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Productivity, Trade, and Institutional Quality: A Panel Analysis

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Recognizing that gains historically attributed to trade capture instead the roles of institutions and geography, we estimate the relationship between labor productivity and trade for a panel of countries, 1980 to 2000. We use real and nominal openness as measures of trade. The endogeneity of trade and institutional quality is accounted for with instruments. Our trade instrument is based on a theoretically motivated gravity equation and uses a more comprehensive data set than in related studies. Fixed- and random-effects and system-GMM panel estimation methods address potential biases associated with cross-section estimations. We find a robust relationship between real openness and labor productivity from the 1990s. Countries that trade more generate higher levels of productivity, supporting an institutional theory of growth. We find evidence that countries with low-quality institutions benefit from openness to trade and that the positive effect of trade on labor productivity is lower for more populated countries.

JEL Classification: F14, F43, O40

1. Introduction

Interest in the relationship between trade and performance (variously taken as levels or growth of output or productivity) is evident across an extensive range of economic research. Empirical evidence points to a relationship between trade and income growth via productivity through, for example, technology transfer effects and scale economies (see Yanikkaya 2003 for a survey), although specific results vary with country sample, time period, and econometric approach. The problematic nature of how to accurately construct and examine this causal relationship is indicated by the range of theoretical investigations undertaken to date.

Developments in applied econometrics have generated varied approaches to investigate how trade and performance are related, but more recent research has focused on whether estimated links capture the roles of institutions and geography, rather than positive trade effects. There is particular agreement that in focusing on improving understanding of the determinants of economic performance, institutions and their differential quality across

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countries must be included (Levchenko 2007). Motivated by related literature we investigate the effect of international trade and institutional quality on productivity across a sample of approximately 100 countries[1] from 1980 to 2000 going beyond the cross-section approach associated with such empirical investigations to date. Our contributions include our focus on a panel estimation approach, application of a theoretically motivated measure of trade using a comprehensive data set, and a comprehensive measure of institutional quality.

The measurement of trade in this literature includes explicit examination of exports only (in export-led growth studies) and their relationship with output, living standards, or productivity. Related 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.[2] The standard measure of openness is the sum of exports and imports expressed as a fraction of GDP, in nominal terms. However, this measure creates difficulties if productivity gains are greater in manufacturing than in services. Specifically, employing Openness as the trade variable creates difficulties because of the potential impact of Balassa-Samuelson effects that arise when wealthy trading economies experience higher consumer price levels than poorer economies because of higher productivity in traded goods sectors being passed on via higher prices to the sheltered parts of the economy.[3] Similarly to Alcala and Ciccone (2004)[4] we use alternative versions of Openness to compare findings and extend their cross-country analysis to a panel setting. To take account of the potential endogeneity of trade and institutional quality and our dependent variable, Productivity, we use instruments. Following the work of Hall and Jones (1999) and Acemoglu, Johnson, and Robinson (2001), the choice of instruments for institutional quality rests on the relationship between historical European influence and diffusion of the European institutional structure.

The work of North (1990) and Landes (1998), in particular, highlighted that differences in income and growth are determined by the institutional framework and has been incorporated into the trade/growth debate. North (1997, p. 114) in his 1993 Nobel lecture offered a definition of institutions as "the humanly devised constraints that structure human interaction. They are made up of formal constraints (rules, laws, constitutions), informal constraints (norms of behavior, conventions, and self imposed codes of conduct), and their enforcement characteristics."

The proposition that weak economic institutions hinder growth is not particularly novel, but an assumption of neoclassical economics that institutional competition and public choice might reduce or eliminate them possibly explains their exclusion from research until recently. Difficulties surrounding measurement in the context of the quotation above provides further practical rationale for their exclusion. Related literature points to several alternative measures to operationalize the concept. Furthermore, given the persistent nature of institutions (Acemoglu and Johnson 2006) availability of sufficient appropriate data is problematic.

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[1] The list of countries included in our estimations is provided in Appendix Table A1.

[2] Although we acknowledge that trade volumes and openness are not conceptually the same and thank a referee for focusing attention on this issue (e.g., a large country open to trade but isolated geographically is but indicative of this argument), we follow convention and use the terms interchangeably to denote trade volumes.

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

[4] See also Rodrik, Subramanian, and Trebbi (2004) and Dollar and Kraay (2003).

Our article is structured as follows. Section 2 provides some background literature on the trade-growth relationship identifying those challenges associated with measures of Openness and Institutional Quality in empirical work. In Section 3 the selected productivity equation we estimate is presented with detailed discussion of the instruments, because a thorough empirical examination must address issues of endogeneity. Analysis and findings based on our estimated results are provided in section 4, and our summary and conclusions are offered in section 5.

2. Empirical Relationships: Trade, Growth, and Productivity

Many arguments potentially explain why trading countries experience higher output or productivity than their more closed counterparts. Open economies can benefit from specialization, which allows for the generation of higher levels of income due to comparative advantage. When more of a country's available resources are devoted to producing goods in which it has comparative advantages (i.e., lower opportunity costs of production) and it can import the goods in which it is less efficient, overall national output and consumption are higher than under autarky. 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 specialization change the economy's production (and labor) mix in line with comparative advantage, and this, coupled with the ability to trade at international prices, leaves consumers better off. If dynamic benefits also accrue, as markets and market access expand, the potential for greater division of labor arises, and the skills of labor may rise in response to greater division of labor. Hence, productivity improvements are observed in an outward expansion of the production possibilities frontier (Myint 1958).

As trade expands, the potential to exploit international communication of ideas and technology increases and may intensify competition in both import and export markets, increasing incentives 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) notes that developing countries rely more heavily on trade (focusing on imports of high technology goods) than do developed countries as a source of productivity growth. Furthermore, foreign exchange constraints may also be eased because 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.

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). Analyses of such issues are evident in the substantial export-led-growth literature (theoretically associated with the view of trade as an engine of growth), in the alternative causal explanation manifest in Verdoorn's law (as explained in Kaldor 1967)[5] and in studies investigating bidirectional

[5] The positive impact on productivity growth of output growth was attributed to economies of scale, learning curve effects, increased division of labor, and the creation of new processes and subsidiary industries. Productivity growth in the industrial sector, in particular, is considered as the principal determinant of output growth, and improved productivity and reductions in unit costs due to increasing returns simply make "it easier to sell abroad" (Kaldor 1967, p. 42) implying a causal relationship from output growth, via productivity growth, to export growth.

causality that may arise when productivity increases that are made through the exploitation of scale economies lead to increased exports (Kunst and Marin 1989), which can occur 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.[6]

In the context of new trade theory, models have been developed indicating how international trade leads to growth by increasing the number of specialized production inputs (Romer 1990; Grossman and Helpman 1991; Rivera-Batiz and Romer 1991). Helpman and Krugman (1985) show that this outcome is ambiguous, and Grossman and Helpman (1991) also pointed out that tariffs could be growth reducing. Yanikkaya (2003) indicates how trade restrictions can promote growth, under particular conditions and especially for developing countries.

Hence, before the inclusion of (explicit) measures of "institutions" research indicated that the impact of trade on growth was equivocal—dependent on market competition, market contestability, and whether the market structure was stable with regard to trade disturbances or might be altered and lead to productivity improvements and changes in technical efficiency. Building on such findings, more recent examinations of trade and growth focus on the extent to which output or productivity changes attributed to trade instead measure the effects of institutions and geography, rather than strictly trade.

The Role of Geography in Explaining Income

A positive correlation between trade and income found in many studies could as validly mean that countries with higher incomes engage in more trade rather than assuming causality from trade to income. Ordinary least squares (OLS) regressions of income on trade neglect the endogeneity of trade and, therefore, fail to accurately identify its effect on income.

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 (or productivity) due to reasons *other* than trade may trade more. Because geography is a strong determinant of trade—as gravity models indicate (e.g., Linneman 1966; Frankel 1997)—and geographical characteristics are not affected by income, a geography-based trade instrument may be estimated. The role of geography in economic growth arises because of geographic conditions that favor economic activity of various types: Access to natural resources, access to coastline and sea for accessing external markets, proximity to strong economies, appropriate resources to support agriculture, and the general conditions supporting human health status, for example, are relevant (Sachs 2000). As the literature indicates, separating the trade effects from nontrade effects in the context of geographical measures proves to be an informative and fruitful line of inquiry in trade-growth analysis.

Frankel and Romer (1999) addressed the simultaneity issue by conducting a two-stage procedure including constructing an instrument using countries' geographic attributes (notably distance from trade partners) that are correlated with trade but uncorrelated with income. In a cross section of countries (98 in their sample) using 1985 trade data, they find that the effect of trade on income is considerably higher (although imprecisely estimated) with instrumental variables (IV) estimation, suggesting that the positive association of trade and income is not

[6] Hence a potential feedback effect exists between export growth and output such as considered in Doyle (2001).

entirely attributable to high-income countries trading more. Trade raises income, through accumulation of physical and human capital and by increasing output for given levels of capital. The OLS method understates the effects of trade, and in the IV estimation a 1% increase in trade shares raises income (per capita) by between 1.5% and 2% (across different sample specifications).

Rodriguez and Rodrik (2001) highlighted the potential for upward bias to the IV estimate unless controls for additional channels (public health, quality of institutions, natural endowments) were included in the trade-growth analysis. They ran the Frankel and Romer regressions extended to incorporate distance from the equator, the percentage of a country's land area that is in the tropics, and a set of regional dummies. All additional variables displayed highly significant coefficients, suggesting that the Frankel-Romer estimates captured such nontrade effects on income. They found that the IV estimates became statistically insignificant (reduced below the OLS) and concluded that the nontrade effects of geography were the main driving forces behind their findings.

Subsequent research by Irwin and Tervio (2002) using the Frankel-Romer method over the twentieth century (across subperiods 1913–1995) generated consistent findings across the period. Although addressing the critique of Rodriguez and Rodrik (2001) did not significantly affect the OLS results, it eliminated the consistent relationship between trade and income in the IV regressions over the entire period. They concluded that trade is measured with substantial error and/or it is an imperfect proxy for other income-enhancing interactions between nations.

As identified in Alcala and Ciccone (2004), potential deficiencies arise in using the standard measure of the trade share, openness (nominal exports plus imports expressed relative to nominal GDP). If trade increases productivity, where gains are greater in manufacturing than in nontradable services, a rise in the relative price of services might result in a decrease in openness. They estimate a measure of real openness[7] in a cross-country analysis of the trade-productivity relationship also using 1985 trade data. Their proposed *real openness* measure uses exports and imports in exchange rate US$, and GDP is measured at PPP US$ prices that are comparable across countries. They find higher *real openness* is directly associated with higher trade rather than cross-country differences in the relative price of nontradable goods. The trade instrument constructed is based on a comprehensive data set with 2.5 times the observations used in Frankel and Romer (1999), and the same data source[8] is used in both cases. Trade is found to be a significant and robust determinant of aggregate productivity with an elasticity of approximately 1.2.

Using a comprehensive data set[9] containing over 270% more observations on bilateral trade than used in Frankel and Romer (1999), Noguer and Siscart (2005, p. 451) explained the contribution of this additional data in the following terms:

> …previous studies faced a shortage in data availability for bilateral trade. To overcome this limitation, the authors imputed "geographically" constructed trade shares … to country pairs for which they lacked bilateral trade data but for which they had geographical and population data (the gravity regressors). … As a consequence, they obtain a relatively weak instrument, especially for those countries for which they had no bilateral trade data at all. In the 98-country sample of Frankel and Romer (1999), a total of 45 countries belong to this group of no

[7] Real openness is measured as nominal openness deflated with the consumer price index. Data are from the Penn World Tables.

[8] That is, Direction of Trade Statistics of the IMF.

[9] World Trade Database (issue 1997).

> available bilateral trade data. … By using a larger data set that allows us to avoid imputation, we get a more powerful instrument. The F-statistic of the exclusion of the instrument from the First Stage for the set of countries for which Frankel and Romer had no bilateral trade data increases from 0.27 to 7.3. For the overall sample, it increases from 8.85 to 35.48.

The result was a statistically significant stronger instrument for their estimations of specifications (following Frankel and Romer 1999 and Rodriguez and Rodrik 2001). The effect of including geographical controls reduced the elasticity of income (per capita) to trade share from 2.5 to between 0.9 and 1.3, and in each specification the coefficient was statistically significant.

To investigate the nontrade effects of geography on income in the context of valid instrumental variables, they examined which geographical variables could be deemed independent determinants of income and suitable for inclusion as controls and which geographical variables (if any) were significantly correlated with the selected instrument. The variables of potential significance for the determination of income were considered as latitude (impacting via institutions) and the percent of population in the tropics (impacting via disease and morbidity), in line with McArthur and Sachs (2001). In the presence of correlation with the instrument, respecification of the income-trade relationship was required,[10] and the trade coefficient was estimated at 1.04. Several proxies for institutional quality were also included as controls to consider the sensitivity of the estimated trade coefficient, which remained robust around 1 and retained its statistical significance.

Institutions Determining Economic Performance

The role and importance of institutions has been examined extensively in, for example, La Porta et al. (1997, 1998) and Acemoglu et al. (2001, 2002, 2003), with agreement that institutions matter for economic performance and are differentiated across northern and southern outcomes. Easterly (2001) outlines that basic institutional requirements to facilitate economic performance include protection of property rights, rule of law, efficient bureaucracy, corruption-free government, and political constraint on the executive. Rather than being defined as ''proximate determinants'' of economic growth, investment in physical and human capital offer a *potential* for growth that without supporting institutions—the ultimate causes of growth—cannot be exploited. Over a number of studies Acemoglu et al. (2001, 2002, 2003) identify that weak (strong) institutional quality causes lower (higher) per capita income and higher (lower) macroeconomic volatility. They focus particularly on the ''historically determined component of institutions'' (2003, p. 71) and do not address the potential contributory role of trade to macroeconomic outcomes.

The authors cited in this section consider institutions as a more significant explanatory variable than geography, the rationale being that once the impact of institutions is included, geography adds little to explaining cross country difference in income—a finding, therefore, at odds with the conclusion of the supremacy of geography in Sachs and Warner (1995, 1999, 2001).

Just how best to measure institutions is not entirely clear. Temple's (1999) review of empirical growth literature identified research that, before publication of the *Economic Freedom of the World* (EFW) Index, examined the role of institutions for economic outcomes:

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[10] If latitude and tropical population are determinants of income, they could be relegated to the error term once neither was correlated with the instrument.

Keefer and Knack (1995) using indicators of property rights (subsequently used in the definition of ''social infrastructure'' in Hall and Jones 1999), Mauro (1995) using measures of corruption, and Barro (1997) using an indicator of political rights. The breadth of measures used arises as Levchenko (2007, p. 791) explains, because the term institutions ''typically refers to a wide range of structures that affect economic outcomes: contract enforcement, property rights, investor protection, the political system, and the like.''

The EFW Index (Gwartney and Lawson 2003; Gwartney, Holcombe, and Lawson 2004; Gwartney 2009)[11] measures institutional quality across five dimensions, namely:

- Size of government
- Legal structure and security of property rights
- Access to sound money
- Freedom to trade internationally
- Regulation of capital, labor, and business

offering both a multifaceted, ''reliable and useful'' (de Haan, Lundstrom, and Sturm 2006) composite measure of institutional quality that focuses more on formal constraints on interactions rather than informal behavioral or chosen conducts that also play a role.

This article reexamines the relationship between labor productivity and trade openness and institutions, favoring labor productivity over income because of an interest in the productive performance of economies rather than on income or living standards, although clearly all are closely related with their divergence depending on unemployment, demographic structure (dependency), and labor force participation. Our estimating approach follows the literature in employing instruments for trade openness and institutions. The main innovation is that we employ repeated cross sections compared to a single cross section of one year (usually 1985) widely used in this literature thus far. This permits a consideration of a wider a range of sensitivity and robustness analyses relating to the finding that countries that trade more experience higher levels of income.

Fixed- and random-effects and system-GMM panel estimation methods are used to address potential biases associated with cross-section estimations such as small sample bias, omitted variable problems, and endogeneity of explanatory variables. Furthermore, we use rich data sets for our trade and institutions instruments, removing any need to rely on imputation of missing data.

3. Estimation Approach

In our approach Labor Productivity is determined by the amount of trade a country engages in, own country size (measured by Population and physical Area), Institutional Quality, with geographical control variables also included, as follows, for the benchmark year:

$$\log\left(\frac{PPPGDP_{it}}{Workforce_{it}}\right) = \alpha_i + \alpha_1 Trade_{it} + \alpha_2 \log Pop_{it} + \alpha_3 \log Area_i + \alpha_4 IQual_{it} + \alpha_5 X_{it} + u_{it}, \qquad (3.1)$$

[11] The authors are grateful to Jim Gwartney and Bob Lawson for making the data available at http://www.freetheworld.com.

where $PPPGDP_{it}/WORKFORCE_{it}$ denotes Labor Productivity per worker in country *i*. *Trade* denotes measures of Openness, and we consider both nominal and real Openness here.[12] As Openness is measured relative to GDP, it offers one indicator of the importance of the size of the economy for economic performance. Two further measures indicate economy size: *Pop* represents domestic scale of production measured as population, and *Area* denotes the land area in square kilometers. These are included because the size or scale of a country impacts not only its propensity to trade externally but also internally (see Frankel and Romer 1999, p. 380); a larger country would be expected to offer more opportunities for within-country trade. Hence, a further geography-based test of trade's impact is considered by examining whether intracountry trade increases productivity, focusing on whether larger countries, measured by population, generate higher productivity. *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 taken from the Penn World Tables, 6.2 (Heston, Summers, and Aten 2006). Area is taken from the *World Development Indicators* (2005) of the World Bank.

Our measure of Institutional Quality for the period 1980–2000 is sourced from the Economic Freedom of the World Index (EFWI). Data are available annually beginning in 2000, and so we use data for 1980, 1985, 1990, 1995, and 2000 for our purposes. We build a subindex that is based on four of the five components of the EFWI. We exclude freedom to trade internationally, because this component is closely associated with openness. Although the EFWI is built using perception-based[13] indicators, and thus measures the perceived level of institutional quality, we use it in the empirical analysis for two reasons. Not only is it available since the early 1980s, meeting our time dimension requirements, but it also covers both developed and developing countries we wish to include in our sample and, being based on a large number of different sources, reduces potential data bias. We are aware of the weaknesses of the data in the early years of the sample, and this is taken into account when evaluating results. Our selected variables allow us to take a minimum of 98 countries for which required data are available for 1980, 1985, and 1990. For 1995 and 2000 data a further 14 countries are available (see Appendix Table A1). As our sample is very close to the 98-country sample used in Frankel and Romer (1999) and Noguer and Siscart (2005), we are able to compare our results with their findings.

To instrument 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.[14] We find the population share speaking English statistically significant and include it with geography control variables including distance from the equator (measures used in Hall

[12] Real openness is national imports plus exports (in US$) divided by national GDP in PPP US$.

[13] Kaufmann, Kraay, and Mastruzzi (2006) argue that perceptions-based data provide valuable insights relative to objective data on governance.

[14] 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 eighteenth and nineteenth centuries as an instrument.

and Jones, 1999)[15] and continent dummies for Europe, Africa, and Asia-Pacific, where the omitted dummy represents America.

To develop our instrument for trade, Frankel and Romer's (1999) method is followed where a gravity equation is used to estimate bilateral trade shares based on countries' geographic characteristics and size. The data set used is a panel data set of bilateral trade flows across 178 countries for each year we consider between 1975 and 2000 (i.e., annual data). The data are from Rose (2005).[16] This represents a substantial increase on the data set used by Frankel and Romer (1999), Rodriguez and Rodrik (2001), and Noguer and Siscart (2005) of approximately 100 countries to instrument for trade.

In our specification of the bilateral trade equation the dependent variable is total trade 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, we include trading partners' dummies as proxies for multilateral resistance terms, which Anderson and van Wincoop (2003) argued must be included to have a theoretically justified gravity-model specification. Thus, the gravity equation we estimate is given by

$$\begin{aligned}\ln(Trade_{ijt}/PPPGDP_i) &= \gamma_i + \chi_j + \varphi_t + \beta_1 \ln Pop_{it} + \beta_2 \ln Pop_{jt} + \beta_3 \ln(A_i A_j) + \beta_4 \ln Dist_{ij} + \beta_5 Landl \\ &\quad + \beta_6 Lang_{ij} + \beta_7 Adj_{ij} + \beta_8 Island_{ij} + \beta_9 Comcol_{ij} + \beta_{10} Currcol_{ij} + \beta_{11} CU_{ij} \\ &\quad + \beta_{12} Colony_{ij} + \beta_{13} RTA_{ijt} + \beta_{14} Gw1 + \beta_{15} Gw2 + \beta_{16} Gsp + \mu_{ijt}, \end{aligned} \tag{3.2}$$

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 that is unity if *i* and *j* have a common language and zero otherwise, *Adj* is a dummy variable that 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 a dummy variable that is unity if *i* and *j* were ever colonies after 1945 with the same colonizer, *Currcol* is a binary variable that is unity if *i* and *j* are colonies at time *t, CU* is a binary variable that is unity if *i* and *j* use the same currency at time *t, Colony* is a binary variable that is unity if *i* ever colonized *j* or vice versa, *RTA* is a binary variable that is unity if *i* and *j* belong to the same regional trade agreement, *Gw*1 and *Gw*2 are binary variables that are unity if *i* and *j* are GATT/WTO members, respectively, and *Gsp* is a binary variable that is unity if *i* extends the GSP to *j* or vice versa. Here μ_{ijt} represents other omitted influences in bilateral trade.

The aggregated bilateral trade shares predicted by the gravity equation provide a geography-based instrument for trade for each of the countries we include in the estimation of our productivity equation (Appendix Figure A1 offers a plot of predicted trade shares and real openness).

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[15] The authors are grateful to Robert Hall for making the data available at http://stanford.edu/*rehall/index_files/Page1379.htm.

[16] The authors are grateful to Andrew K. Rose for making the data available at http://faculty.haas.berkeley.edu/arose/RecRes.htm#Trade.

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 the log of *Openness* and the log of *Real Openness* is high at 0.73. The log of *Real Openness* is more highly correlated with log *Labor Productivity* than *Openness* (compare 0.60 and 0.28).

The results of testing for the Balassa-Samuelson effect are provided in Table 2. We regress the price level on *Real Openness* and other variables included in the productivity equation. Both fixed-effects and random-effects two-stage-least-squares (2SLS) estimations were conducted, and all geography controls and a constant were also included. Results indicate that *Real Openness* has a highly significant positive effect on the price level for specifications including and excluding institutional quality, confirming the trade-related Balassa-Samuelson effect in our sample. Our range of coefficients on Real Openness (between 0.53 and 0.71) is higher than that estimated in Alcala and Ciccone (of 0.31), indicating the highly positive impact of a geography-based instrument of trade on the price level and emphasizing the need to take it into account.

Instruments Estimation

Table 3 contains the first-stage regression results for *Real Openness* and for our measure of *Institutional Quality*. Our geography-based trade instrument is a statistically significant determinant (1%) of Real Openness in all periods, when controlling for population, area, distance from equator, fraction of population speaking English, and the continental dummies. The *F*-statistic for the hypothesis that our instrument can be excluded from the regression is statistically significant over all periods, indicating the appropriateness of its inclusion.

Results of the first-stage regression for our proxy of Institutional Quality indicate that the fraction of population speaking English (englfrac) is statistically significant for all time periods, except 1980. *Distance to the equator* is statistically significant in all periods but 2000. Neither *Population* nor *Area* is significant.[17] Notably, the *F*-statistic is consistently lower in results when compared with those for log real openness, indicating the instruments are weaker in this case.[18] Still, the hypothesis that our instrument can be excluded from the regression finds no support over all periods.

Productivity, Institutions, and Trade

We present cross-section results for our five selected years (1980, 1985, 1990, 1995, 2000) to consider the stability and evolution of the estimated coefficients. Table 4 reports our results using 2SLS estimation[19] when examining the effect of trade on labor productivity.

We find that in 1980 *Institutional Quality* and two of the continent dummies are statistically significant in explaining labor productivity. Results for 1985 reveal the same two continent dummies *Area* and *Institutional Quality* as statistically significant. In these two years, 1980 and 1985, trade measured as real openness does not have an explanatory role for labor

[17] The fraction of population speaking one of the main five languages in Europe was initially included, but it was always insignificant and was not included in the final regressions.

[18] We also used the variable "legal origin" as an additional instrument for institutional quality (http://rru.worldbank.org/Documents/DoingBusiness/2004/DB2004-full-report.pdf) with no significant change in results.

[19] The Stata command ivreg2 with the gmm2s, small, and robust options was used for the estimations.

Table 1. Descriptive Statistics and Correlation Matrix

Variable	Obs	Mean	Std Dev	Min	Max
lprod	555	9.27209	1.11945	6.85246	11.6479
open	559	73.4748	49.7812	9.94422	425.34
lopen	559	4.12493	0.58218	2.29699	6.05289
ropen	555	69.68	46.2731	10.2804	377.685
lropen	559	3.40754	0.83189	1.27318	5.8701
lpop	568	9.15956	1.62302	4.9727	14.0486
IQual	505	5.81374	1.28449	2.1	9.23
efwi	521	5.76781	1.31381	2.5325	9.262

	lprod	lropen	lopen	lpop	larea	IQual	efwi	lgrav	ldisteq	daustrasia	dafrica
lprod	1.000										
lropen	0.5956	1									
lopen	0.2774	0.7321	1								
lpop	−0.1229	−0.4706	−0.587	1							
larea	−0.1636	−0.4366	−0.6067	0.678	1						
IQual	0.6419	0.5235	0.3602	−0.0329	−0.1903	1					
efwi	0.6488	0.5152	0.3393	−0.0161	−0.1724	0.9943	1				
lgrav	0.5443	0.6409	0.5095	−0.3994	−0.5427	0.381	0.3668	1			
ldisteq	0.5	0.1559	−0.0443	0.1052	0.0756	0.3106	0.3139	0.3418	1		
daustrasia	−0.0012	−0.0565	−0.0018	0.3074	0.0281	0.1212	0.121	−0.2135	0.0236	1	
dafrica	−0.6184	−0.2006	−0.0399	−0.0994	0.1065	−0.4263	−0.4338	−0.3271	−0.4617	−0.3288	1
deurope	0.4784	0.3691	0.1424	−0.0323	−0.1219	0.2962	0.2984	0.5968	0.5243	−0.3022	−0.3501

Here lprod is log of real labor productivity, GDP per person employed; open and ropen are openness and real openness: lopen and lropen are the same variables in logs; lpop is the log of population, larea is the log of area in square kilometers, and IQual is the institutional quality index proxied with the EFW index; efwi is constructed using four components of the EFW index, excluding freedom of trade; lgrav denotes the bilateral trade shares predicted by the gravity equation; ldisteq is the distance from the equator. daustrasia, dafrica, deurope are regional dummies that take the value of one when a given country is located in the region, and zero otherwise.

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

	Without IQual		With IQual	
Dep. Var. lprice	Fe	Re	Fe	Re
lropen	0.552*	0.527*	0.691*	0.712*
	2.723	4.301	2.961	9.653
lpop	−0.611+	0.047	−0.337	0.115*
	−2.161	1.039	−0.925	3.991
larea		0.080*		0.053*
		3.133		2.981
ldisteq		0.002		0.018
		0.047		0.582
daustrasia		−0.168		−0.250*
		−1.524		−3.178
dafrica		0.041		−0.097
		0.354		−1.34
deurope		0.016		−0.084
		0.122		−0.834
y85	−0.061	−0.146+	−0.019	−0.053
	−0.851	−2.373	−0.254	−1.282
y90	0.033	−0.184*		−0.080+
	1.007	−2.839	0.003	−2.347
y95	0.046>	−0.325*	−0.065	−0.196*
	1.736	−3.771	−1.021	−6.349
y2000		−0.529*	−0.150>	−0.311*
		−3.952	−1.952	−9.471
IQual			−0.063	0.171>
			−1.234	1.747
cons	8.080*	−0.023	4.694	0.003
	2.65	−0.035	1.146	0.006
R^2	0.639	0.537	0.648	0.637
N	492	492	544	544
F_f			8.540	8.6689
F_fp			0.000	0.000
Hausman	1.18		20.33	
Prob.	0.97		0.002	

T-statistics are reported below each coefficient, and >, +, and * denote statistical significance at the 10%, 5%, and 1% levels, respectively. The dependent variable is lprice, the log of the price level. Fe denotes fixed effects estimation, and Re denotes random effects estimation. lropen is real openness defined as the log of trade at exchange rate US$ relative to GDP at PPP US$. This variable is instrumented with the trade shares predicted by the gravity equation; lpop is the log of population, and ldisteq is the distance from the equator. daustrasia, dafrica, and deurope are regional dummies that take the value of one when a given country is located in the region, and zero otherwise. IQual is institutional quality instrumented using four components of the EFW index, excluding freedom of trade. F_f is the *F*-statistic for the first stage regression, and F_fp is the associated probability. Hausman is a Hausman test for which the null hypothesis is orthogonality between the regressors and the unobserved heterogeneity, and Prob. denotes the associated probability.

productivity, and the amount of variance explained by our regressors is the lowest across our sample periods. For 1990 and 1995 *Institutional Quality* retains significance in explaining productivity as well as *Real Openness* and two *continent dummies*. For 2000, *Real Openness, Institutional Quality,* and the Africa dummy display statistically significant coefficients (1%). The impact of a 1% change in trade (openness) on productivity is estimated at between 0.58% and 0.67%, which is an economically significant impact on labor productivity. Our measured impact lies below the range of estimates of around 1% (for 1985) presented in Noguer and

Table 3. First-Stage Regressions

	For Real Openness					For IQual				
	1980	1985	1990	1995	2000	1980	1985	1990	1995	2000
lgrav	0.215*	0.270*	0.294*	0.374*	0.435*	0.107	0.155	0.108	0.261>	0.220+
	2.844	4.315	4.187	5.472	7.174	0.791	1.129	0.753	1.728	2.114
lpop	−0.222*	−0.267*	−0.248*	−0.138+	−0.098	0.112	0.151	0.072	0.094	0.115
	−4.251	−5.274	−5.018	−2.484	−1.508	1.131	1.482	0.723	0.893	1.274
larea	0.031	0.052	0.048	0.03	0.009	−0.106	−0.15	−0.093	−0.079	−0.105
	0.553	0.937	0.8	0.489	0.123	−0.87	−1.295	−0.815	−0.715	−1.077
ldisteq	−0.031	0.411	0.942>	−0.507	−0.243	1.769	2.006>	2.086>	1.048	1.649>
	−0.061	0.851	1.817	−0.99	−0.433	1.649	1.792	1.766	0.966	1.945
englfrac	0.267>	0.268>	0.253	0.464*	0.489*	0.6	1.016+	1.023+	1.070+	1.117*
	1.842	1.712	1.639	2.925	3.087	1.185	2.003	2.059	2.377	2.896
daustrasia	0.462*	0.469*	0.584*	0.347>	0.219	0.195	0.532	0.466	0.231	−0.209
	2.914	2.715	3.065	1.913	1.174	0.527	1.374	1.252	0.697	−0.742
dafrica	0.490*	0.118	0.00	0.07	−0.218>	−0.535+	−0.175	−0.450>	−0.796*	0
	3.473	0.873	.	0.497	−1.748	−2.191	−0.64	−1.708	−2.934	.
deurope	0.551+	0.262	0.339	0.489+	0.24	−0.132	0.152	0.216	−0.447	0
	2.201	1.218	1.408	2.12	1.07	−0.263	0.302	0.386	−0.905	.
cons	3.287*	2.818*	2.460*	1.497>	0.938	4.400+	3.988+	4.672*	4.031+	4.798*
	3.381	3.444	2.716	1.786	1.163	2.547	2.42	2.769	2.311	3.548
R^2	0.415	0.533	0.531	0.462	0.6	0.216	0.295	0.309	0.28	0.376
N	104	105	105	119	111	100	100	100	107	101
F	14.888	21.534	28.567	21.462	37.607	6.461	8.553	10.327	7.087	10.236
aic	187.924	174.519	192.637	226.890	195.068	309.255	311.262	314.676	331.023	264.368
bic	211.724	198.404	216.523	251.902	219.454	332.701	334.708	338.122	355.078	287.904
rmse	0.573	0.533	0.581	0.605	0.560	1.088	1.099	1.118	1.092	0.858

T-statistics are reported below each coefficient, and >, +, and * denote statistical significance at the 10%, 5%, and 1% levels, respectively. lgrav denotes the bilateral trade shares predicted by the gravity equation; lpop is the log of population, larea is the area of the country in natural logs, and ldisteq is the distance from the equator in natural logs. englfrac is the fraction of inhabitants that speak English. dafrica, deurope, and daustrasia are regional dummies that take the value of one when a given country is located in the region, and zero otherwise.

Table 4. Instrumental Variables Results (2SLS)

	1980	1985	1990	1995	2000
lropen	0.631	0.225	0.667+	0.602>	0.579+
	0.955	0.450	2.006	1.911	2.447
IQual	0.590>	0.524+	0.365+	0.411+	0.535*
	1.67	2.207	2.229	2.541	3.189
lpop	−0.015	−0.095	0.082	0.016	0.034
	−0.09	−0.594	0.976	0.242	0.568
larea	0.099	0.102>	0.04	0.08	0.064
	1.35	1.685	0.87	1.54	1.066
ldisteq	0.167	0.127	0.102	0.161	0.128
	1.127	1.178	0.984	1.51	1.206
daustrasia	−0.759+	−0.565+	−0.663*	−0.312>	−0.172
	−2.411	−2.413	−3.272	−1.728	−1.002
dafrica	−1.082>	−0.902*	−0.881*	−0.606*	−0.551+
	−1.95	−3.545	−3.541	−2.737	−2.447
deurope	−0.402	−0.016	−0.301	0.032	0.002
	−0.806	−0.056	−1.137	0.124	0.01
cons	3.588	5.977*	4.411*	4.205*	3.340*
	1.557	3.048	3.192	3.653	3.221
R^2	0.427	0.557	0.689	0.684	0.727
N	98	98	98	106	101
J	0.938	3.563	2.079	1.379	1.205
Jp	0.333	0.059	0.149	0.240	0.272
estat	8.572	4.420	4.323	7.022	5.855
estatp	0.014	0.110	0.115	0.030	0.054

T-statistics are reported below each coefficient, and >, +, and * denote statistical significance at the 10%, 5%, and 1% levels, respectively. Dependent variable lprod is log of real labor productivity, GDP per person employed; lropen is real openness defined as the log of trade at exchange rate US$ relative to GDP at PPP US$; IQual is institutional quality constructed using four components of the EFW index; lpop is the log of population; larea is the area of the country in natural logs, and ldisteq is the distance from the equator in natural logs. dafrica, deurope, and daustrasia are regional dummies that take the value of one when a given country is located in the region, and zero otherwise. Hansen J test of overidentifying restrictions, acceptance of the null hypothesis, indicates that the instruments are valid (results indicate acceptance of H_0). The last two rows report the Durbin-Wu-Hausman of endogeneity of lropen and IQual and the associated probability of acceptance (the results from the tests indicate rejection of H_0). OLS results are provided in the Appendix for comparison.

Siscart (2005): Their coefficient on trade varied with inclusion of alternative measures of institutional quality, including the International Country Risk Guide Index,[20] corruption (one element in the ICRG), and constraints on the executive from Acemoglu, Johnson, and Robinson (2001). Our results for 1990, 1995, and 2000 are more robust than those obtained in our earlier years, as indicated by improved explanatory power and the *F*-statistic.[21]

Having controlled for trade, institutions, and scale/size effects, our continent dummies indicate that labor productivity is lower in the African continent and in Asia-Pacific than in North America, our default dummy. The evolution over time shows that in Africa and Asia-

[20] An average of five indicators of the quality of public governance: (1) the extent of government corruption, (2) efficacy of the rule of law, (3) perceived efficiency of the government bureaucracy, (4) perceived risk of repudiation of contracts by the government, and (5) average protection against expropriation risk sourced from IRIS Centre (University of Maryland), from monthly International Country Risk Guide (ICRG) data provided by Political Risk Services Group.

[21] We examined the possibility of separating the elements contained in the aggregated Economic Freedom of the World index, but issues of high correlation precluded their simultaneous inclusion in estimations.

Pacific the negative differential has somewhat decreased, with the latter dummy no longer significant in 2000.

For completeness, we also ran OLS regressions for each year using the two alternative measures for the openness variable, with our results provided in Appendix Table A2. Our estimated impact on productivity of a 1% change in trade lies between 0.5% and 0.54%, again both statistically and economically significant. The coefficients are generally more precisely estimated under OLS than under 2SLS, because the standard errors are almost always lower. We perform Durbin-Wu-Hausman tests of the hypothesis that *Openness* and *Institutional Quality* are uncorrelated with the residuals, and thus OLS are unbiased. For most of the coefficients and years we can marginally reject the hypothesis that the OLS and the 2SLS estimates are equal: Results from diagnostic tests are shown in the last two rows of Table 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 we interpret the findings from the analysis accordingly.

Similarly to Frankel and Romer (1999), our results show that the IV and OLS estimates of the trade impact never differ substantially and that moving from OLS to IV increases the estimated impact of both trade and country size on productivity. Interestingly, with respect to institutional quality, moving from OLS to IV significantly increases the estimated impact of this variable on labor productivity in our yearly estimations.[22]

We also present results for the whole panel (an unbalanced panel with a maximum of 512 observations), permitting us to estimate an "average effect" by running a single regression incorporating individual effects and time dummies for the five years analyzed. Both *Real Openness* and *Openness* (nominal) were treated as alternative dependent variables and compared over several alternative specifications. Results are shown in Table 5.

We first estimated a pooled-OLS model (1) with time effects (see columns 2 and 9 for *Real Openness* and *Openness,* respectively). In order to control for unobserved heterogeneity we also estimated the whole panel using a within-2-ways fixed-effects (fe) estimator and the generalized least squares random-effects (re) estimator (fe and re results are presented in columns 3 and 4 for *Real Openness;* 10 and 11 for *Openness*). A Breusch-Pagan test indicates that we may reject the null hypothesis of zero variance of the individual effects, and, therefore, the re model is preferred to the pooled model. However, a Hausman test indicates that we reject the null hypothesis of orthogonality between the random effects and the regressors, implying that only the fe estimates are consistent.

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[22] We also used 3SLS estimation, which provides a comprehensive and, arguably, more complete estimation method across the system of equations that characterize the relationships among our variables of interest. To conserve space these results are available from the authors on request. By using 3SLS we further control for 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. Although we observe that some of the coefficients are higher in magnitude than those obtained with the 2SLS method (Real openness and Area), our main results are unchanged in that Real Openness, Institutional Quality, Area, and Distance, and the continent dummies are statistically significant variables in explaining labor productivity, whereas population is not. The size of the impact of trade on labor productivity is higher according to this method at 0.7% for a given 1% change.

Table 5. Panel-Estimate Comparisons of Real Openness (RO) and Nominal Openness

	RO						NO					
	Pool	Fe	Re	HT	IVre	GMM System	Pool	Fe	Re	HT	IVre	GMM system
lropen	0.136*	0.035*	0.136*	0.067+	0.586*	0.159+	0.106+	0.087+	0.106*	0.083+	1.276>	−0.001
	3.404	3.204	4.478	2.31	3.921	2.58	2.037	2.206	2.626	2.172	1.737	−0.016
IQual	0.044*	0.023*	0.044*	0.023>	0.063>	0.051*	0.049*	0.024>	0.049*	0.027>	0.076	0.080*
	2.584	7.498	2.86	1.651	1.643	3.141	3.091	1.703	3.278	1.928	1.42	8.108
lpop	−0.132+	−0.526*	−0.132*	−0.246*	0.051	0.026+	−0.192*	−0.568*	−0.192*	−0.289*	−0.033	0.009
	−2.474	−16.836	−2.727	−3.834	0.563	2.335	−3.628	−5.662	−3.832	−4.642	−0.249	0.892
larea	0.047		0.047	0.102>	0.018	0.008	0.077		0.077>	0.131+	0.182+	−0.003
	1.071		1.164	1.771	0.351	0.826	1.576		1.766	2.213	2.001	−0.357
ldisteq	0.197+		0.197*	0.178>	0.200+	0.042+	0.194+		0.194*	0.176>	0.205>	0.013
	2.428		2.879	1.741	2.376	2.05	2.327		2.609	1.65	1.794	1.193
daustrasia	−0.145		−0.145	−0.02	−0.436>	−0.012	−0.07		−0.07	0.031	−0.498	0.037
	−0.814		−0.799	−0.074	−1.805	−0.289	−0.352		−0.355	0.113	−1.268	1.195
dafrica	−1.161*		−1.161*	−1.224*	−1.126*	−0.136	−1.178*		−1.178*	−1.237*	−1.319*	0.015
	−6.701		−6.963	−4.902	−5.388	−1.626	−6.252		−6.477	−4.767	−4.535	0.348
deurope	0.286>		0.286	0.381	−0.07	0.022	0.374+		0.374>	0.426	0.016	0.059*
	1.739		1.566	1.403	−0.275	0.642	2.112		1.894	1.517	0.042	3.055
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
lprod (−1)						0.802*						0.526*
						13.406						26.661
N	512	512	512	512	474	395	512	512	512	512	474	395
R^2	0.600	0.216	0.600		0.707		0.552	0.223	0.552		0.515	
Breusch Pagan			699.43		J	33			712.8		j	33
Prob.			0		ar1p	0.003			0		ar1p	0.000
Hausman			−300.5		ar2p	0.818			−42.61		ar2p	0.355
Prob.			0		Hansenp	0.590			0		Hansenp	0.170

T-statistics are reported below each coefficient, and >, +, and * denote statistical significance at the 10%, 5%, and 1% levels, respectively. Dependent variable lprod is log of real labor productivity, GDP per person employed. lropen is real openness defined as the log of trade at exchange rate US$ relative to GDP at PPP US$, IQual is institutional quality constructed using four components of the EFW index, lpop is the log of population, larea is the area of the country in natural logs, and ldisteq is the distance from the equator in natural logs. dafrica, deurope, and daustrasia are regional dummies that take the value of one when a given country is located in the region, and zero otherwise. Breusch Pagan is a test for zero variance of the time-invariant component of the error term (random effects), and Breusch Pagann Prob is the associated probability that indicates rejection of the null. Hausman is a Hausman test for which null hypothesis is orthogonality between the regressors and the unobserved heterogeneity, and Prob. denotes the associated probability.

We find that most of the variability of the data is across countries rather than within countries, because the within-country variability is substantially reduced (R^2 remains around 0.22).

The main difficulty in controlling for the endogeneity of some of the regressors in a panel-data model with fixed effects is that most of the available instruments for the institutional quality variable are time invariant, preventing us from using an instrumental variable estimator with fixed effects, because in this case we are able to explain only the within variation of the dependent variable not being able to obtain coefficients for the time-invariant variables or to use instruments that are time invariant.

We consider three approaches to deal with these issues. First, the Hausman-Taylor estimator can be computed that lies between the within-fixed effects and the GLS-random-effects estimators and considers some variables as endogenous and correlated with the unobserved heterogeneity, while treating others as exogenous. The endogenous variables are then instrumented by using the values of the given variables averaged over time. We consider *Openness* and *Institutional Quality* as endogenous and the rest of regressors as exogenous. The results are presented in columns 5 and 11. A second option is to consider a GLS-2SLS-random-effects model that uses external instruments for the endogenous variables, results for which are presented in columns 6 and 12. Finally, the third option is to eliminate the unobserved heterogeneity by taking first differences of the time-variant variables and estimate the model by using the generalized method of moments (GMM). Because we are also interested in our time-invariant regressors, we specified a system of two equations: one with the variables in levels and the other with the variables in first differences. As valid instruments for two of the endogenous variables (lagged productivity and institutional quality) we use lagged values of the given variables in levels for the equation in first differences and in differences for the variables in levels. For Openness we continue to use the ''gravity-derived'' instrument. Column 7 shows the results when a GMM system is estimated. This last model is specified as a dynamic model, because the corresponding static model did not pass the specification test, and, therefore, the lagged dependent variable is also introduced as a regressor.

We conclude that the best estimates with inclusion of *Real Openness* are the GMM system with time effects. There is support for a statistically significant impact of *Institutional Quality* on productivity in almost all specifications including *Openness* or *Real Openness. Real Openness* appears as statistically significant in all specifications. *Distance from the equator* remains statistically significant across specifications. *Population* is also statistically significant in most cases, indicating this measure of economy size/scale also explains productivity performance. *Area,* while significant using *Openness* in three specifications, is insignificant when *Real openness* is included in the specification, offering limited support for the role for scale, available resources, and perhaps internal trade in explaining productivity.

An interesting aspect of our results is that in some of the panel estimations (fe, re, and HT in Table 5) we find *Population* negatively signed and significant, whereas *Area* is positively signed and significant (re and HT in Table 5). A larger area can have a positive impact on productivity through increased natural resources and/or a negative effect via lower intracountry 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). From the panel results presented in Table 5 we identify a negative scale effect in part of our results, because the coefficient of population is greater in magnitude than the coefficient on area. However, this result is not found in the

GMM system estimations because only population is significant and the effect is positive rather than negative.

Robustness

First, we tested for the robustness of our results to the inclusion of outliers. The results of our sensitivity analysis using the GMM system estimator are provided in Table 6.[23] Statistical significance of *Real Openness* appears robust (although in the case of non-OECD countries, the confidence level is 10%). Findings for *Institutional quality* indicate statistical insignificance in the case of OECD countries, which may result from the nature of the instrument and its measurement, or indicate that these countries have reached the critical level of institutional quality beyond which changes generate no measurable impact on labor productivity. Rodrik (2006) used the term ''binding constraints'' to describe such impacts. *Population* is significant and positively signed, and *Area* remains statistically insignificant over the entire set of analyses. *Distance from the equator* is not statistically significant in most cases.

We also investigated whether countries with a low *Institutional Quality* (20% lowest scores) benefit less in labor productivity terms from trade than countries with higher scores (Bormann, Busse, and Neuhaus 2006). We created a dummy variable (*DIQual*) that takes a value of one if a country belongs to the 20% bottom quintile, and equals zero otherwise. We interact this dummy with *Real Openness* and add both to the list of explanatory variables. The new specification is given by

$$\log\left(\frac{PPP\,GDP_{it}}{Workforce_{it}}\right) = \alpha_i + \alpha_1 Trade_{it} + \alpha_2 \log DScale_{it} + \alpha_3 \log Area_{it} + \alpha_4 IQual_{it} + \alpha_5 X_i + + \alpha_6 DIQual_{it} + \alpha_7 Trade_{it} \times DIQual_{it} + u_{it}. \tag{4.1}$$

Column 6 of Table 6 shows both trade and institutional quality variables have a positive influence on productivity; the coefficients are both significant at the 1% level. The dummy *DIQual* and the interactive term *Trade*DIQual* are both insignificant, showing no evidence that trade has a negative impact on productivity in the countries with low-quality institutions.

We reestimated the extended model for alternative threshold levels but increasing it to 30%, 40%, and 50% did not change the results—the interactive term was always insignificant. Contrary to Bormann, Busse, and Neuhaus (2006) we find no evidence that countries with the worst quality of institutions are unable to benefit from trade.

We also recognize that it is possible that the importance of trade in explaining labor productivity may also be related to country size. A large country might be closed to trade but still maintain high productivity because of the internal, within-country opportunities for trade. The corollary is that a small country that is closed may suffer large relative productivity losses. This possibility calls for an interaction term between trade and country size. The last column of Table 6 estimates the model adding such an interaction term. The negatively signed coefficient indicates that trade has a positive effect on labor productivity, but this effect decreases for more populated countries.[24] Although the impact is small, measured as a coefficient of -0.07 (relative to the estimated effect of trade on productivity of 0.77), it does provide support for the argument that market size confers productivity advantages on larger countries that would be

[23] Results for each of the five years are not provided here but were similar.
[24] We thank a referee for suggesting this extension.

Table 6. Sensitivity Analysis: Productivity Equation for Different Subsamples and for the Extended Model (GMM System)

	GMMS[a]	HKLS[a]	OECD	Non-OECD	Extended Model 1	Extended Model 2
lprod (−1)	0.802*	0.835*	0.847*	0.883*	0.819*	0.839*
	13.406	14.395	43.351	17.596	13.572	12.468
lropen	0.159+	0.125+	0.104+	0.101>	0.134+	0.771+
	2.58	2.055	2.1	1.454	2.154	2.194
IQual	0.051*	0.051*	−0.008	0.097*	0.059*	0.038>
	3.141	3.397	−0.349	6.46	3.582	1.76
lpop	0.026+	0.027+	0.029*	0.033>	0.024+	0.245>
	2.335	2.446	4.681	1.773	2.478	1.956
larea	0.008	0.001	0.011	0.01	0.006	0.003
	0.826	0.073	1.197	0.98	0.685	0.266
ldisteq	0.042+	0.044+	0.133>	0.015	0.038+	0.034
	2.05	2.209	2.051	0.828	2.003	1.434
daustrasia	−0.012	−0.001	0.101	−0.01	−0.014	−0.05
	−0.289	−0.036	1.614	−0.165	−0.375	−0.669
dafrica	−0.136	−0.096		−0.026	−0.117	−0.068
	−1.626	−1.241		−0.409	−1.459	−0.72
deurope	0.022	0.021	0.02	0.139*	0.027	0.022
	0.642	0.65	0.28	3.15	0.858	0.438
y90	0.008	0.009	0.014	−0.002	0.011	0.012
	0.506	0.558	1.274	−0.099	0.665	0.801
y95	−0.036>	−0.029	−0.033+	−0.048+	−0.032	−0.022
	−1.917	−1.519	−2.419	−2.28	−1.653	−1.18
y2000	0.002	0.008	0.085*	−0.065*	−0.001	0.024
	0.092	0.392	4.058	−3.059	−0.048	1.177
dIQual					−0.034	
					−0.146	
tdIQual					0.035	
					0.407	
tlpop						−0.066+
						−2.031
cons	0.819+	0.701>	0.951*	−0.144	0.726>	−1.486
	1.99	1.785	3.665	−0.439	1.761	−1.507
N	395	387	98	288	395	395
j	33	33	32	34	35	34
ar1p	0.003	0.001	0.011	0.001	0.001	0.000
ar2p	0.818	0.735	0.976	0.896	0.745	0.385
hansenp	0.590	0.330	0.940	0.518	0.415	0.875

T-statistics are reported below each coefficient, and >, +, and * denote statistical significance at the 10%, 5%, and 1% levels, respectively. Dependent variable lprod is log of real labor productivity, GDP per person employed. lropen is real openness defined as the log of trade at exchange rate US$ relative to GDP at PPP US$, IQual is institutional quality constructed using four components of the EFW index, lpop is the log of population, larea is the area of the country in natural logs, and ldisteq is the distance from the equator in natural logs. dafrica, deurope, and daustrasia are regional dummies that take the value of one when a given country is located in the region, and zero otherwise. dIQual is a dummy that takes the value of one when the IQual variable belongs to the lower 20% quintile of the distribution. tdIQual = dIQual * lropen and tlpop = lpop * lropen.

[a] HKLS denotes Hong Kong, Luxembourg, and Singapore, which we omitted as outliers from our data sample (following Frankel and Romer 1999), with marginal impact on the coefficient for trade and no impact on the coefficient for Institutional Quality.

difficult if not impossible for smaller countries to imitate, irrespective of their propensity to trade.[25]

Finally, to compare our results with previous research Table 7 presents findings using 1985 data to allow for a comparison with Frankel and Romer (1999) and Noguer and Siscart (2005). Models 1 and 2 in Table 7 are comparable to models 1 and 2 in Noguer and Siscart (2005, p. 450) and to Frankel and Romer (1999, p. 387). We obtain generally similar results using our slightly different sample of countries. The trade coefficient is close to unity when the model is estimated using OLS and considering only population and area as additional explanatory variables. In addition, using instrumental variables the coefficient increases to 1.85 in our results (comparable to 1.62 in Frankel and Romer 1999 and 2.59 in Noguer and Siscart 2005). Similar to the findings in Noguer and Siscart (2005) the trade coefficient is significantly reduced when institutional quality is added as an additional regressor (models 5 and 6 in Table 7). Focusing on 1985, our research supports the contention that gains historically attributed to trade capture instead the roles of institutions and geography.

It is clear, however, that inclusion of our preferred measure of trade (preferred in the context of the Balassa-Samuelson effects evident in our sample data) and our preferred measure of Institutional Quality generate, in Model 5, a statistically insignificant coefficient on the trade variable with the dependent variable of living standards. The weight of evidence generated by our estimations in total, however, leads us to conclude that the empirical results for 1985 do not reflect the strong general tendency of trade impacting positively, in its economic significance, on income and productivity. Furthermore, the evidence generated by Model 6 in this table also indicates the importance of the choice of measures of Institutional Quality because with the inclusion of the component representing Legal Structure and Security of Property Rights in the *Economic Freedom of the World* Index, a finding of a statistically significant coefficient on trade results.

5. Summary and Conclusions

Empirically, a range of results using different techniques across different country samples yield alternative results in terms of how trade relates to growth and productivity. We add to this literature using the real openness measure as a determinant of labor productivity applied in a cross-country panel setting and using a rich data set over the 1980–2000 period. Our findings over this period support the conclusion that trade is significantly positively related to labor productivity. Without the addition of geography controls, we find that an upward bias on the coefficient on trade is evident. Similarly if a measure of institutions is omitted, productivity gains attributed to trade are overstated.

[25] We also estimated the extended model specification using OLS and 2SLS yearly and for the whole panel. To conserve space, results are not reported here but are available on request from the authors. When using OLS, the two new variables are almost always insignificant, and trade remains positively associated with productivity levels, in most years, with a higher coefficient. When using 2SLS, the dummy and the interactive term are always insignificant. For the whole panel, the two additional variables are significant (and with the expected signs) when IV-random-effects are employed. However, the Hausman test indicates that only the fixed-effects results are consistent when instrumental variables are not used.

Table 7. Comparison with Other Results: 1985

	M1	M2	M3	M4	M5	M6
Dep. Var.: lgdpp	OLS	IV	IV	IV	IV	IV
lropen	0.933*	1.846*	1.357*	0.892*	0.448	0.582>
	6.101	7.943	5.069	3.177	1.234	1.781
lpop	0.256*	0.412*	0.244*	0.225+	0.03	0.089
	3.392	5.242	2.941	2.5	0.277	1.059
larea	−0.064	0	−0.018	−0.023	0.043	0.025
	−1.018	−0.005	−0.278	−0.357	0.944	0.552
ldisteq			0.312*	0.125	0.138	0.144
			3.147	1.311	1.539	1.625
daustrasia				−0.744*	−0.533*	−0.511*
				−3.222	−2.829	−3.239
dafrica				−1.160*	−0.976*	−1.084*
				−6.56	−5.557	−6.607
deurope				0.095	0.146	−0.241
				0.381	0.642	−1.426
IQual					0.249+	
					2.437	
a2_						0.175*
						3.691
cons	3.440*	−1.674	2.153	4.058+	5.120*	4.887*
	2.962	−1.076	1.17	2.331	3.077	2.629
R^2	0.33	0.038	0.338	0.614	0.705	0.757
N	105	105	105	105	99	94
j		18.765	22.161	6.697	5.955	4.501
jp		0.000	0.000	0.035	0.051	0.105
estat		5.342	0.623	0.757	0.008	0.252
estatp		0.021	0.430	0.384	0.927	0.616

T-statistics are reported below each coefficient, and >, + and * denote statistical significance at the 10%, 5%, and 1% levels, respectively. Dependent variable lgdpp is log of real GDP per person (from Penn World Tables 6.2). lropen is real openness defined as the log of trade at exchange rate US$ relative to GDP at PPP US$, IQual is institutional quality constructed using four components of the EFW index, lpop is the log of population, larea is the area of the country in natural logs, and ldisteq is the distance from the equator in natural logs. dafrica, deurope, and daustrasia are regional dummies that take the value of one when a given country is located in the region, and zero otherwise. Hansen J test of overidentifying restrictions, acceptance of the null hypothesis, indicates that the instruments are valid (results indicate acceptance of H_0). The last two rows report the Durbin-Wu-Hausman of endogeneity of lropen and IQual and the associated probability of acceptance (the results from the tests indicate in most cases acceptance of H_0). A2_ is one of the components of the EFWI called "legal structure and security of property rights."

Our finding that trade is a statistically significant explanatory variable for labor productivity across our sample of countries, when geography controls and institutional quality are included, emerges from 1990 onward. The results from our preferred panel estimates suggest that a one-percentage-point increase in trade, measured as real openness, raises productivity by 0.16% in the short term—more modest than in other results—while the coefficient for the long term is 0.80 (0.16/(1−0.80), more in line with previous findings in cross-sectional studies. The size of this coefficient is economically significant because a 1% increase in trade (i.e., real openness) leads to an increase of 0.8% in labor productivity.

Although our findings relate to panel estimation, the results of comparison for 1985 place our results in the context of related research. We conclude that gains historically attributed to trade capture instead the roles of institutions and geography, and the trade coefficient is

significantly reduced when institutional quality is added as an additional explanatory variable in an analysis of living standards (GDP per capita).

Additionally, we find no evidence to imply that countries with the lowest quality institutions do not benefit from trade, although the impact of trade increases when controlling for those countries with lowest institutional quality. Our robustness analysis raises questions about the role of institutions for OECD countries and points to the possibility of these countries having reached a critical level of institutions required to facilitate high labor productivity. This highlights the need for further research.

We find support for a scale effect in our panel regressions (GMM system) as the population variable appears with a statistically significant and positively signed coefficient, in support of a positive effect of country size on labor productivity. Taken together with the finding that our interaction term between trade and country size is decreasing with country size this indicates that the theoretical rationale for inclusion of the variable in terms of an absorption effect finds empirical support here.

We find a robust relationship between institutional quality and labor productivity across our entire sample, being more pronounced in the latter periods. It is possible that data quality issues arise in the 1980s, and we know that few reliable measures for institutions exist that are older than 10 years. In using a composite measure of institutions over the time period of this study we sought to take a comprehensive account of their effect in the trade-productivity relationship. While focusing on individual components was not possible because of correlations of the individual components and trade in our study, further research should target an examination of the nuanced nature of the channels through which these impact on productivity and income.

Empirical studies in this area must grapple further with how best to measure Institutional Quality, given its broad coverage and definition, and attempt to identify more specifically the elements that matter most for income and productivity. Nonetheless, the finding that trade matters significantly for national productivity is a strong result from our analyses.

Appendix

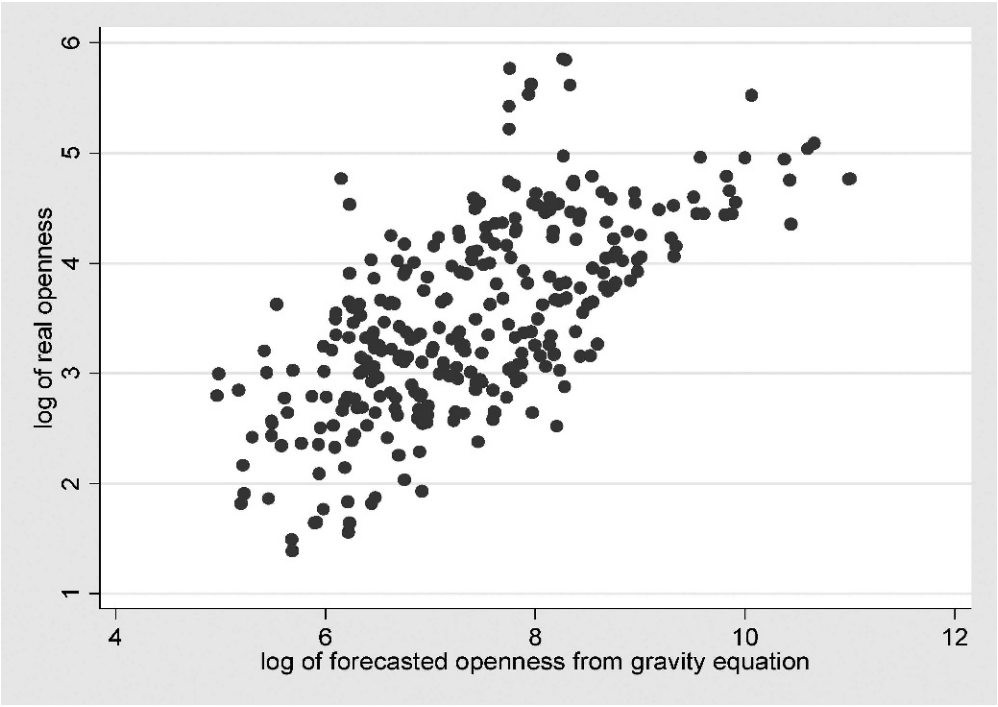

Figure A1. Real Openness (in logs) versus Constructed Trade Measure

Table A1. List of Countries Included in Analyses

List of Countries: 1980–1990		Additional Countries 1995, 2000
Albania	Jordan	Armenia
Argentina	Kenya	Azerbaijan
Australia	Madagascar	Bulgaria
Austria	Malawi	Croatia
Bahamas	Malaysia	Georgia
Bangladesh	Mali	Kazakhstan
Barbados	Mauritius	Kyrgyz Republic
Belize	Mexico	Latvia
Benin	Morocco	Lithuania
Bolivia	Namibia	Luxembourg
Botswana	Nepal	Macedonia
Brazil	the Netherlands	Russia
Burundi	New Zealand	Slovenia
Cameroon	Nicaragua	Ukraine
Canada	Niger	
Chad	Nigeria	
Chile	Norway	
China	Pakistan	
Colombia	Panama	
Congo, Republic of	Papua New Guinea	
Costa Rica	Paraguay	
Cyprus	Peru	
Denmark	Philippines	
Dominican Republic	Poland	
Ecuador	Portugal	
Egypt	Romania	
El Salvador	Rwanda	
Fiji	Senegal	
Finland	Sierra Leone	
France	Singapore	
Gabon	South Africa	
Germany	South Korea	
Ghana	Spain	
Greece	Sri Lanka	
Guatemala	Sweden	
Guinea-Bissau	Switzerland	
Haiti	Syria	
Honduras	Tanzania	
Hong Kong	Thailand	
Hungary	Togo	
Iceland	Trinidad and Tobago	
India	Tunisia	
Indonesia	Turkey	
Iran	Uganda	
Ireland	United Kingdom	
Israel	United States	
Italy	Uruguay	
Jamaica	Venezuela	
Japan	Zambia	

Table A2. OLS Main Results

	Real Openness					Nominal Openness				
	1980	1985	1990	1995	2000	1980	1985	1990	1995	2000
lopen	0.539*	0.500*	0.502*	0.507*	0.540*	0.468*	0.252	0.267>	0.063	0.246>
	3.977	3.343	4.496	4.006	5.261	2.667	1.483	1.788	0.437	1.78
lpop	−0.03	−0.027	0.022	−0.006	0.014	−0.08	−0.114	−0.067	−0.097	−0.053
	−0.416	−0.393	0.411	−0.099	0.287	−1.089	−1.62	−1.014	−1.461	−0.921
larea	0.052	0.071	0.026	0.062	0.051	0.093	0.088	0.054	0.062	0.049
	0.898	1.357	0.527	1.195	1.007	1.548	1.568	1.013	1.091	0.927
IQual	0.154+	0.190+	0.226*	0.251*	0.329*	0.220*	0.276*	0.369*	0.435*	0.527*
	2.097	2.444	3.068	3.239	4.298	3.175	4.152	6.471	8.268	9.27
ldisteq	0.211>	0.168	0.136	0.172	0.155	0.157	0.145	0.159	0.151	0.155
	1.689	1.578	1.296	1.531	1.505	1.295	1.287	1.343	1.213	1.309
daustrasia	−0.639*	−0.462+	−0.498*	−0.266	−0.116	−0.573+	−0.418>	−0.366>	−0.108	−0.054
	−3.227	−2.517	−3.093	−1.575	−0.725	−2.438	−1.923	−1.765	−0.515	−0.268
dafrica	−1.401*	−1.053*	−0.980*	−0.837*	−0.688*	−1.258*	−1.071*	−0.850*	−0.707*	−0.757*
	−6.015	−4.935	−4.971	−4.214	−3.507	−5.796	−5.242	−4.337	−3.535	−3.803
deurope	−0.156	0.041	−0.037	0.036	0.097	0.195	0.245	0.24	0.387>	0.301
	−0.654	0.211	−0.212	0.182	0.523	0.835	1.177	1.229	1.816	1.396
cons	7.079*	6.727*	6.486*	5.986*	5.197*	6.521*	7.377*	6.668*	7.019*	5.320*
	8.394	7.46	10.41	9.735	8.432	5.687	6.29	6.523	7.088	5.593
R^2	0.642	0.655	0.729	0.732	0.762	0.599	0.61	0.672	0.672	0.702
N	98	98	99	107	110	98	98	99	107	110
F	32.636	43.966	67.149	62.611	79.359	30.365	43.811	45.442	36.585	42.110
aic	202.258	196.480	177.189	188.098	187.943	213.452	208.504	195.935	209.587	212.607
bic	225.523	219.745	200.545	212.153	212.247	236.717	231.769	219.291	233.643	236.912
rmse	0.650	0.631	0.567	0.560	0.547	0.688	0.671	0.623	0.619	0.612

T-statistics are presented below coefficients, and >, +, and * denote statistical significance at the 10%, 5%, and 1% levels, respectively. Dependent variable lprod is log of real labor productivity, GDP per person employed. lopen for real openness is the log of trade at exchange rate US$ relative to GDP at PPP US$; for nominal openness lopen is the sum of exports and imports expressed as a fraction of GDP, in nominal terms. IQual is institutional quality proxied with four elements of the Economic Freedom of the World Index, lpop is the log of population, larea is the area of the country in natural logs, and ldisteq is the distance from the equator in natural logs. dafrica, deurope, and daustrasia are regional dummies that take the value of one when a given country is located in the region, and zero otherwise.

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