[8]. As done previously, we also consider the corresponding sub-samples excluding the major oil exporting countries.

For the estimations with the quality index crossed with the export ratio, results obtained for these sub-samples are similar to previous one. In particular, we recover the non-linear pattern

[7] Countries with a real GDP per capita in 2005 below 10 065 USD.

[8] Countries whit a real GDP per capita in 2005 below 3 255 USD.

between trade openness and growth. Estimates indicates that the minimum level of quality of the export basket required for the impact of the export ratio starts to be positive are 4 649 USD, 4 914 USD and 3 966 USD for respectively DC without major oil exporting countries, LIC&MLIC and LIC&MLIC without major oil exporting countries. Taking the last period of our sample (2000-2005), countries below this threshold are mainly African least developed countries[9]. This suggest that increasing the dependency of their economy to trade without ensuring an improvement of the quality of their exports may have negative consequences in terms of growth. Thus, a strategy to add value-added to trade seems crucial for them.

As for estimations with the variety index crossed with the export ratio, results are robust for LIC&MLIC; estimates confirm the non-linear relationship between trade dependency, export variety and growth. Indeed, specifications (5'_o), (5'') and (5''_o) show that while the export variety index has no longer a significant impact on GDP per capita alone, the cross effect with the export ratio is now positive and significant. These results suggest that for the LIC&LMIC group, trade dependency and variety contribute jointly to increase GDP per capita.

[9] Burundi, Benin, Burkina Faso, Central African Republic, Comoros, Ethiopia, Guinea, Mali, Malawi, Solomon Islands, Chad, Uganda, and Congo, Dem. Rep.

Table 3: Robustness analysis using various sub-samples of developing countries

	DC		LIC&LMIC		DC without oil		LIC&LMIC without oil	
Ln (GDP per capita final)	(3')	(5')	(3'')	(5'')	(3'_o)	(5'_o)	(3''_o)	(5''_o)
Ln (GDP per capita init.)	1.297***	1.227***	0.954***	0.988***	0.944***	1.026***	0.922***	0.998***
	(0.409)	(0.151)	(0.060)	(0.074)	(0.087)	(0.093)	(0.056)	(0.096)
Education	-0.008	-0.004	-0.005**	-0.002	-0.004**	-0.003	-0.006***	-0.005*
	(0.016)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.001)	(0.003)
I/GDP	0.023	0.008	0.012***	0.013***	0.014***	0.013***	0.012***	0.013***
	(0.014)	(0.014)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Ln (life expec.)	-1.858	-3.205**	0.557**	-0.227	0.331	-0.246	0.591**	-0.266
	(1.261)	(1.253)	(0.245)	(0.590)	(0.373)	(0.686)	(0.237)	(0.800)
X/GDP	0.025	0.016	-0.051**	-0.002	-0.076***	-0.000	-0.058***	0.001
	(0.059)	(0.010)	(0.024)	(0.003)	(0.021)	(0.002)	(0.020)	(0.003)
Ln (quality)	0.263		-0.096		-0.137		-0.135	
	(0.432)		(0.083)		(0.088)		(0.102)	
X/GDP* Ln (quality)	-0.002		0.006**		0.009***		0.007***	
	(0.006)		(0.002)		(0.002)		(0.002)	
Variety		2.091**		0.031		0.127		0.235
		(0.881)		(0.176)		(0.225)		(0.236)
X/GDP* variety		-0.007		0.008**		0.005		0.008*
		(0.014)		(0.004)		(0.005)		(0.004)
Constant	2.651	9.859**	-1.166	0.746	0.116	0.529	-0.817	0.742
	(2.762)	(4.003)	(1.032)	(1.813)	(1.296)	(2.153)	(1.031)	(2.485)
Observations	462	462	265	265	420	420	239	239
Number of panelid	120	120	74	74	107	107	65	65
AR(2)test p-value	0.108	0.289	0.128	0.099	0.353	0.253	0.332	0.291
Hansen test p-value	0.158	0.779	0.108	0.146	0.053	0.001	0.167	0.116

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Estimation method: two-step GMM system (Arellando and Bover, 1995; Blundell and Bond, 1998) with Windmeijer (2005) correction and orthogonal

deviation. All instruments are collapsed (Roodman, 2006).
All estimations are run using the 1rts lag and further of weakly exogenous variables (as defined in Table 2)[10]. Exogenous variables used as instruments are year dummies (Roodman, 2006) for the system and the predetermined variable initial GDP per capita for the level equation.
Source: Authors' calculations.

[10] Except for specifications (3')-(5') that use only the 3rd lag for all instruments and (5''_o) which uses only the 1rst lag for the investment ratio, export ratio, export variety/quality and the multiplicative interaction term as instruments.

4 - Conclusion

This paper investigates the relationship between trade openness and growth. Starting from the idea that trade openness cannot be fully characterized through trade flows only we propose to account for two additional dimensions of countries' trade integration: export quality and export variety. Then, following Barro and Lee (1994), standard growth regressions are performed where, among the explanatory variables, the commonly used trade ratio (here the export ratio) is complemented by the Haussmann *et al*. (2007)'s export quality index or the Feenstra and Kee (2008)'s export variety index. Our empirical application is based on annual data over the period 1980-2004 for an unbalanced panel of 158 countries. As most explanatory variables are likely to be jointly endogenous with economic growth, we use the system GMM estimator developed for dynamic panel data models.

Our empirical results are in line with New International Economics insights that regarding the relationship between trade openness and growth in addition to the trade ratio, the quality and the variety of the export basket matter. We point out an interesting non-linear pattern between trade openness and growth when export quality is taken into account: trade may have a negative impact on growth when countries have specialized in low quality products; trade clearly enhances growth once countries have specialized in high quality products and their export basket exhibits a minimum required level of quality. Therefore, there is some pattern of complementarity between trade dependency and trade in quality so that the higher the quality of the export basket, the greater the impact of the export ratio on growth.

Estimation results also suggest a non-linear relationship between trade and growth when the variety of exports is taken into account. However, the impact of an increase in the export variety on growth seems positive until a certain degree of dependency of the economy on exports. For most developing countries, we find some pattern of complementarity between trade dependency and variety: the export ratio has a positive impact on GDP per capita and the higher the variety of the export basket, the higher the impact of the trade ratio. It is interesting to note that the cross effect of the trade ratio and trade in variety clearly relates to changes at the intensive margin and at the extensive margin of trade (even if our export ratio cannot be properly disentangled between the two margins). Hence, further investigations are required to clarify the role of trade dependency and trade in variety as regards the relationship between trade and growth.

From an economic policy perspective, these results are very interesting as they show that investment in productive capacity to move developing countries ‘exports up the quality chain could be decisive to enhance growth. Also, they suggest that facilitating access to the export market for new exporters, through export promotion agencies for example, can have important implications for development. As aid for trade, and in particular aid for building productive capacity, intends to focus on these matters, further evidence on its link with the quality and the variety of exports seems to be necessary.

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Annex A: list of countries

Afghanistan
Angola
Albania
United Arab Emirates
Argentina
Armenia
Antigua and Barbuda
Australia
Austria
Azerbaijan
Burundi
Benin
Burkina Faso
Bangladesh
Bulgaria
Bahrain
Bahamas, The
Belarus
Belize
Bolivia
Brazil
Barbados
Brunei Darussalam
Bhutan
Central African Republic
Canada
Switzerland
Chile
China
Cote d'Ivoire
Cameroon
Congo, Rep.
Colombia
Comoros
Cape Verde
Costa Rica
Cyprus
Czech Republic
Germany
Djibouti
Dominica
Denmark
Dominican Republic
Algeria
Ecuador
Seychelles
Syrian Arab Republic
Chad
Togo
Thailand
Tajikistan
Egypt, Arab Rep.
Eritrea
Spain
Estonia
Ethiopia
Finland
Fiji
France
Gabon
United Kingdom
Georgia
Ghana
Guinea
Gambia, The
Guinea-Bissau
Equatorial Guinea
Greece
Grenada
Guatemala
Guyana
Hong Kong SAR, China
Honduras
Croatia
Hungary
Indonesia
India
Ireland
Iran, Islamic Rep.
Iceland
Israel
Italy
Jamaica
Jordan
Japan
Kazakhstan
Kenya
Kyrgyz Republic
Cambodia
Kiribati
Korea, Rep.
Lao PDR
Lebanon
Liberia
Libya
St. Lucia
Tonga
Trinidad and Tobago
Tunisia
Turkey
Tanzania
Uganda
Sri Lanka
Lithuania
Latvia
Morocco
Moldova
Madagascar
Maldives
Mexico
Macedonia, FYR
Mali
Mongolia
Mozambique
Mauritania
Mauritius
Malawi
Malaysia
Niger
Nicaragua
Netherlands
Norway
Nepal
New Zealand
Oman
Pakistan
Panama
Peru
Philippines
Papua New Guinea
Poland
Portugal
Paraguay
Qatar
Romania
Russian Federation
Rwanda
Sudan
Senegal
Solomon Islands
Sierra Leone
El Salvador
Suriname
Slovak Republic
Slovenia
Sweden

Ukraine
Uruguay
United States
Uzbekistan
St. Vincent and the Grenadines
Venezuela, RB

Vietnam	Yemen, Rep.	Congo, Dem. Rep.
Vanuatu	South Africa	Zambia

Annex B: The quality and variety indices

The quality index

The quality of the export basket is constructed following Haussman et *al*. (2007). First, they propose an index called PRODY that attributes a level of productivity to each k (HS-6) line. The total exports for a country i is,

$$X_i = \sum_{k=1}^{n} x_{ik}$$

And the level of productivity $PRODY_k$ associated to each k (HS-6 line) is constructed as

$$PRODY_k = \sum_i \frac{(x_{ik}/X_i)}{\sum_i (x_{ik}/X_i)} Y_i, \tag{1B}$$

where Y_i is the GDP per capita in Purchasing Power Parity of each country I, $\sum_i (x_{ik}/X_i)$ is the sum of the share of product k exported in all countries.

This index is a variant of the Balassa's index of revealed comparative advantage. This way, exports from developed countries are considered as more productive that the ones coming from developing economies.

Finally, the level of productivity associated to the export basket of each country i is,

$$EXPY_i = \sum_k \left(\frac{x_{ik}}{X_i}\right) PRODY_k. \tag{2B}$$

Thus, it depends on the degree of concentration of the export basket, weighted by the quality of the products exported. The underlying idea behind this indicator is that diversifying its exports basket away from products of low productivity may accelerate subsequent growth. We compute a yearly $EXPY_i$ indicator.

The variety index

In order to allow comparability of the index between countries and time, the export variety (or extensive margin of exports) is constructed following a modified version proposed by Feenstra and Kee (2008) of the Hummels and Klenow (2005) index.

Hummels and Klenow (2005) propose a measure of "extensive margin" of trade that is consistent with product variety for a CES function. This indicator can be defined as changes in exports or imports that are due to changes in the number of goods (a change in the variety of products) rather than changes in the amount purchased of each good. Besides the fact that this formula is consistent with trade theory, we choose it among all the definitions of extensive margin available in the literature review because it takes into account the importance of the traded good instead of roughly counting lines.

The construction of the indicator is based on the idea that exports from countries *h* and *F* differ but have some products varieties in common. This common set is denoted by $J \equiv \left(J_{it}^{h} \cap J_{it}^{F}\right) \neq \varnothing$. An inverse measure of export variety from country *h* will be defined by

$$\lambda_{it}^{h}(J) \equiv \frac{\sum_{j \in J} p_{it}^{h}(j) q_{it}^{h}(j)}{\sum_{j \in J_{it}^{h}} p_{it}^{h}(j) q_{it}^{h}(j)} \quad . \tag{3B}$$

Therefore, the ratio $\left[\frac{\lambda_{it}^{F}(J)}{\lambda_{it}^{h}(J)}\right]$ measures the export variety of country *h* relative to country *F*. It increases with the variety exported from country h, and decreases with the variety exported from country F. Thus, to be measured, this indicator needs a consistent comparison country F.

Feenstra and Kee (2008) use the worldwide exports from all countries to the United States (US) as benchmark. Indeed, US appear as the mayor partner in terms of imported variety (US imports almost 99% of all the varieties existing) and provides highly disaggregated trade databases (until 10 digit codes). Nevertheless, as Feenstra and Kee (2008) noted, it would be preferable to use countries' worldwide exports instead of US imports. Indeed, this restriction makes the measure dependent to the import structure of the US. And for countries that export goods that have a small value in the import structure of this partner or that do not export some kind of varieties to it (mostly developing countries), the magnitude of their export variety will appear under-evaluated. Thus, in order to correct for these effects we prefer to work with the entire world as the benchmark *F,* as in Hummels and Klenow (2005), even if this forces us to use only HS-6 desegregated trade data.

Moreover, we need a benchmark *F* that doesn't change thought time, in order to associate any variation in the indicator to a variation in the export variety of the country *h*. So, following Feenstra and Kee (2008) we take the union of all products sold in the world market in any year over the period 1980-2004, and we average real exports sales of each product over years. In this way, $J_i^F \equiv \cup_{h,t} J_{it}^h$ is the total set of varieties imported by the entire world in sector *i* over all years, and $p_i^F(j)q_i^F(j)$ is the average real value of world imports for product *j* (summed over all source countries and averaged across years). Then, comparing country *h* to the world (*F*) allows us to set $\lambda_{it}^h(J) = 1$ and the export variety by country *h* takes the form:

$$\mathrm{A}_{it}^h \equiv \frac{\lambda_{it}^F(J)}{\lambda_{it}^h(J)} = \frac{\sum_{j \in J_{it}^h} p_{it}^F(j) q_{it}^F(j)}{\sum_{j \in J_i^F} p_i^F(j) q_i^F(j)} \quad . \tag{4B}$$

Thus, export variety only changes due to variations in the numerator, and thus, due to changes in the set of goods sold by the country *h*. This allows us to do comparison of export varieties across countries and over time. Moreover, this indicator goes beyond a simple count of trade lines, because it takes into account the relevance of the sector *i* (HS-6 line) in world trade.