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Trade and Growth: Is Sub-Saharan Africa Different?

by

Vincent Leyaro and Oliver Morrissey

Abstract

This paper argues that SSA has derived a minimal growth benefit from trade because of what it exports and that the detrimental effect of primary commodity export dependence on SSA growth can be captured by two structural variables, natural barriers to trade (*NBT*, trade costs) and natural resource endowments (*NRE*, primary commodity dependence). The analysis is based on a large panel of developing countries for 1970 to 2008 and explicitly tests for threshold effects in the structural variables. We find that high trade costs and natural resource endowments have a negative effect on growth and that the combination of these two factors accounts for the SSA dummy: SSA countries tend to have high values of *NRE* and *NBT* and this helps to explain why SSA countries experienced lower growth than other developing countries (the significant negative dummy for SSA). The trade variables also performed as expected. Exports and trade openness generally contribute to growth, but their effect on growth is affected by the structural variables; specifically high values as observed in SSA dampen the positive impact of trade on growth. The poor growth of SSA relative to other regions is largely accounted for by the combination of natural resource endowments and high transport costs so that the dependence on primary commodity exports has not supported growth.

JEL Classification: F10, F43, O40, O55

Keywords: Trade and Growth, Natural Barriers to Trade, Primary Commodity Exports, Sub-Saharan Africa

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Outline

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1 Introduction

Economic theory and empirical evidence lend support to the view that openness to trade advances economic growth and hence reduces poverty. The neoclassical approach explains the gains from trade liberalization by comparative advantage, in the form of resource endowments (as in the Hecksher-Ohlin model) or differences in technology (the Ricardian model). Endogenous growth theory shows that trade openness positively affects per capita income and growth through: diffusion of knowledge and technology; innovation or direct foreign investment and increasing the size of the market that allow for economies of scale.[1] Against this backdrop, most developing countries were encouraged to pursue export-led growth and trade liberalization policies to allow them to exploit their comparative advantage. Asian countries that pursued outward oriented strategies and export-led growth in 1960s and 1970s have achieved rapid growth rates and economic development. African and most Latin American countries, that initially followed import substitution strategies and implemented trade liberalization and export-led growth policies only since the 1980s, have continued to lag behind in rates of growth (Latin America has tended to perform better than Africa).

Africa, especially Sub Saharan Africa (SSA), has exhibited a poor trade and growth performance for over four decades. From the mid 1950s to early 1990s the share of SSA in global trade fell from three per cent to one percent (Yeats, 1996) and has only recently recovered (Ackah and Morrissey, 2005). In value terms, in spite of the rally in the commodity prices since the early 2000s, Africa's share hovers around three per cent of global trade, and intra-regional trade in Africa has remained low, accounting for about ten per cent of cross-border trade (Economic Commission for Africa, 2010). Africa has failed to transform and diversify its exports away from relying on a few primary commodities and export competitiveness has remained low relative to other regions; SSA has derived few benefits from trade preferences such as the Generalized System of Preferences (GSP) or EU schemes such as Everything-But-Arms (EBA) or Lomé/Cotonou (Milner *et al*, 2010), or from regional integration arrangements.

[1] There are theoretical models showing that trade openness may hamper growth (Grossman and Helpman, 1990, 1991; Lucas, 1988; Redding, 1999; Young, 1991). Neither the existing theoretical models nor empirical analyses have produced a definite conclusion.

The underperformance of SSA in trade and growth terms is shown below. On average for the period 1970 -2008 Africa grew by 0.67 per cent, far below the developing countries sample mean of just over two per cent; this relatively poor performance held for most SSA countries and in most sub-periods, at least until very recently. Compared to other regions, SSA faces adverse values of structural variables, in particular relating to resource endowments and trade costs (Mbabazi *et al*, 2006). Why is it that for the past 40 years or so SSA has consistently underperformed both in trade and growth terms? What is it about the structure of African exports that may explain poor performance, of exports and of export-led growth? What are the reasons for this asymmetric development (hence the negative and significant Africa dummy in cross-country growth regressions)? These are the questions addressed here.

A strand of literature emphasizes the contingent relationship between trade and growth (Baldwin, 2003; Rodrik and Rodriguez, 2001; Dufrenot *et al*. 2009; Kim and Lin, 2009). That is, there are differences between countries and regions in the way in which trade affects growth. For example, trade openness may not be conducive to growth in the absence of an appropriate economic, social and political environment; the effect of trade on growth depends on the environment. Following North (1990), institutional arrangements (governance, rent seeking, corruption and policies), market institutions (bureaucracy and competition) and social norms may determine the extent to which trade openness contributes to higher income and growth (e.g. Dollar and Kraay, 2003). Krugman (1990) argues that the expansion of growth augments income if inputs (capital, labour, education, and infrastructure) are increasing. Political factors such as ethnic fractionalization, lack of democracy, quality of governance and high incidence of conflict also affect growth, and may alter the relationship between trade and growth. Kim and Lin (2009) find that trade openness contributes to long-run growth but the effect varies with the level of economic development. Structural characteristics such as geography, demographic issues, ecology diseases and cultural factors are also important (Dufrenot *et al*. 2009; Foster, 2008).

It is clear that numerous factors may be relevant to explain the limited benefits of trade in many developing countries, in particular the poor trade and growth performance in SSA. Following the approach of Mbabazi *et al* (2006), this paper focuses on two structural factors, natural barriers to trade (in particular transport costs) and natural resource endowments. High trade costs have been found to be detrimental for trade (Anderson and van Wincoop, 2004).[2] Such costs are especially high in SSA (Limão and Venables, 2001; Milner *et al*, 2000), in particular high transport costs and poor infrastructure that undermine the potential for trade to stimulate growth. Countries endowed with primary resources and unskilled labour tend to specialize in the export of raw or semi-processed products; trade costs are more important relative to unit price for such commodities that also have experienced volatile world prices and declining term of trade. The export dependence of SSA countries on primary commodities (typically only two or three primary commodities account for most of export earnings of a country) has retarded growth and in some cases resources have been a curse rather than blessing.

This paper considers two structural (non-policy) variables - natural barriers to trade (measured by the cif-fob price differential as a proxy) and natural resource endowment (with the proxy arable land per person) - and uses cross-section and dynamic panel data regression methods as well as the Hansen (2000) endogenous threshold regression technique. The analysis specifically tests heterogeneity in the trade-growth relationship by testing four hypotheses: i) significance of the structural variables as determinants of growth and their limiting impact in the effect of trade openness on growth; ii) whether the combination of these two factors explains the African dummy; iii) the direct effect of trade openness on growth; and iv) test for breaks (thresholds) in the trade-growth relationship in terms of the structural variables. Despite recognition of the importance of structural variables in determining the effects of economic and trade policy on growth, the empirical investigation of the relevance for SSA is limited. Furthermore, studies that include structural variables rarely allow for interaction effects, whereas studies such as Kim and Lin (2009) that consider threshold effects do not incorporate structural variables.

The paper is structured as follows. The next section briefly reviews African experience. Section 3 specifies our empirical model and estimation methods. The data are described and discussed in Section 4. Section 5 presents and discusses the

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[2] Natural barriers to trade are viewed here as the transaction (or trade) costs of conducting business in a particular location and transacting internationally associated with geography (e.g. landlocked, distance), poor quality of infrastructure, inefficient bureaucracy (e.g. customs procedures) and direct transport costs.

empirical results plus the sensitivity analysis. Section 6 summarizes with concluding comments.

2 Trade and Growth in SSA

Although Africa performed well in economic terms in the first half of the 20th century, the second half saw steady deterioration (Maddison, 1987). The decades since independence in SSA have been described as an economic tragedy, with most countries worse off in almost all economic indicators than in the 1960s (Collier and Gunning, 1999; Economic Commission for Africa, 1998). Up until 1980s, the main causes of Africa's slow growth were considered to be internal factors, with a debate focusing on whether the external problems were policy induced or exogenous. The perception that internal factors (especially the import substitution policy adopted by most countries in the 1960s and 1970s) were responsible was based on a series of detailed country studies complemented with some cross-country statistical analyses, such as Balassa (1971), Bhagwati (1978) and Krueger (1978). As a result of these policies, budget and balance of payment deficits generated regular crises that were met by still tighter control over exchange rates and imports and more extensive government intervention in the economy. The net outcome was generally a slowing in the growth rate culminating in the debt crises of 1980s as governments borrowed more to cover for the deficits brought about by import substitution policies.

In the 1980s, the World Bank, the International Monetary Fund and donors came to identify exchange rate and trade policies as the primary causes of slow growth and trade marginalisation in Africa. The Bank argued that orthodox macroeconomic management (and in particular trade liberalization) represents the road to economic recovery in Africa so that major economic adjustment was required (see Elbadawi 1992).[3] In contrast, the Economic Commission for Africa (ECA, 1989) explained SSA problems in terms of deficiencies in basic economic and social infrastructure. Thus, the ECA argued that the Bank-type of analysis and its proposed solution, Structural Adjustment Programs (SAPs), was not only the wrong diagnosis but also inadequate in addressing the real causes of economic, financial and social

[3] A number of other studies arrived at similar conclusions (e.g. Collier and Gunning, 1999; Easterly and Levine 1997; Ghura 1995; Grier and Tullock, 1989).

problems facing African countries.[4] Their main assertion is that falling commodity prices and external protection in OECD markets are largely to blame. This was the rival thesis against the Bank one, often favoured by the African governments; that is, the crisis was due to deteriorating and volatile terms of trade (terms of trade have indeed been more volatile for Africa than for other less developed economies). However, the Bank proposition regarding Africa economic crises has been more influential and by mid 1980s almost all SSA countries had begun to implement comprehensive and substantial economic policy reforms.

Despite the reforms implemented, in the 1990s export response to trade liberalization and growth response to economic policy reforms was sluggish and disappointing (Ackah and Morrissey, 2005), questioning the earlier perception that Africa’s slow economic growth was essentially a trade phenomenon. The factors that have been most strongly associated with growth and development globally have been low or ineffective in SSA countries (Collier and Gunning, 1999) and attention shifted back to emphasizing (internal) domestic causes for slow growth and poor trade performance in Africa. Despite a period of economic policy reform and controlling for a wide range of variables that affect growth, including openness to trade, SSA countries have performed relatively poorly. This is supported by the widespread finding that a SSA dummy is negative and significant in cross-country growth regressions, e.g. Barro (1991), Easterly and Levine (1997), Fosu (1996, 1999), Ghura and Hadjimichael (1996), Gyimah-Brempong and Traynor (1999), Ojo and Oshikoya (1995), Sachs and Warner (1995, 1997), Savvides (1995) and Temple (1998).

In most cross-country growth studies the dependent variable is the average growth rate of per capita GDP over a relatively long period (of a series of sub-periods in panel studies). The empirical specification is based on growth models that are in line with new growth theories (Barro and Sala-i-Martin, 1991, 1995) that control for the core determinants of growth (initial income, investment, primary or secondary school enrolment and population) and add other explanatory variables. Some have used policy measures such as trade openness, debt and inflation. Others use institutional proxies such as legal structure and property rights, corruption indices and governance measures. Yet others use political measures such as index for political

[4] Many analysts supported the ECA line of reasoning (see Adedeji 1993; Fantu 1992; Ngwenya and Bugembe 1987; Stafanski 1990).

structure, political uncertainty, ethnic fractionalization and civil wars. Some researchers have only used economic indicators such as macroeconomic instability, market distortions or external shocks, whilst others include structural factors such as natural resource abundance, climate and geographical characteristics. Many studies, of course, combine many of these potential explanatory factors.

In these studies, Africa's slow growth is 'explained' if it is fully accounted for by differences between Africa and other regions in the standard explanatory variables. If successful, this implies that the SSA dummy will be insignificant (in this sense, most studies are not successful). These studies have been criticized for a number of reasons. Casseli and Esquivel (1996) argued that most suffer from omitted variable bias due to inappropriate treatment of correlated unobserved country specific effects or from endogeneity bias due to the dynamic nature of growth regressions or weak exogeneity among the controls. Collier and Gunning (1999) argued that this approach is highly aggregate and reduced form, unrelated to both case studies and microeconomic research. More recently in a wider literature, authors have looked at the effect of colonial institutions and disease as well as endowments as responsible for slow growth in SSA; studies include Acemoglu *et al.* (2001, 2002), Azam *et al.* (2002), Rodrik, (2005), Rodrik *et al* (2004), Sala-i-Martin *et al* (2004). Much as we agree that most of these factors, particularly the institutional ones, are important, our focus is on two structural variables: natural barriers to trade and natural resource endowments.

3 Empirical Model

Providing a definitive model specification has proved difficult in empirical growth literature given the large number of potential explanatory variables supported by alternative growth theories (Temple, 1998). There is no exhaustive list of control variables that command general agreement, but recently a degree of consensus on the most appropriate empirical specification for modeling growth has emerged. As a result of the work by Levine and Renelt (1992) that searched for a set of robust variables to model growth based on endogenous growth theory of Romer (1986, 1990) and Lucas (1988), there is a agreement that growth models should control for: initial per capita GDP, physical capital, human capital and population growth. This is because the ultimate drivers of per capita growth are technological progress and per capita growth of human and physical capital. Thus, in a standard growth specification, economic growth is regressed on this set of control variables. [5] The most commonly estimated cross-country reduced form model follows the specification of Barro (1991) and Mankiw, Romer and Weil (1992):

$$y_i = \alpha + x_i'\beta + s_i'\gamma + w_i'\varphi + \mu_i \qquad (1)$$

We follow this standard approach where y_i is the dependent variable (growth rate of real GDP per capita), x_i is a vector of the core covariates, s_i are the (trade) variables of specific interest, w_i are the structural variables and μ_i is the error term. The standard controls (x_i) are: initial income measured as log of real GDP per capita ($\ln GDPO_i$), population growth (annual %) ($POPNGR_i$), secondary school enrolment (% gross) (SEC_i) and gross capital formation (% of GDP) (INV_i). Initial income is often used to capture conditional convergence,[6] as per capita growth rate is expected to be inversely related to the starting level of income per capita (but this may also capture country-specific effects). Secondary school enrolment, either initial or the average, is used to proxy human capital, while investment as a percentage of GDP measures physical capital. Capital accumulation is an essential element in the growth process, as it enlarges the economy's capacity to produce while increases in labour or labour force has traditionally been considered a positive factor in stimulating economic growth. By controlling for human and physical capital, this specification is implicitly assuming that trade affects growth only through total factor productivity (TFP) and not through factor accumulation. Technical progress (TFP) is an important and perhaps the main factor in the growth process (for example, advances in technology continue to stimulate growth in rich industrial countries although population growth rates are close to replacement levels). As both factor accumulation and TFP contribute to growth, the coefficients on SEC_i and INV_i are expected to be positive.

[5] In some studies other performance indicators such as total factor productivity, average labor productivity and investment are used as dependent variable (Darlauf and Quah, 2004).
[6] With endogenous technological progress the conditional convergence coefficient captures the rate of diffusion of technology.

As growth theories are formulated in per capita (or labour) terms, population is a core variable. Insofar as more populous countries have larger home markets and depend less on international trade, the coefficient on $POPNGR_i$ is expected to be negative. It is important to control for the impact of other exogenous determinants of growth so as to minimize the likelihood of omitted variable bias (or oversimplification of the model). Thus, in addition to the core determinants of growth in the basic specifications, we also control for inflation which is used to represent policy distortion in the economy and thus used as a proxy measure for the growth retarding features of the economy. In an economy where power is concentrated due to political reasons or institutions, distortions are widespread and rent-seeking is prevalent, we may expect to observe relatively high levels of inflation (and relatively poor growth performance), as seen in most of Latin America and Africa in the 1980s. Other alternative measures that can be used to capture the same effects are inequality or political instability. The percentage change in consumer prices ($INFLN_i$) is expected to have a negative sign. This is our baseline specification, where variables are averaged over the entire period and can be interpreted as showing only the long run (static) effects.

The variables of specific interest in our analysis are denoted s_i and represent the impact of trade on growth (γ). Three measures are used to test if trade, especially exports, positively affects economic growth: trade openness measured as exports over GDP ($XGDP_i$), imports over GDP ($MGDP_i$) and trade over GDP ($TRADE_i$), i.e. (export plus imports)/GDP. We expect trade and exports to have a positive sign, implying that trade openness is good for growth, while the sign for imports is ambiguous (increased access to imported technology and inputs may be beneficial, but increased competition from imports may have an adverse effect, especially for poor countries). To this standard growth specification, we then add the Sub-Saharan African (SSA) dummy, which was found to be negative and significant in most empirical growth studies (mentioned above).

The structural variables are denoted w_i and comprise NRE_i, natural resource endowment (measured by arable land hectares per person), and NBT_i for natural barriers to trade (measured by the import cif/fob ratio). These structural variables are intended to capture the effects of dependence on primary commodities and poor infrastructure that raises trade costs. The coefficients on both NRE_i and NBT_i are expected to have negative signs; that is, expected to limit the effect of trade on growth generally and in Africa in particular. The underlying hypothesis is that countries with relatively low endowments of natural resources but relatively high labour endowments will industrialise to promote export growth and utilize their comparative advantage, whereas countries endowed with natural resources with low skill levels will tend to have export dependence on unprocessed primary commodities (Mayer and Wood, 2001). This dependence can retard growth because extractive industries and largely unprocessed agricultural exports have weak linkages with the rest of the economy and because primary commodities tend to face deteriorating terms of trade.

Although NRE_i does not capture mineral resources or the change in natural resource endowments, it does proxy for how comparative advantage relates to exports and growth. Countries with higher NRE_i values are predicted to exhibit slower growth. In the same way, with regard to measure of natural barriers to trade (NBT_i), there is recent evidence that high transport costs can be a constraint on growth, and in particular can limit the beneficial effects of trade liberalisation (Milner *et al*, 2000). Measures of distance used in other studies have been found to be significant in explaining low growth in developing countries and in particular in SSA. We do not use distance for a number of reasons: i) distance is fixed and does not change over time, therefore does not capture the fact that transport costs do change; ii) it is not clear what distance measure is appropriate; and iii) distance has no policy implications so it is better to find an indicator of transport costs.[7] Though the cif/fob differential is not a perfect measure, it differentiates across countries and over time.

Our main interest is to see whether the combination of these structural variables (NRE_i and NBT_i) can explain (or eliminate) the SSA dummy. When these structural variables are included with SSA dummy we expect the significance of SSA dummy to vanish as Africa is both heavily endowed with natural resources as well as suffering from poor infrastructure. We also test the hypothesis that the effects of trade (openness) on growth for the entire sample (developing countries) and in particular

[7] One can introduce variability over time by weighting distance by the size of foreign markets (their GDP changes), but this still does not capture transport costs.

for SSA are conditional on NRE_i and NBT_i. First we include the trade measures and structural variables in one specification; we expect the positive and significant effect of trade on growth to diminish when structural variables are allowed for. Second we allow for interaction effects between measures of trade openness and structural variables, to capture the fact that the effect of trade openness is contingent on other factors (in our case the structural variables):

$$y_i = \alpha + x_i'\beta + s_i'\gamma + w_i'\varphi + s_i * w_i'\delta + \mu_i \qquad (2)$$

where $s_i * w_i$ is interaction of measures of trade openness ($TRADE_i$ and $XGDP_i$) and SSA dummy with the structural variables (NRE_i and NBT_i). *A priori* we expect the impact of resource endowments (*NRE*) given natural barrier to trade (*NBT*) to be positive and the interaction effects negative. This implies resource endowments are good for economic growth at lower trade costs (good infrastructure). Also, we expect the impacts of exports and trade given the structural variables (*NRE* and *NBT*) to be positive while the interaction effects are negative. This implies that exports and trade promote economic growth at lower values of structural variables (that is lower trade costs and resource endowments). Alternatively, if NRE and NBT are high (the SSA case) trade has a more limited impact on growth.

Many of the earlier cross-country trade-growth studies (as reviewed by Edwards, 1993) assume a static linear specification using cross-section regression and average information over a long period as specified in (1) and (2). Although there are some theoretical arguments to support the use of averages in cross-section analysis (Sala-i-Martin, 1997), there are problems. One is that averaging data over such a long period wastes valuable information on the dynamics of the phenomena under analysis. Evidence shows that dynamic adjustments are quantitatively very important in studies related to growth. In addition, estimates from cross-section specification are more likely to suffer from omitted variables due to unobserved country heterogeneity and measurement error. More critically, variables such as trade and investment are more likely to be endogenous, calling for the use of instruments and giving rise to the problems involved with weak instruments.

Because of this, current analysis is usually based on a dynamic panel specification with growth and all variables averaged over five year sub-periods to reduce large variations in the data and the effects of business cycles, hence:

$$y_{it} = \alpha y_{it-1} + x'_{it}\beta + s'_{it}\gamma + w'_{it}\varphi + s_{it} * w'_{it}\delta + \mu_{it} \qquad (3)$$

Δy_{it} denotes the rate of growth of real GDP per capita and y_{it-1} is the initial income measured as a log of real GDP per capita which follows an AR (1) process with a persistence parameter α (that allows for dynamic conditional convergence). The smaller this rate, the longer it takes for an economy to come closer to its steady state. While under static specifications (1) and (2) per capita income can only grow if any of the growth promoting covariates in the right hand side (RHS) increases over time, under dynamic specifications (3) one can distinguish between 'instantaneous' (short term) growth and long run effects. The former measures the additional growth that a one-time increase in any covariate provides during the current period, the latter provides the effects on steady state income after dynamic adjustment.

To allow for nonlinearity due to thresholds, equation (3) is extended to the Hansen (2000) endogenous threshold regression sample splitting specifications that are a non-linear two regime threshold regression as:

$$\begin{aligned} y_{it} &= \theta_1' x_{it} + \varepsilon_{it}, q_{it} < \sigma \\ y_{it} &= \theta_2' x_{it} + \varepsilon_{it}, q_{it} \geq \sigma \end{aligned} \qquad (4)$$

As before y_{it} is growth rate and $x_i = (1, s_i', w'_i)$ is a vector of explanatory variables, including both thresholds. The corresponding coefficient vector $\theta_j = (\beta, \gamma, \varphi)$ where *j*=1, 2 and q_i is the indicator function used to sort the data into different regimes or groups. The threshold parameter is $\sigma \in \Gamma$, where Γ is strict subset of the support of q_i. This model, which also contains an unobservable country-specific effect η_i and time effect λ_t, permits the regression parameters (θ_1 and θ_2) to switch between regimes depending on whether q_i is smaller or larger than the (unknown) threshold value (σ).

Estimation Methods

Estimating equations (1) to (3) could be biased for a number of reasons. First, it is almost impossible to control for all the determinants of growth, as some of them are not observable, implying omitted variables due to unobserved country heterogeneity. Even if all variables were observed, there is uncertainty and disagreement on how to measure them. For example the measures of openness to trade have generated heated debate and controversies. This is a difficulty associated with measurement errors. More seriously, some variables are endogenous; specifically, while countries that trade more may grow faster, faster growing countries may trade more.

Start by considering the reduced form cross-country regression that many researchers have estimated, as specified in equations (1) and (2). If we believe that the right hand side (RHS) variables explain the left hand side (LHS) variable (y_i), x_i, s_i and w_i are strictly exogenous and uncorrelated with the error term μ_i, the OLS estimator will be efficient producing consistent and unbiased estimates of α, β, γ and φ**.** However, this does not distinguish between two different countries and the same country at different points in time (i.e. does not capture individual country heterogeneity and time effects). To address this panel data is required. Using time dimensions changes equations (1) and (2) into a panel from:

$$y_{it} = \alpha + x'_{it}\beta + s'_{it}\gamma + w'_{it}\varphi + \mu_{it} \qquad (5)$$

where the subscripts t refer to time, with t = 1, … , T time periods (denoting the time series dimension) and i = 1, …, N countries. Ignoring these unobservable country specific effects implies relegating them to the disturbance model, such that:

$$\mu_{it} = \eta_i + \lambda_t + \nu_{it} \qquad (6)$$

The error term as in equation (6) includes a country specific effect η_i which is fixed over time and time specific effect λ_t which varies within a country over time (to account for global cycle effects as well as allow for continuous growth) and ν_{it} is idiosyncratic error term. We now have:

$$y_{it} = \alpha + x'_{it}\beta + s'_{it}\gamma + w'_{it}\varphi + \eta_i + \lambda_t + \nu_{it} \qquad (7)$$

One approach that can be taken to strip equation (7) of unobserved country heterogeneity (eliminate the fixed effects, η_i) is to difference sample observations around the individual sample means (Within-Groups estimator) , permitting the use of OLS to generate consistent and unbiased estimates of α , β , γ and φ. With panel data, the Fixed Effects (FE) estimator has the ability to control for both unobserved country specific and time effects which could be correlated with observed regressors, thus ensuring consistent and unbiased estimation for the parameter of interest.

However, the Within-Groups estimator includes time invariant terms (Λ_i in the FE model):

$$y_{it} = \alpha + x'_{it}\beta + s'_{it}\gamma + w'_{it}\varphi + \eta_i + \Lambda_i + \lambda_t + v_{it} \qquad (8)$$

Differencing in the manner suggested for the Within–Groups estimator would completely remove Λ_i and we won't be able to say anything about the effects of time invariant characteristics such as the structural variables, geographical variables and institutional features on y_{it} . In addition, the fixed effects model is inappropriate when the cross-section data used is drawn from a large population, *N*, such that the cross-section sample is not reasonably exhaustive.[8] When *N* is too large, the fixed effects model involves too many individual dummies, which may worsen the problem of multicolinearity among the regressors (in addition to loss of degrees of freedom).

These problems can be avoided if the η_i is assumed to be random (Baltagi, 2001), giving the Random Effects (RE) model where x_{it} , s_{it} and w_{it} are assumed to be independent of the η_i and v_{it} for all i and t. The RE model is appropriate when the random process is from a large population where one views the individual effects as randomly distributed across the full cross-section. Hence defining $\eta_i = \eta + \tau_i$ where τ_i has zero mean suggesting the RE model specification of the form:

$$y_{it} = \alpha + x'_{it}\beta + s'_{it}\gamma + w'_{it}\varphi + \eta_i + \tau_i + \lambda_t + v_{it} \qquad (9)$$

τ_i represents an individual disturbance term which is fixed over time. The RE approach may suffer from inconsistency due to omitted variables because of the

[8] Fixed Effects is considered reasonable if the cross-section used represents a very large sample of the population, as is the case in a study that covers a 'full' of sample of countries.

treatment of the individual effects as uncorrelated with the other regressors. If η_i is independent of x_{it} , s_{it} and w_{it} and identically distributed, then the best linear unbiased estimator (BLUE) is the generalised least squares (GLS) model (Baltagi, 2001; Hsiao, 1986). A systematic choice between FE and RE models is guided by performing the Hausman test, but rejection or non-rejection does not imply the adoption or rejection of one of the models. Baltagi (2001) suggests going further in testing the restriction implied by the FE model.

Most economic relationships such as that between trade and growth are dynamic in nature. Greenaway *et al*. (2002) argued that failure to account for these dynamic components leads to dynamic misspecification and endogeneity problems. For example, the contemporaneous effects of growth shocks on the determinant of growth will result in the persistence in series and presence of endogeneity. Hence in reality our panel model is dynamic in nature and thus becomes:

$$y_{it} = \alpha y_{it-1} + x'_{it}\beta + s'_{it}\gamma + w'_{it}\varphi + \eta_i + \lambda_t + \nu_{it} \qquad (10)$$

where y_{it-1} is lagged dependent variable – dynamic component. Once we introduce the dynamic element in the relationship as is the case with (3.10), the standard unbiasedness and consistency results underlying OLS and FE/RE models no longer apply. The OLS estimator is asymptotically inconsistent, and biased upwards due to the correlation between the explanatory variable y_{it-1} and country effect η_i . If we consider (10) and take first differences to get rid of η_i we have:

$$y_{it} - y_{it-1} = \alpha(y_{it-1} - y_{it-2}) + (x_{it} - x_{it-1})' + (\lambda_t - \lambda_t) + (\nu_{it} - \nu_{it-1}) \qquad (11)$$

Still we have a problem due to serial correlation between the lagged regressors $\Delta y_{it-1} = y_{it-1} - y_{it-2}$ and $\Delta \nu_{it}$, since clearly y_{it-1} and ν_{it-1} are correlated. As well as the presence of endogeneity emerging due to the correlation between Δx_{it} (or Δs_{it} and Δw_{it}) and $\Delta \nu_{it}$. Due to that, the estimators for either FE (i.e. WG) or RE (i.e. GLS) model are asymptotically inconsistent and biased downwards.

In addition to dynamic misspecification, endogeneity bias due to contemporaneous variables and measurement errors cannot be accounted for by either OLS or FE/RE estimators. The FE estimator is also biased when *N* (number of observation/countries) is large relative to *T* (the number of time periods), which is a case for our panel. The FE (Within Group) estimator is biased downwards of the order 1/*T* and the bias declines as *T* increases (Baltagi, 2001; Wooldridge, 2002).

A different technique is required to overcome all these difficulties. One way to address problems of endogeneity is to use instrumental variables (IV). Instruments have been widely used to account for measurement errors, omitted variables and endogenously determined variables (Angrist and Hah, 1999). The aim is to find an instrument that has no direct association with y_{it} or v_{it}, but is highly correlated with explanatory variables (x_{it} or s_{it} or w_{it}). In practice however, such instruments are often hard to find. The use of instruments that explain little of the variation in the endogenous explanatory variable can lead to large inconsistencies in the IV estimates, even if only a weak relationship exists between IV and v_{it} and y_{it}. This is the problem of weak instruments. Furthermore, in finite samples IV estimates are biased in the same direction as OLS estimates; precise estimation is possible only when the samples are large. Even then, IV generally does not solve the problem but rather re-focuses the debate from the possible endogeneity of explanatory variables to the validity of the instruments. Consequently, the value of the IV approach becomes questionable.

To address these econometric difficulties, Δy_{it-2} and changes in the other RHS exogenous variables may be good instruments for y_{it-1} so that the vector of instruments becomes $Z = (\Delta y_{it-2}, \Delta x_{it})$, which assumes that all variables in Δx_{it} (or Δs_{it} and Δw_{it}) are exogenous (which is not always the case). However, if y_{it-2} is a good instrument then $y_{it-3}, y_{it-4}, ..., y_{it-j}$, are also good instruments, leading to the following moments restrictions (Holtz-Eakin *et al*. 1988; Arellano and Bond, 1991):

$$E(y_{it-j}, \Delta x_{it}) = 0 \quad \text{for } j = 2, 3, \ldots, (\text{T-1}) \tag{12a}$$

and

$$E(\Delta x_{it-k}, \Delta V_{it}) = 0 \quad \text{for } k = 1,2, \ldots, (\text{T-1}) \tag{12b}$$

Both (12a) and (12b) show that there are more valid instruments than endogenous variables. To combine the instruments in an efficient way, Arellano and Bond (1991) propose the use of Hansen (1982) Generalized Method of Moments (GMM), which is computed in two steps. First, all the instruments are put in a single vector:

$$Z = \left[y_{it-2}, y_{it-3}, ..., \Delta x_{it}, \Delta x_{it-1}, \Delta x_{it-2}, ... \right] \tag{13}$$

Secondly, the inverse of the variance-covariance matrix of the instruments, denoted A_H, is computed to combine the instruments efficiently and then used to derive the GMM estimator:

$$\delta_{GMM} = \left(X'Z^* Z^{*'} X \right)^{-1} X'Z^* A_H Z^* y \tag{14}$$

Thus, among the alternative set of instruments, GMM estimator is an IV estimator that uses lagged information optimally to account for the serial correlation among the disturbances caused by the dynamic component in the panel model relationship. Given our dynamic panel model as:

$$y_{it} = \alpha y_{it-1} + x'_{it} \beta + s'_{it} \gamma + w'_{it} \varphi + \eta_i + \lambda_t + v_{it} \tag{15}$$

Equation (15) is first differenced to sweep out the time invariant unobserved country specific effect η_i, such that (15) becomes:

$$\Delta y_{it} = \alpha \Delta y_{it-1} + \Delta x'_{it} \beta + \Delta s'_{it} \gamma + \Delta w'_{it} \varphi + \Delta \lambda_t + \Delta v_{it} \tag{16}$$

Then the regressors in the first differenced equation are instrumented using levels of the series lagged twice or more. The main advantage of the GMM estimator is that it is likely to be efficient and consistent (as it uses more moment restrictions) and if any variables in x_{it} (or in s_{it} and w_{it}) are endogenous, appropriate instruments can be found using pre-determined and exogenous variables within the system. The fact that internal instruments are available to help solve the problem of endogenous explanatory variables makes GMM an appealing estimator. This GMM estimator is therefore referred to as "difference GMM" as it is based on differencing equation (15).

Arellano and Bover (1995) and Blundell and Bond (1998) show that lagged levels of the variables in the system may not be good instruments of current differences if the series is close to a random walk. That is, when the time series are persistent and the number of time series observations is small, as is the case where we have T = 8, the lagged levels of the regressors are weak instruments for the subsequent first differences. Hence the first difference GMM estimator may have a large finite sample bias, which is likely in our panel; Bond and Hoeffler (2001) show that the first difference GMM estimator is problematic in the growth context. To overcome this problem, Arellano and Bover (1995) and Blundell and Bond (1998) propose the system GMM estimator derived from estimation of a system of two equations, the first being the differenced equation in (12b) and the second being the levels equation in (12a). That is, suitably lagged levels of y_{it} and x_{it} (or s_{it} and w_{it}) are used as instruments in the differenced equation while Δy_{it} and Δx_{it} (or Δs_{it} and Δw_{it}), provided that x_{it} (or s_{it} and w_{it}) is strictly exogenous, are used as instruments in the level equation. This approach, which considers the use of further moment conditions that remain informative even for the persistent series, is known as "system GMM" estimator, the combination of the GMM differenced estimator and GMM level estimator.

Empirically, the validity of these additional instruments can be tested using standard Sargan tests of over-identifying restrictions (for system GMM the Hansen test statistic is reported) and AR(1) and AR(2) values to test the null hypothesis of no autocorrelation of first order and second order respectively (Arellano and Bond 1991). The gain in efficiency from system GMM is considerable, and it is our preferred estimator as it addresses problems of measurement errors, omitted variables bias, persistence in series, endogeneity, and choice of instruments (Blundell and Bond, 1998).

For comparison purposes we estimate the base model and linear interaction (contingent relationship) model using pooled OLS, FE/RE and system GMM estimators. The non-linear interaction model is then estimated by applying the Hansen (2000) endogenous threshold regression technique that locates the thresholds, tests for their significance and constructs their confidence intervals.

In estimating the two regime equations (4), three main econometric and statistical problems arise and three procedures are adopted for resolving them. In the first step, we follow Hansen (2000) to eliminate the individual effects in our model. Then the threshold value and the slope parameters are jointly determined after the transformations. This is done by applying the algorithm provided by Hansen (2000) that searches over values for σ sequentially until sample splitting value $\hat{\sigma}$ is found (i.e. least squares estimations through the procedure of minimizing the concentrated sum of square errors) and estimates of $\beta = (\beta_1, \beta_2)$, γ and φ are provided.

The second step is to test the statistical significance of the threshold effects. More specifically, to test the null hypothesis of no threshold effect: $H_0 : \beta_1 = \beta_2$ against the alternative hypothesis of having at least one threshold: $H_1 : \beta_1 \neq \beta_2$. A problem arises in testing the null hypothesis of no threshold effects (that is, a linear formulation) against the alternative of threshold effects, as under the null hypothesis the threshold variable is not identified. Hence, classical tests such as the Lagrange Multiplier (LM) test do not have standard distributions and so critical values cannot be read off standard χ^2 distribution tables. Hansen (2000) recommends a bootstrap procedure to obtain approximate critical values of the test statistics which allows one to perform the hypothesis test. Thus we bootstrap the p-value based on the likelihood ratio (LR) test. The null hypothesis of no threshold effect will be rejected if the bootstrap estimate of the asymptotic p-value for this likelihood ratio test is smaller than the desired critical value.

Once we find a threshold (i.e. $\beta_1 \neq \beta_2$), the last step is to construct confidence intervals for the threshold value and slope coefficient. We test the null hypothesis: $H_0 : \sigma = \sigma_0$, against the alternative hypothesis: $H_0 : \sigma \neq \sigma_0$. This will enable us to attach a degree of certainty as to the threshold for a country with a given level of structural variables. Under normality, the likelihood ratio test statistic $LR_{n(\sigma)} = n \frac{S_n(\sigma) - S_n(\hat{\sigma})}{S_n(\hat{\sigma})}$ is commonly used to test for particular parametric values. Hansen (2000: 582) proves that when the endogenous sample-splitting procedure is employed, $LR_{n(\sigma)}$ does not have a standard χ^2 distribution, so derives the correct distribution function and provides a table of the appropriate asymptotic critical values. The null hypothesis will be rejected if the likelihood ratio test statistic exceeds the desired critical value (we want them to be reasonably small). After the confidence interval for the threshold value is obtained, the corresponding confidence interval for the slope coefficient can also be easily determined because the slope coefficient and the threshold value are jointly determined.

Equation (4) assumes that there exists only a single threshold; similar procedures can be conducted to deal with the case of multiple thresholds. This possibility of existence of more than one threshold represents another advantage of this method over the traditional approaches, which allow for only a single threshold. We allow for the possibility of multiple thresholds in our estimation. To see what the threshold effects mean, let's take for instance the one associated with natural resource endowment. If $\beta_1' \neq \beta_2'$, $\beta'_1 > 0$ and $\beta_1' > \beta_2' > 0$, then the interpretation of this combination of results will be that trade promotes growth in those countries with below threshold level of natural endowment, and reduces it for those with above threshold level endowment. Analogously, the same intuition applies when it comes to natural barriers to trade (*NBT).*

4 Data Description

Most of the data are obtained from World Development Indicators (WDI) 2009. These include: $\ln GDP_{i0}$, $POPGR_{it}$, $INFLN_{it}$, $TRADE_{it}$, $XGDP_{it}$ and NRE_{it}. Data for growth ($GRTH_{it}$), education (SEC_{it}) and natural barriers to trade (NBT_{it}) are obtained from different sources. $GRTH_{it}$ is taken from Penn World Tables (PWT 2008). Part of SEC_{it} is obtained from Global Development Network (GDN) and part from WDI - both of which are from the World Bank; while NBT_{it} is obtained from International Financial Statistics (IFS) data base of IMF.

The data is organized into cross-section and panel formats. For the cross-section specification, a sample of 133 developing countries, 47 of which are Sub Saharan Africa, 37 Latin America and Caribbean, 20 East Asia and Pacific, 16 Middle East and North Africa, 6 South Asia and 10 others mostly from Eastern Europe are averaged over the entire period 1970-2008. Due to removing outliers the sample size is reduced to 117, and due to some missing values the sample ranges between 97 and 110 countries. For the panel specification, we have a sample of 133 developing countries for the entire period 1970 - 2008, with data averaged over each of the first seven 5-year non-overlapping periods and over 4 years for the last sub-period (period 8).[9] As a panel uses data averaged over sub-periods, it can be interpreted as capturing short-run effects. Due to difficulty of data availability, our panel data set is unbalanced. Though for the eight sub-periods with 133 countries we have a panel sample size of 1,063 observations, when we remove outliers the sample size becomes 932 and with missing values the sample then range between 795 and 615. The data set thus comprises a heterogeneous group of countries in terms of size, level of development, degree of openness, population, inflation rates, resource endowments and natural barriers to trade. The list of countries used is provided in Appendix Table A1 while detail on sources and definition of each variable is as provided in Appendix Table A2.

The focus is on what is special about Africa regarding the effects of trade and exports on economic growth, conditional on its structural variables. Consequently, in this data analysis section, we decompose Africa's growth rate of real GDP per capita and other key variables and compare them to other developing countries. We start by comparing Africa's growth with other regions using data averaged over five year periods for the entire period 1970 to 2008 (see Appendix A).

Although SSA performed relatively well in the first half of 1970s, growing on average by 2.7 per cent in 1970-74, similar to Latin America and Caribbean (LAC) and better than South Asia, SSA fell behind all regions from the mid-70s. On average over 1975– 79 SSA grew by 0.91 per cent, far below all other regions including South Asia, and growth performance worsened further in 1980s and first half of 1990s compared to most regions (LAC and MENA also experienced negative growth in some periods). In the second half of 1990s SSA growth started to pick up; the average of 2.8 per cent in 1995-99 was equivalent to South Asia and higher than other regions. Since then, SSA has been generally doing better in terms of growth, compared to earlier periods and many other regions.

Table 1 reports summary statistics on key variables for the whole period (1970 to 2008). In general, SSA is the most poorly performing region with average overall annual growth around 0.67 per cent, followed by MENA (not reported) and LAC (2.1 per cent). The best performing region is East Asia and Pacific at around 3.6 per cent on average followed by South Asia (2.9 per cent on average).

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[9] That is 1970 – 1974 (period 1), 1975 – 1979 (period 2), 1980 – 1984 (period 3), 1985– 1989 (period 4), 1990 – 1994 (period 5), 1995 – 1999 (period 6), 2000 – 2004 (period 7 and 2005 – 2008 (period 8).

Table 1: Summary Statistics for the Main Variable (1970 -2008) by Regions

Variable	Obs	Mean	Std. Dev.	Min	Max
Full Sample					
Growth rate of Real GDP per Capita	893	2.07	3.31	-9.19	12.78
Population growth (annual %)	893	1.99	1.11	-1.07	5.69
Inflation, consumer prices (annual %)	893	18.26	41.31	-0.08	532.26
Trade (% of GDP)	893	77.80	40.88	11.82	226.87
Exports of goods and services (% of GDP)	893	35.62	21.36	4.30	114.79
Arable land (hectares per person) -*NRE*	893	0.24	0.18	0.00	0.97
Ratio of cif unit import prices to fob prices-*NBT*	893	1.13	0.09	0.70	1.67
East Asia & Pacific					
Growth rate of Real GDP per Capita	140	3.57	3.95	-9.29	14.28
Population growth (annual %)	140	1.88	0.87	-0.68	3.81
Inflation, consumer prices (annual %)	140	12.68	27.00	0.19	177.87
Trade (% of GDP)	140	90.17	61.99	1.82	400.96
Exports of goods and services (% of GDP)	140	42.48	33.71	0.57	206.17
Arable land (hectares per person) -*NRE*	140	0.19	0.17	0.00	0.71
Ratio of cif unit import prices to fob prices-*NBT*	140	1.11	0.04	1.06	1.20
Latin America & Caribbean					
Growth rate of Real GDP per Capita	242	2.13	2.84	-6.96	8.84
Population growth (annual %)	242	1.55	0.92	-1.02	3.15
Inflation, consumer prices (annual %)	242	36.99	145.37	0.76	1607.41
Trade (% of GDP)	242	79.59	40.96	15.56	200.49
Exports of goods and services (% of GDP)	242	36.53	19.38	7.40	96.08
Arable land (hectares per person) -*NRE*	242	0.18	0.16	0.02	0.86
Ratio of cif unit import prices to fob prices-*NBT*	242	1.11	0.05	0.70	1.27
South Asia					
Growth rate of Real GDP per Capita	48	2.85	2.26	-2.65	10.82
Population growth (annual %)	48	2.13	0.59	0.77	3.22
Inflation, consumer prices (annual %)	42	8.47	2.95	3.04	17.11
Trade (% of GDP)	46	59.71	66.60	8.67	310.58
Exports of goods and services (% of GDP)	47	27.71	32.50	4.15	137.90
Arable land (hectares per person) -*NRE*	48	0.11	0.08	0.01	0.30
Ratio of cif unit import prices to fob prices-*NBT*	48	1.10	0.03	1.05	1.18
Sub-Saharan Africa					
Growth rate of Real GDP per Capita	341	0.67	3.59	-10.45	17.29
Population growth (annual %)	341	2.64	0.82	-1.38	5.89
Inflation, consumer prices (annual %)	341	21.52	93.67	-3.02	1478.31
Trade (% of GDP)	341	69.50	32.92	15.98	169.70
Exports of goods and services (% of GDP)	341	30.12	17.97	5.15	83.58
Arable land (hectares per person) -*NRE*	341	0.31	0.22	0.01	1.52
Ratio of cif unit import prices to fob prices-*NBT*	341	1.18	0.11	0.91	1.67

Source: Author's calculation for the full sample and sub-samples (i.e. regions samples). Averages are taken of annual values for 1970 – 2008.

The patterns are largely supported by the correlation matrix between all variables in Table 2. The simple correlation suggests that growth is positively associated with trade and exports but negatively associated with both natural resource endowments and natural barriers to trade. At the same time, both natural resource endowments and natural barriers to trade are negatively correlated with trade and exports. Growth too is negatively associated with initial level of development (suggesting convergence), population growth and inflation rate but positively associated with levels of investment and education.

Table 2: Correlation Matrix between all Variables

	GRTH	*LNGDP*	*POPNGR*	*INFLN*	*SEC*	*INV*	*TRADE*	*XGDP*	*NRE*
GRWTH	1.000								
LNGDP	-0.043	1.000							
POPNGR	-0.260	-0.353	1.000						
INFLN	-0.136	0.125	-0.068	1.000					
SEC	0.246	0.546	-0.689	0.031	1.000				
INV	0.405	0.086	-0.233	-0.088	0.350	1.000			
TRADE	0.143	0.170	-0.222	-0.235	0.337	0.327	1.000		
XGDP	0.157	0.249	-0.230	-0.209	0.354	0.300	0.952	1.000	
NRE	-0.175	-0.045	0.148	0.256	-0.226	-0.127	-0.228	-0.185	1.000
NBT	-0.153	-0.324	0.336	-0.043	-0.380	-0.147	-0.093	-0.118	-0.042

***Source*:** World Development Indicators, 2009 and Penn World Tables, 2009 and NBT obtained from IFS website of IMF.

This analysis shows that Africa, and particularly SSA, on average has experienced poor and sluggish economic growth for the entire period. Africa also performed poorly on other core determinants of growth as it had higher population growth and inflation rate and lower levels of education and investment levels. Trade is important for most SSA countries as for other regions; although export ratios are not particularly low, they are unstable. More importantly, SSA compared to other regions has higher natural resource endowments and natural barriers to trade. We posit that higher values of structural variables coupled with high population growth and inflation rates may account for the lower growth rate and also limit the effect of trade (exports) on economic growth in Africa. The principal aim of the econometric analysis is to corroborate this, controlling for other factors, and to try and identify any links that may be causal allowing for heterogeneity.

Table 3: Determinants of Cross-Country Growth: Baseline Specification

	(1)	(2)	(3)	(4)
LNGDPO	-0.671***	-0.668***	-0.722***	-0.799***
	(-3.345)	(-3.355)	(-3.581)	(-3.983)
POPNGR	-0.480**	-0.410**	-0.435**	-0.473**
	(-2.451)	(-2.060)	(-2.190)	(-2.423)
INFLN	-0.001*	-0.001*	-0.001*	-0.001*
	(-1.769)	(-1.799)	(-1.754)	(-1.758)
SEC	0.020**	0.017**	0.017*	0.016 **
	(2.562)	(2.894)	(2.862)	(2.771)
INV	0.120***	0.119***	0.106***	0.099***
	(5.609)	(5.588)	(4.673)	(4.520)
SSA		-0.489**	-0.502**	-0.500**
		(-2.666)	(-2.718)	(-2.749)
TRADE			0.004*	
			(1.762)	
XGDP				0.012***
				(2.556)
F-test	0.000	0.000	0.000	0.000
AdjR2	0.60	0.60	0.61	0.62
Box-Cox				
N	110	110	110	110

Notes: Figures in parentheses are t-ratios: *** denotes significant at 1 percent level, ** significant at 5 percent and * significant at 10 percent. The F-test supports the hypothesis that all coefficients are jointly significant (i.e. rejects the null that all are zero). When the coefficient estimates are very small yet significant, we rescale the data by multiplying by a thousand.

5 Results and Discussion

We begin with the simple cross-section (full period) estimates for the full empirical specifications (1). The results in Column 1 of Table 3 are similar to many empirical studies; the core variables are significant and have the expected sign.[10] Investment (physical capital) is one of the principal determinants of growth and so is human capital (secondary enrolment). The coefficient on initial GDP is negative and significant implying convergence within the sample. The coefficient on inflation (a broad measure of policy distortions) is negative and significant.[11] The coefficient on population growth, as expected, is negative and significant.

[10] Some studies do not find a significant coefficient on human capital; when we change the sample or set of variables the significance of secondary enrolment vanishes or its sign changes.

[11] This simple specification does not address heterogeneity or endogeneity biases, although the use of long period averages mitigates these concerns.

Column 2 includes the dummy for SSA, which is negative and significant as found in most previous cross-country studies. Column 3 and 4 include measures of trade and exports; the coefficients are positive and statistically significant suggesting that trade openness promotes growth.[12] Controlling for both human and physical capital implies that trade and exports affect growth through total factor productivity. To allow for the fuller effects of trade and exports on growth, Appendix Table B1 reports results without controlling for investment; the effects of trade and exports on growth are unaltered (if anything they are more significant).

Table 4: Cross-Country Regression with Structural Variables

	(1)	(2)	(3)	(4)
LNGDPO	-0.896***	-0.896***	-0.882***	-0.884***
	(-4.056)	(-4.030)	(-4.192)	(-3.876)
POPNGR	-0.413**	-0.410**	-0.380**	-0.398**
	(-2.963)	(-2.903)	(-2.799)	(-2.765)
INFLN	-0.002*	-0.002*	-0.002*	-0.002*
	(-1.720)	(-1.785)	(-1.779)	(-1.748)
SEC	0.015**	0.015**	0.016**	0.015**
	(2.754)	(2.887)	(2.775)	(2.840)
INV	0.130***	0.130***	0.142***	0.133***
	(5.496)	(5.459)	(5.240)	(4.792)
NRE	-1.784**	-1.767**	-1.866**	-1.777**
	(-2.130)	(-2.009)	(-2.249)	(-2.027)
NBT	-1.495**	-1.467**	-1.588**	-1.511**
	(-2.029)	(-2.967)	(-2.990)	(-2.978)
SSA		-0.025	-0.012	-0.020
		(-0.081)	(-0.038)	(-0.066)
TRADE			-0.006	
			(-1.288)	
XGDP				0.003
				(0.523)
F-test	0.000	0.000	0.000	0.000
AdjR2	0.69	0.69	0.69	0.69
Box-Cox				
N	110	110	110	110

Note: As in Table 3.

Column 1 in Table 4 introduces *NRE* and *NBT* to the baseline specification; whether included individually or jointly both significantly and adversely affect growth. One unit increases in natural resource endowment and natural barriers to trade reduce growth rate by 1.79 and 1.50 respectively. Column 2 then adds the SSA

[12] As noted, cross-country regressions have been severely criticised (Rodrik and Rodriguez, 2001).

dummy; the combination of the two structural variables renders the SSA dummy insignificant (corroborating Mbabazi *et al*, 2006), and the coefficients on trade variables become insignificant (Columns 3 and 4). The structural variables 'explain' the SSA dummy and potentially the limited effects of trade on growth. The core variables are largely unaffected.

Allowing for Interaction Effects

To further investigate the role structural variables we allow for linear interaction effects in Table 5. To facilitate interpretation of the interaction effects in (2) we transformed the mediating variables by mean centering to give the predicted effects of resource endowment (*NRE*) on growth when natural barriers to trade (*NBT*) equals its sample mean. The coefficients on *NRE* and *NBT* are negative and (weakly) significant, while the interaction term is positive but insignificant. Although higher resource endowments and higher natural barriers to trade are negatively associated with economic growth, this does not appear to be conditional on (mean) *NBT*.

Columns 2 and 3 allow for the effects of exports and trade on growth conditional on the structural variables. When using *XGDP*, the coefficients on *NRE* and *NBT* are insignificant but the coefficients on exports and the interaction terms are negative and statistically significant; when *NRE* (*NBT*) is at the mean value, there is a negative effect of exports on growth. This is consistent with high values of the structural variables (as in SSA) being associated with a negative effect of exports, i.e. the primary commodity export dependence of SSA is not conducive to growth. Broadly similar results are obtained using the trade volume measure (*TRADE*) except that the coefficients on *NRE* and *NBT* are positive and weakly significant. This is difficult to interpret consistently, but suggests that *NRE* and *NBT* are not inherently detrimental to growth; when they are above their mean values benefits of trade openness are eliminated, but when they are below the mean values trade is beneficial (the suggestion is that the benefit derives from imports, as exports were already found to have no positive effect on growth). We also tested interacting the structural variables with the SSA dummy but there were no significant effects.

These linear interaction terms are only one possible form of inter-relationship between variables. An alternative possibility is that interaction changes above a certain value of a variable, i.e. there may be threshold effects (i.e. non-linear interaction effects) in the relationship between trade and growth conditional on structural variables. One strategy is to model the product terms in a polynomial regression with squared terms (the quadratic interaction effect model). An alternative is to (exogenously) split the sample above and below some cut off point, but then the choice of cut-off is arbitrary. A better approach is to endogenously determine the threshold values (see below).

Table 5: Cross-Country Regression: Interaction Terms

	(1)	(2)	(3)
LNGDPO	-0.768***	-0.801***	-0.835***
	(-3.513)	(-4.314)	(-4.607)
POPNGR	-0.393	-0.347	-0.360
	(-2.911)	(-2.554)	(-2.755)
INFLN	-0.002*	-0.002*	-0.002*
	(-1.695)	(-1.734)	(-1.817)
SEC	0.014**	0.017**	0.017**
	(2.860)	(2.990)	(2.026)
INV	0.143***	0.150***	0.154***
	(5.811)	(5.799)	(6.165)
NRE	-1.446**	0.660	1.007*
	(-2.329)	(1.092)	(1.810)
NBT	-4.471*	2.246	3.963*
	(-1.964)	(1.291)	(1.821)
*NRE*NBT*	12.544		
	(1.483)		
XGDP		-0.016**	
		(-2.149)	
NRE XGDP*		-0.068**	
		(-2.730)	
NBT XGDP*		-0.142**	
		(-1.970)	
TRADE			-0.011***
			(-3.445)
NRE TRADE*			-0.038***
			(-4.163)
NBT TRADE*			-0.086**
			(-2.186)
F-test	0.000	0.000	0.000
AdjR2	0.69	0.74	0.75
Box Cox			
N	110	110	110

Note: As in Table 3. *NBT* in Column 1 and *NBT* and *NRE* in Columns 2 -3 are mediating variables and so are mean centred.

Panel Estimation

For the same sample of countries we explore the dynamic effects of trade on growth contingent on structural variables using panel regression. Since the panel uses data averaged over sub-periods, it can be interpreted as capturing relatively short run effects. We start by estimating the basic specification (1) including time dummies, comparing three estimators – pooled OLS (POLS), Random Effects (RE) and system GMM (SYSGMM). The results are reported in Table 6. All coefficients are statistically significant with the expected sign for the three estimators with magnitudes similar to those obtained in the cross-section analysis. The core variables behave as expected; the coefficient on initial income (*LNGDPO)* is negative and significant, implying convergence within the sample (it may also be capturing country specific effects).

Random Effects (RE) is selected over Fixed Effects (FE) for two reasons. First, the relationship between trade and growth potentially suffers from omitted variables that are due to differences across countries but constant over time (i.e. fixed effects) and those which are fixed across countries but vary over time (i.e. between effects); RE is chosen as a weighted average of fixed and between effects. Second, variables like *LNGDPO* and the SSA dummy do not vary over time and others like the structural variables vary very little over time; when FE model is used these are dropped. Hence, any effect of growth that appears to be country-specific is captured by random effects.

The system GMM is our preferred estimator because, besides controlling for omitted variables due to unobserved heterogeneity, measurement errors and endogeneity biases, it also addresses the persistence in our panel series.[13] To account for the validity of instruments used and whether our models are correctly specified we report two test statistics and their corresponding p-values: the Hansen test for over-identifying restrictions and the Arellano-Bond test for serial correlation (see notes to Table 6).

[13] GMM procedures allow freedom in specifying the lag structure for the instruments, but with a trade off: the more lags, the more the information required and more lags can lead to over-fitting and weak instruments. Two key diagnostics to use in checking for these problems are the Hansen test for over-identifying restrictions and the Arellano-Bond test for serial correlation.

Table 6: Panel Regression Baseline Specification

	POLS (1)	RE (2)	SYSGMM (3)
LNGDPO	-0.922*** (-5.065)	-0.931*** (-4.366)	-1.594*** (-8.573)
POPNGR	-0.400** (-2.609)	-0.351** (-2.241)	-0.395*** (-3.783)
INFLN	-0.008** (-1.964)	-0.008*** (-3.319)	-0.002** (-2.586)
SEC	0.021*** (3.159)	0.021** (2.968)	0.029*** (11.742)
INV	0.117*** (6.899)	0.116*** (7.394)	0.091*** (6.673)
Period Dummies	Yes	Yes	Yes
F-test	0.0000	0.0000	0.0000
J			0.403
AR(1)	0.0000[a]	0.0000 [a]	0.000
AR(2)			0.625
N	666	666	666

Notes: POLS is pooled OLS, RE is Random Effects and SYSGMM is the system GMM. Figures in parentheses are t-ratios: *** denotes significant at 1 percent level, ** significant at 5 percent and * significant at 10 percent. The F-test supports the hypothesis that all coefficients are jointly significant (i.e. rejects the null that all are zero). To evaluate whether our models are correctly specified and whether our instruments are valid, we use two criteria: The *J* statistics and the test for first/second order serial correlation of the residual in differenced equation *((AR (1)/m1 a*nd *AR (2)/m2)*. The former is the Sargan/Hansen test for over-identifying restrictions, which, under the null of instrument validity, is asymptotically distributed as a chi-square with degrees of freedom equal to the number of instruments less the number of parameters. If the model is correctly specified, the variables in the instrument set should be uncorrelated with the idiosyncratic component of the error term e_{it}. The *AR (2)/m2* test is asymptotically distributed as a standard normal under the null of no second-order serial correlation, and provides a further check on the specification of the model and on the legitimacy of variables dated *t*-2 as instruments. In order for the instruments to be acceptable, the p-values for the Sargan test and the *AR (2)/m2* test should both be greater be greater than 0.05. The *AR (1)/m1* test is asymptotically distributed as a standard normal under the null of no firs-order serial correlation. According to Arrelano and Bond (1991), the GMM estimator requires that there is first-order serial correlation (*AR (1)/m1*) but no second-order serial correlation (*AR (2)/m2*) in the residuals; hence the p-values for the *AR (1)/m1* test should be less than 0.05.[14] All support the fact that these models are correctly specified.

a For POLS the Arellano and Bond (1991) test for auto correlation is reported and for RE that Breusch-Pagan Lagrangian multiplier test is reported.

[14] The SYSGMM assumes that the twice-lagged residuals are not auto-correlated so we need to test for autocorrelation in the error terms, which is also a test for the validity of instruments, using the *AR (1)/m1* and *AR (2)/m2* procedures for, respectively, first- and second-order residual autocorrelation. According to Arrelano and Bond (1991), the GMM estimator requires that there is first-order serial correlation (m1 test) but that there is no second-order serial correlation (*AR (2)/m2* test) in the residuals. Since the null hypotheses are that there is no first-order (*AR (1)/m1* test) / second-order serial correlation (*AR (2)/m2* test), it means that one needs to reject the null hypothesis in the *AR (1)/m1* test but not to reject it in the *AR (2)/m2* test to get appropriate diagnostics.

Table 7: Panel Regression with SSA Dummy and Trade

	POLS (1)	RE (2)	SYSGMM (3)	POLS (4)	RE (5)	SYSGMM (6)
LNGDPO	-0.935*** (-5.201)	-0.846*** (-3.996)	-1.335*** (-9.467)	-0.953*** (-5.258)	-0.964*** (-4.399)	-0.832*** (-8.824)
POPNGR	-0.347** (-2.224)	-0.236* (-1.617)	-0.227** (-2.297)	-0.355** (-2.274)	-0.346** (-2.190)	-0.223** (-2.984)
INFLN	-0.008** (-1.993)	-0.008*** (-3.279)	-0.002** (-2.642)	-0.008 * (-1.884)	-0.008** (-3.091)	-0.005*** (-10.808)
SEC	0.016** (2.319)	0.014** (2.831)	0.025*** (13.403)	0.016* * (2.202)	0.021** (2.914)	0.014*** (6.334)
INV	0.116*** (6.923)	0.136*** (9.091)	0.096*** (9.950)	0.112*** (6.585)	0.112*** (6.895)	0.112*** (16.097)
SSA	-0.598** (-2.291)	-0.697** (-2.686)	-0.720** (-3.258)	-0.633** (-2.400)	-0.660** (-1.988)	-0.692*** (-4.292)
XGDP				0.011** (2.304)	0.011 ** (1.968)	0.015*** (9.203)
Period Dummies	Yes	Yes	Yes	Yes	Yes	Yes
F-test	0.000	0.000	0.000	0.000	0.000	0.000
J			0.427			0.305
AR(1)	0.000	0.000	0.000	0.000		0.000
AR(2)			0.674			0.766
N	666	666	666	659	659	659

Notes: See Table 6.

A binary SSA dummy is added to our base model in Table 7 and the coefficient is negative and statistically significant. On average, growth is lower by around 0.65 units in SSA compared to other regions. Columns 4-6 introduce measures of trade openness. As expected and found above, the coefficient on exports is positive and statistically significantly for all three estimators used. On average a one unit increase in exports increases growth rate by 0.01(similar results for the trade volume are in Appendix Table B2). This suggests is that for most countries in our sample of 133 countries, trade affects growth through export led growth (it may also be that trade affects growth through facilitating the diffusion of knowledge and technology from direct imports).

Controlling for Structural Variables

Of considerable interest in this study is to assess how structural factors, in our case *NBT* and *NRE*, affect growth. Results are shown on Table 8. The coefficients on both structural variables are negative and statistically significant for all three estimators.

Table 8: Panel Regression with Structural Variables

	POLS (1)	RE (2)	SYSGMM (3)
LNGDPO	-0.956***	-0.959***	-0.562**
	(-5.019)	(-5.297)	(-2.976)
POPNGR	-0.406**	-0.399**	-1.186***
	(-2.572)	(-2.780)	(-5.709)
INFLN	-0.003	-0.004	-0.001
	(-0.896)	(-1.398)	(-0.254)
SEC	0.017**	0.017**	0.031***
	(2.489)	(2.601)	(6.429)
INV	0.122***	0.122***	0.098***
	(6.726)	(7.784)	(6.462)
NRE	-1.940**	-1.942**	-4.471***
	(-2.853)	(-2.854)	(-8.191)
NBT	-2.738**	-2.715**	-5.604***
	(-2.210)	(-1.961)	(-6.365)
Period Dummies	Yes	Yes	Yes
F-test	0.000	0.000	0.000
J			0.641
AR(1)	0.000	0.000	0.000
AR(2)			0.512
N	621	621	621

Notes: As in Table 6.

Table 9: Panel Regression with Trade and Structural Variables

	POLS (1)	RE (2)	SYSGMM (3)	POLS (4)	RE (5)	SYSGMM (6)
	-0.962***	-0.965***	-1.051***	-0.959***	-0.966***	-1.454***
LNGDPO	(-5.075)	(-5.285)	(-5.662)	(-4.987)	(-5.123)	(-8.682)
	-0.394**	-0.386**	-1.080***	-0.406* *	-0.393**	-0.698***
POPNGR	(-2.465)	(-2.642)	(-5.571)	(-2.533)	(-2.652)	(-8.346)
	-0.003	-0.004	-0.001*	-0.003	-0.004	-0.002***
INFLN	(-0.918)	(-1.441)	(-1.629)	(-0.883)	(-1.386)	(-4.612)
	0.016**	0.016**	0.045***	0.016**	0.017**	0.053***
SEC	(2.278)	(2.417)	(9.082)	(2.249)	(2.387)	(11.105)
	0.122***	0.122***	0.090***	0.121***	0.121***	0.041***
INV	(6.731)	(7.745)	(6.130)	(6.554)	(7.350)	(3.621)
	-1.865**	-1.867**	-3.956***	-1.866**	-1.859**	-3.321***
NRE	(-2.628)	(-2.649)	(-7.102)	(-2.592)	(-2.578)	(-8.433)
	-2.634**	-2.604*	-4.904***	-2.536**	-2.497*	-4.063***
NBT	(-2.065)	(-1.834)	(-5.898)	(-1.987)	(-1.735)	(-8.434)
	-0.126	-0.130	-0.177	-0.151	-0.155	0.654**
SSA	(-0.446)	(-0.455)	(-0.504)	(-0.531)	(-0.526)	(2.262)
				0.001	0.001	0.009
XGDP				(0.117)	(0.136)	(1.553)
Period Dummies	Yes	Yes	Yes	Yes	Yes	Yes
F-test	0.000	0.000	0.000	0.000	0.000	0.000
J			0.189			0.133
AR(1)	0.000	0.000	0.000	0.000	0.000	0.000
AR(2)			0.524			0.590
N	621	621	621	615	615	651

Notes: As in Table 6.

Table 8 shows that on average a unit increases in natural resource endowments and natural barriers to trade reduces growth rate by 2.7 and 3.6 units respectively. Other control variables except for inflation have the expected signs and significance with similar magnitudes to Table 7 (except for SYSGMM which yields different coefficient values). Table 9 adds the SSA dummy and exports, both of which are insignificant. The exception is Column 6 when structural variables, SSA dummy and exports are all included together and the SSA dummy becomes positive and significant. This suggests that SSA does relatively well if one allows for all of trade costs, resource endowments and primary commodity export dependence.

Table 10: Panel Regression with Interaction Effects

	POLS (1)	RE (2)	SYSGMM (3)	POLS (4)	RE (5)	SYSGMM (6)
LNGDPO	-0.969***	-0.973***	-0.503**	-0.941***	-0.941***	-0.396*
	(-5.037)	(-5.308)	(-3.044)	(-4.845)	(-5.317)	(-2.116)
POPNGR	-0.399*	-0.391**	-0.528***	-0.413**	-0.413**	-0.634***
	(-2.518)	(-2.705)	(-6.887)	(-2.609)	(-2.959)	(-5.499)
INFLN	-0.003	-0.004	-0.001	-0.004	-0.004	-0.004***
	(-0.896)	(-1.418)	(-0.234)	(-1.084)	(-1.520)	(-4.831)
SEC	0.017**	0.017**	0.023***	0.015**	0.015**	0.008*
	(2.517)	(2.624)	(6.471)	(2.269)	(2.381)	(2.001)
INV	0.123***	0.123***	0.094***	0.125***	0.125***	0.139***
	(6.746)	(7.786)	(5.474)	(6.790)	(7.871)	(10.279)
NRE	-2.000**	-2.002**	-2.027***	0.185	0.185	-0.028
	(-2.869)	(-2.901)	(-3.976)	(0.158)	(0.154)	(-0.057)
NBT	-1.259	-1.154	-1.084***	3.397	3.397	3.561
	(-1.505)	(-1.527)	(-3.391)	(1.418)	(1.345)	(1.409)
*NRE*NBT*	4.989	4.977	6.227**			
	(0.733)	(0.715)	(2.348)			
XGDP				-0.003	-0.003	-0.008**
				(-0.526)	(-0.534)	(-2.789)
*NRE*XGDP*				-0.063**	-0.063**	0.027**
				(-2.097)	(-2.101)	(1.982)
*NBT*XGDP*				-0.230**	-0.230**	-0.202**
				(-2.728)	(-2.818)	(-2.507)
Period Dummies	Yes	Yes	Yes	Yes	Yes	Yes
F-test	0.000	0.000	0.000	0.000	0.000	0.000
J			0.807			0.677
AR(1)	0.000	0.000	0.000	0.000	0.000	0.000
AR(2)			0.549			0.581
N	795	795	795	795	795	795

Notes: As in Table 6. *NBT* in Columns 1-3 and *NBT* and *NRE* in Columns 4-6 are mediating variables and so are mean centred such that effects of *NRE* in Column 1-3 and *XGDP* in Column 4-6 are conditional on mean of interaction variable.

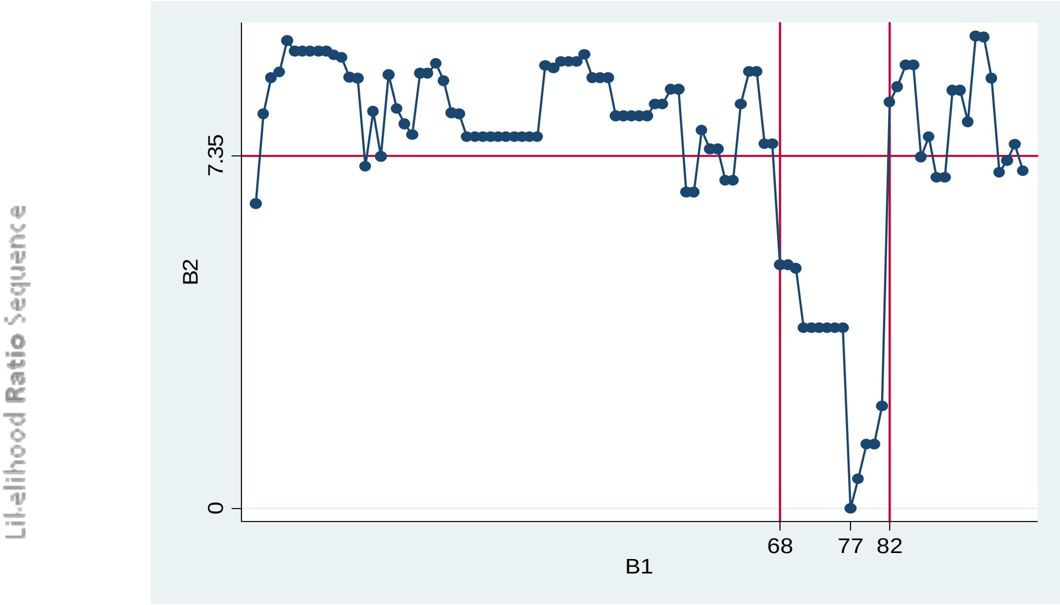
Linear interaction effects are included in Table 10 and results for trade and structural variables (and inflation) are sensitive to the estimator and which interactions are included. Including only the structural variables (Columns 1-3) we focus on SYSGMM results (which are more significant, but not qualitatively different). The coefficients on *NRE* and *NBT*, as previously, are negative and significant but their interaction term *(NBT*NRE)* is positive and significant; *NRE* is positively associated with growth when *NBT* is at the mean. Put differently, for countries to benefit from resource endowments in soft commodities they need good infrastructure (low transport costs).

Exports are included in Columns 4-6 (see also Appendix Table B3). Again we focus on SYSGMM results as being more significant but qualitatively similar. The coefficients on *NRE* and *NBT* are now insignificant but their interaction terms with *XGDP* are significant; exports are negatively associated with growth when *NBT* is at the mean but positively associated when *NRE* is at the mean (comparing coefficient on *XGDP* to the interaction terms). Having and exporting resources is beneficial unless transport costs are high. Again, it seems to be high trade costs that are detrimental to growth.

Endogenous Threshold Regression Model

The linear interaction terms used above may be misspecified so we now employ the Hansen (2000) endogenous threshold regression technique. We start by treating *NBT* as the threshold identifying variable for *NRE* in Figure 1, i.e. we search for a threshold where the relationship between *NBT* and *NRE* changes (previously we conditioned the interaction on the mean value of *NBT* so in effect we are refining that decision). Eight cut off points are identified, but only one break at the 77^{th} percentile (the upper threshold) is significant. Denoting the percentiles of natural barriers to trade *(NBT)* by σ, the 95% confidence interval for the threshold estimates is obtained by plotting the likelihood ratio sequence in σ, $LR_{n(\sigma)}$, against σ and drawing a flat line at the critical value (e.g. the 95% critical value is 7.35). The segments of the curve that lie below the flat line are the ‘no rejection region’, that is the confidence interval of the threshold estimate. Figure 1 shows the 95% confidence interval for the threshold value (the 77^{th} percentile), which lie within the bound [p(68), p(82)] in terms of percentiles. Since only a small portion lies in the ‘no rejection region’, this threshold is significant.

Figure 1: 95% Confidence Interval for NBT as Threshold for NRE

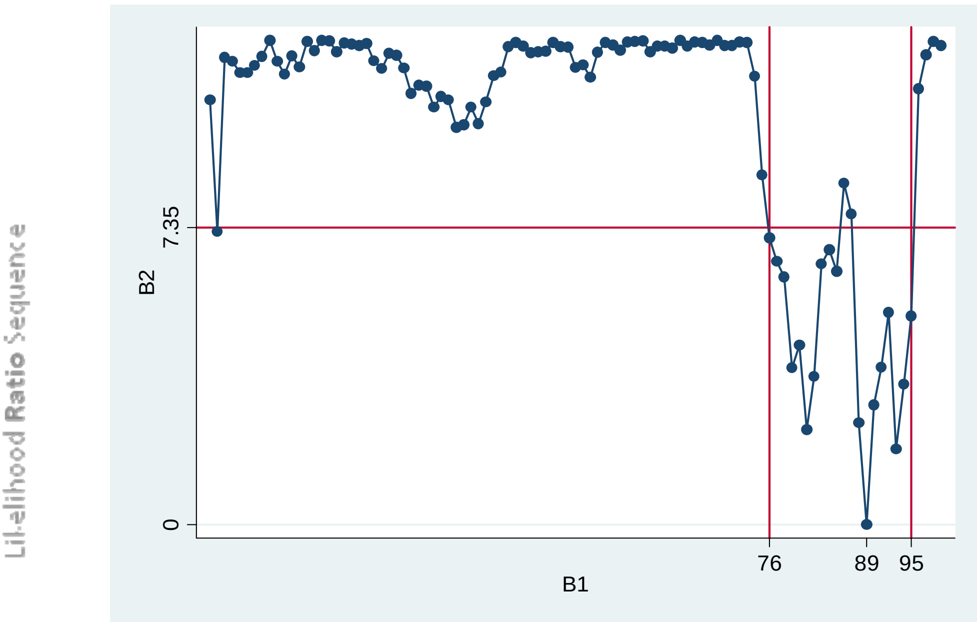


Percentiles (Natural Barrier to Trade)

The seven other cut-off values (below the line) are not significant (the 95% confidence intervals for these thresholds are wide and encompass most of the region below the flat line). As a result we are less sure in these cases as to where the ‘true’ value at which the break-point lies and therefore do not consider these as true thresholds. Thus we use the break point at the 77th percentile to split the data into above and below threshold estimates. The results for below threshold values for the three estimators are shown in Table 11 below (those for above threshold are shown in Appendix Table B4).

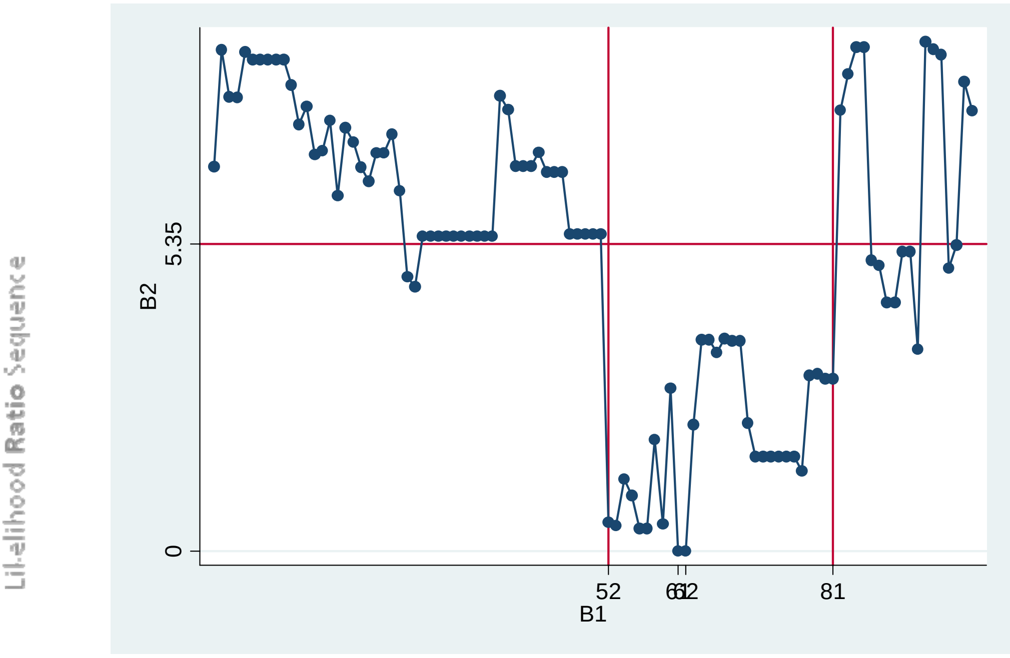
Next we use resource endowments (*NRE*) and natural barriers to trade (*NBT*) to endogenously determine the cut off points at which measures of trade openness (especially exports) affect growth differently. The threshold values for *NRE* in its influence on the relationship between exports and growth is shown in Figure 2. Five cut-off points were identified but only one, the threshold at the 89th percentile (the upper threshold) is significant. As above the 95% confidence interval (below critical value of 7.35) is identified as within the bound [p(76), p(95)] in terms of percentiles.

Figure 2: 95% Confidence Interval for NRE as Threshold Variable



Percentiles (Natural Resource Endowment)

Figure 3: 90% Confidence Interval for NBT as Threshold Variable



Percentiles (Natural Barrier to Trade)

Figure 3 endogenously identifies the thresholds for NBT at which the relationship between exports and growth switches sign. Many cut offs are identified but all are insignificant except at the 62nd percentile (significant at 10 percent). The 95 percent confidence interval for this threshold is wide and encompasses most of the region below the flat line. As a result, we are less sure where the 'true' value at which the break in the parameter lies. For that reason we opt for the 90 percent confidence interval yielding the threshold at the 62nd percentile, which is within the bound [p(52), p(81)] in terms of percentiles.

These two cut off points, 89th percentile for *NRE* and 62nd percentile for *NBT,* locate the breaks and locations in the data for both structural variables and determines their significance (i.e. thresholds at which the sign of relationship between exports or trade and growth switches). We use these two switching points to split the sample into above and below thresholds, and then replicate the interaction effects estimation using the three estimators. The results for below the thresholds are reported in Table 12 (those for above thresholds are in Appendix Table B4).

A potential problem with this approach to identifying the thresholds is that the trade variables (and others) are potentially endogenous while the Hansen (2000) method requires that independent variables are exogenous. For this reason, in terms of identifying the income threshold at which the relationship between trade and growth may alter, Kim and Lin (2009) applied the Caner and Hansen (2004) method using instrumental variables in the threshold identification. Our context is somewhat different as we seek to identify thresholds in two structural variables that are both plausibly exogenous (they do not require instruments) with respect to growth and to the effect of trade on growth. Indeed, insofar as the concern is with the endogeneity of trade, the structural variables may act as instruments. Furthermore, having used the Hansen method to split the sample on thresholds for the two structural variables the subsequent estimation with SYSGMM accounts for endogeneity. As SYSGMM and other estimators yield very consistent results, this approach seems justified in the present context.

Table 11 reports the results for *NRE* and *NBT* on growth given that *NBT* is below the threshold value (77th percentile); the three estimators provide similar results. The core variables are all significant with the expected sign. The coefficients on both structural variables are positive and significant; when *NBT* is low (below the threshold) both *NBT* and *NRE* are conducive to growth (relative to their effect when *NBT* is high). However, the interaction term is negative and significant: the combination of relatively high *NBT* and *NRE* even when *NBT* is below the threshold still has a negative effect on growth. This result is corroborated when we replicate the same specification using the above threshold *NBT* sample (Appendix Table B4). The core finding is that when *NBT* is (relatively) high, the structural variables and the interaction between *NRE* and *NBT* have a negative effect on growth. High trade costs are detrimental, especially for natural resource dependent economies.

Table 3.11: Endogenous Threshold Regression with Structural Interactions

	POLS (1)	RE (2)	SYSGMM (3)
LNGDPO	-0.954*** (-5.178)	-0.950*** (-4.570)	-1.426*** (-11.527)
POPNGR	-0.416** (-2.673)	-0.374* (-2.425)	-0.834*** (-12.449)
INFLN	-0.007* (-1.704)	-0.007** (-2.913)	-0.006*** (-11.580)
SEC	0.018** (2.725)	0.018** (2.579)	0.016*** (6.185)
INV	0.119*** (7.040)	0.118*** (7.634)	0.077*** (8.488)
NRE<77th	3.596** (2.339)	3.159** (2.006)	3.328*** (3.369)
NBT <77th	0.656** (2.702)	0.587** (2.163)	0.543*** (4.692)
*NRE<77th * NBT <77th*	-3.080** (-1.996)	-2.622* (-1.867)	-4.169** (-2.959)
Period Dummies	Yes	Yes	Yes
F-test	0.000	0.000	0.000
J			0.235
AR(1)	0.000	0.000	0.000
AR(2)			0.594
N	667	667	667

Notes: As explained in Table 6. The thresholds denoted *NRE<77th * NBT <77th* are for the structural variables when *NBT* is below the 77th percentile (observations above the threshold are thus treated as zero).

Table 12: Endogenous Threshold Regression with Trade Interaction Effects

	NBT			*NRE*		
	POLS	RE	SYSGMM	POLS	RE	SYSGMM
	(1)	(2)	(3)	(4)	(5)	(6)
LNGDPO	-1.00***	-1.01***	-1.48***	-0.93***	-0.93***	-0.92***
	(-5.14)	(-5.33)	(-9.36)	(-5.17)	(-4.48)	(-9.65)
POPNGR	-0.40**	-0.39**	-0.60***	-0.41**	-0.35**	-0.41***
	(-2.58)	(-2.68)	(-4.50)	(-2.65)	(-2.28)	(-3.69)
INFLN	-0.01	-0.01**	-0.00***	-0.01*	-0.01**	-0.01***
	(-1.30)	(-1.98)	(-11.28)	(-1.66)	(-2.40)	(-5.91)
SEC	0.02***	0.02***	0.02***	0.02**	0.02**	0.02***
	(3.04)	(3.11)	(4.04)	(2.79)	(2.66)	(7.54)
INV	0.13***	0.12***	0.09***	0.11***	0.11***	0.10***
	(6.71)	(7.55)	(5.90)	(6.59)	(7.11)	(13.46)
XGDP	0.07**	0.07**	0.11**	0.08*	0.01*	0.01**
	(2.37)	(2.32)	(2.37)	(1.76)	(1.80)	(2.21)
NBT <62nd	4.99**	4.89**	5.38**			
	(-2.81)	(-2.63)	(-2.27)			
NBT<62nd **XGDP*	0.07**	0.06**	0.11**			
	(-2.35)	(-2.28)	(-2.34)			
NRE <89th				2.03**	2.21**	2.54***
				(-2.90)	(-2.79)	(-5.89)
NRE<89th **XGDP*				0.08*	0.05**	0.02**
				(-1.87)	(-2.48)	(-2.14)
Period Dummies	Yes	Yes	Yes	Yes	Yes	Yes
F-test	0.000	0.000	0.000	0.000	0.000	0.000
J			0.413			0.212
AR(1)	0.000	0.000	0.000	0.000	0.000	0.000
AR(2)			0.490			0.435
N	615	615	615	658	658	658

Notes: As explained in Tables 6 and 11 except that the thresholds are for *NBT* below the 62nd percentile and *NRE* below the 89th percentile.

The trade variable is introduced in Table 12 to assess the effects of exports on growth contingent on the structural variables being below their threshold values (with respect to the export-growth relationship), the 89th percentile for *NRE* (Columns 4-6) and 62nd for *NBT* (Columns 1- 3). As expected the impact of exports on growth is positive and significant when *NBT* and *NRE* are below the threshold values; the coefficients on *NBT* and *NRE* and their interactions with *XGDP* are all positive and significant. Exports (or trade) contribute to economic growth for countries with lower (more favourable) values of the structural variables (supported for estimates with values above the thresholds as shown in Appendix Table B5). All other variables have the expected sign and are significant.

6 Concluding Comments

Although theory and empirical evidence suggests that trade is beneficial for growth, not all countries and regions have benefited from trade. While trade, especially exports, appears to have contributed to growth in East Asian economies, countries in Africa, in particular SSA, do not appear to have benefited from trade. This is not because trade is unimportant for SSA: although SSA accounts for a small (and until recently declining) share of world trade, trade is significant for most SSA countries. Relative to other developing country regions, imports are a relatively high share of GDP in SSA and so too are exports (on average). However, export earnings, and hence export to GDP ratios, tend to be quite volatile for SSA countries, reflecting their dependence on primary commodities. The reason SSA has derived a minimal growth benefit from trade is largely because of what it exports rather than because SSA countries do not engage in trade.

This paper argues that the detrimental effect of primary commodity export dependence on SSA growth can be captured by two structural variables, natural barriers to trade (*NBT*, trade costs) and natural resource endowments (*NRE*, primary commodity dependence). In addition to testing the importance of these structural variables as determinants of growth, and whether in combination they account for the SSA dummy effect in cross-country growth regressions, we specifically assess if the relationship between trade openness and growth is conditional on (threshold values of) the structural variables.

The analysis is based on panel data for up to 133 developing countries for the period 1970 to 2008. Results are presented for cross-section and dynamic panel data regressions, with allowance for measurement errors, omitted variables and endogeneity bias. The Hansen (2000) endogenous threshold regression technique is used to locate threshold values for the structural variables: for *NRE* with respect to *NBT* and for the trade-growth effect conditional on *NRE* and on *NBT*. The main results were quite consistent, at least in qualitative terms, across the variety of estimation methods employed. The core variables were significant with the expected sign. Higher levels of physical capital (investment) and human capital (secondary school enrolment) were conducive to growth. High population growth and inflation were negatively associated with growth. The coefficient on initial income was negative, suggesting (conditional) convergence within the sample.

The structural variables were also generally significant with the expected sign: high trade costs and natural resource endowments, especially in combination, had a negative effect on growth. Furthermore, the combination of these two factors accounts for the SSA dummy: SSA countries tend to have high values of *NRE* and *NBT* and this explains why, given control variables, SSA countries experienced lower growth than other developing countries (the significant negative dummy for SSA). The trade variables also performed as expected. Exports and trade openness generally contribute to growth, but their effect on growth is affected by the structural variables; trade costs and natural resources reduce the growth benefits of trade. In fact, there are cut off points (thresholds) for *NRE* and *NBT* above which exports have a negative effect on growth and below which trade has beneficial (positive) effects on economic growth. This supports our contention that the composition of exports is what matters for SSA.

The results provide evidence that thresholds and interactions between the structural variables are important for growth and the effect of trade on growth. As the effect of resource endowments on growth may be conditional on trade costs, in particular because transport costs are more important relative to price for primary commodities, we tested for the effects of the structural variables and their interaction when *NBT* is (relatively) high in addition to the effect of trade on growth when both structural variables are high. The effect of trade on growth is found to be conditional on both *NRE* and *NBT* such that exports make a positive contribution to growth only when both are below a threshold value. High trade costs are detrimental to growth, especially for natural resource dependent economies, largely because they undermine the potential benefits from exports; this offers an explanation for why SSA exports (primary commodities with high trade costs) have not contributed to growth.

The analysis supports the conjecture that trade costs and resource endowments are important in affecting growth, in particular insofar as they capture the relationship between exports and growth. As SSA countries tend to have unfavourable values for these variables, the poor growth performance of SSA relative to other regions is largely accounted for by the combination of natural resource endowments and high transport costs, so that the dependence on primary commodity exports has not supported growth. It must be acknowledged, however, that the measures used are limited. The measure of transport costs used is only a partial measure of trade costs and, as an aggregate (total exports) measure it does not capture variations in trade and transport costs across sectors. Nevertheless, it appears to capture the major variations across countries. The use of arable land as a proxy for resource endowments is quite limited as it may not capture the importance of mineral resources. Future work could aim to extend both measures, but especially the measure of resource endowments.

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Appendices

Appendix A provides sources and descriptive statistics and plots correlations among the key variables. Figures A1a and A1b plot the correlation between growth and measures of trade openness (total trade and export shares) and trade openness is positively correlated with economic growth. Figure A2 plots the correlation between growth and structural variables and both structural variables are associated with lower growth. When we look at the associations between exports (or trade) and structural variables in Figure A3, again structural variables are associated with lower trade and export volumes. What all these correlations suggest is that structural variables not only hamper growth but they limit the effect of trade policy on economic growth.

Appendix B provides tables of supplementary econometric results

Table A1: List of Countries

Albania	Czech Republic	Lesotho	Saudi Arabia
Algeria	Djibouti	Liberia	Senegal
Angola	Dominica	Libya	Seychelles
Antigua and Barbuda	Dominican Republic	Madagascar	Sierra Leone
Argentina	Ecuador	Malawi	Singapore
Bahamas, The	Egypt, Arab Rep.	Malaysia	Slovak Republic
Bahrain	El Salvador	Maldives	Slovenia
Bangladesh	Equatorial Guinea	Mali	Solomon Islands
Barbados	Ethiopia	Malta	Somalia
Belize	Fiji	Mauritania	South Africa
Benin	Gabon	Mauritius	Sri Lanka
Bhutan	Gambia, The	Mexico	St. Kitts and Nevis
Bolivia	Ghana	Mongolia	St. Lucia
Botswana	Grenada	Morocco	St. Vincent & the Grenadines
Brazil	Guatemala	Mozambique	Sudan
Brunei	Guinea	Myanmar	Suriname
Bulgaria	Guinea-Bissau	Namibia	Swaziland
Burkina Faso	Guyana	Nepal	Syria
Burundi	Haiti	Nicaragua	Tanzania
Cambodia	Honduras	Niger	Thailand
Cameroon	Hong Kong, China	Nigeria	Togo
Cape Verde	Hungary	Pakistan	Tonga
Central African Rep.	India	Oman	Trinidad and Tobago
Chad	Indonesia	Panama	Tunisia
Chile	Iran, Islamic Rep.	Papua New Guinea	Turkey
China	Jamaica	Paraguay	Uganda
Colombia	Jordan	Peru	Uruguay
Comoros	Kenya	Philippines	Vanuatu
Congo, Dem. Rep.	Kiribati	Poland	Venezuela, RB
Congo, Rep.	Korea, Rep.	Puerto Rico	Vietnam
Costa Rica	Kuwait	Romania	Yemen, Rep.
Cote d'Ivoire	Lao PDR	Russian Federation	Zambia
Cyprus	Lebanon	Rwanda	Zimbabwe

Source: World Bank Data Website

Table A2: Definition and Sources of Data

Variable	Definition	Source
GRTH	growth rate of Real GDP Laspeyres2 per capita	Penn World Tables 2008
LNGDPO	initial income measured as log of real GDP per capital at the beginning of the period, same as lag dependent variable	World Development Indicators (WDI) 2009
POPNGR	Population growth (annual %)	WDI 2009
INFLN	Inflation, consumer prices (annual %)	WDI 2009
SEC	School enrolment, secondary (% gross)	WDI 2009
INV	Gross capital formation (% of GDP)	WDI 2009
NRE	Arable land (hectares per person)	WDI 2009
NBT	CIF/FOB factor	*IMF* International Financial Statistics Yearbooks (2008)
TRADE	Trade (export + imports, % of GDP)	WDI 2009
XGDP	Exports of goods and services (% of GDP)	WDI 2009
SSA	is a dummy of 1 for SSA countries and 0 otherwise	

Sources: Most of the data sets used to estimate the empirical specifications are obtained from World Bank Data Website (WDI), except NBT obtained from IFS website and growth from Penn World Tables.

Table A3: Trade, Growth, Population, Inflation, Trade and Structural Variables by Regions

	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99	2000-04	2005-08
East Asia & Pacific								
Growth	5.37	3.90	2.17	2.15	3.51	2.06	2.13	4.35
Popn Growth	2.37	2.03	2.21	2.02	2.00	1.76	1.47	1.46
Inflation	12.18	20.99	22.67	18.71	16.70	10.18	5.04	6.18
Export (% GDP)	36.09	34.32	34.06	33.64	38.27	43.40	55.84	69.07
Trade (% GDP)	64.51	70.23	77.04	78.99	87.80	94.27	115.23	138.52
NRE	0.18	0.22	0.22	0.22	0.20	0.19	0.19	0.18
NBT	1.10	1.12	1.11	1.11	1.10	1.11	1.12	1.12
Latin America & Caribbean								
Growth	3.31	2.71	-0.04	1.81	1.55	2.07	1.24	3.61
Popn Growth	1.82	1.72	1.76	1.49	1.53	1.41	1.30	1.17
Inflation	20.16	26.60	39.49	166.74	145.83	12.86	7.91	7.38
Export (%)	28.38	37.27	35.49	36.42	39.11	38.52	38.24	38.48
Trade (%)	59.16	81.31	80.65	78.17	85.01	85.60	85.34	86.75
NRE	0.23	0.22	0.21	0.19	0.18	0.17	0.16	0.16
NBT	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
Middle East & North Africa								
Growth	3.23	3.33	-0.91	-1.20	1.73	0.75	2.19	3.12
Popn Growth	3.33	3.84	3.37	3.19	1.31	2.20	1.92	1.89
Inflation	6.97	10.91	11.12	20.87	13.33	9.37	5.42	6.21
Export (% GDP)	39.93	48.85	42.52	36.87	39.94	39.42	43.84	53.18
Trade (% GDP)	75.93	99.33	96.31	85.07	91.27	82.42	84.20	102.41
NRE	0.28	0.24	0.20	0.18	0.16	0.15	0.13	0.12
NBT	1.14	1.15	1.14	1.15	1.14	1.14	1.14	1.14
South Asia								
Growth	0.54	2.40	3.75	2.89	2.64	2.82	3.84	3.75
Popn Growth	2.45	2.48	2.38	2.33	2.18	1.89	1.72	1.57
Inflation	10.74	6.26	11.65	8.18	9.63	8.22	5.41	8.73
Export (% GDP)	10.26	33.71	33.50	22.64	26.15	31.81	31.38	29.33
Trade (% GDP)	24.18	77.85	80.76	50.54	58.23	65.96	64.04	48.27
NRE	0.16	0.14	0.13	0.12	0.10	0.09	0.08	0.08
NBT	1.11	1.10	1.10	1.11	1.10	1.10	1.10	1.10
Sub-Saharan Africa								
Growth	2.66	0.91	-1.01	1.18	-1.93	2.83	2.36	2.75
Popn Growth	2.48	2.77	2.90	2.81	2.33	2.61	2.37	2.26
Inflation	8.35	18.18	17.78	18.11	186.79	53.94	13.39	8.40
Export (% GDP)	27.32	29.08	28.22	28.02	27.01	30.61	35.16	38.28
Trade (% GDP)	58.72	69.84	69.50	65.64	65.54	72.33	77.47	83.36
NRE	0.46	0.42	0.36	0.32	0.30	0.28	0.26	0.25
NBT	1.15	1.18	1.18	1.18	1.18	1.18	1.18	1.18

***Source*:** World Development Indicators, 2009 and Penn World Tables, 2009

Figure A1a: Correlation between Growth and Trade

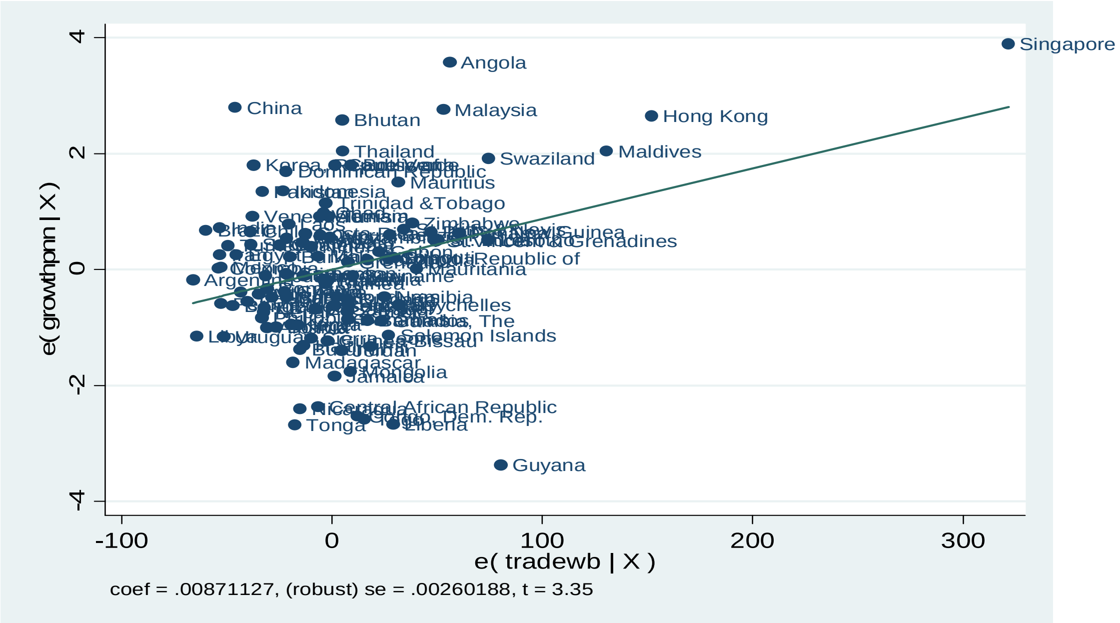


Figure A1b: Correlation between Growth and Exports

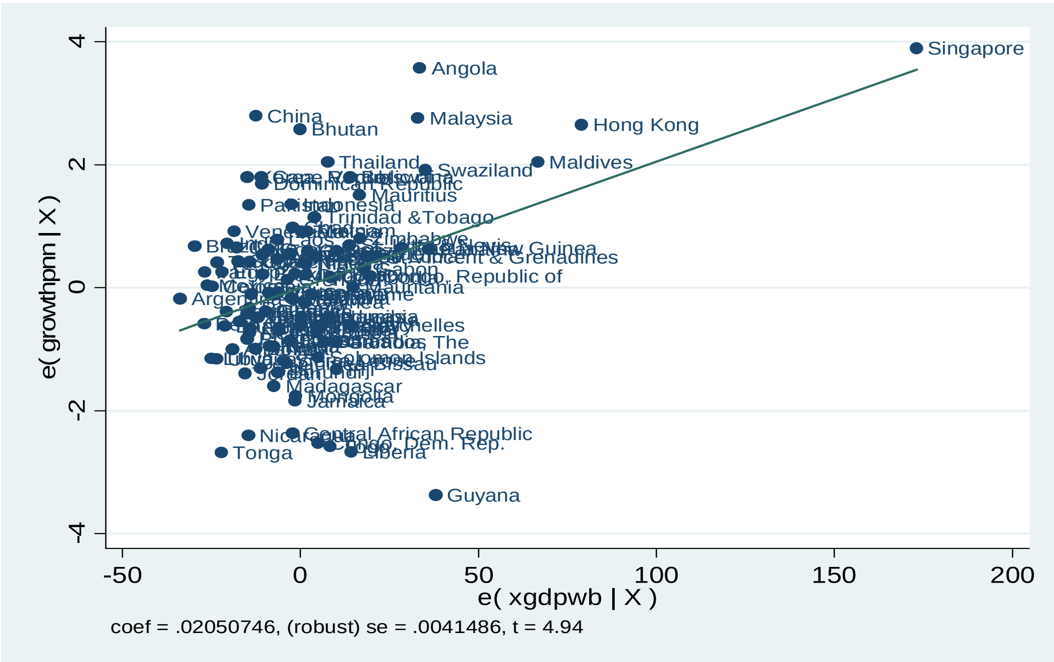


Figure A2: Correlation between Growth and Structural Variables

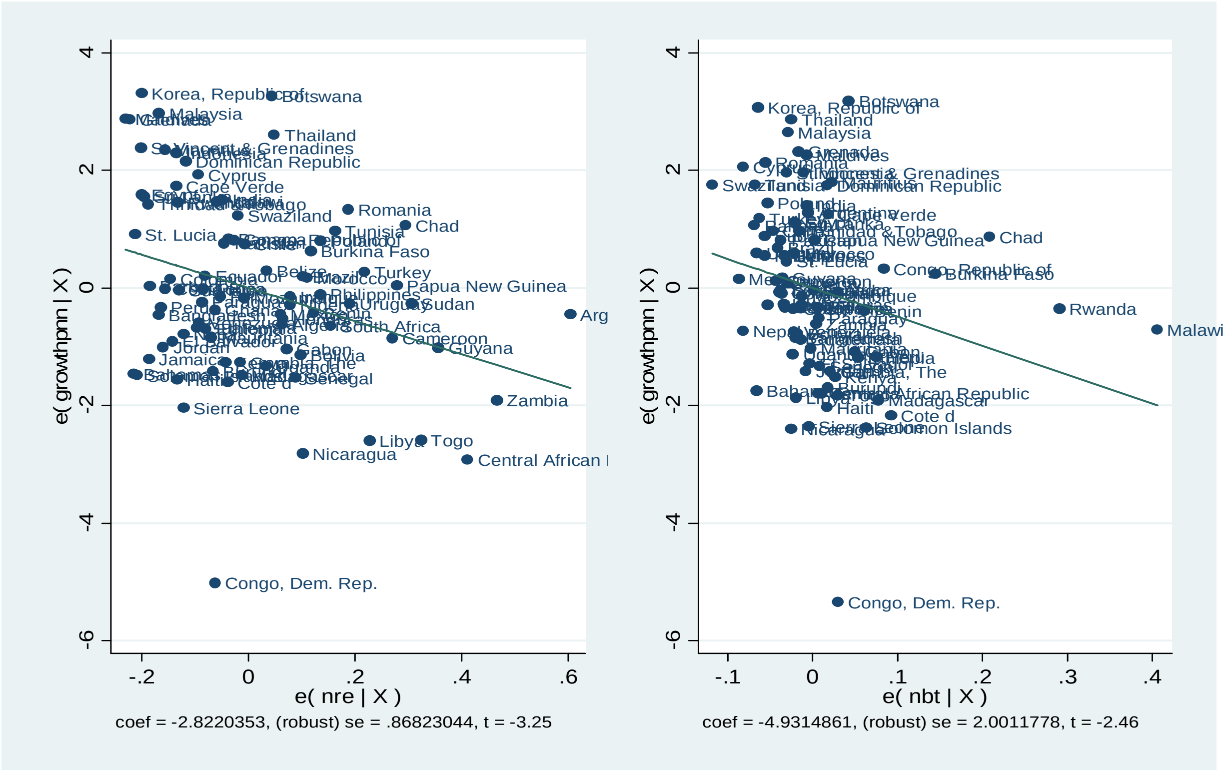
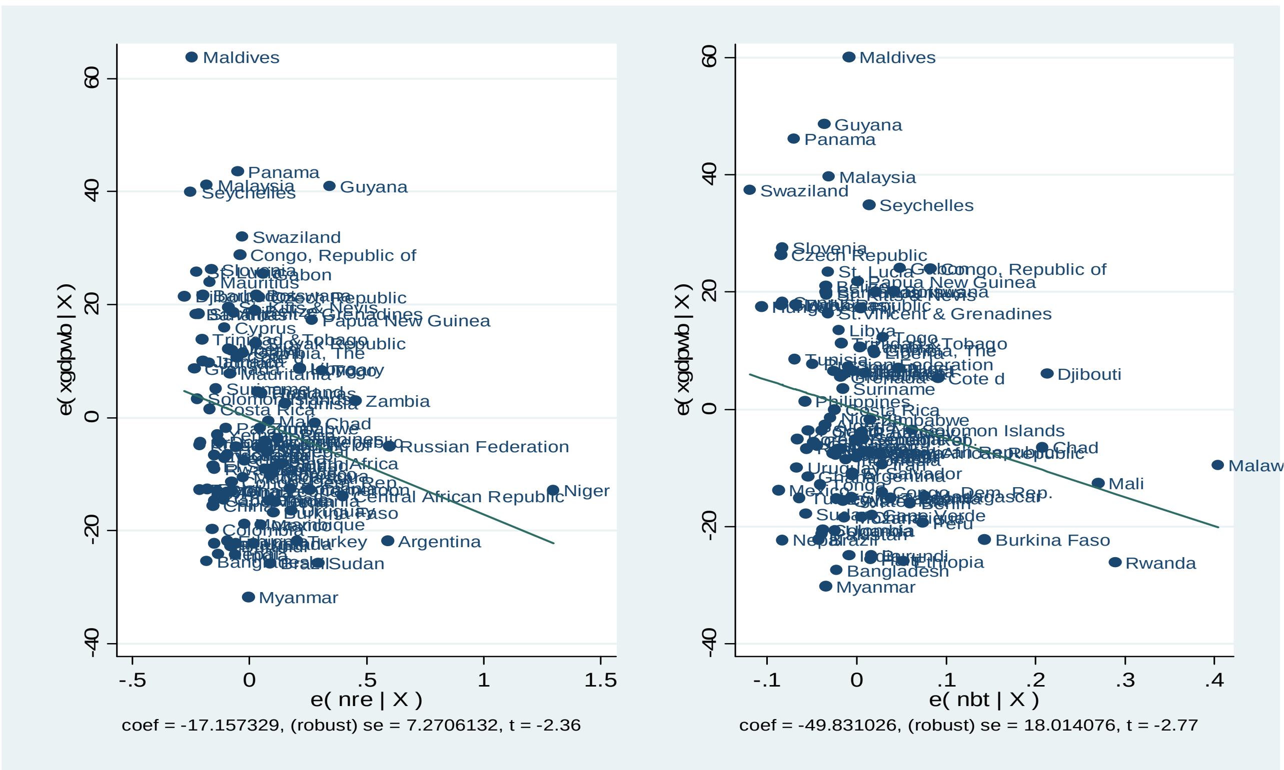


Figure A3: Correlation between Trade and Structural Variables



Appendix B: Additional Econometric Results

Table B1: Fuller Effects of Trade and Exports on Growth

LNGDPO	-0.930*** (-3.792)	-0.979*** (-4.031)
POPNGR	-0.359* (-1.830)	-0.399** (-2.522)
INFLN	-0.004*** (-3.986)	-0.004*** (-3.496)
SEC	0.033** (3.255)	0.031** (3.245)
SSA	-0.271** (-2.844)	-0.287** (-2.926)
TRADE	0.008** (2.957)	
XGDP		0.017*** (4.231)
F-test	0.000	0.000
AdjR2	0.54	0.56
Box-Cox		
N	110	110

Notes: As explained in Table 3.

Table B2: Panel Regression with Trade and Structural Variables

	POLS (1)	RE (2)	SYSGMM (3)	POLS (4)	RE (5)	SYSGMM (6)
LNGDPO	-0.960*** (-5.394)	-0.994*** (-4.718)	-1.018*** (-10.627)	-0.983*** (-5.257)	-0.990*** (-5.430)	-1.189*** (-5.394)
POPNGR	-0.338* (-2.168)	-0.295* (-1.880)	-0.001 (-0.011)	-0.388* (-2.435)	-0.380** (-2.625)	-0.668*** (-5.274)
INFLN	-0.008 (-1.954)	-0.008** (-3.265)	-0.004*** (-6.147)	-0.004 (-0.937)	-0.004 (-1.454)	-0.003*** (-3.750)
SEC	0.017* (2.440)	0.018* (2.415)	0.017*** (7.147)	0.017** (2.465)	0.018** (2.616)	0.008** (2.123)
INV	0.122*** (7.318)	0.119*** (7.262)	0.108*** (12.871)	0.133*** (7.609)	0.132*** (8.089)	0.115*** (8.928)
SSA	-0.629** (-2.394)	-0.654** (-2.091)	-0.681*** (-3.535)	-0.144 (-0.510)	-0.148 (-0.518)	0.422* (1.655)
TRADE	0.004* (1.788)	0.004* (1.668)	0.004** (2.342)	-0.003 (-0.836)	-0.002 (-0.778)	-0.004** (-2.453)
NRE				-1.999** (-2.811)	-1.997** (-2.829)	-2.856*** (-7.009)
NBT				-2.530** (-2.972)	-2.493** (-2.774)	-5.196*** (-5.684)
Period Dummies	Yes	Yes	Yes	Yes	Yes	Yes
F-test	0.000	0.000	0.000	0.0000	0.000	0.000
J			0.337			0.712
AR(1)	0.000	0.000	0.000	0.000	0.000	0.000
AR(2)			0.789			0.628
N	621	621	621	615	615	651

Notes: As explained in Table 6.

Table B3: Panel Regression with Interaction Effects

	POLS (1)	RE (2)	SYSGMM (3)	POLS (4)	RE (5)	SYSGMM (6)
LNGDPO	-0.994*** (-5.290)	-0.994*** (-5.667)	-1.141*** (-8.331)	-0.970*** (-5.146)	-0.973*** (-5.420)	-1.437*** (-8.425)
POPNGR	-0.415** (-2.632)	-0.415** (-3.002)	-0.669*** (-6.610)	-0.372* (-2.341)	-0.367* (-2.534)	-0.524*** (-5.127)
INFLN	-0.004 (-1.225)	-0.004 (-1.743)	-0.001 (-0.492)	-0.004 (-1.034)	-0.004 (-1.553)	0.002** (3.328)
SEC	0.017* (2.540)	0.017** (2.668)	0.016*** (6.562)	0.015* (2.110)	0.015* (2.238)	0.020*** (4.646)
INV	0.136*** (7.848)	0.136*** (8.500)	0.144*** (15.243)	0.124*** (6.865)	0.124*** (7.923)	0.134*** (15.651)
NRE	0.321 (0.282)	0.321 (0.258)	2.529*** (10.774)	-1.240 (-1.371)	-1.250 (-1.408)	3.299*** (6.962)
NBT	2.555 (0.808)	2.555 (0.816)	0.709 (0.390)	-6.501 (-1.858)	-6.507 (-1.817)	-1.776 (-0.594)
TRADE	-0.005 (-1.458)	-0.005 (-1.436)	-0.007*** (-6.782)			
NRE TRADE*	-0.033** (-2.614)	-0.033* (-2.269)	-0.034*** (-11.027)			
NBT TRADE*	-0.082* (-1.711)	-0.082* (-1.830)	-0.057** (-2.028)			
SSA				-0.067 (-0.232)	-0.071 (-0.250)	-0.737** (-3.390)
NRE SSA*				-1.925 (-1.322)	-1.895 (-1.355)	-4.371*** (-5.307)
NBT SSA*				4.193 (1.136)	4.234 (1.115)	-0.324 (-0.098)
Period Dummies	Yes	Yes	Yes	Yes	Yes	Yes
F-test	0.000	0.000	0.000	0.000	0.000	0.000
J			0.693			0.669
AR(1)	0.000	0.000	0.000	0.000	0.000	0.000
AR(2)			0.929			0.846
N	615	615	615	621	621	621

Notes: As explained in Table 6.

Table B4: Endogenous Threshold Regression with Structural Interactions

	POLS (1)	RE (2)	SYSGMM (3)
LNGDPO	-0.956***	-0.957***	-1.834***
	(-5.020)	(-5.316)	(-12.745)
POPNGR	-0.396*	-0.391**	-0.959***
	(-2.491)	(-2.717)	(-7.269)
INFLN	-0.004	-0.004*	-0.006***
	(-1.023)	(-1.682)	(-5.737)
SEC	0.017**	0.017*	0.028***
	(2.473)	(2.569)	(8.628)
INV	0.126***	0.126***	0.037**
	(6.958)	(8.065)	(2.920)
$NRE \geq 77^{th}$	-1.192**	-1.185* *	-2.007***
	(-2.039)	(-2.046)	(-5.047)
$NBT \geq 77^{th}$	-0.582**	-0.574*	-0.587***
	(-2.595)	(-2.397)	(-7.186)
$NRE \geq 77^{th}$	-0.576*	-0.576*	-3.782***
$* NBT \geq 77^{th}$	(1.875)	(1.769)	(3.898)
Period Dummies	Yes	Yes	Yes
F-test	0.000	0.000	0.000
J			0.283
AR(1)	0.000	0.000	0.000
AR(2)			0.620
N	667	667	667

Notes: As explained in Table 11.

Table B5: Endogenous Threshold Regression with Trade Interactions

	NBT			*NRE*		
	POLS	RE	SYSGMM	POLS	RE	SYSGMM
	(1)	(2)	(3)	(1)	(2)	(3)
LNGDPO	-0.845***	-0.943***	-0.605***	-0.989**	-1.001***	-0.826***
	(-4.23)	(-4.970)	(-4.42)	(-5.49)	(-4.96)	(-8.99)
POPNGR	-0.416**	-0.369**	-0.565***	-0.490**	-0.412	-0.395
	(-2.63)	(-2.50)	(-4.34)	(-3.12)	(-2.72)	(-6.02)
INFLN	-0.005	-0.005*	-0.003***	-0.006*	-0.007**	-0.00***
	(-1.31)	(-1.89)	(-6.60)	(-1.60)	(-2.61)	(-13.43)
SEC	0.016**	0.018**	0.013***	0.0179**	0.018**	0.014**
	(2.33)	(2.68)	(5.11)	(2.75)	(2.69)	(5.57)
INV	0.125***	0.125***	0.101***	0.112**	0.112**	0.107**
	(6.81)	(7.57)	(7.50)	(6.54)	(7.12)	(14.00)
XGDP	-0.022**	-0.017**	-0.013***	-0.028**	-0.026**	-0.007**
	(-2.09)	(-1.79)	(-3.53)	(-2.68)	(-2.06)	(-2.06)
NBT ≥ 62nd	-0.112	-0.070	-1.612*			
	(-0.08)	(-0.04)	(-1.74)			
*NBT≥ 62nd *XGDP*	-0.028**	-0.025**	-0.011**			
	(2.66)	(2.90)	(2.78)			
NRE ≥ 89th				-0.213	-0.501	-0.897**
				(-0.25)	(-0.54)	(-2.47)
*NRE≥ 89th *XGDP*				-0.036***	-0.035**	-0.029***
				(3.30)	2.76)	(10.90)
Period Dummies	Yes	Yes	Yes	Yes	Yes	Yes
F-test	0.000	0.000	0.000	0.000	0.000	0.000
J			0.490			0.178
AR(1)	0.000	0.0000	0.000	0.000	0.000	0.000
AR(2)			0.387			0.559
N	615	615	615	658	658	658

Notes: As corresponding to Table 12.