Trade and Productivity

by

Francisco Alcalá
Universidad de Murcia

and

Antonio Ciccone
Universitat Pompeu Fabra, CEPR, and IZA

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Abstract: We estimate the effect of international trade on average labor productivity across countries. Our empirical approach relies on a summary measure of trade that, we argue, is preferable to the one conventionally used on both theoretical and empirical grounds. In contrast to the marginally significant and non-robust effects of trade on productivity found previously, our estimates are highly significant and robust even when we include institutional quality and geographic factors in the empirical analysis. We also examine the channels through which trade and institutional quality affect average labor productivity. Our finding is that trade works through labor efficiency, while institutional quality works through physical and human capital accumulation. We conclude with an exploratory analysis of the role of trade policies for average labor productivity. (JEL F43, O40)

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1 Introduction

Theories about international trade increasing aggregate productivity at the country level are nearly as old as economics. But how large is this effect empirically? Answering this question is difficult because any particular summary measure of trade is likely to miss some aspects of how trading activities affect countries' productivity. Moreover, while international trade may increase aggregate productivity, the reverse also seems likely. Empirical work therefore has to make sure to identify the effect of trade on productivity instead of the other way round.

The summary measure of trade nearly always used in empirical work is nominal imports plus exports relative to nominal GDP, usually referred to as *openness*. For recent examples see Coe and Helpman (1995), Ades and Glaeser (1999), Gustavsson, Hansson, and Lundberg (1999), Alesina, Spolaore and Wacziarg (2000), Dinopoulos and Thompson (2000), and Miller and Upadhyay (2000). Openness is also the measure of trade used in Frankel and Romer's (1999) innovative work on the *causal* effect of trade on average labor productivity across countries. The idea underlying their empirical approach is that trade is partly determined by (geographic) characteristics of countries that are unrelated to productivity. These characteristics should therefore allow for estimation of the causal effect of trade on productivity using an instrumental-variables approach. They implement this idea empirically for a large set of countries in 1985 and find a positive, but rather imprecisely estimated, effect of trade on average labor productivity. According to their estimate, the effect of trade on productivity is just significant at the 5-percent level (see also Frankel and Rose (2000)). Further research using the same approach by Irwin and Tervio (2000) has shown, however, that trade no longer affects average labor productivity significantly once countries' distance to the equator is included in the empirical analysis. This result suggests that the positive effect of trade on productivity across countries found by Frankel and Romer may be driven by spatially correlated omitted variables.

We argue that estimates of international trade's effect on productivity in the existing literature give a misleading picture of the true productivity-gains caused by trade because of the summary measure of trade used in the empirical analysis. Summarizing trade using nominal imports plus exports relative to nominal GDP (openness) has drawbacks for empirical cross-country productivity analysis that are easily explained. Suppose that international trade increases productivity but that the implied productivity-gains are greater in the tradable manufacturing goods sector than in the non-tradable services sector. Will countries that are more productive because of trade have higher values of openness? Not necessarily, because the relatively greater productivity-gains in the traded-goods sector lead to a rise in the relative price of non-traded services, which may decrease openness when the demand for services is inelastic. We show this formally in a model where productivity-gains from international trade arise due to increasing returns to specialization (Helpman (1981), Krugman (1981), Ethier (1982)).

This problem with the conventionally used summary measure of trade motivates our simple alternative, which we will refer to as *real openness*. Real openness is defined as imports plus exports in exchange rate US$ relative to GDP in purchasing-power-parity US$ (PPP GDP). Using real openness instead of openness eliminates cross-country differences in the relative price of non-traded services from the summary measure of trade.

Ultimately, choosing the best summary measure of international trade for cross-country productivity analysis is an empirical issue. We show that measures of trade based on real openness are capable of explaining a greater amount of the variation in cross-country productivity than openness. This result, combined with our theoretical work, leads us to stress real openness in our investigation of international trade's effect on cross-country average labor productivity.

Our empirical analysis takes into account the key role of institutions for productivity and income per capita found by Hall and Jones (1999) and Acemoglu, Johnson, and Robinson (2000). Acemoglu, Johnson, and Robinson estimate the effect of expropriation risk on income per capita in former colonies, while Hall and Jones consider the effect of a more broadly defined index of institutional quality (including expropriation risk) on average labor productivity for a larger set of countries. Both use an instrumental-variables approach to address reverse causation. We adapt their approach in order to estimate how international trade affects productivity or income per capita for a given level of institutional quality or expropriation risk. Our empirical work also incorporates geographic factors, like distance from the equator included in the analysis of Irwin and Tervio (2000).

The result of our empirical analysis is that international trade's effect on average labor productivity and income per capita is highly significant and extremely robust to the inclusion of institutional quality, expropriation risk, and geography controls. For example, using the largest possible sample of countries in 1985, we find that the instrumental-variables estimate of the elasticity of average labor productivity with respect to real openness is 1.44 when we do not include any controls for institutional quality and geography in the empirical analysis. The standard error of this estimate is 0.19. Trade is therefore a statistically significant determinant of productivity at the 0.001-percent level. When institutional quality and geography controls (distance from the equator and continent dummies) are included in the empirical analysis, we find that a 1-percent increase in real openness raises average labor productivity by 1.45 percent with a standard error of 0.35. Hence, the estimated elasticity of average labor productivity with respect to real openness does not change at all with the inclusion of institutional quality and geography controls. The standard error increases however. Still, trade remains a statistically significant determinant of productivity at the 0.01-percent level.

Our estimates of international trade's effect on average labor productivity imply that an increase of real openness that takes a country from the 30th percentile to the median value almost doubles productivity.[1] An increase of real openness that takes a country from the 20th percentile to the median value almost triples productivity, and an increase of real openness that takes a country from the 10th to the 90th percentile increases average labor productivity by a factor of ten.

To determine the channels through which trade and institutional quality affect average labor productivity, we also estimate the effect of trade and institutional quality on the (physical) capital-output ratio, average human capital, and labor efficiency. Our findings indicate that trade is a significant determinant of labor efficiency but not of the capital-output ratio or average human capital. Institutional quality, on the other hand, is a significant determinant of the capital-output ratio and average human capital but not of labor efficiency.

Our theoretical criticism of openness as a summary measure of international trade in cross-country productivity analysis rests on the hypothesis that international trade raises the price of non-traded services relative to traded manufacturing goods. A higher relative price of services should translate into a higher price level (compared to some benchmark country). We test for this link by estimating the relationship between real openness and

[1] A more precise version of this statement (given that real openness is endogenous) is that a change in exogenous variables that takes real openness from the 30th percentile to the median value almost doubles productivity.

the price level across countries and find that an increase in real openness has a positive, statistically significant effect on the price level.

We conclude our empirical analysis of the link between trade and average labor productivity with an *exploratory* analysis of the effect of trade policies on real openness and average labor productivity. The analysis leads us to the tentative conclusion that policies favorable for trade may be an effective tool for increasing productivity.

The remainder of this paper is structured in the following way. Section 2 explains the potential theoretical drawbacks of openness as a summary measure of trade in empirical cross-country productivity analysis. Our analysis is based on a simple trade model of increasing returns due to specialization with traded and non-traded goods. Section 3 contains the equations that will be estimated and details on the instrumental-variables approach. Section 4 discusses the data and the quality of the instruments. Section 5 presents the results on the effects of international trade and institutional quality on average labor productivity in 1985 and 1990, as well as on income per capita in former colonies in 1995. The section also contains our estimates of the effects of trade and institutional quality on the capital-output ratio, average human capital, and labor efficiency**,** and summarizes our findings on the empirical relationship between real openness and the price level. Section 6 concludes with our exploratory analysis of the causal effect of trade policies on real openness and average labor productivity.

2 Increasing Returns to Specialization, Trade, and Productivity

The potential drawbacks of the ratio of nominal imports plus exports to nominal GDP as a summary measure of trade in empirical work on cross-country productivity can be illustrated using a simple static, small open economies model with increasing returns to specialization in the spirit of Helpman (1981), Krugman (1981), and Ethier (1982). The key element of the argument is that specialization affects productivity in the traded manufacturing goods sector more strongly than in the non-traded services sector.

Suppose that each country can potentially produce a unit measure of commodities indexed by $i \in [0,1]$. Commodities $i \in [0,t]$, $0 < t < 1$, are traded manufacturing goods, while the remaining fraction $1-t$ of commodities are non-traded services. The measure of manufacturing goods produced in country c will be denoted by d_c. As the measure of manufacturing goods produced domestically decreases, countries will be said to have become *more specialized*.

Firms in traded-goods sectors $i \in [0,t]$ are assumed to be able to produce output y using labor l according to the following constant-returns-to-scale production function

$$y = B_c g(d_c, L_c) l\,, \tag{1}$$

where B_c is a productivity parameter specific to country c and L_c is aggregate employment. The (continuously differentiable) function $g(\bullet)$ allows us to capture increasing returns due to specialization as well as increasing returns to the aggregate scale of production. Increasing returns to specialization is defined as marginal labor productivity in manufacturing increasing as the range of manufacturing goods produced domestically *decreases*, $g_1(d_c, L_c) < 0$ (subscripts 1,2 denote partial derivatives with respect to the first and second argument respectively). Increasing returns to the aggregate scale of production is defined as marginal labor productivity in manufacturing increasing with aggregate employment, $g_2(d_c, L_c) > 0$. We assume increasing returns to specialization and to the aggregate scale of production throughout our analysis.

Suppose that increasing returns are limited to traded manufacturing goods. Non-traded services $i \in (t,1]$ are produced according to the constant-returns-to-scale production function

$$s = B_c l\,. \tag{2}$$

The assumption that increasing returns are completely absent in the production of non-traded services is made for simplicity only. Our argument goes through as long as increasing returns are weaker in the production of non-traded services than in the production of traded manufacturing goods.

Households are assumed to supply an aggregate amount of labor L_c inelastically. Their preferences over consumption goods are given by

$$U = b^{\frac{1}{e}} \left(\min(x_i : i \in [0,t])\right)^{\frac{e-1}{e}} + (1-b)^{\frac{1}{e}} \left(\min(s_i : i \in (t,1])\right)^{\frac{e-1}{e}}, \tag{3}$$

where x_i denotes consumption of different traded goods and s_i consumption of different non-traded services; $e > 0$ captures the elasticity of substitution between services and manufacturing goods and $0 < b < 1$ is a distribution parameter. We assume perfect complementarity among manufacturing goods and among services respectively because the elasticity of substitution within these groups of commodities plays no role for our argument. The elasticity of substitution between traded manufacturing goods and non-traded services is crucial for our analysis however. We assume throughout that $e < 1$ and hence that the demand for services is inelastic.

Goods and labor markets are assumed to be perfectly competitive. The price of all manufacturing goods in international markets is taken to be identical and normalized to unity. In equilibrium, the relative price of non-traded services (relative to manufacturing goods) produced in the same country will be identical. Across countries, the relative price of services will vary endogenously. The relative price of services produced in country c will be denoted by q_c.

The fact that both different manufacturing goods and different services enter preferences in a perfectly complementary way implies that households in country c consume the same amount of each manufacturing good and the same amount of each service. These quantities will be denoted by x_c and s_c respectively. Household preferences also imply that the demand for non-traded services in country c relative to the demand for manufacturing goods is equal to

$$\frac{s_c}{x_c} = \frac{q\,t}{1-t} q_c^{-e} \,, \tag{4}$$

where $q \equiv (1-b)t^{e-1} / b(1-t)^{e-1}$.

In equilibrium, trade of each country with the rest of the world must be balanced. Hence, the total value of imports of traded manufacturing goods $(t-d_c)x_c$ must be equal to the total value of manufacturing exports. For simplicity we concentrate on symmetric equilibria where countries produce the same quantity y_c of all domestic manufacturing goods. In this case, the total value of manufacturing exports is $d_c(y_c - x_c)$. Balanced trade $(t-d_c)x_c = d_c(y_c - x_c)$ implies that aggregate consumption of traded goods is equal to aggregate production of traded goods

$$tx_c = d_c y_c \,. \tag{5}$$

Wages in the traded goods sector and in the non-traded goods sector will be equalized in labor market equilibrium. Combined with the assumption that increasing returns are limited to the production of traded manufacturing goods, this yields that the equilibrium relative price of services q_c reflects the productivity of labor in the manufacturing goods sector relative to the services sector,

$$q_c = g(d_c, L_c) \,. \tag{6}$$

Non-traded services will therefore be relatively more expensive in countries where the production of traded goods is relatively more efficient. This yields a link between countries' degree of specialization and their relative price of services that is key to our criticism of openness as a summary measure of trade.

Wage-equalization, balanced trade, and the relative demand for services combined with market clearing and the production functions for goods and services imply that

$$B_c g(d_c, L_c) L_{yc} = (1-t) q^{-1} q_c^e s_c = q^{-1} g(d_c, L_c)^e B_c (L_c - L_{yc}) \ , \tag{7}$$

where L_{yc} and $L_c - L_{yc}$ denote the aggregate amount of labor used in the production of traded manufacturing goods and non-traded services respectively. Simplifying yields the aggregate amount of labor employed in the traded goods sector as a function of aggregate employment L_c and the measure of traded goods produced domestically d_c,

$$L_{yc} = \frac{L_c}{1 + q\, g(d_c, L_c)^{1-e}} \, . \tag{8}$$

Purchasing power parity (PPP) GDP in the model is defined as

$$Y_{PPP,c} \equiv d_c y_c + (1-t) q s_c \, , \tag{9}$$

where q is the relative price of services in the benchmark country. This definition combined with the production functions for goods and services yields that

$$Y_{PPP,c} = B_c g(d_c, L_c) L_{yc} + q B_c (L_c - L_{yc}) \, . \tag{10}$$

Combining PPP GDP with the allocation of labor across sectors implies that PPP average labor productivity can be written as a function of aggregate employment and the measure of traded manufacturing goods produced domestically,

$$\frac{Y_{PPP,c}}{L_c} = B_c \frac{g(d_c, L_c) + qq\, g(d_c, L_c)^{1-e}}{1 + q\, g(d_c, L_c)^{1-e}} \quad . \tag{11}$$

Differentiating (11), making use of our maintained hypothesis $e < 1$, yields that PPP average labor productivity increases with aggregate employment and decreases with the measure of manufacturing goods produced domestically (increases with the degree of specialization).

2.1 Openness, Real Openness, and Productivity

The model implies that trade increases countries' PPP average labor productivity by allowing them to consume all the different types of manufacturing goods while specializing in the production of a subset only. But will this effect of trade on productivity lead to productivity being a monotonically increasing function of openness? We show that this is not necessarily the case because of the effect of specialization on the relative price of non-traded services. The relationship between real openness and productivity is, however, strictly increasing.

Openness

GDP is defined as $Y_c \equiv d_c y_c + (1-t) q_c s_c$ in our model. Openness therefore corresponds to

$$Open_c \equiv 2\frac{(t-d_c)x_c}{d_c y_c + q_c(1-t)s_c} = 2\frac{1-d_c/t}{1+q\,g(d_c,L_c)^{1-e}} \tag{12}$$

where the second equality makes use of (4), (5), and (6).

To see that the model may imply a non-monotonic relationship between openness and PPP average labor productivity, suppose that specialization economies are strong in the sense that $g(d_c, L_c) \to \infty$ as $d_c \to 0$ for all $L_c > 0$ (this assumption is not necessary for the argument but simplifies the exposition). In this case, holding aggregate employment constant, *Open* tends to zero as the economy becomes more and more specialized, $d_c \to 0$. Clearly, *Open* is also equal to zero when the economy produces all manufacturing goods domestically and does not specialize at all, $d_c = t$. Continuity of *Open* as a function of the degree of specialization therefore implies that all levels of openness between zero and the maximum value correspond to at least two different degrees of specialization. Countries with different degrees of specialization (and the same level of aggregate employment) may therefore have the same level of *Open*. This implies that countries with the same level of exogenous productivity B, aggregate employment, and openness may have different PPP average labor productivity. The result that *Open* will be equal to zero if the country is not specialized at all and if the country is extremely specialized also yields that *Open* must at some point decrease as the economy becomes more specialized (holding aggregate employment constant). An increase in openness may therefore be associated with a decrease in PPP average labor productivity.[2]

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[2] For example, suppose that $g(d_c, L_c) = (L_c / d_c)^g$ as well as $L_c = 1$, $g = 2$, $e = 0.5$, and $t = 0.5$. Then (12) implies that $Open_c$ is a hump-shaped function of d_c with the maximum value of $Open$ (reached at $d_c = 0.22$) equal to 0.45.

It is straightforward to show that the relationship between PPP average labor productivity and openness (given exogenous productivity and aggregate employment) will be non-monotonic for many different specifications of the increasing returns function $g(d,L)$, even if productivity in manufacturing does *not* tend to infinity as the economy becomes more and more specialized.

Real Openness

Real openness in our model corresponds to

$$ROpen_c \equiv 2\frac{(t-d_c)x_c}{d_c y_c + q(1-t)s_c} = 2\frac{1-d_c/t}{1+q\,qg(d_c,L_c)^{-e}}\,, \tag{13}$$

where q is the relative price of services in the benchmark country first introduced in the definition of PPP GDP. Hence, the degree of specialization is strictly increasing in real openness (and vice versa). To see that (13) implies that PPP productivity is increasing in both real openness and aggregate employment, notice that relative productivity in the manufacturing sector (relative to the services sector) g_c can be written as an increasing function of both real openness and aggregate employment

$$g_c = h(ROpen_c, L_c)\,, \tag{14}$$

$h_1(\bullet) > 0,\ h_2(\bullet) > 0$. This can be seen formally by implicitly differentiating (13), making use of $g_c = g(d_c, L_c)$. Combined with the result in (11) that PPP average labor productivity is increasing in the relative productivity of the manufacturing sector, (14) yields that PPP average labor productivity can be written as a strictly increasing function of real openness, aggregate employment, and the country-specific productivity parameter B_c,

$$\frac{Y_{PPP,c}}{L_c} = B_c f(ROpen_c, L_c)\,, \tag{15}$$

$f_1(\bullet) > 0,\ f_2(\bullet) > 0$.

2.2 Real Openness and the Price Level

Our theoretical criticism of openness as a summary measure of trade in cross-country productivity analysis rests on the hypothesis that the relative price of non-traded services is increasing in the degree of specialization. We now show that this link implies that the price level of countries (relative to the benchmark) is increasing in real openness.

The price level in our model is

$$P_c \equiv \frac{Y_c}{Y_{PPP,c}} = \frac{d_c y_c + (1-t) q_c s_c}{d_c y_c + (1-t) q s_c} = \frac{1 + q\, q_c^{1-e}}{1 + q\, q q_c^{-e}} , \tag{16}$$

where the last equality makes use of (4) and (5). Hence, the price level is increasing in the relative price of non-traded services. Combined with (6) and (14), this yields that the price level is an increasing function of real openness and aggregate employment

$$P_c = k(ROpen_c, L_c) , \tag{17}$$

$k_1(\bullet) > 0,\ k_2(\bullet) > 0$. We will test this implication of the link between the degree of specialization and the relative price of non-traded services empirically. It is interesting to note that our theoretical work does not imply that the price level is increasing in openness, as the possible non-monotonicity between the degree of specialization and openness stemming from (12) translates into a non-monotonicity between openness and the price level.

3 Estimation

Our empirical work comes in three parts. In the first part we estimate the effect of international trade and institutional quality on average labor productivity across countries using openness and real openness as alternative summary measures of the intensity with which countries trade. We also estimate the effect of trade on income per capita in former colonies. In the second part we analyze the effect of trade and institutional quality on capital-output ratios, average levels of human capital, and levels of labor efficiency to determine the channels through which trade and institutional quality affect average labor productivity. The third part estimates the effect of real openness and openness on the price level across countries.

3.1 Trade and Productivity

The equation that we use to estimate the effect of trade, the aggregate scale of production, and institutional quality on countries' average labor productivity is

$$\log\left(\frac{PPP\ GDP_c}{Workforce_c}\right) = a_0 + a_1 ITrade_c + a_2 \log(Workforce_c) + a_3 \log(Area_c) + a_4 IQual_c + a_5 X_c + u_c \tag{18}$$

where *ITrade* stands for measures of the intensity with which country c trades with the rest of the world, *Workforce* denotes the size of the country's work force, *Area* refers to the land area of the country in square kilometers, *IQual* stands for the quality of the country's institutions, and X denotes a set of geographic control variables. The variation in average labor productivity not captured by our empirical analysis is summarized by u, and $a_0, \ldots, a_5$ denote the parameters that will be estimated.

The choice between different measures of the intensity with which countries trade is ultimately an empirical question. Equation (18) will therefore be estimated using the following two different, already mentioned measures for *ITrade*:

1. *Open*, defined as nominal imports plus exports divided by nominal GDP. This is the measure used in existing empirical research. Because theory is inconclusive on how *Open* is supposed to enter the estimating equation, we also try log*Open*. The main difference between the two specifications is that the specification with log*Open* assumes that a 1-point increase in *Open* has larger effects on average labor productivity in countries that start from lower levels of openness.
2. Because of the theoretical drawbacks of *Open* discussed in the previous section, we consider imports plus exports in exchange rate US$ divided by GDP in PPP US$ (*ROpen*) as an alternative measure of *ITrade*. We also try log*ROpen* for the same reasons as log*Open*.

Area is included in the estimating equation to facilitate comparisons with the work of Frankel and Romer (1999). See Frankel and Romer as well as Frankel and Rose (2000) for theories that imply that average labor productivity depends on the land area of countries. (Like Frankel and Romer, we usually find that area is a statistically insignificant determinant of productivity however.)

IQual will be measured using indices of bureaucratic quality, law and order, and property-rights protection developed by *Political Risk Services*. These indices have previously been used by Knack and Keefer (1995) and Hall and Jones (1999) in their empirical investigations of the effect of institutional quality on the growth rate and level of productivity.

The geography controls (X) used in the estimating equation are countries' distance from the equator and continent dummies. These variables are included to account for spatially correlated omitted determinants of productivity.

Our empirical analysis of the role of trade in former colonies follows Acemoglu, Johnson, and Robinson (2000) and estimates (18) with income per capita on the left-hand side and expropriation risk instead of institutional quality on the right-hand side.

We will refer to (18) without institutional quality and geography controls as the *benchmark* trade-specification.

The parameters in (18) cannot be estimated consistently using ordinary least squares because countries' trade intensity, work force, and institutional quality are endogenous and measured with error. Our estimation strategy will therefore rely on instrumental variables. The instruments will be constructed following Frankel and Romer (1999) as well as Hall and Jones (1999) and Acemoglu, Johnson, and Robinson (2000).

To determine the causal effect of trade on average labor productivity across countries, Frankel and Romer use a two-step approach to construct an instrument for their measure of trade intensity (openness). The first step consists of estimating a gravity equation for bilateral trade shares that uses countries' geographic characteristics and population only as explanatory variables (i.e. the estimating equation does *not* include measures of productivity or income). The second step of the approach aggregates bilateral trade shares predicted by the gravity equation to obtain a predicted value for countries' trade intensity. This value is then used as an instrument for openness. We use the same approach for constructing instruments for real openness.

The gravity equation estimated to obtain predicted bilateral trade shares is

$$\begin{aligned}
&\log\left(\frac{t_{ij}}{PPP\ GDP_i}\right) = \\
&a_0 + a_1 \log Dist_{ij} + a_2 \log Pop_i + a_3 \log Area_i \\
&+ a_4 \log Pop_j + a_5 \log Area_j + a_6 (Ldl_i + Ldl_j) \\
&+ a_7 Cb_{ij} + a_8 Cb_{ij} \log Dist_{ij} + a_9 Cb_{ij} \log Pop_i \\
&+ a_{10} Cb_{ij} \log Area_i + a_{11} Cb_{ij} \log Pop_j + a_{12} Cb_{ij} \log Area_i \\
&+ a_{13} Cb_{ij} (Ldl_i + Ldl_j) + v_{ij}
\end{aligned} \tag{19}$$

where t_{ij} denotes exports of country i to country j plus exports from j to i; $Dist_{ij}$ is the distance between the two countries, Pop_i, Pop_j denote the population of the two countries; $Area_i, Area_j$ denote the area of the two countries; Ldl_i, Ldl_j are dummies indicating whether countries i, j are landlocked; Cb_{ij} is a dummy indicating whether or not the two countries have a common border; and v_{ij} summarizes the variation in bilateral trade shares no captured by our empirical approach.[3] The common border dummy is included by itself in the regression as well as interacted with other explanatory variables to capture trade between neighboring countries more accurately. The ordinary least-squares estimates of the coefficients in (19) can be used to determine the predicted value of the bilateral trade share for all countries for which there is data on the right-hand-side variables (even if we do not have any bilateral trade data for those countries).

Predicted bilateral trade shares are then aggregated to obtain the predicted value of aggregate imports plus exports relative to PPP GDP for each country

$$TFit_i \equiv \sum_j \exp\left(\text{Predicted Value of } \log\left(\frac{t_{ij}}{PPP\ GDP_i} \right) \text{using (19)} \right). \tag{20}$$

The sum includes all countries for which data on the right-hand-side variables in (19) are available. We will use both the variable *TFit* (which we will refer to as the fitted-trade intensity) and the variable log*TFit* as instruments when estimating (18). We also try fitted-trade intensities based on gravity equations without population and area respectively as instruments in our empirical analysis.

Additional instruments to estimate the effect of trade and institutional quality on average labor productivity and income per capita come from the work of Hall and Jones (1999) and Acemoglu, Johnson, and Robinson (2000). Hall and Jones estimate the effect of social infrastructure—defined as a weighted average of what we call institutional quality and the Sachs-Warner (1995) policy-measure of openness—on productivity across countries. They address the reverse causality problem by using the fraction of the population speaking English at birth, the fraction of the population speaking one of the five primary European languages (including English) at birth, the distance from the equator, and the Frankel-Romer fitted-trade intensity as instruments. Hall and Jones argue, based on historical considerations, that the first three variables are correlated with past European influence and therefore with the transmission of the (growth-enhancing) European institutional framework. They check the validity of distance from the equator as an instrument by testing the hypothesis that distance from the equator does *not* affect productivity directly once social infrastructure is accounted for and find that this hypothesis cannot be rejected at conventional significance levels. We find that distance

[3] Distance is calculated as the great-circle distance between countries' principal cities.

from the equator does not affect average labor productivity in (18) in a statistically significant way once institutional quality and trade are included in the empirical analysis.

Acemoglu, Johnson, and Robinson (2000) estimate the effect of expropriation risk between 1985 and 1995 on income per capita in a sample of former colonies using settler mortality between the 17th and 19th century as an instrument for expropriation risk.[4] They demonstrates that historic settler mortality explains a considerable amount of the variation in average expropriation risk 1985-1995 across former colonies and argue that this correlation arises because institutions permitting short-run extraction of income from colonies were more likely when conditions for long-term European settlements were unfavorable. Following their argument, we use settler mortality as one of the instruments when estimating the effect of trade on income per capita for a given level of expropriation risk.

Other instruments used to estimate (18) are the geography controls included as right-hand-side variables, land area, and population.

3.2 Trade, Capital, and Labor Efficiency

We are also interested in whether trade affects average labor productivity mostly through physical capital, human capital, or labor efficiency once institutional quality is taken into account. This is done following the approach of Hall and Jones (1999), who in turn follow David (1977), Mankiw, Romer, and Weil (1992), and Klenow and Rodriguez-Clare (1997). The starting point of the approach is the constant-returns-to-scale Cobb-Douglas aggregate production function $Y = K^{a}(AhL)^{1-a}$, where Y denotes aggregate output, K aggregate capital, L aggregate employment, h average human capital, and A labor efficiency.[5] This production function implies that average labor productivity can be written as the product of labor efficiency, the (physical) capital-output ratio raised to the power $a/(1-a)$, and the average level of human capital,

$$\frac{Y_c}{L_c} = A_c \left(\frac{K_c}{Y_c} \right)^{\frac{a}{1-a}} h_c . \tag{21}$$

[4] Interestingly, their empirical analysis validates the use of distance from the equator as an instrument in the work of Hall and Jones (1999).

[5] Our terminology does not follow Hall and Jones, who refer to A as productivity, because this could generate confusion with what we call average labor productivity. We do not refer to A as labor-augmenting technology because A will also capture institutional quality in our empirical analysis.

We will analyze how trade and institutional quality affect the three components of average labor productivity on the right-hand side of (21).

3.3 Trade and the Price Level

The relationship between the price level and real openness as well as aggregate employment will be estimated using the following equation

$$\log P_c = b_0 + b_1 \log ROpen_c + b_2 \log Workforce_c + b_3 Z_c + v_c \, , \tag{22}$$

where v summarizes the variation in the log price level not captured by our empirical analysis, and $b_0, \ldots, b_3$ denote the parameters to be estimated. Z_c contains the usual geographic controls as well as a variable (z_c) that captures cross-country differences in log-productivity not explained by increasing returns to specialization or aggregate employment: $z_c \equiv \log(Y_{PPP,c} / L_c) - \hat{a}_1 \log ROpen_c - \hat{a}_2 \log Workforce_c$, where $\hat{a}_1, \hat{a}_2$ are estimates of the effect of $\log ROpen$ and $\log Workforce$ on log-productivity obtained using (18). This variable is considered as a control to account for cross-country productivity-differences not explained by increasing returns affecting the price level through the Balassa-Samuelson effect.[6] Equation (22) will be estimated using instrumental variables, with the geography controls included among the right-hand-side variables, the fitted-trade intensities, the Hall-Jones language variables, and population as instruments. We will also estimate a version of (22) with openness instead of real openness on the right-hand side.

4 Data and Quality of the Instruments

The data on average labor productivity in PPP US$, the number of workers, population, openness, and the price level are from the Penn World Tables, Mark 5.6 (PWT).[7] Real openness is calculated by dividing total imports plus exports in US$ by GDP in PPP US$, with both imports plus exports in US$ and PPP GDP calculated using PWT data.

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[6] The Balassa-Samuelson hypothesis states that cross-country differences in productivity are positively correlated with cross-country differences in the price level because cross-country productivity differences in the manufacturing sector are greater than in the services sector (see Heston, Nuxoll, and Summers (1994) and Rogoff (1996) for empirical work on the Balassa-Samuelson effect).

[7] This is a revised version of Summers and Heston (1991). The data are available online at http://pwt.econ.upenn.edu.

We employ four different samples in our empirical work. The first two samples include all countries for which the relevant data are available for 1985 and 1990. We focus on 1985 and 1990 because these are benchmark years of the PWT. The third sample consists of the 1985 98-country sample used by Mankiw, Romer, and Weil (1992) and Frankel and Romer (1999). The fourth sample is the group of former colonies in Acemoglu, Johnson, and Robinson (2000). In this last case, we use (their data on) PPP income per capita in 1995 on the left-hand-side of the estimating equation in (18).[8] Moreover, we use 1995 population from the *World Development Indicators* instead of workforce on the right-hand-side of the estimating equation because the latest version of the PWT contains data only up to 1992.

Our measure of institutional quality is created following Hall and Jones (1999). They construct a measure of institutional quality using data from the *International Country Risk Guide* concentrating, like Knack and Keefer (1995), on five of the twenty-four categories provided.[9] Two of the five categories relate to the role of governments in providing services and protecting against private diversion: bureaucratic quality and law and order. The three remaining categories relate to the role of governments in diversion: corruption, risk of expropriation, and government repudiation of contracts. Our index of institutional quality, which we refer to as *IQual*, consists of an equally weighted average of these five measures standardized to lie between zero (worst institutional quality) and unity (highest quality).[10] We also tried the type of economic organization as classified by *Freedom House* (Finn (1994)) as a measure of institutional quality, but do not present these results as they turned out to be very similar to those obtained using *IQual*.[11] The

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[8] The source of their data is the *World Development Indicators.*

[9] The *International Country Risk Guide* is produced by *Political Risk Services* and the methodology is explained in Coplin et al. (1996). The data are available online at http://www.countrydata.com.

[10] *IQual* corresponds to the index of government anti-diversion policies (*GADP*) in Hall and Jones. One reason why Hall and Jones use social infrastructure instead of *GADP* is that the overidentifying restrictions are rejected for the model where *GADP* is taken as the *only* determinant of productivity, but not for the model where social infrastructure is taken as the only determinant of productivity. We find that the overidentifying restrictions can never be rejected at conventional significance levels when *IQual* is combined with *ITrade* or continent dummies (or both).

[11] The empirical results provide somewhat more support for the importance of trade and somewhat less support for the role of institutional quality in determining productivity when we use the *Freedom House* index instead of *IQual*.

data on institutional quality are not available for all countries, which implies that smaller samples have to be used whenever this variable is included in the analysis.[12]

The data on average expropriation risk between 1985 and 1995 in former colonies is taken from Acemoglu, Johnson, and Robinson (2000). Their measure of expropriation risk is the *International Country Risk Guide* index of protection against expropriation of private foreign investment and ranges from one (highest risk) to ten (lowest risk).

The data used to construct the continent dummies are taken from Rand McNally (1993). Countries' distance from the equator is measured as the absolute value of their latitude and is taken from Hall and Jones (1999), which is also the source for the two language-spoken-at-birth instruments.[13]

The bilateral trade data to obtain the instrument for *ITrade* is taken from different *Yearbook* issues of the *Direction of Trade Statistics* published by the *International Monetary Fund*. These statistics contain 7928 non-zero observations on bilateral trade for the 1985 150-country sample and 10569 observations for the 1990 115-country sample.[14]

The three components on the right-hand side of (21) are calculated following the approach of Hall and Jones (1999). They calculate average levels of human capital across countries by combining the data on average schooling across countries in Barro and Lee (1993) and Mincerian estimates of the individual return to schooling in countries with different average levels of education.[15] Formally, their estimate of average human capital in country c is $h_c = \exp(f(S_c))$, where S_c is average schooling in the country and $f(\bullet)$ is a piecewise linear function capturing estimated Mincerian returns.[16] Aggregate capital K_c across countries is calculated with the investment data in the PWT according to the perpetual inventory method. Hall and Jones calculate capital-output ratios and average labor productivity using a measure of output Y_c that subtracts mining output (which includes oil and gas) from PPP GDP given in the PWT. To obtain $(K_c / Y_c)^{a/(1-a)}$, they use data on (physical) capital-income shares to calibrate a at a value of $1/3$. Finally, the

[12] For 1985, there are data on 150 countries for the specification without institutional quality and on 137 countries once institutional quality is added. For 1990, there are data on 115 countries for the specification without institutional quality and on 110 countries once institutional quality is added. For the 98-country sample in 1985, we only lose one observation by including institutional quality in the specification.

[13] The calculations are based on the latitude of the center of countries' most populated region.

[14] For comparison, Frankel and Romer (1999) work with 3969 observations on bilateral trade for 1985 (they do not have data for 1990).

[15] See also Bils and Klenow (2000).

[16] For the first four years of schooling, Hall and Jones assume a return of 13.4 percent per year. For the next four years, 10.1 percent per year. Starting with the eighth year, the assumed return is 6.8 percent per year.

efficiency of labor across countries A_c is obtained by combining the values of a, h_c, and $(K_c/Y_c)^{a/(1-a)}$ with data on average labor productivity and (21). We follow exactly the same approach as Hall and Jones but use the updated average schooling data in Barro and Lee (2000) instead of the 1993 data. The relevant data are available for 127 countries in 1985.[17]

Table 1 (all tables are in the appendix) gives detailed measures of the quality of the gravity-equation instruments for *ITrade* in the different samples used, concentrating on two measures of *ITrade*: *Open* because it turns out to work better than log*Open* in (18), and log*ROpen* because it works better than *ROpen*.[18] Each column gives the following statistics:

- $R^2(1)$, which is the R^2 of the least-squares regression of the measure of *ITrade* heading the column (*Open* or log*ROpen*) on *Area*, log*Area*, *Pop*, log*Pop*, *TFit*, log*TFit*, and the geography controls whenever it says so in the third row from the bottom.
- $R^2(2)$, which is the R^2 of the least-squares regression of the measure of *ITrade* heading the column on all the variables listed above except *TFit* and log*TFit*.
- $(R^2(1)\text{-}R^2(2))/R^2(2)$, which is the proportional increase of the R^2 due to the inclusion of the fitted-trade intensities *TFit* and log*TFit* among the explanatory variables.
- The P-value of the hypothesis that *TFit*, log*TFit* can be excluded from the equation.

For example, according to the top entry in column (1), *Area*, log*Area*, *Pop*, log*Pop*, *TFit*, log*TFit* explain 54.4 percent of the variation of *Open* across 150 countries in 1985. The third entry from the top in column (1) indicates that the increase in the explanatory power associated with the inclusion of *TFit* and log*TFit* is 12.9 percent. And according to the fourth entry from the top in column (1), the hypothesis that *TFit* and log*TFit* do not affect *Open* can be rejected at the 0.001-percent significance level. The top entry in column (2) indicates that geography controls (*GeoControls*, which are dummies for four of the five continents—the regression includes a constant—and distance from the equator) add very little to the prediction of *Open* relative to the specification in column (1). According to the third entry from the top in column (2), the inclusion of geography controls reduces the increase in the explanatory power associated with the inclusion of *TFit* and log*TFit* from 12.9 percent to 6 percent.

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[17] We concentrate on 1985 because the sample of countries is greater for 1985 than for 1990 (because of missing values on education and physical capital for 1990). Still, the results for 1990 are very similar to those for 1985.

[18] The simple correlation between our fitted (log) trade shares and actual (log) trade shares in 1985 and 1990 varies between 0.60 and 0.73.

One of the interesting patterns in Table 1 is that, according to the R^2 criterion, the instruments tend to work somewhat better for *Open* than for log*ROpen*. The additional explanatory power of *TFit* and log*TFit* once the other instruments have been included in the regression tends to be somewhat better for log*ROpen* than for *Open* however. The overall message of Table 1 is that the instruments work well for predicting a substantial amount of *ITrade*.[19]

The Hall-Jones European/English language-spoken-at-birth instruments also help in explaining countries' trade intensity. For example, for the 150-country sample in 1985, the two language instruments are a (jointly) significant determinant of log*ROpen* at the 2-percent level when added to the specification in column (8) of Table 1, raising the R^2 by 2.5 percentage points (not in the table). For the 1990-sample, the two instruments are a significant determinant of log*ROpen* at the 8-percent level when added to the specification in column (12) of Table 1, raising the R^2 by 3 percentage points (not in the table). Hence, the increase in R^2 due to the language instruments is more than half of the increase produced by the fitted-trade intensities for 1985 and more than one-third of the increase produced by the fitted-trade intensities for 1990. The explanatory power of the Hall-Jones language instruments for real openness may capture that past European influence led to a favorable environment for trade or that historical ties between European countries and former colonies translate into policies to encourage trade between them.

The explanatory power of the four Hall-Jones instruments for our measure of institutional quality is analyzed in Table 2, which contains the results of regressing *IQual* on the instruments using least squares. The table shows that the instruments combined explain a large part of the variation in institutional quality across countries. For example, column (6) indicates that for the 1990-sample the R^2 of the regression of *IQual* on the four instruments is 0.62. According to column (7), the R^2 of the regression remains quite high even if distance from the equator is omitted. Furthermore, comparing column (8) with column (10) yields that the instruments have considerable additional explanatory power when added to the continent dummies. Columns (1)-(5) repeat the analysis for the 150-country sample in 1985. The results for the 98-country sample in 1985 (not in the table) are very similar.

The explanatory power of historic settler mortality for average expropriation risk 1985 to 1995 in former colonies is documented in detail in Acemoglu, Johnson, and

[19] For comparison, the instruments used by Frankel and Romer (1999) produce about half of the $(R^2(1)-R^2(2))/R^2(2)$ in the case where geography controls are included and imply P-values of the exclusion restriction for *TFit* and log*TFit* between 0.07 and 0.04.

Robinson (2000). They show that regressing expropriation risk on the log of historic settler mortality yields an R^2 of 0.25. Interestingly, settler mortality remains a highly significant determinant of expropriation risk even if continent dummies for Africa and Asia are included in the analysis (while the dummies turn out to be insignificant).

5 Results

The effects of trade and institutional quality on average labor productivity and income per capita are analyzed first. Then we turn to the effect of trade on the capital-output ratio, average human capital, and labor efficiency. Finally we investigate the effect of trade on the price level.

5.1 Trade and Productivity

We start by presenting the results using the different summary measures of trade in the baseline trade-specification of (18). Then we turn to the results when institutional quality and geography controls are included in the empirical analysis.

Baseline Model

Table 3 summarizes the results of the baseline trade-specification of (18) for each of the four proposed measures of *ITrade* and the three samples with data on average labor productivity. For example, column (1) contains the results of estimating (18) with the largest possible sample in 1985, using *Open*, log*Workforce*, and log*Area* only as right-hand-side variables. The estimation method employed is the generalized method of moments (GMM) with robust standard errors. Instruments used are *Area*, log*Area*, *Pop*, log*Pop*, *TFit*, and log*TFit*. Calculation of the standard errors takes into account that the last two instruments are estimated (the details of the necessary adjustments are explained in Frankel and Romer (1999)). The three bottom rows of the table contain the R^2 of the regression, the generalized R^2 of the regression, as well as the P-value of the test of the (three) overidentifying restrictions. Notice that the R^2 is sometimes negative. It is well known that this is a possibility with instrumental-variables estimation. This is one of the reasons why the R^2 is neither a useful measure of how well the regression “fits” the data nor a valid criterion for model selection when there are endogenous right-hand-side variables. To select among models in this case, it is necessary to use the generalized R^2, which is a measure of explanatory power for models with endogenous right-hand-side variables (Pesaran and Smith (1994)). The generalized R^2 is obtained as the R^2 of the least-squares regression once the endogenous right-hand-side variables in the baseline specification are replaced by their predicted values using all instruments. Table 3 indicates that, according to the generalized R^2 criterion, the baseline trade-specification with log*ROpen* as a measure of *ITrade* does better than the model with *Open* in all three samples. The improvement in the generalized R^2 is around 20 percent for the two 1985 samples and 56 percent for the 1990 sample. The P-values of the test of overidentifying restrictions indicate that none of the models can be rejected at the 10-percent level with the two 1985 samples. With the 1990 sample, however, all models, except the one using log*ROpen* as a measure of the intensity with which countries trade, can be rejected at the 5-percent level. The ranking of models according to the generalized R^2 criterion that emerges from the baseline trade-specification prevails when we estimate (18) using all the right-hand side geographic and institutional control variables in the empirical analysis.

The explanatory power of the different models suggests that *Open* works better than log*Open* as a measure of *ITrade* in cross-country productivity analysis and that log*ROpen* works better than *ROpen*. Our empirical work will therefore concentrate on the specifications with openness and the log of real openness as a measure of *ITrade* in (18).

Openness and Productivity

Table 4 contains the results on the effect of openness on average labor productivity. Estimation is based on (18) with *Open* as a measure of *ITrade*. The estimation method employed is GMM with robust standard errors. Column (1) is the baseline trade-specification for the largest possible sample in 1985. It can be seen that the effect of *Open* on productivity is large. The point estimate indicates that increasing *Open* by one percentage point increases productivity by 4.13 percent. The 95-percent confidence interval of this effect is between 2.28 and 6 percent, and the hypothesis that *Open* is not a determinant of productivity can be rejected at the 0.1-percent significance level. This finding contrasts with the result of Frankel and Romer (1999) who, using the same sample, estimate the effect of *Open* to be less than half of our estimate (1.97) and just significant at the 5-percent level.[20] There are three reasons for this discrepancy: (1) we use more data to construct fitted-trade intensities, resulting in better instruments; (2) we use a more efficient estimation method (Frankel and Romer's estimation method is just identified two-stage least-squares with non-robust standard errors); (3) we instrument for *Workforce* in (18) using population. When the Hall-Jones language variables are included

[20] The results using the specification, data, and estimation technique of Frankel and Romer are summarized in Table 13.

among the instruments, the effect of *Open* on productivity falls to 2.14 with a standard error of 0.61 (not in the table).

Column (2) estimates (18) including geography controls (continent dummies and distance from the equator) but not institutional quality as right-hand-side control variables. The point estimate on *Open* drops to 1.78, less than half of the estimate in the baseline trade-specification, but *Open* remains statistically significant at the 1-percent level.[21] The effect of the workforce on productivity becomes insignificant at the 10-percent level however. This is inconsistent with theories implying aggregate scale effects conditional on trade. When the Hall-Jones language variables are included among the instruments, the effect of *Open* on productivity falls to 1.59 with a standard error of 0.57 (not in the table).

Column (3) estimates (18) excluding geography controls but including *IQual*, the measure of institutional quality constructed following Hall and Jones (1999), as a right-hand-side control variable.[22] In this case, only institutional quality is a significant determinant of productivity and has the right sign. *Open* and the aggregate scale of production enter with the wrong sign and are statistically insignificant. The two variables remain insignificant as determinants of average labor productivity in column (4) where both geography controls and institutional quality are included in the analysis. The result that, once *IQual* is included in the estimating equation, trade and the aggregate scale of production become insignificant determinants of productivity is not driven by the reduction in sample size from 150 to 137 countries when institutional quality is included in the analysis. Estimating the baseline trade-specification using only countries where data on institutional quality is available yields results (not in the table) that are similar to those of the 150-country sample. For example, the coefficient on *Open* is 4.33 with a standard error of 1.15, which is similar to the result in column (1). Including geography controls reduces this estimate to 1.77 with a standard error of 0.83, which is similar to the result in column (2).

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[21] This contrasts with the non-robustness of openness as a determinant of productivity in Irwin and Tervio (2000). Our findings differ from those in Irwin and Tervio for the same reasons they differ from those in Frankel and Romer.

[22] Table 14 presents the results of estimating the specification with institutional quality only, using GMM with robust standard errors. We find that the effect of institutional quality on average labor productivity is quite similar to the effect of social infrastructure found by Hall and Jones (1999). Columns (3), (6), and (9) in Table 14 indicate that the hypothesis that distance from the equator is a significant determinant of average labor productivity once institutional quality is accounted for can be rejected at conventional significance levels. Furthermore, the table also indicates that the effect of institutional quality on average labor productivity is robust to the inclusion of continental dummies.

The finding that trade and scale become insignificant as determinants of average labor productivity once institutional quality is added to the estimating equation persists for the other two average-labor-productivity samples used. Columns (7) and (8) contain the results for the 98-country sample in 1985 and columns (11) and (12) for the largest possible sample in 1990.

The results in Table 5 demonstrate that, once institutional quality is added to the empirical analysis, openness and the aggregate scale of production do not affect productivity in a statistically significant way even if all insignificant geography controls are eliminated from the analysis.

Real Openness and Productivity

Table 6 contains the results on the effect of real openness on average labor productivity. Estimation is based on (18) with log*ROpen* as a measure of *ITrade*. The estimation method employed is GMM with robust standard errors. Column (1) gives the result of the baseline trade-specification. The point estimate of the elasticity of productivity with respect to *ROpen* is 1.44 and very precisely estimated. This estimate implies that an increase of real openness that takes a country from the median value (31 percent) to the 60^{th} percentile (39 percent) increases productivity by 37 percent. The standard error of the estimate implies that the 95-percent confidence interval of this effect is from 28 to 48 percent. An increase of real openness that takes a country from the 30^{th} percentile (19 percent) to the median value increases productivity by 91 percent, with a 95-percent confidence interval from 72 to 125 percent. And an increase of real openness that takes a country from the 30^{th} percentile to the 70^{th} percentile (51 percent) increases productivity by 253 percent, with a 95-percent confidence interval from 179 to 309 percent.[23] When the Hall-Jones language variables are included among the instruments, the effect of log*ROpen* on productivity increases to 1.61 with a standard error of 0.17 (not in the table). Hence, the productivity-gains of international trade are estimated very precisely in the baseline trade-specification when real openness is used as a summary measure.

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[23] It might be useful to compare our point estimate of the effect of trade on productivity in column (1) of Table 6 with the estimate in Frankel and Romer (1999). This can be done using the identity $ROpen \equiv Open * P$, where P is the price level**.** The identity implies that an increase in *Open* from 70 percent (the average value in 1985) to 80 percent raises average labor productivity by 21 percent when holding the price level constant (in our theoretical model the price level is endogenous of course). The magnitude of this effect is similar to the one implied by the estimate of Frankel and Romer. But our (log) specification yields that the effect of *Open* on productivity is greater (smaller) than their estimate for countries with levels of *Open* below (above) average.

Column (2) estimates (18) including geography controls (continent dummies and distance from the equator) but not institutional quality as right-hand-side control variables. The point estimate of the effect of trade on average labor productivity remains basically unchanged and is significant at the 0.1-percent level. Furthermore, the inclusion of geography controls in the empirical analysis does not alter the effect of aggregate employment on productivity. When the Hall-Jones language variables are included among the instruments, the effect of log*ROpen* on productivity is 1.34 with a standard error of 0.19 (not in the table).

Column (3) estimates (18) including institutional quality, in addition to all geography controls, as a right-hand-side control variable. Both the estimate of the effect of trade on productivity and its standard error change little compared to column (2). Comparing column (3) with the baseline trade-specification in column (1) yields that the point estimates of the effect of both log*ROpen* and the aggregate scale of production remain basically unchanged. The standard errors increase but both variables remain highly significant determinants of average labor productivity. Columns (4) and (5) exclude the insignificant geography controls from the specification. Not surprisingly, the effect of trade and the aggregate scale of production on productivity change little. Institutional quality becomes a statistically significant determinant of productivity however. These results, combined with our finding that the historic forces captured by the Hall-Jones language instruments affect not only institutional quality but also trade intensities, imply that countries fortunate enough to have history and geography work together saw productivity increased by trade as well as by the quality of institutions.

Columns (6) to (10) and columns (11) to (15) present the results on the effect of real openness on average labor productivity for the 98-country sample in 1985 and for the largest possible sample in 1990, respectively. The results for the largest possible sample in 1990 echo those for the largest possible sample in 1985. For example, the results of the baseline trade-specification in column (11) and of the specification with all geography controls and *IQual* in column (13) are similar as far as the effect of trade and the aggregate scale of production on productivity are concerned. Again, standard errors increase as more controls are added, but log*ROpen* and aggregate employment remain highly significant determinants of average labor productivity even in the most complete specification. The results for the Mankiw, Romer, and Weil (1992) 98-country sample in 1985 indicate that trade and the aggregate scale of production are significant determinants of productivity once insignificant geography controls are excluded from the empirical analysis.[24] Overall, the results indicate that, in contrast to *Open*, log*ROpen* is a significant determinant of productivity irrespectively of the control variables included in the analysis and the sample used.

Table 7 estimates (18) for the largest possible sample in 1985 using log*ROpen* as a measure of *ITrade* but constructing the fitted-trade intensities with gravity equations that exclude either population, in columns (1) and (2), or area, in columns (3) and (4), as explanatory variables for bilateral trade shares. It can be seen that the results change very little and, in particular, that trade and scale remain highly significant and very robust determinants of productivity. Similar results hold for the 98-country sample in 1985 and the 1990-sample (not in the table).

Other Specifications

Tables 8 and 9 contain the results of estimating (18) using log*Open* and *ROpen* respectively as measures of *ITrade*. From Table 8 it can be seen that log*Open* is not a statistically significant determinant of productivity when controls for geography and institutional quality are included in the empirical analysis. The results in Table 9 indicate that *ROpen* holds up better than log*Open* as a determinant of productivity when controls for geography and institutional quality are included in the analysis, but that the effect of aggregate employment on average labor productivity becomes insignificant at standard significance levels.

Real Openness and Income per Capita in Former Colonies

Table 10 analyzes the effect of trade measured by real openness on income per capita in the Acemoglu, Johnson, and Robinson (2000) sample of former colonies. The left-hand-side variable of the estimating equation is income per capita in 1995 and the right-hand-side variables considered are real openness, the aggregate scale of production measured by population (because of a lack of data on workforce), area, expropriation risk, institutional quality, and geography controls. The estimation method is GMM with robust standard errors. Column (1) analyzes the effect of average expropriation risk 1985-95 (*ExprR*) only on income per capita, reproducing the result in Acemoglu, Johnson, and Robinson using their sample of former colonies with the exception of Vietnam (because of missing trade data in the PWT). The instrument used is the log of historic settler mortality. Columns (2) and (3) demonstrate that the large effect of expropriation risk on income per capita is robust to the inclusion of continent dummies for Africa and Asia and that distance from the equator is not a significant determinant of income per capita (once

[24] Like Frankel and Romer (1999), we find that least-squares estimates of the effect of trade tend to be smaller than instrumental-variables estimates in the baseline trade-specification This finding disappears, however, once we control for geographic location and institutional quality.

expropriation risk is accounted for). The instruments used are the log of historic settler mortality and the geography controls used as right-hand-side variables.

Columns (4) to (7) in Table 10 include log*ROpen* and the scale of production (proxied by population in 1995 as data on the workforce is unavailable) in the empirical analysis. The data on real openness is for 1985 because the PWT do not contain data for 1995 and because missing data for former colonies reduces the sample to 54 countries if we use 1990 trade data instead.[25] The instruments used are the log of historic settler mortality, *Area*, log*Area*, *Pop*, log*Pop*, *TFit*, log*TFit*, and the geography controls used as right-hand-side variables. It can be seen that trade remains a highly significant determinant of income per capita across all specifications. The same result holds when we combine our data with Acemoglu, Johnson, and Robinson's data on expropriation risk and historic settler mortality to estimate the effect of trade and scale on average labor productivity in former colonies in 1985 or 1990 conditional on expropriation risk (not in the table). Column (8) differs from (7) in that the Hall-Jones language variables are also used as instruments. Trade and expropriation risk are both significant determinants of income per capita in this case. Column (9) uses the same instruments as (8) but our measure of institutional quality (based on Hall and Jones) instead of expropriation risk. Both trade and institutional quality turn out to be significant. Finally, column (10) re-estimates (9) without the log of historic settler mortality as an instrument.

5.2 The Effect of Trade on Capital and Labor Efficiency

Table 11 contains the 1985 values, relative to the US, for PPP average labor productivity, y_c, average human capital, h_c, the capital-output ratio raised to the power $a/(1-a)$, $(K_c/Y_c)^{a/(1-a)}$, and labor efficiency, A_c. These values differ from those in Hall and Jones (1999). For example, labor efficiency in Italy and France is now 4 percent and 20 percent below the US instead of 20 percent and 13 percent above. These changes are driven by the use of the revised Barro-Lee average schooling data.[26]

Table 12 takes the logarithm of the three components determining average labor productivity according to (21) and uses each of them on the left-hand side of the

[25] The results for the 54-country sample using trade data for 1990 are almost identical to those in Table 10 however. In particular, the point estimates are very similar and all the right-hand-side variables that are significant (insignificant) in Table 10 remain so in the 54-country sample.

[26] Hall and Jones' calculations are based on 1988 data, while the calculations in Table 11 are based on 1985 data (because this is the year used in our empirical analysis). Using Barro and Lee (2000), we find basically the same relative values for 1988 (not in the table) than for 1985 however.

estimating equation in (18). All specifications include significant continent dummies as control variables. They do not include distance from the equator, however, because it is highly insignificant in the empirical analysis (the P-value of the exclusion restriction is never below 0.4).[27] The results in the table show a clear pattern. Institutional quality is a highly significant determinant of the capital-output ratio and the amount of human capital, while both trade and scale are statistically insignificant. When it comes to explaining labor efficiency, however, the pattern is reversed. Institutional quality is insignificant but trade and aggregate employment are significant.[28] Hence, the empirical results indicate that institutional quality increases average labor productivity only through human and physical capital accumulation, while trade works only through labor efficiency.

5.3 Trade and the Price Level

Table 15 summarizes the results of estimating (22) for the largest possible sample in 1985. The estimation method employed is GMM with robust standard errors. The control variable z_c is calculated as $\log(Y_{PPP,c}/L_c) - 1.45 \log ROpen_c - 0.3 \log L_c$ using the estimates of the effect of real openness and aggregate employment on productivity in column (3) of Table 6. It can be seen from column (1) of Table 15 that the effect of real openness and aggregate employment on the price level is positive and highly significant in the specification with real openness and aggregate employment only. The addition of geography controls (distance from the equator and four continent dummies) in column (2) does not change this result. And real openness continues to have a positive, highly significant effect on the price level even when the variable capturing productivity differences not explained by increasing returns to specialization and aggregate employment (z_c) is added to the estimating equation in columns (3) and (4). According to the most general specification in column (4), real openness is significant at the 1-percent level and aggregate employment at the 5-percent level. Productivity differences that are not explained by increasing returns are also a significant determinant of the price level. (Real openness remains a significant determinant of the price level when institutional quality is used instead of z as a control variable (not in the table). Institutional quality is insignificant however.) The results for the 98-country sample in

[27] Distance from the equator is used as an instrument however. If we include distance from the equator directly in the regression, the significance of *IQual* decreases and the significance of the log*ROpen* increases.

[28] It is interesting to note that log*Area* is a significant determinant of the capital-output ratio. This is probably due to larger countries requiring more capital for transportation.

1985 and the largest possible sample in 1990 (not in the table) show even stronger effects of real openness and aggregate employment on the price level.[29]

Columns (5) to (8) differ from (1) to (4) in two respects. First, openness is used instead of real openness on the right-hand side of the estimating equation. Second, given our finding that openness and aggregate employment are insignificant determinants of productivity in column (4) of Table 4, we include average labor productivity without any adjustments for increasing returns to specialization and aggregate employment (instead of z_c) as an additional control variable. The results indicate that neither openness nor aggregate employment is a statistically significant determinant of the price level once we include geography controls or average labor productivity in the analysis.

6 Conclusions and Some Tentative Remarks on Trade Policy

Our analysis of the effect of international trade on average labor productivity across countries emphasizes imports plus exports in exchange rate US$ relative to GDP in purchasing-power-parity US$ (real openness) as a summary measure of trade. Using real openness we find that the causal effect of trade on productivity across countries is large, highly significant, and very robust. We also analyze the channels through which international trade affects average labor productivity and find that trade works through labor efficiency.

The large effect of international trade on average labor productivity raises the question of whether trade policies may be effective in increasing productivity. A thorough investigation of this issue is beyond our scope here, but it may still be worthwhile to conclude with a tentative analysis based on the Sachs and Warner (1995) measure of trade policies. According to the Sachs and Warner criterion, a country has "open" trade policies in a given time period if it satisfies all of the following criteria: (1) non-tariff barriers cover less than 40 percent of trade, (2) average tariff rates are less than 40 percent, (3) any black market premium is less than 20 percent (this criterion only applies to the 1970s and 1980s), (4) the country is not classified as socialist by Kornai (1992), and (5) the government does not monopolize major exports. Based on annual information on the Sachs-Warner criterion we calculate the fraction of years countries have had "open" trade policies between 1960 and 1985, which yields a variable between

[29] The effect of real openness and aggregate employment on the price level remains positive and highly significant when we include average labor productivity instead of z in the estimating equation. Our empirical analysis of the price level can be seen as a test of whether the Balassa-Samuelson effect works through the productivity-gains caused by trade and the aggregate scale of production.

zero and unity (higher values indicating policies that are more favorable for trade) that we refer to as *YsOpen*.

The effect of *YsOpen* on real openness is estimated using the following equation

$$\log ROpen_c = c_0 + c_1 \log TFit_c + c_2 YsOpen_c + c_3 Mining_c + c_4 X_c + u_c, \qquad (23)$$

where *TFit* captures real openness explained by geography and population; *Mining* is the fraction of GDP produced in the mining and quarrying sector (taken from Hall and Jones (1999)); X denotes the usual geography controls; u captures the variation in real openness not explained by our empirical approach; and $c_0,\ldots,c_4$ are the parameters to be estimated.

The key issue in estimating (23) is that *YsOpen* is endogenous and measured with error. We therefore require instruments for estimating its effect on real openness consistently. The instruments used are the Hall-Jones European/English language-spoken-at-birth variables and population in 1960. The language instruments capture the possibly favorable attitude towards free market policies in general and international trade in particular associated with past European influence. The population instrument captures that larger countries can benefit from productivity-gains associated with market size even if they are less open, translating into a smaller incentive for adopting policies that are favorable for trade (Alesina, Spolaore, and Wacziarg (2000)). Our identifying hypothesis is that population in 1960 and the Hall-Jones language variables affect real openness only through the right-hand-side variables in (23). The full list of instruments used for estimation is: log*TFit*, log-population in 1960, the fraction of the population speaking English at birth, the fraction of the population speaking one of the five principal languages of Europe at birth, mining, and all the usual geography controls. (Table 16 gives the results of the least-squares regression of *YsOpen* on all the instruments used. It can be seen that population in 1960 has a significantly negative effect on *YsOpen* between 1960 and 1985, while the Hall-Jones European language variable has a significantly positive effect.) As the number of instruments exceeds the number of right-hand-side variables in the estimating equation, we test the (two) overidentifying restrictions.

Table 17 contains the results of estimating (23) with GMM. Column (1) indicates that trade explained by geography, policies favorable for trade, and the fraction of GDP produced in the mining and quarrying sector have a positive, highly significant effect on real openness. Moreover, the P-value of the test of overidentifying restrictions indicates that these restrictions cannot be rejected at conventional significance levels. Column (2) includes the population instrument and column (3) includes the Hall-Jones language instruments in (23) to test whether these variables have a direct effect on real openness. The hypothesis that the instruments have a direct effect can in all cases be rejected at conventional significance levels. Columns (4) and (5) give the results of some alternative specifications of (23).

To get a sense for the effect of trade policies on productivity implied by our empirical analysis, notice that the results in Table 17 imply that a 0.1-point increase in *YsOpen* raises real openness by at least 15 percent. Combined with the effect of real openness on productivity estimated in Table 6, this yields that a 0.1-point increase in *YsOpen* implies a 24-percent increase in productivity. An increase in *YsOpen* from zero to unity—which according to the Sachs and Warner criterion corresponds to going from policies least favorable for trade to policies most favorable—implies an eightfold increase in productivity.

Quantifying the stance of trade policies using the Sachs-Warner measure has recently been criticized by Rodriguez and Rodrik (1999) because, according to their empirical analysis, little of the explanatory power of the measure for economic *growth* stems from the non-tariff and tariff barriers criteria. We therefore check the robustness of our results by repeating the analysis substituting *YsOpen* in (23) by a dummy capturing whether countries have been "open" (unity) or "closed" (zero) during the 1970-1989 period according to the non-tariff/tariff criteria of the Sachs and Warner measure only. Using this variable, taken from Rodriguez and Rodrik, reduces our sample to 94 countries. Estimating the effect of the non-tariff/tariff barrier dummy on real openness using the same method and instruments employed for *YsOpen* yields that a change in trade policies from zero to unity raises log*ROpen* by 1.71 with a standard error of 0.41 (not in the table). This estimate is actually somewhat *larger* than the result obtained when quantifying trade policies using *YsOpen* in Table 17. Combined with the effect of real openness on productivity, the estimate implies that going from policies least favorable for trade to policies most favorable increases average labor productivity by a factor of 12.

As a further robustness check, we also estimate (23) using import duties as a percentage of the value of imports in 1984-1985, also taken from Rodriguez and Rodrik, instead of *YsOpen* as a measure of trade policies. In this case our sample is reduced to 92 countries. Estimating the effect of import duties relative to imports on real openness using the same method employed for *YsOpen* yields that a one-point increase in relative import duties reduces *ROpen* by 7 percent with a standard error of 2.4 percent (not in the table). Combined with the effect of real openness on average labor productivity, this yields that a one-point increase in relative import duties reduces productivity by 10 percent. Reducing relative import duties from 27 percent (average of the ten highest relative-import-duties countries) to 0.5 percent (average of the ten lowest relative-import-duties countries) therefore raises productivity by a factor of 14.

Our exploratory empirical analysis therefore suggests that policies favorable for trade may be an effective tool for increasing real openness and consequently productivity.

References

Acemoglu, Daron, Simon Johnson, and James A. Robinson (2000), "The Colonial Origins of Comparative Development: An Empirical Investigation," NBER Working Paper No 7771 (forthcoming *American Economic Review*).

Ades, Alberto and Edward L. Glaeser (1999), "Evidence on Growth, Increasing Returns, and the Extent of the Market," *Quarterly Journal of Economics*, August, *114*(3), pp. 1025-45.

Alesina, Alberto, Enrico Spolaore, Romain Wacziarg (2000), "Economic Integration and Political Disintegration," *American Economic Review*, December, *90*(5), pp. 1276-96.

Barro, Robert and Jongwha Lee (1993), "International Comparisons of Educational Attainment," *Journal of Monetary Economics*, December, *32*(3), pp. 363-94.

Barro, Robert and Jongwha Lee (2000), "International Comparisons of Educational Attainment: Updates and Implications," mimeo, Harvard University, February.

Bils, Mark and Peter Klenow (2000), "Does Schooling Cause Growth?" *American Economic Review*, December, *90*(5), pp. 1160-83.

Coe, David, and Elhanan Helpman (1995): "International R&D Spillovers," *European Economic Review*, May, *39*(5), pp.859-87.

Coplin, William D., Michael K. O'Leary, and Tom Sealy (1996), *A Business Guide to Political Risk for International Decisions*. Syracuse, Political Risk Services.

David, Paul (1977), "Invention and Accumulation in America' s Economic Growth: A Nineteenth-Century Parable," *Journal of Monetary Economics*, Supplementary series, *6*(0), pp. 176-228.

Dinopoulos, Elias, and Peter Thompson (2000), "Endogenous Growth in a Cross-Section of Countries," *Journal of International Economics*, August, *51*(2), pp. 335-62.

Ethier, Wilfred J. (1982), "National and International Returns to Scale in the Modern Theory of International Trade," *American Economic Review*, June, *72*(3), pp. 389-405.

Finn, Hames (ed.) (1994), *Freedom in the World: The Annual Survey of Political Rights and Civil Liberties*, 1993-1994. New York, Freedom House.

Frankel, Jeffrey and David Romer (1999), "Does Trade Cause Growth?" *American Economic Review*, June, *89*(3), pp. 379-99.

Frankel, Jeffrey and Andrew Rose (2000), "Estimating the Effect of Currency Unions on Trade and Output," NBER Working Paper No 7857.

Gustavsson, Patrik, Par Hansson, and Lars Lundberg (1999), "Technology, Resource Endowments and International Competitiveness," *European Economic Review*, August, *43*(8), pp. 1501-30.

Hall, Robert and Charles Jones (1999), "Why do some countries produce more output per worker than others?" *Quarterly Journal of Economics*, February, 114(1), pp. 83-116.

Helpman, Elhanan (1981), "International Trade in the Presence of Product Differentiation, Economies of Scale, and Monopolistic Competition: A

Chamberlin-Heckscher-Ohlin Approach," *Journal of International Economics*, August, *11*(3), pp. 305-40.

Heston, Alan, Daniel Nuxoll, and Robert Summers (1994), "The Differential-Productivity Hypothesis and Purchasing-Power Parities: Some New Evidence," *Review of International Economics*, October, (2)3, pp. 227-243.

International Monetary Fund, *Direction of Trade Statistics*. Various years, IMF, Washington D.C.

Irwin, Douglas and Marko Tervio (2000), "Does Trade Raise Income: Evidence from the Twentieth Century," NBER Working Paper No 7745.

Klenow, Peter and Andres Rodriguez-Clare (1997), "The Neoclassical Revival in Growth Economics: Has It Gone Too Far?" In Ben Bernanke and Julio Rotemberg (eds.), *NBER Macroeconomics Annual*. Cambridge, MA, MIT Press.

Knack, Stephen, and Philip Keefer (1995), "Institutions and Economic Performance: Cross-Country Tests Using Alternative Institutional Measures," *Economics and Politics*, November, *7*(3), pp. 207-27.

Kornai, Janos (1992), *The Socialist System: The Political Economy of Communism*, Pricenton, Princeton University Press.

Krugman, Paul (1981), "Intraindustry Specialization and the Gains from Trade," *Journal of Political Economy*, October, *89*(5), pp. 959-73.

Mankiw, Gregory, David Romer and David Weil (1992), "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, May, *107*(2), p. 407-37.

Miller, Stephen M. and Mukti P. Upadhyay (2000), "The Effects of Openness, Trade Orientation, and Human Capital on Total Factor Productivity," *Journal of Development Economics*, December, *63*(2), pp. 399-423.

Pesaran, Hashem and Richard Smith (1994), "A Generalized R^2 Criterion for Regression Models Estimated by the Instrumental Variables Method," *Econometrica*, May, *62*(3), pp. 705-10.

Summers, Robert, and Alan Heston (1991), "The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988," *Quarterly Journal of Economics*, May, *106*(2), pp. 327-68.

Rand McNally (1993), *Quick Reference Atlas*, Chicago, Rand McNally.

Rodriguez, Francisco and Dani Rodrik (1999), "Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence," NBER Working Paper No 7081.

Rogoff, Kenneth (1996), "The Purchasing Power Parity Puzzle," *Journal of Economic Literature*, Vol. XXXIV, June, pp. 647-668.

Sachs, Jeffrey and Andrew Warner (1995), "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity*, 1, pp. 1-95.

World Bank, *World Development Indicators*, Various years, World Bank, Washington D. C.

Appendix

Table 1. The quality of the gravity-equation instruments for trade intensity

	(1)	(2)	(3)	(4)	(5)	(6)
	Open	*Open*	*Open*	*Open*	*Open*	*Open*
$R^2(1)= R^2$ with all instruments	0.544	0.548	0.591	0.631	0.567	0.584
$R^2(2)= R^2$ excluding *TFit*/log*TFit*	0.482	0.517	0.414	0.529	0.43	0.492
$(R^2(1)- R^2(2))/ R^2(2)$	0.129	0.060	0.428	0.193	0.319	0.187
P-value of excluding *TFit*/log*TFit*	0.000	0.001	0.000	0.000	0.000	0.000
GeoControls included?	no	yes	no	yes	no	yes
Observations	150	150	98	98	115	115
Year	1985	1985	1985	1985	1990	1990

	(7)	(8)	(9)	(10)	(11)	(12)
	log*ROpen*	log*ROpen*	log*ROpen*	log*ROpen*	log*ROpen*	log*ROpen*
$R^2(1)$	0.508	0.54	0.49	0.573	0.559	0.595
$R^2(2)$	0.377	0.496	0.285	0.491	0.39	0.501
$(R^2(1)- R^2(2))/ R^2(2)$	0.347	0.089	0.719	0.197	0.433	0.188
P-value of excluding *TFit*/log*TFit*	0.000	0.001	0.000	0.001	0.000	0.000
GeoControls included?	no	yes	no	yes	no	yes
Observations	150	150	98	98	115	115
Year	1985	1985	1985	1985	1990	1990

Notes: Results of regressing the measure of *ITrade* heading the column (*Open* and log*ROpen*) on *Area*, log*Area*, *Pop*, log*Pop*, *TFit*, log*TFit*, and the geography controls whenever it says so in the third row from the bottom. The methods used is least squares. $R^2(1)$ is the R^2 of the regression using all the aforementioned variables. $R^2(2)$ is the R^2 of the regression of the measure of *ITrade* on all the instruments used in the previous row except *TFit* and log*TFit*. $(R^2(1)-R^2(2))/R^2(2)$ is the proportional increase in the R^2 associated with the inclusion of *TFit*, log*TFit* among the instruments. The fourth row gives the P-value of the hypothesis that *TFit* and log*TFit* can be excluded from the equation. All regressions include a constant. *GeoControls* refers to four continent dummies (Oceania is excluded) and distance from the equator.

Table 2. The quality of the Hall-Jones instruments for institutional quality

		(1)	(2)	(3)	(4)	(5)
		IQual	*IQual*	*IQual*	*IQual*	*IQual*
EnglL	Est.	0.11	0.16	0.09	0.12	
	S.e.	0.05	0.07	0.05	0.06	
EuroL	Est.	0.08	0.11	0.14	0.15	
	S.e.	0.03	0.04	0.04	0.04	
TFit	Est.	0.006	0.14	0.004	0.003	
	S.e.	0.002	0.002	0.002	0.002	
AbsLati	Est.	0.65		0.48		
	S.e.	0.07		0.1		
Continent Dummies included?		no	no	yes	yes	yes
Observations		137	137	137	137	137
Year		1985	1985	1985	1985	1985
R^2		0.54	0.25	0.59	0.52	0.43

		(6)	(7)	(8)	(9)	(10)
		IQual	*IQual*	*IQual*	*IQual*	*IQual*
EnglL	Est.	0.13	0.18	0.08	0.12	
	S.e.	0.05	0.08	0.05	0.06	
EuroL	Est.	0.07	0.09	0.11	0.115	
	S.e.	0.03	0.04	0.04	0.0	
TFit	Est.	0.005	0.1	0.004	0.004	
	S.e.	0.001	0.01	0.002	0.002	
AbsLati	Est.	0.65		0.48		
	S.e.	0.06		0.1		
Continent Dummies included?		no	no	yes	yes	yes
Observations		137	137	137	137	137
Year		1990	1990	1990	1990	1990
R^2		0.62	0.29	0.66	0.59	0.43

Notes: Results of regressing *IQual* on the variables in the first column of the table using least squares with robust standard errors. Standard errors in the table also take into account that *TFit* and log*TFit* have been estimated. The construction of *IQual* is explained in the main text. All regressions include a constant.

Table 3. Specification of the trade model

		(1) *Open*	(2) log*Open*	(3) *ROpen*	(4) log*ROpen*	(5) *Open*	(6) log*Open*
ITrade	Est.	4.13	2.96	3.41	1.44	3.19	1.86
	S.e.	1.21	0.8	0.59	0.19	0.71	0.52
log*Workforce*	Est.	0.29	0.48	0.14	0.34	0.39	0.49
	S.e.	0.14	0.14	0.075	0.068	0.12	0.13
log*Area*	Est.	0.36	0.14	0.21	0.01	0.07	0.03
	S.e.	0.12	0.1	0.07	0.05	0.12	0.1
Year		1985	1985	1985	1985	1985	1985
Observations		150	150	150	150	98	98
R^2		neg.	neg.	0.37	0.28	neg.	neg.
Generalized R^2		0.165	0.15	0.18	0.198	0.207	0.2
P-value overident. Restrictions		0.12	0.25	0.11	0.25	0.13	0.13

		(7) *ROpen*	(8) log*ROpen*	(9) *Open*	(10) log*Open*	(11) *ROpen*	(12) log*ROpen*
ITrade	Est.	2.73	1.28	2.03	2.44	2.14	1.47
	S.e.	0.73	0.24	0.68	0.62	0.47	0.23
log*Workforce*	Est.	0.28	0.41	0.34	0.46	0.27	0.38
	S.e.	0.092	0.09	0.099	0.12	0.077	0.076
log*Area*	Est.	0.08	-0.01	0.049	0.12	0.01	0.028
	S.e.	0.1	0.07	0.11	0.11	0.08	0.066
Year		1985	1985	1990	1990	1990	1990
Observations		98	98	115	115	115	115
R^2		0.13	0.28	neg.	neg.	0.295	0.33
Generalized R^2		0.233	0.249	0.181	0.166	0.219	0.282
P-value overident. Restrictions		0.19	0.11	0.005	0.048	0.006	0.12

Notes: Results of the baseline regression in (18) estimated using the four different measures of *ITrade*. The left-hand-side variable is the log of average labor productivity in PPP US$. The construction of the generalized R^2 is explained in the main text. The estimation method is GMM with robust standard errors. Standard errors in the table also take into account that *TFit* and log*TFit* have been estimated. Instruments used are *Area*, log*Area*, *Pop*, log*Pop*, *TFit*, log*TFit* in all cases. The last row gives the P-value of the test of overidentifying restrictions. All regressions include a constant.

Table 4. The specification using openness as a summary measure of trade

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Open	Est.	4.13	1.78	-0.9	0.43	3.19	1.11	-0.7	0.26	2.03	1.59	-0.8	0.16
	S.e.	1.21	0.86	0.89	0.73	0.71	0.29	0.48	0.28	0.68	1.09	0.53	0.5
log*Workforce*	Est.	0.298	0.12	-0.3	-0.16	0.397	0.18	-0.1	0.033	0.34	0.27	-0.1	-0.01
	S.e.	0.139	0.11	0.1	0.12	0.122	0.066	0.08	0.077	0.099	0.11	0.09	0.1
IQual	Est.			8.25	3.55			6.75	2.78			7.03	4.67
	S.e.			1.31	1.16			0.87	0.89			1.03	1.11
log*Area* included?		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
GeoControls included?		no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
Year		1985	1985	1985	1985	1985	1985	1985	1985	1990	1990	1990	1990
Observations		150	150	137	137	98	98	97	97	115	115	110	110
R^2		neg.	0.46	neg.	0.67	neg.	0.73	0.38	0.79	neg.	0.57	0.33	0.69

Notes: Results of estimating (18) using *Open* as a measure of *ITrade*. The left-hand-side variable is the log of average labor productivity in PPP US$. The estimation method is GMM with robust standard errors. Instruments always used are *Area*, log*Area*, *Pop*, log*Pop*, *TFit* and log*TFit*. Standard errors in the table also take into account that *TFit* and log*TFit* have been estimated. When institutional quality (*IQual*) is included as a right-hand-side variable, then the instruments include the fraction of the population speaking English at birth, the fraction of the population speaking one of the five principal languages of Europe at birth, and the distance from the equator. The construction of *IQual* is explained in the main text. *GeoControls* refers to four continent dummies (Oceania is excluded) and distance from the equator. When *GeoControls* is included as a right-hand-side variable, then the set of instruments includes *GeoControls*. All regressions include a constant.

Table 5. The specification using openness and excluding insignificant geography control variables

		(1)	(2)	(3)
Open	Est. S.e.	0.48 0.75	0.38 0.27	0.08 0.49
log*Workforce*	Est. S.e.	-0.12 0.1	0.04 0.05	-0.02 0.077
log*Area*	Est. S.e.	0.06 0.06	-0.01 0.04	-0.04 0.05
Africa	Est. S.e.		-0.54 0.18	
Asia	Est. S.e.	0.85 0.22		0.58 0.21
America	Est. S.e.	0.99 0.13	0.59 0.14	0.9 0.13
Europe	Est. S.e.			
AbsLati	Est. S.e.	1.64 0.62	1.28 0.61	
IQual	Est. S.e.	3.51 0.84	2.71 0.66	5.28 0.37
Year Observations R^2		1985 137 0.65	1985 97 0.79	1990 110 0.65

Notes: Results of estimating (18) using *Open* as a measure of *ITrade*. The left-hand-side variable is the log of average labor productivity in PPP US$. The estimation method is GMM with robust standard errors. Instruments always used are *Area*, log*Area*, *Pop*, log*Pop*, *TFit* log*TFit*, the fraction of the population speaking English at birth, the fraction of the population speaking one of the five principal languages of Europe at birth, and the distance from the equator. Standard errors in the table also take into account that *TFit* and log*TFit* have been estimated. When continent dummies and distance from the equator (*AbsLati*) are included as right-hand-side variables, then the set of instruments also includes them. The construction of *IQual* is explained in the main text. All regressions include a constant. The specification excludes geographic variables that are not significantly different from zero at the 10-percent level.

Table 6. The specification using the log of real openness as a summary measure of trade

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
log*ROpen*	Est.	1.44	1.32	1.45	1.33	1.32	1.28	0.81	0.49	0.92	0.91	1.47	1.32	1.18	1.01	0.99
	S.e.	0.19	0.29	0.35	0.29	0.3	0.24	0.17	0.3	0.3	0.29	0.23	0.26	0.39	0.31	0.32
log*Workforce*	Est.	0.34	0.3	0.3	0.26	0.25	0.41	0.23	0.14	0.23	0.21	0.38	0.4	0.34	0.28	0.27
	S.e.	0.068	0.1	0.14	0.11	0.11	0.092	0.068	0.087	0.11	0.1	0.079	0.11	0.17	0.11	0.12
log*Area*	Est.	0.01	0.026	0.039	0.058	0.059	-0.01	-0.01	-0.04	-0.01	-0.01	0.019	-0.04	-0.05	-0.018	-0.017
	S.e.	0.05	0.045	0.14	0.05	0.05	0.074	0.052	0.04	0.05	0.05	0.06	0.061	0.06	0.05	0.05
Africa	Est.		-1.1	-0.57	-0.6	-0.64		-1.03	-0.87	-0.53	-0.58		-1.26	-0.54	-0.47	-0.49
	S.e.		0.25	0.49	0.22	0.22		0.38	0.44	0.2	0.22		0.32	0.5	0.22	0.22
Asia	Est.		-0.45	-0.01				-0.42	-0.31				-0.78	-0.06		
	S.e.		0.3	0.54				0.41	0.45				0.39	0.56		
America	Est.		-0.01	0.65	0.65	0.62		0.18	0.34	0.75	0.71		-0.06	0.68	0.74	0.72
	S.e.		0.24	0.47	0.22	0.22		0.38	0.38	0.2	0.21		0.31	0.44	0.2	0.2
Europe	Est.		-1	-0.55				-0.71	-0.52				-0.97	-0.36		
	S.e.		0.35	0.5				0.39	0.4				0.35	0.46		
AbsLati	Est.		1.96	1.11	0.40			2.68	1.94	1.02			1.78	0.74	0.24	
	S.e.		0.63	0.85	0.67			0.48	0.66	0.70			0.58	0.82	0.63	
IQual	Est.			1.13	1.09	1.4			1.38	1.4	2.25			2.46	2.31	2.55
	S.e.			1.29	0.9	0.66			1.24	1.01	0.71			1.43	1.15	0.74
Year		1985	1985	1985	1985	1985	1985	1985	1985	1985	1985	1990	1990	1990	1990	1990
Observations		150	137	137	137	137	98	97	97	97	97	115	110	110	110	110
R^2		0.27	0.5	0.52	0.55	0.53	0.3	0.81	0.65	0.72	0.68	0.24	0.66	0.67	0.68	0.66

Notes: Results of estimating (18) using log*ROpen* as a measure of *ITrade*. The left-hand-side variable is the log of average labor productivity in PPP US$. The estimation method is GMM with robust standard errors. Instruments always used are *Area*, log*Area*, *Pop*, log*Pop*, *TFit* and log*TFit*. Standard errors in the table also take into account that *TFit* and log*TFit* have been estimated. Instruments also include the geography controls (continents and absolute latitude, *AbsLati*) whenever used as right-hand-side variables. When institutional quality (*IQual*) is included as a right-hand-side variable, then the instruments include the fraction of the population speaking English at birth, the fraction of the population speaking one of the five principal languages of Europe at birth, and the distance from the equator. The construction of *IQual* is explained in the main text. All regressions include a constant.

Table 7. Robustness checks. Fitted trade calculated without using population or area in the bilateral trade regression

		(1)	(2)	(3)	(4)
log*ROpen*	Est.	0.99	1.5	1.54	1.47
	S.e.	0.2	0.33	0.21	0.33
log*Workforce*	Est.	0.25	0.31	0.37	0.32
	S.e.	0.05	0.14	0.07	0.14
log*Area*	Est.	-0.02	0.04	-0.001	0.02
	S.e.	0.04	0.05	0.05	0.06
IQual	Est.		0.14		1.71
	S.e.		1.29		1.17
GeoControls included?		no	yes	no	yes
Year		1985	1985	1985	1985
Observations		150	150	150	150
R^2		0.375	0.54	0.228	0.47

Notes: Results of estimating (18) using the log*ROpen* as a measure of *ITrade*. The left-hand-side variable is the log of average labor productivity in PPP US$. The estimation method is GMM with robust standard errors. Instruments always used are *Area*, log*Area*, *Pop*, log*Pop*, *TFit* and log*TFit*. *TFit* is constructed based on the bilateral-trade regression in (19), without including population, in columns (1) and (2), and without including area, in columns (3) and (4), as explanatory variables. Standard errors in the table also take into account that *TFit* and log*TFit* have been estimated. *GeoControls* refers to four continent dummies (Oceania is excluded) and distance from the equator. When *GeoControls* is included as a right-hand-side variable, then the set of instruments includes *GeoControls*. When institutional quality (*IQual*) is included as a right-hand-side variable, then the instruments include the fraction of the population speaking English at birth, the fraction of the population speaking one of the five principal languages of Europe at birth, and the distance from the equator. The construction of *IQual* is explained in the main text. All regressions include a constant.

Table 8. Specification with the log of openness, excluding insignificant geography control variables

		(1)	(2)	(3)
log*Open*	Est.	2.81	0.83	1.2
	S.e.	1.58	0.56	0.82
log*Workforce*	Est.	0.41	0.14	0.23
	S.e.	0.33	0.15	0.17
log*Area*	Est.	0.21	0.03	0.01
	S.e.	0.12	0.05	0.07
Africa	Est.	-0.62	-0.63	-0.38
	S.e.	0.4	0.22	0.26
Asia	Est.	1.11		
	S.e.	0.6		
America	Est.		0.71	0.98
	S.e.		0.24	0.33
Europe	Est.			
	S.e.			
AbsLati	Est.			
	S.e.			
IQual	Est.	1.88	3.23	3.71
	S.e.	1.24	0.5	0.64
Year		1985	1985	1990
Observations		137	97	110
R^2		neg.	0.71	0.51

Notes: Results of estimating (18) using log*Open* as the measure of *ITrade*. The left-hand-side variable is the log of average labor productivity in PPP US$. The estimation method is GMM with robust standard errors. Instruments always used are *Area*, log*Area*, *Pop*, log*Pop*, *TFit* log*TFit*, the fraction of the population speaking English at birth, the fraction of the population speaking one of the five principal languages of Europe at birth, and the distance from the equator. Standard errors in the table also take into account that *TFit* and log*TFit* have been estimated. Instruments also include continent dummies whenever used as right-hand-side variables. The construction of *IQual* is explained in the main text. All regressions include a constant. The specification excludes geographic variables that are not significantly different from zero at the 10-percent level.

Table 9. Specification with real openness, excluding insignificant geography control variables

		(1)	(2)	(3)
ROpen	Est. S.e.	2.47 0.63	0.9 0.58	0.95 0.58
log*Workforce*	Est. S.e.	0.08 0.08	0.052 0.05	0.1 0.08
log*Area*	Est. S.e.	0.099 0.05	-0.03 0.05	-0.04 0.04
Africa	Est. S.e.	-0.73 0.22	-0.57 0.2	-0.58 0.2
Asia	Est. S.e.			
America	Est. S.e.	0.47 0.2	0.56 0.16	0.54 0.17
Europe	Est. S.e.			
AbsLati	Est. S.e.			
IQual	Est. S.e.	2.19 0.54	3.31 0.45	3.55 0.57
Year Observations R^2		1985 137 0.47	1985 97 0.72	1990 110 0.69

Notes: Results of estimating (18) using the *ROpen* as a measure of *ITrade*. The left-hand-side variable is the log of average labor productivity in PPP US$. The estimation method is GMM with robust standard errors. Instruments always used are *Area*, log*Area*, *Pop*, log*Pop*, *TFit* log*TFit*, the fraction of the population speaking English at birth, the fraction of the population speaking one of the five principal languages of Europe at birth, and the distance from the equator. Standard errors in the table also take into account that *TFit* and log*TFit* have been estimated. Instruments also include continent dummies whenever used as right-hand-side variables. The construction of *IQual* is explained in the main text. All regressions include a constant. The specification excludes geographic variables that are not significantly different from zero at the 10-percent level.

Table 10. Trade and institutions in former colonies

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
log*ROpen*	Est.				1.53	1.48	1.44	1.43	0.83	1.15	1.15
	S.e.				0.29	0.28	0.22	0.25	0.33	0.22	0.22
log*Pop*	Est.				0.44	0.34	0.44	0.35	0.16	0.19	0.20
	S.e.				0.14	0.14	0.14	0.14	0.11	0.1	0.11
log*Area*	Est.				0.03	0.06		0.05	0.03	0.06	0.05
	S.e.				0.06	0.06		0.05	0.04	0.04	0.04
Africa	Est.		-0.55	-0.55	-1.56	-1.42	-1.51	-1.42	-1.12	-1.26	-1.27
	S.e.		0.27	0.33	0.22	0.21	0.2	0.21	0.2	0.16	0.16
Asia	Est.		-0.74	-0.81	-0.98	-0.61	-0.87	-0.59	-0.64	-0.9	-0.72
	S.e.		0.31	0.4	0.28	0.31	0.27	0.31	0.24	0.26	0.26
Other	Est.						0.56	0.56	-0.55	-0.64	-0.66
Continent	S.e.						0.25	0.25	0.23	0.24	0.25
AbsLati	Est.			-1.69		2.56		2.33	1.81	2.1	2.1
	S.e.			1.33		0.72		0.72	0.54	0.53	0.53
IQual										2.33	2.37
										0.72	0.74
ExprR	Est.	0.94	0.82	0.88	0.06	-0.06	0.001	-0.08	0.35		
	S.e.	0.19	0.23	0.39	0.09	0.09	0.1	0.13	0.18		
Year		1995	1995	1995	1995	1995	1995	1995	1995	1995	1995
Observation		63	63	63	63	63	63	63	63	63	63
R^2		0.19	0.44	0.33	0.61	0.66	0.63	0.67	0.76	0.73	0.73

Notes: The left-hand-side variable of the estimating equation is the log of 1995 GDP per capita in PPP US$ taken from Acemoglu, Johnson, and Robinson (2000). The right-hand-side variables are in the leftmost column. The variable *ExprR* refers to the average risk of expropriation 1985-95. The PWT have data on trade only for a subset of former colonies after 1985. The data on *ROpen* are therefore for 1985. Moreover, the PWT lack data on Vietnam, leaving us with 63 of the 64 observations in Acemoglu et al. The estimation method is GMM with robust standard errors. Instruments used are the geography controls whenever used as right-hand-side variables (to make the analysis consistent with Acemoglu et al, we omit America and define *Other Continent* as Europe and Oceania). Moreover:

- Columns (1) to (7) additionally use the following instruments: Log of historic settler mortality taken from Acemoglu et al. (2000), and *Area*, log*Area*, *Pop*, log*Pop*, *TFit* and log*TFit* when population, area, and log*ROpen* are used as right-hand-side variables.
- Column (8) uses the instruments in (7) plus the fraction of the population speaking English at birth and the fraction speaking one of the five principal languages of Europe at birth.
- Column (9) uses the instruments in (8).
- Column (10) uses the instruments in (9) except for the log of historic settler mortality.

Standard errors in the table take into account that *TFit* and log*TFit* have been estimated. The construction of *IQual* is explained in the main text. All regressions include a constant.

Table 11. Countries ranked by their average labor productivity relative to the US in 1985

Country	Relative(y)	Relative(h)	Relative($(K/Y)^{0.5}$)	Relative(A)
U.S.A.	1	1	1	1
CANADA	0.91	0.90	1	1
SWITZERLAND	0.88	0.87	1.17	0.86
AUSTRALIA	0.84	0.88	1.11	0.86
NETHERLANDS	0.84	0.78	1.05	1.02
BELGIUM	0.82	0.77	1.04	1.03
ITALY	0.82	0.79	1.07	0.96
WEST GERMANY	0.82	0.82	1.12	0.89
FRANCE	0.81	0.93	1.09	0.79
NORWAY	0.80	0.79	1.16	0.87
SWEDEN	0.80	0.83	1.03	0.93
NEW ZEALAND	0.78	0.98	1.08	0.74
AUSTRIA	0.72	0.78	1.07	0.86
DENMARK	0.71	0.84	1.06	0.80
. .	. .	. .	. .	. .
U.S.S.R.	0.41	0.84	1.22	0.40
ALGERIA	0.38	0.62	0.95	0.65
TAIWAN	0.37	0.89	0.88	0.47
BARBADOS	0.37	0.95	0.77	0.50
YUGOSLAVIA	0.34	0.91	1.16	0.32
PORTUGAL	0.33	0.72	1.01	0.45
BRAZIL	0.33	0.69	0.87	0.54
REPUBLIC OF KOREA	0.31	0.77	0.90	0.45
URUGUAY	0.31	0.86	0.96	0.37
PANAMA	0.30	0.83	0.90	0.41
FIJI	0.29	0.88	0.92	0.35
MALAYSIA	0.28	0.73	1	0.39
SOUTH AFRICA	0.27	0.75	0.98	0.36
COLOMBIA	0.26	0.69	0.83	0.46
COSTA RICA	0.26	0.75	0.85	0.41

Table 11 continued.

Country	Relative(y)	Relative(h)	Relative($(K/Y)^{0.5}$)	Relative(A)
. .	. .	. .	. .	. .
GUINEA-BISS	0.04	0.52	0.86	0.09
MYANMAR	0.04	0.61	0.59	0.11
MOZAMBIQUE	0.04	0.54	0.36	0.20
COMOROS	0.04	0.52	0.86	0.09
ANGOLA	0.04	0.52	0.51	0.14
CENTRAL AFRICAN REPUBLIC	0.04	0.56	0.57	0.12
UGANDA	0.04	0.59	0.37	0.17
CHAD	0.03	0.52	0.36	0.18
ZAIRE	0.03	0.60	0.51	0.11
MALAWI	0.03	0.65	0.69	0.07
NIGER	0.03	0.54	0.69	0.08
BURUNDI	0.03	0.52	0.49	0.12
TANZANIA	0.03	0.52	0.67	0.08
BURKINA FASO	0.03	0.52	0.56	0.10
ETHIOPIA	0.02	0.52	0.45	0.09

Notes: The method of calculation for h, $(K/Y)^{a/(1-a)}$ for $a = 1/3$, and A are explained in the main text; y stands for Y/L. All values are relative to the US. The table contains data for selected countries only.

Table 12. Effects of trade and institutional quality on the components of productivity

		$\log(K/Y)^{a/(1-a)}$	$\log(H/L)$	$\log A$
log*ROpen*	Est. S.e.	-0.036 0.023	-0.0009 0.025	0.81 0.3
log*Workforce*	Est. S.e.	0.02 0.06	0.049 0.055	0.21 0.08
log*Area*	Est. S.e.	0.03 0.016	0.0007 0.012	0.003 0.04
IQual	Est. S.e.	0.73 0.17	1.13 0.15	0.55 0.6
Continent Dummies included?		yes	yes	yes
Year Observations R^2		1985 127 0.45	1985 127 0.68	1985 127 neg.

Notes: Results of estimating (18) for the three components of log-productivity in (21), $\log(K/Y)^{a/(1-a)}$ for $a=1/3$, $\log(H/L)$, and $\log A$, using log*ROpen* as a measure of *ITrade*. The estimation method is GMM with robust standard errors. Continent dummies included are Africa, America, and Asia (the P-value of the exclusion restriction for Europe is 0.52). Instruments used are *Area*, log*Area*, *Pop*, log*Pop*, *TFit*, log*TFit*, the fraction of the population speaking English at birth, the fraction of the population speaking one of the five principal languages of Europe at birth, distance from the equator, and continent dummies included as controls. Standard errors in the table also take into account that *TFit* and log*TFit* have been estimated. The construction of *IQual* is explained in the main text. All regressions include a constant. We concentrate on 1985 because the sample of countries is greater for 1985 than for 1990 (because of missing values on education and physical capital for 1990). Still, the results for 1990 mirror those for 1985.

Table 13. Effects of openness on productivity using the Frankel and Romer (1999) data and estimation method

		(1)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(11)	(12)
Open	Est.	1.96	0.88	0.95	0.34	-1.44	2.96	3.42	3.36	0.58	-1.18
	S.e.	0.91	0.79	0.7	0.76	0.94	1.34	1.9	1.27	0.86	0.89
log*Workforce*	Est.	0.19	-0.03	-0.02	-0.02	-0.31	0.35	0.34	0.34	0.057	-0.26
	S.e.	0.088	0.09	0.07	0.07	0.11	0.14	0.26	0.16	0.094	0.12
log*Area*	Est.	0.086	0.11	0.11	-0.01	-0.04	0.2	0.29	0.28	-0.02	-0.07
	S.e.	0.097	0.069	0.069	0.07	0.09	0.17	0.17	0.14	0.11	0.11
Africa	Est.		-1.05	-1.22				-1.3	-1.72		
	S.e.		0.29	0.13				0.71	0.24		
Asia	Est.		0.15					-0.93	-1.35		
	S.e.		0.35					0.79	0.42		
America	Est.		0.23					0.52			
	S.e.		0.29					0.84			
Europe	Est.		0.8	0.61				0.37			
	S.e.		0.36	0.19				0.74			
AbsLati	Est.				3.64					4.08	
	S.e.				0.44					0.47	
IQual	Est.					6.74					6.89
	S.e.					1.27					0.98
Year		1985	1985	1985	1985	1985	1985	1985	1985	1985	1985
Observations		150	150	150	150	137	98	98	98	98	97
R^2		neg.	0.51	0.509	0.42	0.15	neg.	0.034	0.052	0.55	0.35

Notes: Results of estimating (18) using the *Open* as a measure of *ITrade*. The left-hand-side variable is the log of average labor productivity in PPP US$. The estimation method used for the specifications without institutional quality (*IQual*) is exactly identified two-stage least-squares. Instruments used are *TFit*, log*Workforce*, log*Area* and whatever geography controls are included as right-hand-side variables. *TFit* is constructed using the Frankel and Romer data-set on bilateral trade (with about half of the observations on bilateral trade data used in this paper). The specifications with *IQual* as a right-hand-side variable uses as additional instruments the fraction of the population speaking English at birth, the fraction of the population speaking one of the five principal languages of Europe at birth, and the distance from the equator. The construction of *IQual* is explained in the main text. All regressions include a constant.

Table 14. The institutional quality model

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
IQual	Est. S.e.	4.07 1.06	4.37 0.65	3.95 0.82	4.22 0.61	4.58 0.55	4.18 0.67	4.49 0.74	4.62 0.65	4.62 0.84
AbsLati	Est. S.e.			0.55 0.68			0.82 0.64			-0.001 0.67
AbsLati used as instrument?		no	yes	yes	no	yes	yes	no	yes	yes
Continent Dummies included?		yes	yes	yes	yes	yes	yes	yes	yes	yes
Year Observations		1985 137	1985 137	1985 137	1985 98	1985 98	1985 97	1990 110	1990 110	1990 110

Notes: The left-hand-side variable is the log of average labor productivity in PPP US$. The right-hand-side variables are listed in the first column. The estimation method is GMM with robust standard errors. Instruments always used are the fraction of the population speaking English at birth, the fraction speaking one of the five principal languages of Europe at birth, and continent dummies. Distance from the equator is used as instrument if indicated. The construction of the measure of institutional quality (*IQual*) is explained in the main text. All regressions include a constant. Continent dummies are (jointly) statistically significant at the 1-percent level in all specifications. It can be seen from columns (3), (6) and (9) that *AbsLati* is not significant when included as a control variable. Hence, the hypothesis that it is a valid instrument cannot be rejected at conventional significance level. (Like Hall and Jones (1999), we find that the overidentifying restrictions can be rejected at standard significance levels for the model with *IQual* only as a determinant of average labor productivity. The overidentifying restrictions can no longer be rejected, when continent dummies are included in the analysis however).

Table 15. Real openness, openness, and the price level

		(1)	(2)	(3)	(4)
		log*P*	log*P*	log*P*	log*P*
log*Ropen*	Est.	0.39	0.36	0.42	0.55
	S.e.	0.05	0.06	0.08	0.09
log*Workforce*	Est.	0.07	0.06	0.07	0.1
	S.e.	0.02	0.03	0.02	0.03
z	Est.			0.14	0.22
	S.e.			0.05	0.06
GeoControls included?		no	yes	no	yes
Year		1985	1985	1985	1985
Observations		150	150	150	150
R^2		0.51	0.53	0.52	0.55
Generalized R^2		0.18	0.21	0.26	0.28

		(5)	(6)	(7)	(8)
		log*P*	log*P*	log*P*	log*P*
log*Open*	Est.	0.56	0.30	0.13	0.09
	S.e.	0.13	0.18	0.12	0.12
log*Workforce*	Est.	0.1	0.03	0.005	0.001
	S.e.	0.03	0.05	0.03	0.04
log(*Y/L*)	Est.			0.23	0.34
	S.e.			0.05	0.07
GeoControls included?		no	yes	no	yes
Year		1985	1985	1985	1985
Observations		150	150	150	150
R^2		0.22	0.05	0.31	0.37
Generalized R^2		0.089	0.11	0.14	0.15

Notes: Results of estimating (22) in columns (1) to (4). The left hand-side variable is the log of the price level. Columns (5) to (8) estimate (22) after replacing real openness by openness on the right-hand side. The estimation method is GMM with robust standard errors. z is $\log(Y_{PPP}/L) - 1.45\log ROpen - 0.3\log L$. *GeoControls* refers to four continent dummies (Oceania is excluded) and distance from the equator. Instruments always used are *Pop*, log*Pop*, *TFit* log*TFit*, the fraction of the population speaking English at birth, and the fraction of the population speaking one of the five principal languages of Europe at birth. The geographic variables are also used as instruments whenever they are included among the right-hand-side variables. Standard errors in the table take into account that *TFit* and log*TFit* have been estimated. All regressions include a constant. Real openness remains a significant determinant of the price level when institutional quality is used as a control variable in (2) (institutional quality is insignificant however). Adding institutional quality as a control variable in (6) implies that openness becomes insignificant (institutional quality is significant).

Table 16. The quality of the instruments used to predict trade policies

		(1) *YsOpen*	(2) *YsOpen*
log*TFit*	Est.	0.12	0.017
	S.e.	0.04	0.05
Mining	Est.	-0.23	-0.3
	S.e.	0.3	0.33
log*Pop* in 1960	Est.		-0.05
	S.e.		0.02
EngL	Est.		0.13
	S.e.		0.16
EuroL	Est.		0.24
	S.e.		0.08
GeoControls included?		yes	yes
Observations		130	130
Year		1985	1985
R^2		0.34	0.43

Notes: Results of regressing *YsOpen* on the variables in the first column of the table using least squares with robust standard errors. *YsOpen* is calculated following Sachs and Warner (1995). All regressions include a constant. The results in column (2) indicate that the fraction of the population speaking one of the five primary European languages (including English) at birth (*EuroL*) has a positive effect on *YsOpen*, while the fraction of the population speaking English at birth (*EngL*) is insignificant. Log-population in 1960 affects *YsOpen* between 1960 and 1985 negatively. Comparing columns (1) and (2) yields that the proportional increase in R^2 due to the inclusion of log-population in 1960 and the Hall-Jones European/English language-spoken-at-birth instruments in the regression is 26 percent.

Table 17. The effect of trade policies on real openness

		(1)	(2)	(3)	(4)	(5)
		log*ROpen*	log*ROpen*	log*ROpen*	log*ROpen*	log*ROpen*
log*TFit*	Est.	0.53	0.53	0.53	0.65	0.58
	S.e.	0.1	0.11	0.11	0.11	0.11
YsOpen between 1960 and 1985	Est.	1.55	1.48	1.92	3.24	1.83
	S.e.	0.34	0.35	0.61	0.84	0.73
Mining	Est.	2.96	2.88	2.95	4.13	2.83
	S.e.	0.74	0.7	0.76	1.5	0.67
log*Pop* in 1960	Est.		-0.04			
	S.e.		0.04			
EngL	Est.			0.21		
	S.e.			0.21		
EuroL	Est.			-0.34		
	S.e.			0.27		
log(*Y*/*L*) in 1960	Est.				-0.36	
	S.e.				0.32	
IQual	Est.					-0.53
	S.e.					1.36
GeoControls included?		yes	yes	yes	yes	yes
Observations		130	130	130	130	130
Year		1985	1985	1985	1985	1985
R^2		0.61	0.62	0.35	0.59	0.53
P-value overidentifying restrictions		0.43				

Notes: Results of estimating (23). The left-hand-side variable is the log of real openness. The estimation method is GMM with robust standard errors. *GeoControls* refers to four continent dummies (Oceania is excluded) and distance from the equator. Instruments used are log*TFit*, log-population in 1960, the fraction of the population speaking English at birth (*EngL*), the fraction of the population speaking one of the five principal languages of Europe at birth (*EuroL*), *Mining* and all geography controls. Standard errors in the table take into account that *TFit* and log*TFit* have been estimated. All regressions include a constant. The P-value in column (1) corresponds to the test of the four overidentifying restrictions. Columns (2) and (3) add log-population and the Hall-Jones language variables directly to (23). It can be seen that these variables do not have a significant direct effect on real openness. Columns (4) and (5) add GDP per worker in 1960 and institutional quality to (23) to check the robustness of the effect of *YsOpen* on real openness.