The Productivity, Trade, & Institutional Quality Nexus: A Panel Analysis

By Eleanor Doyle * and Inmaculada Martínez-Zarzoso[Ψ]

* Department of Economics, University College Cork, Ireland
e-mails: e.doyle@ucc.ie, martinei@eco.uji.es

[Ψ] Ibero Amerika Institut for Economic Research, Universitaet-Goettingen, Germany and Department of Economics, Universitat Jaume I, Castellon, Spain.
Financial support from Fundación Caja Castellón-Bancaja, Generalitat Valenciana and the Spanish Ministry of Education is gratefully acknowledged (P1-1B2005-33, Grupos 03-151, INTECO; Research Projects GV04B-030, SEJ 2005-01163 and ACOMP06/047). We are grateful to Stefan Klasen and Matthias Busse for their helpful comments and suggestions.

ABSTRACT

We estimate the relationship between productivity and trade for a panel of countries over the period 1980 to 2000 using instrumental-variables estimation of a productivity equation. We note that some estimates of productivity gains attributed to trade capture instead the roles of institutions and geography. The endogeneity of trade and institutional quality is accounted for by using instruments. We extend the Frankel and Romer (1999) specification, using real openness to measure trade (following Alcala and Ciccone, 2004), which allows for identification of channels through which trade and production scale affect productivity. The trade instrument is based on a 'theoretically motivated' gravity equation. The instruments for institutional quality come from Gwartney, Holcombe and Lawson (2004). Contrary to Alcala and Ciccone, our results suggest no robust relationship between real openness and labour productivity in the 1980s. Conversely, the relationship between productivity and real openness appears to be robust from 1990 onwards and similarly in the case of institutional quality. We also find evidence implying that countries with low-quality institutions are also able to benefit from openness to trade.

JEL: F14, F43, O40

Key words

Productivity, trade, institutional quality, real openness, nominal openness, instrumental variables estimation.

1. Introduction

Interest in the relationship between trade, or openness, and growth is evident across an extensive range of economic research. Empirical evidence points to a relationship between trade and income growth via productivity (see Yanikkaya 2003 for a survey) although specific results vary with country sample, time period and econometric approach and exactly how to accurately construct and examine this causal relationship is problematic as further indicated by an array of theoretical investigations of the link. Developments in applied econometrics have allowed for various approaches to be used to investigate how trade and growth or productivity are related but more recent research has focussed on whether estimated links between trade and productivity capture the roles of institutions and geography.

The measurement of trade in this literature includes explicit examination of exports only (in export-led growth studies) and their relationship with output and/or productivity. Some research includes openness as the measure of trade taking into account both exports and imports as separate but related channels that drive output or productivity growth. The standard measure of openness is a nominal measure of the sum of exports and imports expressed as a fraction of nominal GDP. However, this measure creates difficulties as outlined in Alcala and Ciccone (2004) due to the potential for Balassa-Samuelson effects[1], which they presented for cross-country analysis using 1985 data.

Motivated by the substantial literature in this area, this paper investigates the effect of international trade on productivity across a sample of 66 countries[2] over the period 1980 to 2000. Alternative measures of openness are used to compare the implications of using measures for real or nominal openness and to take account of the potential endogeneity of trade and institutional quality instruments are used. The selected instrument for trade follows the standards of Frankel and Romer (1999), which argues that trade is determined partially by country factors unrelated to productivity.

[1] The trade-related Balassa-Samuelson (Balassa 1964; Samuelson, 1964) hypothesis implies that if trade increases productivity, where gains are greater in manufacturing than in non-tradable services, a rise in the relative price of services might result in a decrease in openness.

[2] The number of countries included in the yearly regressions varies from 56 in 1980 to 66 in 1995 due to missing data.

The work of North (1990) and Landes (1998), in particular, highlighted that differences in income and growth are determined by the institutional framework which has been incorporated into the trade-growth debate. The proposition that weak economic institutions hinder growth is not particularly novel, however, but neoclassical assumptions that institutional competition and public choice might eliminate the hindrance possibly explains lack of specific research focus on this area until relatively recently. Following the work of Hall and Jones (1999) who coin the term 'social infrastructure' to describe institutions, and Acemoglu, Johnson and Robinson (2001), the choice of instruments for institutional quality rest on the relationship between historical European influence and diffusion of the European institutional structure.

The paper is structured as follows. In Section 2 the background literature on the trade-growth relationship is provided and the challenges associated with measures of openness and institutional quality in empirical work are identified. In Section 3 the selected productivity equation estimate is presented with detailed discussion of the instruments. Analysis and findings based on the estimated results are provided in Section 4 while conclusions are offered in Section 5.

2. Relating Trade, Productivity & Institutional Quality

Open economies can benefit from specialisation, which allows for the generation of higher levels of income. This means that as greater amounts of a country's available resources are devoted to producing goods in which it has comparative advantages (measured as lower relative opportunity costs of production), and it can import the goods in which it is less efficient, overall national output/income and consumption rise. Through creating international demand for domestic resources that might otherwise remain unused, a further (demand-side) basis for making more efficient use of resources exists in relation to trade. Static effects of specialisation change the economy's production (and labour) mix inline with comparative advantage, which coupled with the ability to trade at international prices leaves consumers better off. If dynamic benefits are also possible then as the market and market access expand, the potential for greater division of labour arises, and the skills of labour may rise in response to greater division of labour. Hence, productivity improvements are observed in an outward expansion of the production possibilities frontier (Myint, 1958).

As countries open up to trade, international communication of ideas and technology also becomes increasingly possible and may have the effect of intensifying competition in both import and export markets, increasing the incentive for both imitation and innovation and accelerating the rate of technical progress that can lead to efficiency gains through more competitive cost structures and productivity improvement. Connolly (2003), focusing on imports of high technology goods, notes that developing countries rely more heavily on trade than developed countries as a source of productivity growth. Foreign exchange constraints may be eased also since increased exports provide a source of foreign exchange for countries that wish to purchase imports of final products or inputs that embody domestically unavailable technology.

In a scenario where increased exports lead to cost reductions and increased efficiency the underlying causal direction is from trade (particularly export growth) to output growth. Such cases describe export-led-growth, which is theoretically associated with the view of trade as an engine of growth. The extent to which positive externalities are generated from involvement in international markets, through resource allocation, economies of scale and pressure on new training, for example, underpin how the hypothesis operates in practice (Medina-Smith, 2001).

An alternative causal explanation is manifest in Verdoorn's law which holds that output growth has a positive impact on productivity growth. Kaldor (1967) attributed this relationship to factors including economies of scale, learning curve effects, increased division of labour, and the creation of new processes and subsidiary industries. In this case productivity growth in the industrial sector, in particular, is considered as the principal determinant of output growth. Improved productivity and reductions in unit costs due to increasing returns simply make "it easier to sell abroad" (Kaldor, 1967: 42) implying a causal relationship from output growth, via productivity growth, to export growth.

Bidirectional causality is a possibility when productivity increases that are made through the exploitation of scale economies lead to increased exports (Kunst and Marin, 1989). This occurs if the market structure changes (brought about by increased trade) result in fewer firms and if scale economies allow for increased competitiveness through further cost reductions. Hence a potential feedback effect exists between export growth and output (Sharma *et al*, 1991). Bhagwati (1988) also considered the possibility for two-way causation between growth and exports (or trade in general) arguing that increased trade, regardless of its cause, stimulated increased output and in turn additional income facilitated more trade, generating a process of a virtuous circle of growth and trade.

In terms of new trade theory, Romer (1990), Grossman and Helpman (1991) and Rivera-Batiz and Romer (1991) developed models where an expansion of international trade increases growth by increasing the number of specialized production inputs. In models of imperfect competition and increasing returns to scale, however, this outcome is ambiguous (Helpman and Krugman, 1985) and Grossman and Helpman (1991) also pointed out that tariffs could be growth reducing. The impact of trade on growth appears to depend on market competition, market contestability and whether the market structure is stable with regard to trade disturbances or will be altered and lead to productivity improvements and technical efficiency. Marin (1992) included models of imperfect competition in her analysis of the exports-output relationship and posited that exports lead to output growth (through productivity enhancement) the smaller the country and the less entry that occurs. She based this view on the fact that minimum efficient scale of production is large relative to the home market so that the potential of exploitation of scale economies through export expansion was high. An export expansion is more likely to lead to productivity improvements if the entry of new firms instigates greater competition forcing inefficient firms to exit and increasing the incentive for incumbents to invest in R&D.

Recent examinations of trade and growth examine the extent to which productivity changes attributed to trade instead measure the effects of institutions and geography, rather than trade. The inclusion of variables to control for geography and institutional quality rendered trade insignificant in a number of studies (Rodrik, 2000; Rodriguez and Rodrik, 2001; Irwin and Tervio, 2002). Frankel and Romer (1999) outline the difficulty in trying to find if trade *causes* growth since if the trade share (or openness) is endogenous, countries with high incomes due to reasons other than trade, may trade more. Since geography is a strong determinant of trade – gravity models

(Linneman, 1966; Frankel, 1997) are indicative - and geographical characteristics are not affected by income, it can be used as an instrument for trade.

In this context, Alcala and Ciccone (2004) identify potential deficiencies in using the standard measure of openness (nominal exports plus imports expressed relative to nominal GDP) for the trade share and estimate a measure of *real openness*[3] used in a cross-country analysis of the trade-productivity relationship using 1985 data. Trade is found to be a significant and robust determinant of aggregate productivity. Our study follows extends this approach in a time-series context from 1980 to 2000 across a sample of 66 countries.

3. Empirical Approach

The essence of Alcala and Ciccone (2004) is that the trade-related Balassa-Samuelson hypothesis (Balassa 1964; Samuelson, 1964) implies that using nominal openness as a measure of trade is problematic. If trade increases productivity, where gains are greater in manufacturing than in non-tradable services, a rise in the relative price of services might result in a decrease in openness. This is shown in a trade model with gains from specialisation, which is defined as the production of fewer varieties of tradable goods but in larger quantities. From the model, GDP in country c equals aggregate consumption (assuming balanced trade)

$$GDP_c = d_c y_c + a_c\,(1-t)x_c = tx_c + a_c\,(1-t)x_c \qquad (1)$$

where

d_c measures the number of varieties of tradable goods produced in country c (as this measure of tradable goods produced domestically falls, the country becomes more specialized);

y_c denotes production of each tradable good

a_c reflects the equilibrium price of non-tradable goods in country c (reflecting factor efficiency in tradable goods sectors relative to non-tradable goods sectors). It is assumed that $a_c = g\,(d_c, L_c)$ where L denotes households' supply of labour. It is further assumed that households want to consume the same quantity of each tradable and non-tradable good irrespective of the price of non-tradables.

(1-t) denotes the fraction of commodities that are non-tradable

t denotes the fraction of tradable goods produced in country c

x_c denotes consumption of each good.

[3] Real openness is measured as nominal openness deflated by each country's price level relative to the US price level: data are from the Penn World Tables, 6.1.

The production function in tradable goods is constant returns to scale where $y = A_c l$ where A_c is country-specific factor efficiency and l denotes labour. In turn, it is given by

$$A_c = B_c g\,(d_c, l_c) \tag{2}$$

where B is an exogenous parameter, and l is aggregate employment. Gains from specialisation occur assuming $\delta g/\delta d_c < 0$. Increasing returns to aggregate employment occur assuming $\delta g/\delta l_c > 0$. Gains from specialisation are limited to this sector and no increasing returns are possible in non-tradable goods which are produced according to the production function $s = B_c l$.

Assuming balanced trade and labour market clearing, Alcala and Ciccone (2004) show that the share of labour allocated to non-tradable goods production is $(1-t)a_c / t + (1-t)a_c$. Given this and the production functions and the equation for ac, PPP GDP is shown to depend on specialisation.

$$\frac{PPP\,GDP_c}{L_c} = \frac{t + a(1-t)}{g(d_c, L_c)^{-1} t + (1-t)} B_c \tag{3}$$

where average labour productivity in PPP increases in the degree of specialisation and in aggregate employment.

In equilibrium nominal openness is

$$Open_c = 2\frac{\boldsymbol{Im}\,ports_c}{GDP_c} = 2\frac{t - d_c}{t + (1-t)a_c} \tag{4}$$

An increase in specialization can affect openness in two ways. A higher degree of specialisation, for a given price of non-tradable goods, raises openness as it implies a larger volume of imports. According to the equation deriving a_c, a higher degree of specialisation raises the price of non tradables, which lowers openness. Hence, higher openness is not necessarily associated with higher PPP labour productivity. Real openness is given by

$$ROpen_c = 2\frac{\boldsymbol{Im}\,ports_c}{PPP\,GDP_c} = \frac{t - d_c}{t + (1+t)a} \tag{5}$$

which implies that as the price of non-tradables used to value production is the same across countries, real openness is a linear and increasing function of the degree of specialisation and average labour productivity in PPP can be written as an increasing function of real openness.[4]

3.1 Estimating Equation and Data

We extend the specification in Frankel and Romer (1999) to consider the relationship between productivity and trade, following Alcala and Ciccone (2004). The benchmark specification is,

$$\log\left(\frac{PPP\,GDP_{it}}{Workforce_{it}}\right) = \alpha_0 + \alpha_1 Trade_{it} + \alpha_2 \log DScale_{it} + \alpha_3 \log Area_i + \alpha_4 IQual_{it} + \alpha_5 X_i + + u_{it} \qquad (6)$$

where $PPPGDP_{it}$ denotes Productivity per Worker in country i at time t. *Trade* represents measures of openness (both nominal and real are considered here where real openness is national imports plus exports (in US $) divided by national GDP in PPP US$ (instrumenting is discussed below). *DScale* represents the domestic scale of production, measured as population. This is included since the size or scale of a country impacts not only its propensity to trade externally, but also internally (Frankel and Romer 1999: 380). Hence, a second geography-based test of trade's impact is considered by examining whether domestic trade increases income focusing on whether larger countries, measured by population or workforce, have higher productivity.[5] *Area* denotes the land area in square kilometres. *IQual* denotes institutional quality and *X* represents geography control variables. Finally, u_{it} denotes the error term, assumed to be well behaved.

Data for productivity, nominal imports and exports, GDP in PPP US$ used to measure openness, and population to measure scale are all taken from the Penn World Tables, 6.1 (Heston *et al*, 2002). For comparison purposes, labour productivity data were also taken from the Groningen Growth and Development Centre (GGDC) Total

[4] Alcala and Ciccone (2004) pointed out that although all gains from specialization are supposed to occur in tradables, this assumption is not necessary for specialization to increase the price of non-tradables.

[5] Frankel and Romer (1999) use income per person. In line with Alcala and Ciccone (2004) our focus is on productivity.

Economy Database.[6] A 66-country sample is considered for which labour productivity data are available from both sources. Data limitations require that a smaller sample than in Alcala and Ciccone (2004) is employed. However, countries in our sample have more reliable data and are larger in size; hence their productivity is less likely determined by idiosyncratic factors (Frankel and Romer 1999:387). Area data are from the World Development Indicators (2005) of the World Bank.

Institutional quality data are from Gwartney and Lawson (2003). Since we are conducting time-series analysis we require a measure spanning the period 1980-2000. The Economic Freedom of the World Index (Gwartney and Lawson, 2003: Gwartney, Holcombe and Lawson, 2004)[7] measures institutional quality across five dimensions: size of government, legal structure and security of property rights, access to sound money, exchange with foreigners and regulation of capital, labour and business. Data for 100 countries are available over the time period we consider for the specific years 1980, 1985, 1990, 1995 and 2000. Although the index is built using perception-based[8] indicators and thus measures the perceived level of institutional quality, we consider it reliable for our purposes. Not only is it available since the early 1980s but it covers developed and developing countries and it is based on a large number of different sources, which reduces potential data bias. However, we are aware of the weaknesses of the data in the early years of the sample and this is taken into account when evaluating the results.

Since *IQual* is likely to be endogenous, instruments are required. In instrumenting for institutional quality, Hall and Jones (1999) use the population share speaking English since birth, the population share speaking one of the five primary European languages, distance from the equator and Frankel and Romer's (1999) geography–based trade measure.[9] Geography control variables (following Hall and

[6] The Conference Board and Groningen Growth and Development Centre, Total Economy Database, May 2006, http://www.ggdc.net.
[7] The authors are extremely grateful to Jim Gwartney and Bob Lawson for making the data available at http://www.freetheworld.com.
[8] Kaufmann, Kraay and Mastruzzi (2005) argue that perceptions-based data provide valuable insights relative to objective data on governance.
[9] Hall and Jones (1999) considered that the first three variables are correlated with historical influence of Europe and with providing a channel for the European institutional framework to have a growth impact. Alcala and Ciccone (2004) drop the fraction of English speaking population finding it does not support prediction of the endogenous variables in the specifications used. Acemoglu, Johnson and Robinson (2001) use European settler mortality during the 18th and 19th centuries as an instrument.

Jones (1999)) include distance from the equator and continent dummies for Europe, Africa, America, Asia and the omitted dummy is represented by the intercept.

If trade and institutional quality are endogenous, OLS cannot be used for the estimating equation and two-stage least squares is appropriate. To develop the instrument for trade, Frankel and Romer's (1999) method is followed. A gravity equation is used to estimate bilateral trade shares using countries' geographic characteristics and size as explanatory variables. The comprehensive e data set used is a cross-section of bilateral trade flows across 178 countries between 1980 and 2000. The data are from Rose (2005)[10].

In the specification of the bilateral trade equation the dependent variable is total trade in real terms relative to PPP GDP ($Trade_{ijt}/PPPGDP_i$) in logs. We include log population and log area as measures of size, log distance as measure of transport costs and a number of dummy variables that proxy for countries' geographic characteristics and integration agreements. In addition, following Anderson and van Wincoop (2003) we include exporter and importer country dummies as proxies for multilateral resistance terms. Anderson and van Wincoop (2003) demonstrated that these terms have to be included in order to have a "theoretically justified" gravity-model specification.

Thus, the equation we estimate is given by

$$\begin{aligned}\ln(Trade_{ijt} / PPPGDP_{it}) &= \gamma_i + \chi_j + \phi_t + \beta_1 \ln Pop_{it} + \beta_2 \ln Pop_{jt} + \beta_3 \ln(A_i A_j) \\ &+ \beta_4 \ln Dist_{ij} + \beta_5 \; Landl_{ij} + \beta_6 Lang_{ij} + \beta_7 Adj_{ij} + \beta_8 Island_{ij} + \beta_9 Comcol_{ij} \\ &+ \beta_{10} Currcol_{ij} + \beta_{11} CU_{ij} + \beta_{12} Colony_{ij} + \beta_{13} \; RTA_{ijt} + \beta_{14} Gw1 + \beta_{15} Gw2 \\ &+ \beta_{16} Gsp + \mu_{ijt}\end{aligned} \quad (7)$$

where i denotes the exporter, j denotes the importer, and t denotes the year. The explanatory variables γ_i and χ_j are exporter and importer country dummies, *Pop* is population, *A* is area, *Dist* is the distance between i and j, *Landl* is the number of landlocked countries in the country pair, *Lang* is a dummy variable which is unity if i and j have a common language and zero otherwise, *Adj* is a dummy variable which is unity if i and j have a common border and zero otherwise, *Island* is the number of island nations in the pair i, j, *Comcol* is is a dummy variable which is unity if i and j

---

[10] The authors are extremely grateful to Andrew K. Rose for making the data available at http://faculty.haas.berkeley.edu/arose/.

were ever colonies after 1945 with the same colonizer, *Currcol* is a binary variable which is unity if *i* and *j* are colonies at time *t*, *CU* is a binary variable which is unity if *i* and *j* use the same currency at time *t*, *Colony* is a binary variable which is unity if *i* ever colonized *j* or *vice versa*, *RTA* is a binary variable which is unity if *i* and *j* belong to the same regional trade agreement, *Gw1* and *Gw2* are binary variables which are unity if *i* and *j* are GATT/WTO members respectively and *Gsp* is a binary variable which is unity if *i* extends the *GSP* to *j* or *vice versa*. μ_{ijt} represents other omitted influences in bilateral trade.

The bilateral trade shares predicted by the gravity equation are aggregated providing a geography-based instrument for trade for each of the 66 countries we include in the estimation of the productivity equation (Figure A1 in the appendix provides a plot of the predicted shares and real openness).

4. Descriptive Statistics and Estimation Results

Table 1 contains descriptive statistics and the correlation matrix for selected variables. Real openness displays a lower mean than openness and the correlation between openness and real openness is high at 0.86. Real openness is more highly correlated with log labour productivity than openness (compare 0.27 and 0.45 for the GGDC productivity measure). The differences are emphasised further when the logged trade measures are used (compare 0.30 to 0.58). In line with Alcala and Ciccone (2004) the differences can be attributed to the Balassa-Samuelson effect, further tested below.

Insert Table 1 here.

4.1 Instruments Estimation

Table 2 contains the first-stage regression results for log real openness (lropen) and for our proxy of institutional quality (iqual).

Insert Table 2 here.

Our geography-based trade instrument is a statistically significant determinant of log real openness in the final two estimation periods of 1995 and 2000, when controlling for population, area, distance from equator, fraction of population speaking English and the continental dummies. The F-statistic of the hypothesis that our instrument can be excluded from the regression is statistically significant over all periods.

Results of the first-stage regression for our proxy of institutional quality indicate that the distance variable is statistically significant in 2000 only. Neither population nor area is significant. The fraction of population speaking English (*englfrac*) is statistically significant over all time periods. The fraction of population speaking one of the main five languages in Europe was also initially included, but due to its insignificance was not included in the final regressions. Notably, the F-statistic is consistently lower in these results when compared to those for log real openness. Therefore the instruments are weaker in this case. We also used the variable "legal origin"[11] as an additional instrument for institutional quality; however the results did not improve.

4.2 Productivity, Institutions and Trade

We begin by presenting cross-section results for five selected years in order to analyse the stability and evolution of the estimated coefficients over time and to compare our results with those obtained in previous research. Table 3 reports our results using two-stage least squares (2SLS) estimation when examining the effect of trade on productivity, where our dependent variable for labour productivity is taken first from the Gronongen Center and second from the Penn World Tables.

Our first set of results show that in 1980, the *area* variable is significant at 5% level and only three of the continent dummies are statistically significant (1%) in explaining labour productivity when controlling for population, area, distance from the equator, institutional quality and continent dummies. Results for 1985 are somewhat similar with distance to the equator also indicating significance. In 1990 distance and the Australasia dummy are significant (at 1%), and institutional quality is significant (at 5%), in explaining productivity. For 1995 and 2000, real openness and area display a statistically significant coefficient (at 1%). The 2000 results indicate that our measure of institutional quality, together with real openness, area and three of the continent dummies are determinants of labour productivity. The results obtained

[11] This variable is taken from: http://www.doingbusiness.org/.

in 2000 are more robust than those obtained in the previous years since the explanatory power is relatively higher as is the F-Statistic.

Consideration of the continent dummies reveals that once the trade, institutions and scale effects are controlled for, labour productivity is lower in the African continent and in Asia (excluding East Asia) than in North America (the default dummy). The evolution over time shows that in Sub-Saharan Africa the situation has worsened whereas in Europe and East Asia the negative differential has somewhat decreased and the dummy is no longer significant in the 1990s.

The second set of results indicates that when data from the Penn World Tables are used, real openness is only significant in 2000.

Insert Table 3 here.

Next, we present estimation results for the entire data panel. While Table 3 reveals that the absolute value and significance of the coefficients varies for different years, we expect to find an "average effect" by running a single regression with time dummies for the five years under analysis. We considered both openness and real openness in estimation and used both GGDC and PWT measures of productivity for comparison purposes, results for which are shown in Table 4. The first half of the table present the results obtained with nominal openness as dependent variable, with both the Groningen Centre and the PWT data respectively and the second half of the table presents the results using real openness. We first estimated equation (6) using 2SLS with time effects. We also estimated the whole panel with the within (2 ways-fixed-effects) and the generalised 2SLS (random effects) but the results in terms of magnitude and sign of the coefficients did not vary.

The results from the F-tests indicate that using real openness[12] as dependent variable points to rejection of the existence of individual effects and the Hausman test indicates that the inclusion of random effects provides more efficient estimates than the inclusion of fixed effects. We find that most of the variability of the data are across-countries rather than within countries, since the within variability is

[12] With nominal openness as dependent variable the tests indicate the significance of the individual effects and the Hausman test indicate that the effects should be treated as fixed. However, the results from the within estimator using nominal openness also indicate that nominal openness is no-significant and even negative signed.

substanially reduced (R^2 within is always around 0.11 or even smaller). We conclude that the best estimates for real openness are the 2SLS with only time effects.

Insert Table 4 here

Results in Table 4 indicate that institutional quality explains productivity when either openness or real openness are included in the specifications and when either productivity measure is employed. Distance from the equator is also statistically significant across specifications and productivity measures. Real openness appears to be statistically significant only when GGDC productivity data are used. Population is statistically insignificant in all cases. Area is insignificant when using openness for both productivity measures but is significant when real openness is included in the specification.

For completeness, we also ran OLS regressions for each year and using the two alternative measures of productivity. The results are shown in Table A1 in the Appendix. The coefficients are generally more precisely estimated under OLS than under 2SLS, since the standard errors are almost always lower. We perform Wu-Hausman and Durbin-wu-Hausman tests of the hypothesis that trade and institutions quality are uncorrelated with the residuals, and thus OLS are unbiased. For most of the coefficients and years we cannot reject the hypothesis that the OLS and the 2SLS estimates are equal. Results from the diagnostic tests are shown in the last rows of Tables 3 and 4. Both tests are, in the usual classical statistical sense, conservative about concluding endogeneity. If theory or evidence from other studies or even common sense suggests endogeneity, this may suffice to proceed with the 2SLS regardless of the results of the test. In this case, it is convenient to report both the OLS and the IV estimates and the test results, and interpret the findings from the analysis accordingly. In particular, endogeneity is always rejected when productivity data from the Groningen centre are employed. Our results are in line with those found in Frankel and Romer (1999), since they show that the IV and OLS estimates of the trade impact on income never differ substantially. The authors also find that moving from OLS to IV increases the estimated impact of trade and country size on income. However, we find that examining the link between trade and productivity using OLS overstates rather than understates the effect of trade. We believe this accords with theory, since countries that are more open are likely to adopt other policies that enhance productivity and may be expected to have better infrastructures and transportation systems.

For thoroughness, we also used 3SLS estimation to examine the trade-productivity relationship across our sample of countries. This method provides a comprehensive and, arguably, more complete estimation method across the system of equations that characterise the relationships among our variables of interest. These results are presented in Table 5. By using 3SLS we also control for the existence of cross-correlation of the residuals in the three different equations. 3SLS combines the seemingly unrelated regression (SUR) technique with the 2SLS technique and it is therefore more accurate. We observe that some of the coefficients are higher in magnitude than those obtained with the 2SLS method (real openness and area) but the main results are unchanged: real openness, institutionsl quality, area and distance and the continent dummies are statistically significant, whereas population is not.

Insert Table 5 here

One interesting aspect of our results is that in most of the regressions we find that population is insignificant and negatively signed. Alcala and Ciccone (2004) show in their regression results (Table 5:34) a positive and significant coefficient for population, however, Table I (Alcala and Ciccone, 2004: 30) shows a negative correlation between population and real openness. In this table they do not show the correlation coefficient between area and population, it could be that in their sample population and area are highly correlated and the population variable is showing the effect of the area variable (the area variable is insignificant in Alcala and Ciccone, 2004). In our results, the area variable is positively signed and significant. A larger area can have a positive impact on productivity via increased natural resources and a negative one via lower intra-country trade. Focusing on country size and holding population density constant (population/area) the effect of country size on productivity would be the sum of both the log of population and the log of area coefficients (Frankel and Romer 1999). Only with this hypothesis are we able to find a positive scale affect in our results.

Furthermore, we test for the Balassa-Samuelson Effect and results are provided in Table 6. We regressed the price level on real openness and other variables included in the productivity equation and both OLS and 2SLS estimations were employed. All geography controls and a constant were also included. Results indicate that real openness has a highly significant positive effect on the price level, confirming the trade-related Balassa-Samuelson effect.

Insert Table 6 here.

4.3 Robustness

We tested the robustness of our results for the inclusion of outliers. The results of our sensitivity analysis are provided in Table 7 (results for each year (1980, 1985, 1990, 1995 and 2000) are not provided here but were similar). Statistical significance of real openness (lropen) appears robust, however, but not for the non-OECD countries in our sample. Similar findings for institutional quality are evident. Population is insignificant and area remains statistically significant over the entire set of analyses. Distance from the equator is not statistically significant for the OECD sample of countries.

Insert Table 7 here

In addition, since we are mainly interested in the robustness of the observed linkage between real openness and productivity, we try to investigate whether countries with a low raking for institutional quality (countries with the lowest 20% of scores) benefit less from trade than countries with higher institutional quality (Bormann, Busse and Newhaus, 2006). With this aim, we create a dummy variable (*DIQual)* which takes a value of one if a country belongs to the 20% bottom quintile, and zero otherwise. We then interact this dummy with real openness and add both to the list of explanatory variables. The new specification for a single year, is given by,

$$\log\left(\frac{PPP\,GDP_c}{Workforce_c}\right) = \alpha_0 + \alpha_1 Trade_c + \alpha_2 \log DScale_c + \alpha_3 \log Area_c + \alpha_4 IQual_c + \alpha_5 X_c + \\ + \alpha_6 DIQual + \alpha_7 Trade_c * DIQual_c + u_c \quad (7)$$

We estimate the extended model specification using OLS and 2SLS yearly and for the complete panel. When using OLS, the results for the yearly regressions show that the two new variables are almost always insignificant and trade is still positively associated with productivity levels in most years. When using 2SLS, the dummy and the interactive term are always insignificant. For the entire panel, the two additional variables are only significant (and with the expected signs) when fixed or random effects are considered[13], but they lose significance when instruments for institutional quality and trade variables are used. When using 2SLS, the random effects model is more efficient than the fixed effects model and both are consistent according to the results from the Hausman test. The last column of Table 7 provides the panel-random effects 2SLS results for the extended model. Trade has still a positive influence on productivity; the coefficient is significant (at 10%), whereas institutional quality is only significant (at 10%) for the group of countries with the 20% worse scores on institutional quality. The interactive term *trade*DIQual* is negatively signed but insignificant, showing no evidence that trade has a negative impact on productivity in the countries with lowest quality institutions.

Following Bormann *et al.* (2006) we re-estimate the extended model choosing different threshold levels for the institutions dummy. Increasing the threshold level to 30, 40 and 50 per cent did not improve the results. The interactive term was always insignificant. Hence, contrary to Bormann *et al.* (2006) we do not find evidence implying that countries with the worse quality of institutions are not able to benefit from trade.

5. Conclusions

A considerable range of research examines the role of trade in growth and productivity. Empirically, a range of results using different techniques across different country samples, yield alternative stories of how trade relates to productivity and growth. We add to this literature using the real openness measure as a determinant of labour productivity applied in a cross-country setting over the 1980-2000 period.

Using the measure of real openness, we find that it is a statistically significant explanatory variable for labour productivity across our sample of countries, when geography controls and institutional quality are included, for the data from 1995 and 2000. The effect is more modest than the previous literature suggested. The estimates suggest that a one-percentage-point increase in real openness raises productivity by only 0.55 per cent. Between 1980 and 1990, we find no statistically significant relationship between real openness and labour productivity. This differs to

[13] The Hausman test indicate that only the fixed effects results are consistent when instrumental variables are not used.

the findings of Alcala and Ciccone (2004) but different data sources and country sample were used and in particular we used an alternative measure of institutional quality: notably, in Alcala and Ciccone, while the majority of data refer to 1985, the institutional quality data were from 1997/1998. Hence, while the rationale underlying the use of real openness was supported in our data with the finding of the Balassa-Samuelson effect, we cannot argue in favour of a robust relationship between real openness and labour productivity for our country sample for the years 1980, 1985 and 1990.

Concerning institutional quality, we find a robust relationship between this variable and productivity from 1990 onwards. The reason why this is not the case in the 1980s could be that the quality of the data is poor and there are hardly any other measures for institutions older than ten years. Additionally, contrary to Bormann *et al.* (2006) we do not find evidence implying that countries with the worst quality institutions are not able to benefit from trade.

We find partial support for the scale effect. Population is statistically significant in our first-stage regression for openness only. Using population alone has no impact on labour productivity. The theoretical rationale for inclusion of the variable in terms of the absorption effect finds no empirical support here. However, the area variable is significant and positive signed, thus considering the joint effect of area and population we are able to find a small positive effect of increasing size with population density held constant.

The use of different data sources for labour productivity reveals that this makes a substantial difference to the results of our analysis and the inferences we can make. More research is needed here to identify the sources of difference in the data that give rise to diverse results. This is where our further research is to be directed.

We also leave for further research the analysis of the channels through which openness affects growth and productivity in a dynamic setting.

References

Acemoglu, D., Johnson, S., and Robinson, J.A., (2001) The Colonial Origins of Comparataive Development: An Empirical Investigation, *American Economic Review*, pp. 1369-1401.

Alcala, F. and Ciccone, A. (2004) Trade and Productivity, *Quarterly Journal of Economics*, 119, 2, pp. 613-646.

Anderson, J. E. and Wincoop, E. (2003) Gravity with Gravitas: A Solution to the Border Puzzle, *American Economic Review* 93 (1), pp.170-192.

Balassa, B. (1964) The Purchasing Power Parity Doctrine: A Reappraisal, *Journal of Political Economy*, 72, December, pp. 584-596.

Bhagwati, J. (1988) Export-Promoting Trade Strategy: Issues and Evidence, *World Bank Research Observer,* 3, 1, 27-57.

Borrmann, A., Busse, M. and Neuhaus, S. (2006) Institutional Quality and the Gains from Trade , *Kyklos*, Vol. 59, No. 3, pp. 345-368.

Connolly, M. (2003), The Dual Nature of Trade: Measuring its Impact on Imitation and Growth, *Journal of Development Economics*, Vol. 72, No. 1, pp. 31-55.

Dollar, D. and Kraay, A. (2003) Institutions, Trade and Growth: Revisiting the Evidence, World Bank Policy Research Working Paper, 3004.

Frankel, J. and Romer, D. (1999) Does Trade Cause Growth, *American Economic Review*, 89, 3. (June), pp. 379-399.

Gwartney, J.D. and Lawson, R.A (2003) *Economic Freedom of the World: 2003 Annual Report*, Vancouver: Fraser Institute.

Gwartney, J.D., Holcombe, R.G. and Lawson, R.A. (2004) Economic Freedom, Institutional Quality, and Cross-Country Differences in Income and Growth, *Cato Journal*, 24, 3, Fall, pp. 205-233.

Heston, A., Summers, R. and Aten, B. (2002) Penn World Table Version 6.1, Center for International Comparisons at the University of Pennsylvania (CICUP), October.

Irwin, D.A.and M. Tervio, 2002. Does Trade Raise Income? Evidence from the Twentieth Century, *Journal of International Economics,* 58, pp. 1-18.

Kaldor, N. (1967) *Strategic Factors in Economic Development*, New York State School of Industrial and Labour Relations, Cornell University.

Kaufmann A. Kraay, and M. Mastruzzi (2006) Measuring Governance Using Cross-Country Perceptions Data, forthcoming in the Handbook of Economic Corruption edited by Susan Rose-Ackerman.

Kunst, R. and Marin, D. (1989) On Exports and Productivity: A Causal Analysis, *Review of Economics and Statistics*, 71, 4, 699-703.

Landes, D. S. (1998) The Wealth and Poverty of Nations: Why Some Are So Rich, and Some So Poor. New York: W. W. Norton.

Lewis, W.A. (1980) The Slowing Down of the Engine of Growth, *American Economic Review*, 70, 4, pp. 555-64.

Linneman, H. (1966) *An Econometric Study of International Trade Flows, Amsterdam*: North-Holland.

Medina-Smith, E.J. (2001) Is the Export-led Growth Hypothesis valid for Developing Countries? A Case Study of Costa Rica, Policy Issues in International Trade and Commodities Series, No. 7, United Nations.

Myint, H. (1958) The Classical Theory of Trade and the Underdeveloped Countries, *Economic Journal,* June, pp. 317-37.

North, D. C. (1990) Institutions, Institutional Change, and Economic Performance. Cambridge: Cambridge University Press.

Redding, S. (2002) Specialization Dynamics, *Journal of International Economics*, 58, pp. 299-334.

Rodrik, D. (2000) Comments on Frankel and Rose, 'Estimating the Effects of Currency Unions on Trade and Output', mimeo, Kennedy School of Government, Harvard University.

Rodriguez, F. and Rodrik, D. (2001) Trade Policy and Economic Growth: A Sceptik's Gruide to the Cross-National Evidence, *Macroeconomics Annual 2000*, Bernanke, B. and Rogoff, K.S. (editors), MIT Press for NBER.

Rodrik, D., Subramanian, A., and Trevvi, F. (2004) Institutional Rule: The Primacy of Institutions over Geography and Integration in Economic Development, *Journal of Economic Growth*, 9, 2, pp. 131-165.

Rose, A. K. (2005) Does the WTO Make Trade More Stable? *Open Economies Review* 16, 1, pp.7-22.

Samuelson, P. (1964) Theoretical Notes on Trade Problems, *Review of Economics and Statistics*, Vol. 46, No. 2. May,, pp. 145-154.

Yanikkaya, Halit (2003) Trade Openness and Economic Growth: A Cross-country Empirical Investigation, *Journal of Development Economics*, Vol. 72, No. 1, pp. 57-89.

World Development Indicators, 2005, World Bank.

Table 1. Descriptive Statistics and Correlation Matrix

Variable	*Obs*	*Mean*	*Min*	*Max*	*Std. Dev.*
lproac	314	9.77	6.89	11.54	0.93
lpro	365	9.66	6.90	10.98	0.91
openc	323	72.68	11.51	439.03	59.20
lopenc	323	4.07	2.44	6.08	0.64
ropen	323	53.27	4.00	348.02	56.87
lropen	323	3.56	1.39	5.85	0.90
lpop	365	9.73	5.43	14.05	1.68
iqual	353	5.91	2.30	9.10	1.40

	lproac	*lpro*	*openc*	*lopenc*	*ropen*	*lropen*	*lpop*	*iqual*
lproac	1.00							
lpro	0.93	1.00						
openc	0.29	0.27	1.00					
lopenc	0.32	0.30	0.88	1.00				
ropen	0.48	0.45	0.86	0.74	1.00			
lropen	0.60	0.58	0.71	0.78	0.86	1.00		
lpop	-0.43	-0.44	-0.50	-0.60	-0.57	-0.67	1.00	
iqual	0.56	0.59	0.46	0.48	0.51	0.55	-0.31	1.00

	lpro	*lproac*	*iqual*	*englfrac*	*eurfrac*	*disteq*	*lropen*	*lopenc*	*lopenf*
lpro	1.00								
lproac	0.92	1.00							
iqual	0.57	0.54	1.00						
englfrac	0.30	0.29	0.34	1.00					
eurfrac	0.37	0.37	0.18	0.44	1.00				
disteq	0.57	0.64	0.21	0.16	0.01	1.00			
lropen	0.59	0.60	0.53	0.11	-0.02	0.35	1.00		
lopenc	0.28	0.29	0.45	-0.04	-0.21	0.06	0.76	1.00	
lopenf	0.53	0.54	0.37	0.04	0.06	0.54	0.68	0.51	1.00

Notes:
lproac and lpro are the log of labour productivity per worker from Penn World Tables and from the Groningen Growth and Development Centre respectively;
openc and ropen are openness and real openness, and lopenc and lropen are the same variables in logs;
lpop is the log of population and iqual is the institutional quality index;
lopenf denotes the bilateral trade shares predicted by the gravity equation.

Table 2: First stage regressions

Variables	*1980*		*1985*		*1990*		*1995*		*2000*	
lropen	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***
lopenf	0.17	1.69	0.19	1.80	0.20	1.76	0.28	3.06	0.24	2.99
lpop	-0.22	-3.34	-0.22	-3.03	-0.18	-2.15	-0.11	-1.44	-0.17	-2.21
lar	-0.11	-1.33	-0.09	-1.01	-0.14	-1.37	-0.13	-1.84	-0.13	-1.89
disteq	0.58	1.06	0.92	1.63	0.84	1.48	0.79	1.50	0.66	1.28
englfrac	0.56	3.08	0.57	2.54	0.29	0.95	0.35	1.43	0.34	1.55
dafrica	0.13	0.50	0.00	0.00	0.12	0.47	-0.18	-0.67	-0.24	-1.01
deurope	0.03	0.12	-0.13	-0.44	0.09	0.30	-0.10	-0.40	-0.02	-0.09
dasia	-0.27	-1.26	-0.18	-0.77	0.00	-0.01	-0.22	-1.08	-0.09	-0.32
deastasia	0.74	2.55	0.67	2.13	0.59	1.48	0.76	2.09	0.62	1.79
dsubsafrica	0.33	0.73	0.25	0.59	0.10	0.29	0.65	1.14	0.49	1.34
constant	5.62	4.03	4.84	3.32	5.12	3.53	4.05	3.78	4.74	4.34
R-squared	0.72		0.70		0.62		0.67		0.74	
Nobs	58		58		58		61		59	
F(10,47)	14.56		11.51		13.55		14.94		23.10	

	1980		*1985*		*1990*		*1995*		*2000*	
iqual	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***
lopenf	0.31	1.52	0.13	0.54	0.13	0.55	0.28	1.39	0.15	0.92
lpop	-0.05	-0.39	-0.21	-1.36	-0.07	-0.49	-0.09	-0.65	-0.07	-0.57
lar	0.00	-0.02	-0.01	-0.07	-0.13	-0.73	-0.13	-0.89	-0.22	-1.47
disteq	-0.19	-1.02	0.17	0.78	0.25	1.16	0.22	1.11	0.38	2.12
englfrac	1.44	2.56	1.96	3.26	2.04	4.00	1.88	3.87	1.74	3.41
dafrica	-0.38	-0.66	-0.14	-0.25	-1.05	-1.98	-1.16	-1.79	-0.91	-1.43
deurope	-0.03	-0.06	-0.09	-0.16	-0.50	-0.84	-0.95	-1.80	-0.76	-1.71
dasia	-0.98	-2.38	-0.05	-0.10	-1.27	-2.75	-1.18	-2.64	-1.05	-2.58
deastasia	1.40	5.15	1.35	3.15	2.17	4.27	1.70	3.72	1.11	3.48
dsubsafrica	-1.61	-1.99	0.46	0.42	0.89	0.77	0.74	0.67	1.37	1.61
constant	3.29	1.18	6.49	2.03	7.60	2.47	7.50	2.92	9.84	4.01
R-squared	0.51		0.30		0.40		0.42		0.49	
Nobs	64		68		68		65		58	
F(9,54)	7.26		3.63		8.31		8.35		8.12	

Table 3. Instrumental Variables results (2SLS)[14]

Variables:	***1980***		***1985***		***1990***		***1995***		***2000***	
lpro	***Coef.***	***t***	***Coef.***	***t***	***Coef.***	***t***	***Coef.***	***t***	***Coef.***	***t***
lropen	1.01	1.54	0.14	0.28	0.26	0.49	0.75	2.12	0.66	2.04
iqual	0.01	0.03	0.33	1.65	0.26	1.75	0.20	1.48	0.32	2.41
lpop	0.04	0.23	-0.17	-1.29	-0.13	-1.13	0.01	0.17	0.05	0.76
lar	0.16	1.77	0.02	0.24	0.02	0.17	0.14	1.99	0.12	2.03
ldisteq	0.77	0.90	0.30	2.67	0.29	2.61	0.75	1.13	0.07	0.94
daustrasia	-0.64	-2.34	-0.66	-2.78	-0.62	-1.99	-0.43	-1.91	-0.39	-2.33
dafrica	-1.28	-3.32	-0.86	-2.64	-0.73	-1.66	-0.89	-2.83	-0.63	-2.93
deurope	-0.76	-2.27	-0.63	-2.00	-0.60	-1.35	-0.40	-1.24	-0.15	-0.64
deastasia	-0.59	-1.57	-0.32	-0.94	-0.14	-0.38	-0.32	-0.92	-0.21	-0.94
dsubsafrica	-1.18	-1.77	-0.21	-0.45	-0.13	-0.25	-1.32	-3.12	-1.52	-4.84
constant	3.94	1.17	9.83	3.84	9.24	3.11	4.14	1.97	3.72	2.08
R-squared	0.78		0.85		0.75		0.70		0.87	
Nobs	56.00		58.00		58.00		66.00		59.00	
F(10,45)	18.68		3.68		10.51		16.09		36.65	
Wu-Hausman F test	0.85		0.98		0.20		1.44		0.84	
Durbin-Wu-Hausman	2.13		0.97		0.51		3.44		2.09	
Sargan test (N*R-sq)	1.22		0.26		0.19		1.43		0.51	
Basmann test Chi-sq(1)	0.98		0.21		0.15		1.17		0.41	

Variables:	***1980***		***1985***		***1990***		***1995***		***2000***	
lproac	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***
lropen	-0.97	-0.42	-0.51	-0.49	0.44	1.04	0.39	0.79	0.53	1.82
iqual	0.83	0.89	0.60	1.46	0.29	2.08	0.24	1.28	0.34	2.62
lpop	-0.37	-0.71	-0.29	-1.06	0.01	0.12	-0.02	-0.36	0.02	0.34
lar	-0.10	-0.36	0.00	0.00	0.05	0.59	0.06	0.68	0.09	1.67
ldisteq	0.31	1.15	0.14	0.96	0.13	1.63	0.15	1.91	0.11	1.37
daustrasia	-0.30	-0.52	-0.50	-1.55	-0.58	-2.4	-0.41	-2.2	-0.32	-2.04
dafrica	-0.10	-0.12	-0.40	-0.88	-0.29	-0.99	-0.36	-1.45	-0.09	-0.4
deurope	-0.02	-0.03	-0.10	-0.24	-0.26	-0.77	-0.09	-0.26	-0.03	-0.13
deastasia	-0.49	-0.89	-0.44	-0.97	-0.35	-1.24	-0.07	-0.28	-0.06	-0.28
dsubsafrica	0.20	0.09	-1.33	-2.15	-1.63	-4.7	-1.63	-4	-2.08	-6.51
cons	14.32	1.21	11.58	2.34	6.55	2.9	6.85	3.49	4.79	2.93
R-squared	0.38		0.43		0.57		0.51	0.86	0.89	
Nobs	54		56		56		56	59	58	
F(10,45)	16.88		23.22		24.64		24.68	40.51	48.72	
Wu-H.F test		2.06		3.72		1,54		0.98		0.39
Durbin-Wu-Hausman		4.93		7.80		3.41		2.31		0.99
Sargan Test		0.18		0.32		0.28		1.25		0.43
Basmann		0.14		1.49		0.345		0.932		0.51

Notes: lproac and lpro are the log of labour productivity per worker from PWT and from the GGDC respectively. W-Hausman and Durbin-Wu-Hausman are tests of endogeneity of lropen and iqual (the results from the tests indicate acceptance of H0: Regressors are exogenous). Sargan N*R-sq and Basmann are tests of over-identifying restrictions, a rejection of the null hypothesis casts doubt on the validity of the instruments (results indicate acceptance of H_0).

[14] OLS results are provided (for both data sources of labour productivity) in the appendix, for information.

Table 4. Comparing Openness with Real Openness (2SLS panel)

Results with openness in nominal terms					Results with real openness[3]			
Lpro/lproac	**Coef[1]**	**t**	**Coef[2]**	**t**	**Coef[1]**	**t**	**Coef[2]**	**t**
Lopenc/lropen	0.74	1.46	0.10	0.20	0.55	2.33	0.32	1.43
iqual	0.33	4.35	0.40	5.44	0.23	2.69	0.32	3.96
lpop	-0.05	-0.70	-0.10	-1.45	-0.04	-0.92	-0.04	-0.72
lar	0.10	1.57	0.04	0.71	0.08	2.31	0.06	2.02
ldisteq	0.33	3.17	0.19	2.04	0.20	4.71	0.16	4.02
daustrasia	-0.67	-3.53	-0.46	-2.74	-0.54	-5.39	-0.47	-5.41
dafrica	-1.10	-3.29	-0.35	-1.23	-0.84	-5.81	-0.34	-2.82
deurope	-0.51	-2.09	-0.03	-0.15	-0.47	-3.09	-0.14	-1.03
deastasia	-0.42	-2.24	-0.22	-1.16	-0.29	-2.25	-0.26	-2.09
dsubsafrica	-0.25	-0.64	-1.29	-4.33	-0.73	-4.24	-1.46	-7.90
y85	0.04	0.38	-0.01	-0.13	0.25	1.85	0.13	1.02
y90	-0.12	-1.12	-0.10	-1.11	0.07	0.60	0.01	0.06
y95	-0.30	-2.56	-0.27	-2.60	-0.04	-0.26	-0.15	-1.22
y2000	-0.48	-2.88	-0.34	-2.19	-0.04	-0.23	-0.17	-1.19
constant	5.12	1.81	8.13	3.06	6.50	5.25	7.08	6.02
Adj. R-squared	0.66		0.74		0.77		0.82	
Nobs	292		283		292		283	
Wu-Hausman F test	3.22		7.67		0.64		6.81	
Durbin-Wu-Hausman Chi-sq test	6.68		15.43		1.35		13.79	
Sargan test (N*R-sq)	1.50		5.56		0.44		5.81	
Basmann test, Chi-sq(1)	1.57		5.35		0.42		5.60	
F test that all u_i=0	F(62,221)=2.19**		F(61,213)=2.66**		F(62,221)=1.01		F(61,213)=1.15	
Hausman test (fixed versus random effect)	-35.27**		-1.83		0.71		0.40	

Notes: W-Hausman and Durbin-Wu-Hausman are tests of endogeneity of lropen (lopenc) and iqual (the results from the tests indicate acceptance of H_0: Regressors are exogenous). Sargan N*R-sq and Basmann are tests of overidentifying restrictions; the joint null hypothesis is that the instruments are valid instruments, i.e., uncorrelated with the error term and correctly excluded from the estimated equation. Results indicate acceptance of H_0.

[1] The dependent variable is log of productivity measured as GDP per person employed in 1990 GK $ from the Groningen Centre.

[2]The dependent variable is log of productivity measured as GDP per person employed in 1990 GK $ from the PWT.

[3]With pooled OLS we obtain basically the same coefficients as with random effects.

Table 5. Panel results (Three-stage least-squares regression with time dummies)

variables	*Coef.*	*Z*	*variables*	*Coef.*	*Z*	*variables*	*Coef.*	*Z*
lpro			**lropen**			**iqual**		
lropen	0.65	2.71	lopenf	0.16	3.69	lpop	-0.10	-1.95
lpop	-0.01	-0.26	lpop	-0.18	-6.68	lar	-0.18	-3.71
lar	0.11	2.62	disteq	0.95	3.33	disteq	1.27	2.36
iqual	0.20	2.35	lar	-0.14	-4.74	eurfrac	0.37	1.84
disteq	0.71	2.43	eurfrac	0.25	2.40	englfrac	2.04	7.18
dafrica	-0.81	-5.84	englfrac	0.30	2.05	dafrica	-0.49	-1.78
deurope	-0.48	-3.52	dafrica	0.14	1.00	deurope	-0.20	-0.82
daustrasia	-0.51	-5.21	deurope	0.09	0.66	daustrasia	-0.68	-3.11
deastasia	-0.42	-3.11	daustrasia	0.03	0.28	deastasia	1.73	7.68
dsubsafrica	-1.00	-5.94	deastasia	0.68	5.81	dsubsafrica	0.37	1.10
y85	0.30	2.16	dsubsafrica	0.40	2.31	y85	0.06	0.32
y90	0.11	0.89	y85	-0.35	-3.71	y90	0.49	2.86
y95	0.00	0.03	y90	-0.14	-1.47	y95	1.05	6.15
y2000	0.01	0.05	y95	-0.05	-0.53	y2000	1.45	8.40
constant	5.18	4.10	y2000	-0.05	-0.61	constant	7.91	15.16
			constant	5.40	9.68			

Equation	*Obs*	*Parms*	*RMSE*	*R-sq*
lpro	292.00	14.00	0.45	0.77
lropen	292.00	15.00	0.48	0.69
iqual	292.00	14.00	0.92	0.54

Table 6. Testing for the Balassa-Samuelson Effect (2SLS)

Without Iqual			***With Iqual***		
lprice	**Coef.**	**t**	**lprice**	**Coef.**	**t**
lropen	0.63	7.72	lropen	0.48	3.01
lpop	0.05	1.82	iqual	0.06	1.04
lar	0.07	4.17	lpop	0.03	0.94
ldisteq	0.18	6.34	lar	0.05	2.17
daustrasia	-0.24	-4.06	ldisteq	0.17	6.02
dafrica	-0.49	-6.16	daustrasia	-0.20	-2.95
deurope	-0.25	-3.22	dafrica	-0.43	-4.29
deastasia	-0.16	-1.85	deurope	-0.16	-1.55
dsubsafrica	0.65	5.64	deastasia	-0.18	-1.96
y85	-0.10	-1.53	dsubsafrica	0.65	5.46
y90	-0.10	-1.75	y85	-0.18	-1.98
y95	-0.18	-3.26	y90	-0.18	-2.11
y2000	-0.37	-6.72	y95	-0.27	-2.87
constant	1.07	1.66	y2000	-0.48	-4.30
			_cons	1.68	1.98
Adj. R-squared		0.74	Adj. R-squared		0.72
Nobs		292	Nobs		292
Wu-Hausman F test		0.02	Wu-Hausman F test		0.46
Durbin-Wu-Hausman Chi-sq test		0.02	Durbin-Wu-Hausman Chi-sq test		0.97
Sargan test (N*R-sq)		3.71	Sargan test (N*R-sq)		3.53
Basmann test, Chi-sq(1)		3.55	Basmann test, Chi-sq(1)		3.34

Note: lprice is the log of the price level from the PWT.

Table 7. Sensitivity analysis. Productivity equation for different sub-samples and for the extended model

Variables	***Bench-mark***		***Excluding HK, Lux., Sing.***		***OECD***		***NON-OECD***		***Extended model (2SLS with re)***	
lpro	Coef.	t	Coef.	t	Coef.	t	Coef.	t	Coef.	t
lropen	0.55	2.33	0.57	2.72	0.28	2.30	0.70	1.23	0.75	1.58
iqual	0.23	2.69	0.21	2.73	0.21	4.65	0.37	1.57	0.18	0.87
lpop	-0.04	-0.92	-0.04	-0.96	0.01	0.54	0.01	0.08	-0.02	-0.28
lar	0.08	2.31	0.10	3.09	0.06	3.20	0.13	2.82	0.11	1.59
ldisteq	0.20	4.71	0.22	4.66	-0.03	-0.29	0.16	2.59	0.21	3.33
daustrasia	-0.54	-5.39	-0.55	-5.52	-0.14	-1.82	-0.55	-1.56	-0.55	-4.13
dafrica	-0.84	-5.81	-0.87	-6.21	-		-0.41	-1.67	-0.85	-4.02
deurope	-0.47	-3.09	-0.48	-3.31	0.07	0.85	-0.08	-0.19	-0.56	-2.01
deastasia	-0.29	-2.25	-0.30	-2.32	-0.10	-0.90	-0.53	-1.73	-0.29	-1.75
dsubsafrica	-0.73	-4.24	-0.69	-3.77	-		-1.49	-6.44	-0.69	-2.73
y85	0.25	1.85	0.26	2.06	0.12	1.69	0.29	0.90	0.32	1.57
y90	0.07	0.60	0.09	0.76	0.04	0.56	0.10	0.36	0.14	0.72
y95	-0.04	-0.26	-0.02	-0.15	-0.07	-0.94	-0.15	-0.46	0.05	0.2
y2000	-0.04	-0.23	-0.02	-0.12	0.03	0.36	-0.26	-0.64	0.06	0.21
constant	6.50	5.25	6.39	5.76	6.96	10.01	4.21	1.54	5.75	2.46
DIQual									1.00	1.54
Lropen*DIQual									-0.32	-1.1
Adj. R-squared	0.77		0.77		0.71		0.68		0.77	
Nobs	292		286		115		163		292	
f(14,277)	61.34		60.64		17.38		27.51		55.14	
Wu-Hausman F test	0.53		0.64		0.87		5.52		Davidson-MacKinnon test of exogeneity:	
Durbin-Wu-Hausman Chi-sq test	0.51		1.35		1.96		11.46		F(2,217)	1.09
Sargan test (N*R-sq)	0.64		0.67		6.60		1.63			
Basmann test, Chi-sq(1)	1.35		0.63		6.15		1.48			
Hausman Test (pr)									4.71	(0.91)

Notes: W-Hausman and Durbin-Wu-Hausman are tests of endogeneity of lropen (lopenc) and iqual (the results from the tests indicate acceptance of H_0: Regressors are exogenous). Sargan N*R-sq and Basmann are tests of overidentifying restrictions, acceptance of the null hypothesis indicate that the instruments are valid.

Table A1. OLS main results

	1980		*1985*		*1990*		*1995*		*2000*	
Variables	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***
lpro										
lropen	0.71	5.94	0.16	0.73	0.24	1.57	0.60	7.46	0.66	7.65
lpop	0.01	0.12	-0.15	-1.95	-0.10	-1.44	-0.05	-0.93	0.01	0.14
lar	0.10	2.33	0.03	0.59	0.02	0.33	0.12	3.26	0.13	4.01
iqual	0.06	1.00	0.34	3.29	0.33	3.61	0.13	2.83	0.24	4.97
ldisteq	0.15	3.03	0.28	3.07	0.28	3.45	0.17	2.24	0.11	1.46
daustrasia	-0.65	-3.49	-0.63	-3.01	-0.58	-3.33	-0.47	-2.70	-0.39	-2.33
dafrica	-1.09	-7.45	-0.84	-3.42	-0.65	-3.26	-0.89	-6.14	-0.71	-5.19
deurope	-0.48	-2.45	-0.61	-2.43	-0.59	-2.85	-0.32	-1.69	-0.21	-1.29
deastasia	-0.46	-2.60	-0.34	-1.58	-0.25	-1.24	-0.04	-0.18	-0.12	-0.54
dsubsafrica	-1.06	-4.71	-0.23	-0.42	-0.19	-0.36	-1.18	-4.60	-1.39	-6.14
constant	6.23	6.71	9.33	6.49	8.59	7.50	6.46	7.97	4.72	5.01
R-Squared	0.88		0.76		0.76		0.88		0.90	
Nobs	59		61		61.00		65.00		62.00	
F(10,48)	48.68		18.88		24.60		42.48		59.06	

Note: Labour productivity data are from the Groningen Centre.

	1980		*1985*		*1990*		*1995*		*2000*	
Variables	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***	***Coef.***	***t-ratio***
lproac										
lropen	0.66	4.66	0.61	5.69	0.47	5.03	0.48	6.38	0.57	7.91
lpop	-0.01	-0.07	-0.03	-0.40	-0.03	-0.56	-0.05	-0.93	0.00	0.05
lar	0.09	2.10	0.08	2.07	0.06	1.51	0.08	2.37	0.10	3.21
iqual	0.06	0.71	0.07	1.42	0.16	3.61	0.14	3.19	0.26	5.22
ldisteq	0.14	2.01	0.15	2.26	0.15	2.47	0.18	2.34	0.14	1.54
daustrasia	-0.67	-2.72	-0.62	-2.84	-0.64	-4.38	-0.45	-2.62	-0.35	-2.30
dafrica	-0.61	-2.59	-0.49	-1.64	-0.37	-1.77	-0.39	-2.27	-0.14	-0.92
deurope	-1.42	-3.80	-0.27	-1.30	-0.25	-1.72	-0.19	-1.10	-0.08	-0.50
deastasia	-0.33	-1.41	-0.20	-0.97	-0.07	-0.35	0.09	0.40	-0.01	-0.05
dsubsafrica	-0.37	-1.57	-1.34	-3.90	-1.58	-6.02	-1.65	-6.01	-1.99	-7.60
constant	3.48	2.35	7.19	7.12	5.22	4.60	5.16	5.62	2.63	2.46
R-Squared	0.85		0.86		0.90		0.88		0.91	
Nobs	57		59.00		59.00		62.00		60.00	
F(10,48)	32.41		45.18		53.41		30.75		48.53	

Note: Labour productivity data are from PWT.

.

Figure A1: Real Openness (in logs) Versus Constructed Trade Measure