Abstract

This paper estimates a structural model of economic geography using cross-country data on per capita income, bilateral trade, and the relative price of manufacturing goods. More than 70% of the variation in per capita income can be explained by the geography of access to markets and to sources of supply of intermediate inputs. These results are robust to the inclusion of other geographical, social, and institutional characteristics. The estimated coefficients are consistent with plausible values for the structural parameters of the model. We find quantitatively important effects of distance, access to the coast, and openness on levels of per capita income.

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Economic Geography and International Inequality

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1. Introduction

In 1996, manufacturing wages at the 90th percentile of the cross-country distribution were more than fifty times higher than those at the 10th percentile. Despite increasing international economic integration, these vast disparities in wages have not been bid away by the mobility of manufacturing firms and plants. There are many potential reasons for the reluctance of firms to move production to low wage countries, including endowments, technology, institutional quality, and geographical location. This paper focuses on the role of geographical location. We estimate its effects using a fully-specified model of economic geography (that of Fujita, Krugman, and Venables, 1999) and cross-country data including per capita income, bilateral trade, and the relative price of manufacturing goods.

Geographical location may affect per capita income in a number of ways, through its influence on flows of goods, factors of production, and ideas. In this paper we concentrate on two mechanisms. One is the distance of countries from the markets in which they sell output, and the other is distance from countries that supply manufactures and provide the capital equipment and intermediate goods required for production. Transport costs or other barriers to trade mean that more distant countries suffer a market access penalty on their sales and also face additional costs on imported inputs. As a consequence, firms in these countries can only afford to pay relatively low wages – even if, for example, their technologies are the same as those elsewhere.

The potential impact of these effects is easily illustrated. Suppose that the prices of output and intermediate goods are set on world markets, transport costs are borne by the producing country, and intermediates account for 50% of costs. *Ad valorem* transport costs of 10% on both final output and intermediate goods have the effect of reducing domestic value added by 30% (compared to a country facing zero transport costs), the reduction in value added rising to 60% for transport costs of 20%, and to 90% for transport costs of 30%.[1] Transport costs of this magnitude are consistent with recent empirical evidence. For example using customs data Hummels (1999)

1. Radelet and Sachs (1999) show how transport costs which are a small share of the value of gross output can have a very large effect on value added.

finds that average expenditure on freight and insurance as a proportion of the value of manufacturing imports is 10.3% in US and 13.3% in Paraguay. Limao and Venables (2001) relate transport costs to features of economic geography. Based on shipping company data on the costs of transporting a standardized 40 foot container around the world, they find that the median land-locked country's shipping costs are more than 50% higher than those of the median coastal country. Each of these papers focuses on transport costs narrowly defined (pure costs of freight and insurance) and may understate the true magnitude of barriers to trade if there are other costs to transacting at a distance (such as costs of information acquisition and monitoring). The model outlined in the paper formalises the role of economic geography in determining equilibrium factor prices, and the exact specifications suggested by theory are used to estimate the magnitude of these effects. We find that more than 70% of the cross-country variation in per capita income can be explained by the geography of access to markets and sources of supply.

The methodology we employ is as follows. We develop a theoretical trade and geography model to derive three key relationships for empirical study. The first of these is a gravity-like relationship for bilateral trade flows between countries. Estimation of this enables us to derive economically meaningful estimates of each country's proximity to markets and suppliers - measures that we call market access and supplier access respectively. Market access is essentially a measure of market potential, measuring the export demand each country faces given its geographical position and that of its trading partners; 'supplier access' is the analogous measure on the import side, so is an appropriately distance weighted measure of the location of import supply to each country. The second relationship is a zero profit condition for firms, that implicitly defines the maximum level of wages a representative firm in each country can afford to pay, given its market access and supplier access. We call this the wage equation, and use it to estimate the relationship between actual wages (or per capita income levels) and levels predicted by each country's market access and supplier access. The third relationship is a price index, suggesting how the prices of manufactures should vary with supplier access; we also estimate this, as a check on one of the key mechanisms in our approach.

Throughout the paper we remain very close to the theoretical structure of the trade and geography model, seeking to show how much of the cross-country income variation can be explained simply by each country's location relative to other countries. We find that our market access and supplier access measures are important determinants of income, and that the estimated coefficients are consistent with plausible values for the structural parameters of the model. The effects of features of economic geography on per capita income are shown to be quantitatively important. For example, we find that access to the coast and openness yield predicted increases in per capita income of over 60% and 70% respectively, while halving a country's distance from all of its trade partners yields an increase of over 70%. An implication of the theoretical model is that distance only matters for per capita income in so far as it affects a country's market access and supplier access. Using instrumental variables estimation, we test and are unable to reject this identifying assumption. We also establish the robustness of our results with respect to the inclusion of a number of other variables. These include measures of physical geography (as used by Gallup, Sachs and Mellinger, 1998), the variables that Hall and Jones (1999) argue are ultimate determinants of social infrastructure (including distance from the equator and language mix), and other institutional, social, and political controls (see, for example, Knack and Keefer, 1997 and Acemoglu *et al*., 2000).

The idea that access to markets is important for factor incomes dates back at least to Harris (1954), who argued that the potential demand for goods and services produced in any one location depends upon the distance-weighted GDP of all locations. However, much of the traditional geography literature focussed instead on implications for the location of production (see for example Dicken and Lloyd, 1977), and contains little structural econometric estimation. Early econometric investigations of the relationship between market access and per capita income include Hummels (1995) and Leamer (1997). Hummels (1995) finds that the residuals from the augmented Solow-Swan neoclassical model of growth are highly correlated with three alternative measures of geographical location. Leamer (1997) extends traditional market access measures to both improve their treatment of the domestic market and exploit information on the distance coefficient from a gravity model. He finds that Central and Eastern European countries differing access to Western European markets suggests that these countries differ in their potential to achieve higher standards of living. Davis and Weinstein (1998) use a similar methodology to Leamer to examine the implications of idiosyncratic demand for the location of production across countries.

Although the focus is not on access to markets *per se*, Frankel and Romer (1999) use geography measures as instruments for trade flows. They find evidence of a positive relationship between per capita income and exogenous variation in the ratio of trade to GDP due to the geography measures. This is different from our approach both conceptually and empirically. For example, the correlation coefficients between the trade share and our preferred measures of market and supplier access are 0.14 and 0.37 respectively.[1] Our work complements the analysis of market access and wages for US counties by Hanson (1998). It differs from his work in geographical focus (on countries rather than regions), the use of trade data to reveal both observed and unobserved determinants of market access, the introduction of supplier as well as market access, and in having labour immobile between geographical units. The introduction of supplier access enables us to test an independent prediction of the model for cross-country variation in the relative price of manufacturing goods.

The paper is structured as follows. In the next section we set out the theoretical model and derive the three structural equations that form the basis of the econometric estimation. Section 3 discusses the empirical implementation of the model. Sections 4 and 5 estimate the trade equation and the wage equation respectively. Section 6 considers alternative possible explanations for our results to economic geography, and presents further evidence that it is the geography of access to markets and sources of supply that is driving our findings. Section 7 establishes the robustness of the results to the inclusion of other variables. Section 8 exploits the structure of the theoretical model to relate the estimated coefficients to values of the structural parameters, and Section 9 shows how our approach can be used to disentangle the effects of a variety of features of economic geography for per capita income. Section 10 concludes.

2. Theoretical Framework

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2. We also present empirical results linking factor prices to *foreign* market and supplier access. The correlation coefficients between the trade share and our measures of foreign market and supplier access are 0.20 and 0.24 respectively.

The theoretical framework is based on a standard new trade theory model, extended to have transport frictions in trade and intermediate goods in production.[2] The world consists of $i = 1,...R$ countries, and we focus on the manufacturing sector, composed of firms that operate under increasing returns to scale and produce differentiated products.

On the demand side, each firm's product is differentiated from that of other firms, and is used both in consumption and as an intermediate good. In both uses there is a constant elasticity of substitution, F, between pairs of products, so products enter both utility and production through a CES aggregator taking the form,

$$U_j = [\sum_i^R \int_{n_i} x_{ij}(z)^{(\sigma-1)/\sigma} dz]^{\sigma/(\sigma-1)} = [\sum_i^R n_i x_{ij}^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)}, \qquad \sigma > 1, \tag{1}$$

where z denotes manufacturing varieties, n_i is the set of varieties produced in country i, and $x_{ij}(z)$ is the country j demand for the zth product from this set. The second equation makes use of the fact that, in equilibrium, all products produced in each country i are demanded by country j in the same quantity, so we dispense with the index z and rewrite the integral as a product. Dual to this quantity aggregator is a price index for manufactures in each country, G_j, defined over the prices of individual varieties produced in i and sold in j, p_{ij},

$$G_j = [\sum_i^R \int_{n_i} p_{ij}(z)^{1-\sigma} dz]^{1/1-\sigma} = [\sum_i^R n_i p_{ij}^{1-\sigma}]^{1/1-\sigma} \tag{2}$$

where the second equation makes use of the symmetry in equilibrium prices.

Country j's total expenditure on manufactures we denote E_j. Given this expenditure, country j's demand for each product is, (by Shephard's lemma on the price index),

$$x_{ij} = p_{ij}^{-\sigma} E_j G_j^{(\sigma-1)}. \tag{3}$$

3. The exposition follows Fujita, Krugman, and Venables (1999), Chapter 14. See also Krugman and Venables (1995). The full general equilibrium model consists of an agricultural and manufacturing sector. Manufacturing can be interpreted as a composite of manufacturing and service activities.

Thus, the own price elasticity of demand is F, and the term $E_j G_j^{\sigma - 1}$ gives the position of the demand curve facing a single firm in market j. We shall refer to this as the '*market capacity*' of country j; it depends on total expenditure in j and on the number of competing firms and the prices they charge, this summarised in the price index, G_j.

Turning to supply, a single representative country i firm has profits B_i,

$$\pi_i = \sum_j^R p_{ij} x_{ij} / T_{ij} - G_i^{\alpha} w_i^{\beta} v_i^{\gamma} c_i [F + x_i]. \tag{4}$$

The final term is costs. The total output of the firm is $x_i = \sum_j x_{ij}$, and technology has increasing returns to scale, represented by a fixed input requirement $c_i F$ and marginal input requirement c_i, these technology parameters potentially varying across countries. The inputs required are a composite of primary factors and intermediate goods. We assume that this takes a Cobb-Douglas form with two primary factors, labour (with price w_i and input share $) and 'other primary factors' (with price v_i and input share (), together with intermediate goods (with price G_i and input share ", " + $ + (= 1).

The first term in (4) is revenue earned from sales in all markets. T_{ij} is an iceberg transport cost factor, so if $T_{ij} = 1$ then trade is costless, while $T_{ij} - 1$ measures the proportion of output lost in shipping from i to j. With demand function (3), profit maximising firms set a single f.o.b. price, p_i, so prices for sale in different countries are $p_{ij} = p_i T_{ij}$. The price, p_i, is a constant mark up over marginal cost, given by

$$p_i = \frac{\sigma}{\sigma - 1} G_i^{\alpha} w_i^{\beta} v_i^{\gamma} c_i. \tag{5}$$

Given this pricing behaviour, profits of a country i firm are,

$$\pi_i = \left(\frac{p_i}{\sigma}\right)\left[x_i - (\sigma - 1)F\right]. \tag{6}$$

Thus, the firm breaks even if the total volume of its sales equals a constant, which we shall denote $\bar{x}$ / (F - 1)F. From the demand function, (3), it will sell this many units if its price satisfies[4]

$$p_i^{\sigma}\bar{x} = \sum_j^R E_j G_j^{\sigma-1}(T_{ij})^{1-\sigma}. \qquad (7)$$

Substituting the profit maximising price, equation (5), firms break even if

$$\bar{x}\left(\frac{\sigma}{\sigma-1}G_i^{\alpha}w_i^{\beta}v_i^{\gamma}c_i\right)^{\sigma} = \sum_j^R E_j G_j^{\sigma-1}T_{ij}^{1-\sigma}. \qquad \textbf{W} \qquad (8)$$

We call this the *wage equation* (W), and it constitutes a key relationship in the empirical analysis below. It says that the maximum level of costs - including the wage - that a firm in country *i* can afford to pay is a function of the sum of distance weighted market capacities. This sum we will refer to as the '*market access'* of country *i*.

The second relationship we use in the empirical analysis is that defining bilateral trade flows between countries. The demand equations (3) give the volume of sales per firm to each location, and expressing these in aggregate value gives exports from *i* to *j* of,

$$n_i p_i x_{ij} = n_i p_i^{1-\sigma}(T_{ij})^{1-\sigma}E_j G_j^{\sigma-1}. \qquad \textbf{T} \qquad (9)$$

The right hand side of this equation contains both demand and supply variables. The term $E_j G_j^{\sigma-1}$ is country *j* market capacity, as defined above. On the supply side, the term $n_i p_i^{1-\sigma}$ measures the '*supply capacity*' of the exporting country; it is the product of the number of firms and their price competitiveness, such that doubling supply capacity (given market capacities) doubles the value of sales. In addition, the term $(T_{ij})^{1-\sigma}$ measures bilateral transport costs between countries.

The price index forms the third main relationship used in the empirical analysis to follow. This is already defined in equation (2), and given our assumption about transportation costs it becomes,

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4. The transport cost term enters with exponent 1- F not - F; because total shipments to market *i* are T_{ij} times quantities consumed.

$$G_j = \left[\sum_i n_i (p_i T_{ij})^{1-\sigma}\right]^{1/(1-\sigma)}. \qquad \textbf{P} \qquad (10)$$

Notice that the term in the square bracket is a sum of supply capacities, weighted by transport costs, so measures what we shall term the '*supplier access*' of country *j*. It is important because an increase in this supplier access reduces the price index and the cost of intermediate goods, and therefore reduces the costs of production in country *j* (equation (8)). Supplier access thus summarises the benefit of proximity to suppliers of intermediate goods.

The full general equilibrium of the model is explored in Fujita, Krugman and Venables (1999), and involves specifying factor endowments and hence factor market clearing to determine income and expenditure (E_i), the output levels of each country's manufacturing (the values of n_i) and output in other sectors (primary and non-tradable). Here we take E_i and n_i as exogenous and simply ask, given the locations of expenditure and of production, what wages can manufacturing firms in each location afford to pay?

3. Empirical Framework

The empirical analysis is derived directly from the theory, and proceeds in several stages. First, we estimate the trade equation (9) in order to obtain empirical estimates of bilateral transport costs between countries, and of each country's market and supply capacities. Labelling these m_i and s_i respectively, they are defined as

$$m_i = E_i G_i^{\sigma-1}, \qquad s_i = n_i p_i^{1-\sigma}, \qquad (11)$$

and allow the trade equation (9) to be rewritten as,

$$n_i p_i x_{ij} = s_i (T_{ij})^{1-\sigma} m_j. \qquad \textbf{T} \qquad (12)$$

We estimate this gravity type relationship on bilateral trade flow data and from it we obtain predictions for $(T_{ij})^{1-\sigma} m_j$ and $s_i (T_{ij})^{1-\sigma}$ for each exporting country i and importing partner j.

Second, we construct the market access of each exporting country i, MA_i, and the supplier access of each importing country j, SA_j,

$$\begin{aligned} MA_i &= \sum_j E_j G_j^{\sigma-1} T_{ij}^{1-\sigma} = \sum_j (T_{ij})^{1-\sigma} m_j, \\ SA_j &= \sum_i n_i \left(p_i T_{ij}\right)^{1-\sigma} = \sum_i s_i (T_{ij})^{1-\sigma}. \end{aligned} \qquad (13)$$

Thus, market access is the appropriately distance weighted sum of the market capacities of all partner countries, and supplier access is the analogous sum of supplier capacities. Using predicted values of $(T_{ij})^{1-\sigma} m_j$ and $s_i (T_{ij})^{1-\sigma}$ from the trade equation, we construct empirical predictions for these two variables.

Third, using equations (8), (10), (11) and (13), the wage equation for country i can be written as a log-linear function of its supplier access and market access,

$$\begin{aligned} \left(w_i^{\beta} v_i^{\gamma} c_i\right)^{\sigma} &= A G_i^{-\alpha\sigma} \sum_j^R E_j G_j^{\sigma-1} T_{ij}^{1-\sigma} \\ &= A\left[\sum_j s_j (T_{ij})^{1-\sigma}\right]^{\frac{\alpha\sigma}{\sigma-1}} \left[\sum_j (T_{ij})^{1-\sigma} m_j\right] = A\left(SA_i\right)^{\frac{\alpha\sigma}{\sigma-1}} \left(MA_i\right) \end{aligned} \qquad \mathbf{W} \qquad (14)$$

where the left-hand side of equation (14) contains the wage, w_i, the prices of other factors of production, v_i, and a measure of technology differences, c_i; the constant A on the right-hand side combines constants from equation (8). The equation says that countries with high market access and high supplier access pay relatively high wages. We estimate this equation using predicted values of supplier access and market access as right hand side variables, and cross-country data on factor incomes as the dependent variable. This estimation establishes the extent to which observed variation in factor incomes can be explained by these geographical determinants, and the estimated coefficients on these variables can be clearly related to the values of the structural coefficients of the model.

$$G_j = [SA_j]^{1/(1-\sigma)}. \qquad \mathbf{P} \qquad (15)$$

Finally, from equations (10) and (13), the price index for manufacturing goods, G_j, may be written as a function of supplier access, SA_j,

We estimate equation (15) using predicted values of supplier access as the right-hand side variable and data on the relative price of manufacturing goods on the left-hand side.

4. Trade Equation Estimation

4.1 Data sources and sample size

Data on bilateral trade flows for a cross-section of 101 countries are obtained from the World Bank's COMTRADE database. We combine the trade data with information on geographical characteristics (eg bilateral distance, existence of a common border) and data on GDP and population from the World Bank. See Appendix A for further details.

4.2 Econometric estimation

The value of bilateral trade flows in the trade equation, (12), depends upon exporting country characteristics (supply capacity, m_i), importing partner characteristics (market capacity, s_j), and bilateral transportation costs (T_{ij}). In the main econometric specification, these exporting and importing country characteristics (supply and market capacity) are captured with country and partner dummies (denoted by cty_i and ptn_j respectively). The use of dummies addresses the fact that we cannot observe economic variables that correspond exactly to the theory, and also controls for any component of transport costs or trade policy that is common across all partners for a particular exporting country or common across all suppliers of an importing country. Section 9 of the paper repeats the analysis using economic measures of supply and market capacity, and shows that the main results of the paper are robust to the use of either approach. The bilateral component of transportation costs is modelled using data on the distance between capital cities ($dist_{ij}$) and a dummy for whether an exporting country and importing partner share a common border ($bord_{ij}$). Equation (12) thus becomes,[5]

$$\ln(X_{ij}) = \alpha + \beta.cty_i + \gamma.ptn_j + \delta_1.\ln(dist_{ij}) + \delta_2.bord_{ij} + u_{ij} \tag{16}$$

where X_{ij} denotes the value of exports from country i to partner j and u_{ij} is a stochastic error. There are a number of observations of zero bilateral trade flows and, throughout the following, we normalise the trade data by adding 1 before taking logarithms.[6]

Column (1) of Table 1 presents the results of estimating equation (16) on 1994 data using OLS. The distance between capital cities and common border variables are correctly signed according to economic priors and statistically significant at the 1% level. The null hypothesis that the coefficients on either the country dummies or the partner dummies are equal to zero is easily rejected at the 1% level with a standard F-test, and the model explains approximately 80% of the cross-section variation in bilateral trade flows. However, the specification in column (1) does not take into account the fact that the trade data is left-censored at zero. In column (2), we re-estimate the model for the censored sample using OLS. Column (3) explicitly takes into account the truncated nature of the data by using the Tobit estimator. This increases the absolute magnitude of the coefficient on the distance variable and reduces the size of the coefficient on the common border dummy. We use the Tobit estimates as the basis for our next step.

The values of the country and partner dummies in the trade equation (16) provide estimates of the market and supply capacities of each country, m_i and s_j, and the distance and border coefficients provide estimates of the bilateral transport cost measure, $(T_{ij})^{1-\sigma}$. We use these to construct predicted values of market access and supplier access, as defined in equation (13), and taking the form:

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5. This specification is more general than the standard gravity model, in which country and partner dummies are replaced by income and other country characteristics, see for example Frankel (1997). The partner dummies capture the manufacturing price index, G_j, and thus control for the effects of what Anderson and van Wincoup (2000) term 'multilateral resistance.'

6. The COMTRADE database records the values of bilateral trade flows to a high degree of accuracy; these zeros are genuine zeros rather than missing values. The effects of adding 1 before taking logarithms can be made arbitrarily small by choice of units in which to measure trade flows.

$$\hat{MA}_i = D\hat{MA}_i + F\hat{MA}_i = (\exp(ptn_i))^{\gamma}\left(T_{ii}\right)^{1-\sigma} + \sum_{j \neq i} (\exp(ptn_j))^{\gamma} . dist_{ij}^{\delta_1} . bord_{ij}^{\delta_2} \quad (17)$$

$$\hat{SA}_j = D\hat{SA}_j + F\hat{SA}_j = (\exp(cty_j))^{\beta}\left(T_{jj}\right)^{1-\sigma} + \sum_{i \neq j} (\exp(cty_i))^{\beta} . dist_{ij}^{\delta_1} . bord_{ij}^{\delta_2} \quad (18)$$

Notice that we have split each of these into a domestic and foreign part (DMA and FMA respectively). The reason is that the trade equation does not provide us with estimates of 'intra-country' transport cost measures, $(T_{ii})^{1-\sigma}$. We consider three alternative ways of getting hold of these measures. First, we assume that internal trade costs are equal to the cost of shipping to a foreign country 100km away and with a common border; using these we develop series $D\hat{MA}_i(1)$ and $D\hat{SA}_j(1)$.[7] Second, we link intra-country transport costs to the area of the country, by using the formula $dist_{ii} = 0.33(area/\pi)^{1/2}$, to give the average distance between two points in a circular country; we construct series $D\hat{MA}_i(2)$ and $D\hat{SA}_j(2)$ using $T_{ii}^{1-\sigma} = dist_{ii}^{\delta_1}$. Third, to capture the likelihood that internal transport costs are less than international, we construct series $D\hat{MA}_i(3)$ and $D\hat{SA}_j(3)$ using $T_{ii}^{1-\sigma} = dist_{ii}^{\delta_1/2}$.

5. Wage Equation Estimation

Having obtained predicted values for market and supplier access, we move on to the econometric estimation of the wage equation. From equation (14), factor incomes in country j are related to market and supplier access as follows,

$$\ln w_i = \xi + \varphi_1 . \ln SA_i + \varphi_2 . \ln MA_i + \eta_i, \quad (19)$$

7. The minimum bilateral distance between any two trade partners in our data set is 42km. The negative effect of national borders on trade flows is well-documented: see for example Anderson and Van Wincoup (2000) and McCallum (1995).

and substituting predicted for actual values of market and supplier access,

$$\ln w_i = \zeta + \phi_1 . \ln \hat{SA}_i + \phi_2 . \ln \hat{MA}_i + \varepsilon_i \tag{20}$$

Before presenting estimates of this equation, a number of issues merit discussion. The stochastic error in (19), 0_i, includes differences in the prices of other factors of production, $\ln(v_i)$, and exogenous differences in technology across countries, $\ln(c_i)$. In consigning these differences to the residual, we do not mean to imply that they are unimportant.[8] The spirit of the paper is to take a structural model of economic geography seriously and examine how much of the variation in cross-country per capita income can be explained simply by countries' locations relative to one another - without resort to exogenous technology differences. Therefore, we begin by assuming that any cross-country differences in technology and/or in the price of other factors of production contained in the residual are uncorrelated with the explanatory variables. We return to consider these differences in Sections 6 and 7 of the paper.

Since the predicted values for market and supplier access are generated from a prior regression (the trade equation), the stochastic error in equation (20), g_i, includes the trade equation residuals. The presence of generated regressors (Pagan, 1984) means that, as in Two Stage Least Squares, the OLS standard errors are invalid. We employ Bootstrap Techniques (Efron, 1979; 1981 and Efron and Tibshirani, 1993) to obtain standard errors that explicitly take into account the presence of generated regressors.[9]

Consistent estimation of the parameters n_1 and n_2 requires that shocks to the dependent variable are uncorrelated with the predicted values for market and supplier access obtained from

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8. If capital is internationally mobile, its rate of return will be equal across countries, and $\ln(v_i) = \ln(v)$ will be captured in the constant of the regression. Note also that, even in the absence of exogenous technology differences, measured aggregate productivity may vary substantially across countries due to differences in the transport cost inclusive price of manufacturing inputs and output. In order to arrive at a 'true' measures of aggregate Total Factor Productivity (TFP), one must embrace a multi-sector model with intermediate inputs and obtain disaggregated data on the transport cost inclusive price of manufacturing goods. See Redding and Venables (2000).

9. Each bootstrap replication re-samples the over 10,000 country-partner observations in the dataset, estimates the first-stage trade regression, generates predicted values for market and supplier access, and estimates the second-stage wage equation. The conventional number of bootstrap replications used to estimate a standard error is 50-200 (Efron and Tibsharini, 1993). The standard errors reported in the paper are based on 200 bootstrap replications.

the trade equation. In order to abstract from contemporaneous shocks that affect both left and right-hand side variables the predicted values for market and supplier access are constructed from trade equation estimates for 1994. These are then used to explain the cross-country distribution of manufacturing wages in 1996.[10] However, there could be unmodelled (third) variables that are persistent over time, that vary across countries, and that are correlated with both manufacturing wages and market/supplier access. This is a particular problem for domestic market/supply capacity; any third variable which affects domestic market/supply capacity may also have a direct effect on wages. Therefore, in much of the analysis that follows, we present results with both total market/supplier access (as defined in (17) and (18)) and with only *foreign* market/supplier access (*ie* excluding all domestic information).

This does not eliminate the possibility of unmodelled (third) variables, that are correlated with both *foreign* market/supplier access and manufacturing wages, including cross-country differences in technology and/or the price of other factors of production contained in the residual. We consider a number of approaches to this potential problem. Section 6 tests the key identifying assumption of the model, that distance from other countries only affects manufacturing wages in so far as it changes foreign market/supplier access. This assumption would be violated if there were a third variable (*eg* technology), which has an independent effect on manufacturing wages, but is also correlated with distance from other countries (and hence with foreign market/supplier access). We test the validity of the identifying assumption using instrumental variables estimation. The instruments are distance from the three main markets and sources of supply of manufactures (the United States, Western Europe, and Japan) and have high explanatory power in the first-stage regression. In a test of the model's overidentifying restrictions we are unable to reject the null hypothesis that the excluded exogenous variables are uncorrelated with the wage equation residuals. This is consistent with our identifying assumption, and suggests that the results are not being driven by omitted third variables included in the residual and correlated with distance from other countries.

Section 6 also undertakes a number of experiments which provide additional tests of whether our results are being driven by something other than economic geography. In each case

10. Since all data are in current price US$ the move from 1994 to 1996 $ prices is captured in the constant . of the wage equation.

we find evidence that it is the geography of access to markets and sources of supply that is important. In Section 7 we show that our empirical findings with regard to market and supplier access are robust to the inclusion of a series of control variables. These include characteristics of physical geography, together with social, political, and institutional variables that have been proposed as fundamental determinants of technology and/or the prices of other factors of production in the cross-country growth literature.

Turning now to the data used in our main estimation results, we take GDP per capita as a proxy for manufacturing wages (this variable may also control for the price of other primary factors of production used in manufacturing, v_i). These data have the advantage of being available for all 101 countries in our sample. We also explore the robustness of our results to using manufacturing wage data from the UNIDO Industrial Statistics Database, although these are available only for a sub-sample of 62 countries.

Finally, predicted market and supplier access are, in practice, highly correlated.[11] Therefore, we begin by regressing the log manufacturing wage on market access and supplier access separately. In Section 8 of the paper we include both measures and exploit a theoretical restriction on the relative value of the estimated coefficients.

Table 2 presents our baseline results. Column (1) regresses log GDP per capita on predicted *foreign* market access using OLS. The estimated coefficient on foreign market access is positive and statistically significant at the 5% level. Taking into account the presence of generated regressors raises the standard error of the estimated coefficient, but this remains highly statistically significant. Foreign market access alone explains approximately 35% of the cross-country variation in GDP per capita. It is noteworthy that our theory-based approach dominates an *ad hoc* measure of distance weighted GDP in other countries from the traditional geography literature. If the specification in column (1) is re-estimated using an *ad hoc* measure, the R^2 of the regression falls by about a third to 0.24.[12]

In column (2), we use total market access (foreign plus domestic), employing our first measure of domestic market access. The estimated coefficient is again positive and statistically

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11. The correlation coefficient between our preferred measures of market and supplier access (MA(3) and SA(3)) is 0.88.

12. The estimated coefficient (*standard error*) is 0.958 (0.177).

significant at the 5% level, and the R^2 of the regression rises to 0.64. In columns (3) and (4), cross-country variation in internal area is incorporated in the construction of DMA, corresponding to our second and third measures. Estimated coefficients are positive and statistically significant at the 5% level, and with DMA(3) the model explains 73% of the cross-country variation in GDP per capita. Finally, as a robustness test, column (5) enters log foreign and log domestic market access (DMA(3)) as separate terms in the regression equation. Theory tells us that this regression is mis-specified, and we see that the R^2 is lower than with the correct specification (column (4)). However, both terms are positively signed and statistically significant at the 5% level.

Figures 1 to 4 plot log GDP per capita against the four alternative measures of log market access considered in columns (1) - (4) of Table 2. Each country is indicated by a three letter code (see Appendix A for details). It is clear from these figures that the relationship between GDP per capita and market access is very robust, and is not due to the influence of a few individual countries. In Figure 1, using FMA alone, the main outliers are remote high per capita income countries (Australia, New Zealand, Japan and the USA). Remaining figures use estimates of DMA, as required by theory, and each illustrates a different treatment of the internal transportation costs. In Figure 2, DMA is included with the same measure of internal transport costs for all countries – which seems to make large countries outliers to the right (India, China, USA) and small ones outliers to the left (*eg* Israel), exactly as would be expected. Letting internal transport costs vary with area, and treating internal distance identically to external distance (Figure 3) seems to over-compensate – Singapore and Hong Kong come to have much better market access than Germany or the USA. In Figure 4, we let internal transport costs vary with area, but allow the costs of transporting goods a given distance internally to be lower than for the same external distance. This is the solution which produces the best fit, as well as according with economic priors on the relative magnitudes of internal and external transport costs.

6. Identifying the Effects of Economic Geography

In this section we provide additional evidence that our results are capturing the effects of economic geography as suggested by the theory. One key concern is that there may be unmodelled (third) variables included in the residual which are correlated with both foreign market/ supplier access and GDP per capita. In Table 3, we investigate this hypothesis by using instrumental variables techniques to test the model's key identifying assumption. In Section 7, we demonstrate the robustness of our results to the inclusion of control variables.

The three instruments we use are distance from the United States, Belgium (as a central point in the European Union), and Japan, capturing proximity to the three main markets and sources of supply of manufacturing goods in the world.[13] The identifying assumption is that distance from these centres of world economic activity only influences GDP per capita in so far as it affects foreign market access. The IV estimate of the coefficient on foreign market access is extremely close to that estimated using OLS, as shown in column (1). In a Hausman specification test, we are unable to reject the null hypothesis that OLS is consistent and efficient at the 5% level, as reported in the middle of the table.

In columns (2) and (3), we present the reduced-form regressions underlying the IV results in column (1). Since they are reduced-forms, these regressions do not have a structural interpretation. Nonetheless, each of the coefficients on the exogenous variables is signed according to economic priors and highly statistically significant. From column (2), there is a close relationship between the instruments and our theory-based measure of foreign market access: the three instruments explain 88% of the cross-country variation in this variable. Nonetheless, from column (3), it is clear that using the theory-based measure of foreign market access we are able to explain more of the cross-country variation in GDP per capita than when using the three instruments directly. The table reports the results of a Sargan test of the model's overidentifying restrictions. We are unable to reject the null hypothesis of orthogonality of the wage equation residuals and the excluded exogenous variables. This suggests that the results are not being driven by omitted third variables included in the residual and correlated with measures of proximity to centres of world economic activity that explain the vast majority of the cross-country variation in foreign market access.

A second concern is that GDP per capita in one country is being explained using measures of demand and supply capacity in other countries (foreign market access) that are likely to be

13. The United States, Belgium, and Japan are here excluded from the sample. ln (distance to the United States) is undefined for the United States, and specifying an arbitrarily small value for this variable in the United States would introduce the possibility of it simply acting as a US dummy.

correlated with their GDP. Therefore, GDP per capita in one country is being explained by something correlated with GDP in other countries. Are the results just picking up that rich countries tend to be located next to rich countries, particularly within the OECD? Are our measures of transport costs (distance between countries and the existence of a common border) really important for the results, or is everything being driven by common shocks to GDP across countries? These concerns have also been addressed by the IV estimation, where we have shown that distance from the three centres of world economic activity both matters for income per capita *and* is important because it affects *foreign market access*. However, to provide further evidence that our results are due to the geography of access to markets and sources of supply, we consider alternative approaches to each of these concerns below.

First, are the results being driven by the OECD? Column (1) of Table 4 re-estimates the baseline foreign market access specification for the sample of non-OECD countries.[14] The coefficient on foreign market access remains of a similar magnitude and is highly statistically significant. Furthermore, Figures 1-4 presented evidence of a positive relationship between GDP per capita and market access that held at all levels of GDP per capita - for both rich and poor countries. Second, are the results being driven by the fact that, even with the non-OECD, rich countries tend to be located next to each other? In Column (2) of Table 4, we again present estimation results for the *non-OECD*, but, this time, foreign market access is calculated only using information on market capacity in *OECD* countries, together with distance and common border information. Here, we examine the extent to which variation in income per capita across less-developed countries be explained by the geography of access to OECD markets. The observations on GDP per capita on the left-hand side of the regression are for an entirely different set of countries (the non-OECD) to the observations on market capacity used on the right-hand side (the OECD). The estimated coefficient on foreign market access remains positive and is highly statistically significant.[15]

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14. Since the concern is about the industrialized OECD countries, we exclude 22 of the 23 original members of the OECD (the missing country is Iceland). The results are very similar if we instead exclude all current OECD members.

15. We also re-estimated the model using data on manufacturing wages per worker rather than GDP per capita as the dependent variable. These data are available for the subset of 62 countries indicated in the Appendix. In the specification in column (1) of Table 2, the estimated coefficient (*standard error*)

Third, are our measures of transport costs (distance between countries and the existence of a common border) really important for the results, or is everything being driven by common shocks to GDP across countries? We address this concern in two ways. First, we examine what happens to the results if, instead of using actual data on distance and the existence of a common border, we use incorrect values for these variables. Second, we compare the results using data on bilateral distance and the existence of a common border (which correspond closely to the mechanisms emphasized in the theory) to those using a measure of alternative linkages between countries - namely, institutional or political linkages. One form of institutional or political linkages that has been emphasized in the growth literature is a colonial relationship, and we therefore, consider a dummy for whether one country was a former colony of another.[16]

Column (3) of Table 4 reports the results of regressing GDP per capita on foreign market access when incorrect values of bilateral distance and the existence of a common border are used. Specifically, we number the rows of the 101×101 matrix of bilateral distances from 1 to 101. Each row corresponds to one particular country's vector of distances to all other countries. The rows of the matrix are then re-sorted in descending rather than ascending order, so that country 101's distance vector is assigned to country 1, country 100's distance vector is assigned to country 2, and so on. The 101×101 matrix of dummies for whether one country shares a common border with another is resorted in exactly the same way. The trade equation is then re-estimated using the incorrect values for bilateral distance and a common border, and foreign market access is

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on foreign market access was 0.612 *(0.129)*. This is slightly larger than that estimated using GDP per capita, which is exactly as one would expect if labour is immobile, while some other factors included in GDP (such as capital) have the cross-country variation in their returns reduced by international factor mobility.

16. See Appendix for further details concerning the data used. In principle, any variable which influences the cost of two countries' trading (whether those costs are physical or, for example, informational) will affect foreign market access. Therefore, it is perfectly consistent with the theoretical model presented earlier if the fact that one country was a former colony of another matters for bilateral trade flows and foreign market access. Nonetheless, one would expect bilateral distance and the existence of a common border to be more closely correlated with transportation costs, and there may be other ways in which colonial status matters for GDP per capita than through foreign market access. If transportation costs are really driving our results, we would, therefore, expect measures of foreign market access based on bilateral distance and the existence of a common border to dominate those based on colonial relationships.

constructed in an analogous way to before.[17] As would be expected, the estimated coefficients on the incorrect variables are statistically insignificant in the trade equation (the estimated coefficients (*standard errors*) are respectively 0.052 *(0.050)* and 0.218 *(0.207)*). More interestingly, we find no evidence of a positive relationship between GDP per capita and the resulting measure of foreign market access. As shown in Column (3) of Table 4, the estimated coefficient on foreign market access is actually negative. This is consistent with the idea that our measures of transportation costs (distance and a common border) are important, and that our results are not being driven by common shocks to GDP across countries.

Columns (4) and (5) of Table 4 examine the implications of including information on whether one country was a former colony of another. In the first specification we consider, this is the only bilateral relationship between countries included in the trade equation. The estimated coefficient on the colonial dummy is positive and statistically significant, with a coefficient (*standard error*) of 2.023 *(0.379)*. Thus, bilateral trade flows are positively correlated with the existence of a colonial relationship. However, when we calculate foreign market access using colonial links as the only bilateral relationship between countries, we actually find evidence of a negative relationship between GDP per capita and foreign market access, as shown in column (4). This again emphasizes the importance of the bilateral distance and existence of a common border variable in explaining our results. The finding of a negative coefficient on foreign market access in column (4) is consistent with the fact that many (though by no means all) former colonies are located far from the main centres of world economic activity.

This is perhaps too strong a test of the alternative hypothesis that there are other relationships between countries that matter for GDP per capita rather than the transportation costs and market access mechanisms emphasized in the theory. Column (5) of Table 4 explores the implications of simultaneously including the colonial dummy, bilateral distance, and a common

17. The following, more sophisticated estimation procedure was also adopted. Numbers between 1 and 101 were chosen randomly without replacement. The first number chosen became the row of the distance / common border matrix assigned to country 1, the second number chosen became the row assigned to country 2, and so on. The trade equation was then estimated using the incorrect values for bilateral distance and existence of a common border. Measures of market and supplier access were constructed in an analogous manner to before, and the wage equation was re-estimated. This whole procedure was repeated 50 times. The mean estimated values of the coefficient and standard error on the market access variable were compared to those using correct distance and bilateral border information. The conclusions of this procedure were identical to those of the experiment reported in the main text.

border in the trade equation estimation. The estimated coefficients on all three variables are consistent with economic priors and highly statistically significant (for example, the distance and colonial dummy coefficients (*standard errors*) are -1.743 *(0.043)* and 2.052 *(0.334)* respectively). The inclusion of bilateral distance and common border information means that the estimated coefficient on foreign access is of a similar magnitude to before and highly statistically significant. With the inclusion of one more variable, the R^2 in the trade equation necessarily rises. However, the R^2 in the wage equation using this measure of foreign market access is actually lower than when foreign market access is calculated using only bilateral distance and a common border (see column (1) of Table 2).

Most of this paper is concerned about the relationship between per capita income and the geography of access to markets and sources of supply. However, one of the key theoretical mechanisms by which location affects income per capita is through the manufacturing price index, $G_i = [SA_i]^{1/(1-\sigma)}$. Countries which are remote from sources of supply of manufactured goods incur greater transport costs, and have higher values of the price index, G_i, this reducing the wage they can afford to pay.[18] Since some cross-country data are available on manufacturing prices, we now turn to examine this key theoretical prediction.

Our empirical proxy for G_i is the relative price of Machinery and Equipment, a sector whose output is used as an input in many other industries. The data on the relative price of Machinery and Equipment are obtained from Phase V of the United Nations International Comparisons (ICP) project (United Nations 1994) that contains information on the price of a large number of individual commodities in local currency units per dollar. These commodity-specific Purchasing Power Parities (PPPs) are also aggregated to derive corresponding PPPs for particular industries and for GDP as a whole. Our measure of the relative price of Machinery and Equipment is thus the PPP for Machinery and Equipment divided by the PPP for GDP. The data are available for the 46 countries listed in Appendix A and are for 1985. The relative price of Machinery and Equipment is 1 in the United States and reaches a maximum of 4.68 in Sri Lanka.

18. Thus, economic geography provides an alternative explanation for the importance of the relative price of Machinery and Equipment (an empirical proxy for G_i) to those in the cross-country growth literature (*eg* De Long and Summers, 1991) and the literature on trade in capital goods and knowledge spillovers (*eg* Eaton and Kortum, 2000).

Table 5 presents the results of regressing the relative price of Machinery and Equipment against our measure of supplier access, SA_i. Column (1) considers foreign supplier access, FSA_i, alone, while column (2) introduces both domestic and foreign supplier access using our third measure of supplier access. Column (3) presents the results excluding Tanzania, which is an outlier. In all three columns, the estimated coefficient on supplier access is negative and statistically significant at the 5% level. As predicted by the theoretical model, countries with high levels of supplier access are characterised by a lower relative price of Machinery and Equipment.

7. Robustness of Results

The approach so far has been both parsimonious and theory based. We now proceed to examine the robustness of results to the inclusion of a whole series of variables which control for unobserved variation across countries in technology and the price of other factors of production. Each of these variables has been proposed as an exogenous or fundamental determinant of levels of income per capita in the empirical growth literature. In order to address the potential endogeneity of domestic market and supply capacity, we follow Table 2 in presenting results with both total market access and with foreign market access alone. In the interests of brevity, we restrict consideration to our preferred measure of total market access (with DMA(3)).

The conventional approach in the empirical growth literature takes as its starting point the Solow-Swan neoclassical model of growth. Many studies either directly analyse the relationship between factor inputs and aggregate output (as in the growth accounting approach of Benhabib and Spiegel, 1994) or examine the model's predictions for the steady-state levels of income per capita (as in Mankiw, Romer, and Weil, 1992). There are a number of respects in which the present analysis differs from this approach; three are worth noting here. First, the theoretical analysis emphasises the role of transport costs and consequent cross country variation in prices of both outputs and intermediate inputs. Second, in contrast to the essentially closed economy Solow-Swan model, our framework emphasis the international location decisions of firms, and the implications of these decisions for equilibrium wages. Third, many of the variables considered in the empirical growth literature (eg rates of investment in physical and human capital) will themselves be endogenous to economic geography. Here, we seek to address the exogenous or fundamental determinants of levels of income per capita.

The first set of control variables we consider are measures of exogenous factor endowments. These include arable land area, hydrocarbons per head, and a broader measure of countries' mineral wealth.[19] The availability of the hydrocarbons per head data reduces the sample to 99 countries.[20] Columns (1) and (4) of Table 6 present the results with total and foreign market access respectively. In both cases, the estimated market access coefficient is of similar magnitude to before and highly statistically significant. In the foreign market access regression all three endowment measures are statistically significant, but none affects our conclusions concerning the relationship between market access and GDP per capita.

The second set of controls we consider are two other features of physical geography emphasised in the work of Gallup, Sachs, and Mellinger (1998): the fraction of a country's land area in the geographical tropics and the prevalence of Malaria. Columns (2) and (5) of Table 6 present the results using total and foreign market access respectively. Both variables are signed according to economic priors, although only the prevalence of Malaria is statistically significant at the 5% level. This finding is entirely consistent with the model presented here if the effect of Malaria is to reduce levels of technical efficiency, as indeed suggested by Gallup et al.. The coefficient on market access remains positive and highly statistically significant.

A number of studies in the cross-country growth literature have emphasized the role of institutions, 'social capability', or 'social infrastructure' in determining levels of per capita income (see, for example, Acemoglu et al., 2000; Knack and Keefer, 1997; Hall and Jones, 1999; and Temple and Johnson, 1998), while McArthur and Sachs (2001) emphasize a combination of institutions and physical geography. Therefore, in columns (3) and (6), we augment the specification further by considering a number of other institutional, social, and political characteristics of countries. These include the protection of property rights (a widely-used measure of institutions or 'social capability'), socialist rule during 1950-95, and the occurrence of an external

19. See Appendix A for further details concerning the data used.

20. Data on hydrocarbons per head are unavailable for Moldova and Yemen.

war. Once again, we find that our market access results are robust to the inclusion of these other variables.[21]

In Hall and Jones (1999), 'social infrastructure' is measured as the average of an index of property rights protection and an index of international openness, and is related to a number of exogenous or fundamental determinants. These include a measure of geography (distance from the equator), together with the fraction of the population speaking English and the fraction speaking a European language. Distance from the equator is interpreted as a reflection of Western European influence. However, the trade and geography model considered here suggests that this variable will matter for per capita income in so far as captures the geography of access to markets and sources of supply. There may also be additional effects through social infrastructure or through changes in technical efficiency associated with climate and disease.

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21. Higher values of the property rights index correspond to *weaker* protection of property rights, and a negative estimated coefficient on this variable is expected. Data on property rights protection are unavailable for Central African Republic, Guatemala, Kazakhstan, Kyrgyz Republic, Madagascar, Macedonia, Mauritius, and Chad. The sample in Columns (3) and (6) of Table 6 is thus reduced to 91 countries.

The Hall and Jones data are available for 86 of the 101 countries in our sample.[22] Column (1) and (3) of Table 7 respectively present the results of re-estimating the market access and foreign market access regressions for the reduced sample. The estimated coefficients are extremely similar to those reported for the full sample in Table 2. In Columns (2) and 4 of Table 7, we introduce distance from the equator, the fraction of the population speaking English, and the fraction of the population speaking a European language.[23] All variables are signed according to economic priors, and distance from the Equator and fraction of the population speaking a European language are statistically significant at the 5% level.

The estimated coefficient on foreign market access in Column (4) remains positive and highly statistically significant. The size of the estimated coefficient is reduced somewhat, suggesting that some of the variation in foreign market access used to identify this parameter is between regions near to and far from the equator. In the absence of technology differences the theoretical model implies that distance from the equator matters simply because it changes distance to markets and sources of supply. In practice, as discussed above, there may be additional effects (eg of climate and disease on levels of technical efficiency), and it is likely to be hard to separately identify these additional effects from considerations of pure economic geography. Nonetheless, even if we exclude all variation in foreign market access associated with distance from the equator, we find a positive and statistically significant effect of foreign market access on GDP per capita.

Finally, we consider the robustness of our results to the inclusion of dummy variables for the following economic regions: Africa, Latin America and the Caribbean, South East Asia, Other Asia, Eastern Europe and the former USSR, and the Middle-East.[24] This controls for all observed and unobserved heterogeneity across regions. The theoretical model suggests that one of the reasons that African countries are poor is that they are typically located far from markets and sources of supply for manufactured goods. Here, we abstract from all such variation and identify the parameters of interest solely from variation in market access within regions. This is a strong test of

22. See Appendix A for further details concerning the data used.

23. Hall and Jones (1999) also consider the Frankel and Romer (1999) predicted trade share as an ultimate determinant of social infrastructure. Information concerning geography's effect on access to markets and sources of supply is already incorporated into the analysis.

24. The countries included in these economic regions are listed in Appendix A.

the underlying mechanisms emphasized by the theory. Column (1) of Table 8 reproduces the estimation results from Column (4) of Table 2, while in column (2) we include dummies for the six economic regions (the excluded category is the industrialised countries of North America, Western Europe, and Oceania). The estimated coefficients on all dummy variables are negative, as is expected given the excluded category and the fact that this is a regression for levels of per capita income. The dummies for Africa, South-east Asia, and Other Asia are statistically significant at the 5% level. The coefficient on market access remains positive, is of a similar magnitude, and is highly statistically significant. Columns (3) and (4) of Table 8 repeat this analysis for foreign market access alone. The estimated coefficients on the dummy variables are again all negative, and, with the exception of South East Asia, each is statistically significant at the 5% level. Thus, even if we identify the relationship between foreign market access and per capita income using only variation within regions, we find a positive and statistically significant effect.

8. Market and Supplier Access

We now extend the analysis to incorporate information on supplier access, SA_i, and relate the estimated coefficients to underlying structural parameters of the model. Again we present results with both total market/supplier access and with foreign market/supplier access alone. The first column of Table 9 reports the relationship between income per capita and foreign supplier access, and is comparable to the foreign market access regression in Column (1) of Table 2. The estimated coefficient on foreign supplier access is positive and highly statistically significant, and explains 38% of the cross-country variation in income per capita. Column (4) of Table 9 presents the analogous regression for total supplier access; once again the estimated coefficient is positive and highly statistically significant, and the model now explains approximately 68% of the cross-country variation per capita incomes.

While the high degree of correlation between market access and supplier access means that it is difficult to separately identify their individual effects, we can proceed by exploiting a theoretical restriction on the relative magnitude of their estimated coefficients. From equation (14), the estimated values of n_1 and n_2 in (20) are related to the structural parameters of the model as follows,

$$\phi_1 = \frac{\alpha}{\beta(\sigma - 1)}, \quad \phi_2 = \frac{1}{\beta\sigma}, \quad \textit{implying} \quad \phi_1 = \phi_2 \alpha\sigma/(\sigma - 1) \tag{21}$$

Thus, if we select values of " and F (the cost share of intermediates and the elasticity of substitution between varieties), a linear restriction is imposed on the values of n_1 relative to n_2. We estimate (20) subject to this restriction, for a series of different values of " and F. From the estimated value of n_2, we then compute the implied value of \$ (the share of labour in unit costs).

Columns (2) and (3) of Table 9 report the regression results for foreign market/supplier access using a share of intermediate in unit costs of " = 0.5 and an elasticity of substitution between manufacturing varieties of F = 8 and F = 10 respectively. Columns (5) and (6) present the analogous results for total market / supplier access. Table 10 reports a range of values for F and " in the rows and columns, and the implied values of \$ in the body of the table. An intermediate share of 50% (" = 0.5) and an elasticity of substitution of 8 is consistent with a labour share of 39% (or 78% of value added). If the elasticity of substitution is raised to 10, the implied labour share is 31% (62% of value added). These parameter values are broadly consistent with data on the share of intermediates and labour in unit costs, and with independent econometric estimates of the elasticity of substitution between manufacturing varieties.

9. Economic Structure and Policy Analysis

The estimates of the trade equation that we have used so far are based on country and partner dummies. This approach has the advantage of capturing relevant country characteristics that are not directly observable but are nevertheless revealed through trade performance (for example the degree of openness of the country, and the values of prices and prices indices within the country). However, it does not allow us to quantify the effects on per capita income of particular country characteristics (for example, being land-locked), since all such effects are contained in the dummies. This section, therefore, considers an alternative econometric specification in which we replace country dummies by economic and geographic variables. This additional economic structure in the modelling of supply capacity and market capacity enables us to calculate the predicted effects of these country characteristics on per capita income.

Thus, in equation (22), supply capacity, s_i, and demand capacity, m_j are modelled using country and partner GDP data (Y_i and Y_j respectively). Trade barriers and transportation costs are captured by dummy variables for whether exporting countries and importing partners are land-locked ($llock_i$ and $llock_j$ respectively), islands (isl_i and isl_j respectively), and pursue open trade policies ($open_i$ and $open_j$ respectively).[25] As before, the country-partner pair specific elements of transportation costs are captured by distance between capital cities ($dist_{ij}$) and a dummy variable for whether or not an exporting country and importing partner share a common border ($bord_{ij}$). The first-stage trade regression therefore becomes,

$$\begin{aligned} \ln(X_{ij}) = \alpha + \beta \ln(Y_i) + \gamma \ln(Y_j) + \delta_1 \ln(dist_{ij}) + \delta_2 \ln(bord_{ij}) + \delta_3 isl_i \\ + \delta_4 isl_j + \delta_5 llock_i + \delta_6 llock_j + \delta_7 open_i + \delta_8 open_j + u_{ij} \end{aligned} \qquad (22)$$

This trade equation is again estimated using 1994 data and the Tobit estimator.[26] All variables are correctly signed according to economic priors and statistically significant at the 5% level. Both a country's own GDP (supply capacity) and its trade partner's GDP (demand capacity) have a positive effect on bilateral trade flows, with a coefficient slightly greater than one. The distance and land-locked variables have a negative effect on trade, while the common border and island variables have positive effects. We find evidence of a positive relationship between bilateral trade flows and the Sachs and Warner (1995) trade policy-based measure of international openness.

Predicted values of market access and supplier access are obtained from equation (22) in a manner exactly analogous to that used before,

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25. We employ the Sachs and Warner (1995) measure of international openness. This is based on tariff barriers, non-tariff barriers, the black market exchange premium, the presence of a state monopoly on major exports, and the existence of a socialist economic system.

26. Full estimation results are available from the authors on request.

$$\hat{MA}_i = D\hat{MA}_i + F\hat{MA}_i = (Y_i)^{\phi}\left(T_{ii}\right)^{1-\sigma} + \sum_{j \neq i} (Y_j)^{\phi} . dist_{ij}^{\delta_1} . bord_{ij}^{\delta_2} . \Lambda \qquad (23)$$

$$\hat{SA}_j = D\hat{SA}_j + F\hat{SA}_j = (Y_j)^{\beta}\left(T_{jj}\right)^{1-\sigma} + \sum_{i \neq j} (Y_i)^{\beta} . dist_{ij}^{\delta_1} . bord_{ij}^{\delta_2} . \Lambda \qquad (24)$$

$$\Lambda = [\exp(isl_i)]^{\delta_3}[\exp(isl_j)]^{\delta_4}[\exp(llock_i)]^{\delta_5}[\exp(llock_j)]^{\delta_6}[\exp(open_i)]^{\delta_7}[\exp(open_j)]^{\delta_8}$$

In order to address the potential endogeneity of domestic market and supply capacity, we again present results with both total market/supplier access and with foreign market/supplier access alone. Table 12 presents the main estimation results, and is analogous to Table 9. The pattern of estimated coefficients is extremely similar to that using country and partner dummies, as can be seen from comparison of the two tables.

We now move on to consider the effects of country characteristics on predicted income per capita. The estimates of the trade equation are used to evaluate the effect of a particular economic variable (eg whether a country is land-locked, or whether it pursues open trade policies) on market and supplier access. This is combined with the estimated coefficients from Table 11 to give the effect of each variable on predicted income per capita. We present predictions based on foreign market and supplier access (excluding domestic information). Specifically, we take the parameter estimates from Column (3) of Table 11, based on an intermediate share of α=0.5 and an elasticity of substitution of σ=10, which were shown earlier to be consistent with plausible values for the parameter β (the share of labour in unit costs).

Table 13 reports the results of undertaking such an analysis for seven countries. Three of these are islands, at varying stages of economic development: Australia, Madagascar, and Mauritius. Four of the countries are land-locked, and five are, to some degree, closed on the Sachs and Warner (1995) definition of international openness. From equations (23) and (24) changes in one geographic or economic characteristic (such as whether a country is land-locked) have the same proportional effect on foreign market and supplier access for all countries. We find that access to the coast raises predicted per capita income by 64%,[27] while loss of island status has a more modest effect, reducing predicted income by 6%. The effect of pursuing open trade policies is constant across countries that have the same initial level of openness, and is of a similar size to gaining a coastline, being equal to 75% in Madagascar, Central African Republic, and Zimbabwe. The effect is smaller in Hungary and Paraguay, which begin with more open trade policies. To evaluate the quantitative importance of proximity to large markets and sources of supply, Column (4) of Table 13 undertakes the hypothetical experiment of halving a country's distance from all of its trade partners. Once again, the gains are large, and the increase in income of 74% is of a similar magnitude to gaining a coastline or pursuing open trade policies. Column (5) considers the effect on market and supplier access of moving the four developing countries located far from centres of world economic activity (Central African Republic, Madagascar, Mauritius, Paraguay, and Zimbabwe) to central Europe.[28] Gains range from 308% for Madagascar to 89% for Paraguay. This emphasises the economic advantages conveyed to the transition economies of Central and Eastern Europe by their location on the edge of high-income Western Europe.

The importance of geographical proximity is shown again in Table 13, which examines the effect of having a common border. Common borders between Germany and the Czech Republic and the United States and Mexico have substantial effects on predicted income per capita in the smaller countries. Thus, removing the common border gives a fall in predicted income per capita in the Czech Republic of 49%, and in Mexico of 52%. However, the effect of eliminating of a common border between low income developing countries who trade very little with one-another, such as the Central African Republic and Chad, is negligible. This suggests that the gains from closer regional integration between low income developing countries may be relatively small compared to those to be had from closer integration with high income developed countries.

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27. Limao and Venables (2001) directly estimate the effect of being landlocked on transport costs. The median landlocked country is found to have transport costs 58% higher than the median coastal country.

28. Specifically, we replace a country's distance and common border vectors by those of Hungary.

10. Conclusions

The increasing integration of world goods and financial markets has not caused the enormous cross-country differences in income per capita and manufacturing wages to be arbitraged away by the mobility of firms and plants. There are many potential reasons for the reluctance of firms to move production to low wage locations, one of which is remoteness from markets and sources of supply. This paper has used a structural model of economic geography to examine these effects, and to show the amount of the variation in per capita income and manufacturing wages that can be explained simply by these geographical factors.

Estimates based on bilateral trade flows provide measures of market and supplier access for each country, which in turn determine the wage that manufacturing firms can afford to pay. These measures were found to explain up to 70% of the cross-country variation in per capita income. Instrumental Variables estimation provided evidence in support of a key identifying assumption of the model - that distance from other countries matters for per capita income because of its effect on market and supplier access. The lack of correlation between the instruments and the residuals from the wage equation suggests that the results are not driven by omitted third variables correlated with geography. We present additional evidence that the mechanisms of economic geography are at work. Our results are robust to the inclusion of a wide range of control variables; for a number of different samples; across a variety of econometric specifications; using alternative measures of the manufacturing wage; and to identifying the parameters of interest solely from variation within economic regions. As predicted by the model, the relative price of manufacturing goods was found to be negatively and statistically significantly related to a country's supplier access. The estimated regression coefficients were shown to be consistent with plausible values for the structural parameters of the model. We establish that the effects of geography are quantitatively extremely important, with, for example, access to the coast raising per capita income by over 60%.

Our results may seem rather pessimistic for developing countries, suggesting that even if tariff and institutional obstacles to trade and investment are removed the penalty of distance will continue to hold down the incomes of remote regions. However, it is important to recall that our results are derived for a given location of production and expenditure. As new markets and centres of manufacturing activity emerge, so the market and supplier access of neighbouring countries improves. Our results point to the importance of understanding the role of geography in shaping the evolution of the cross-country distribution of income.

Table 1: Trade equation (country, partner dummies)

$\ln(X_{ij})$	(1)[a]	(2)[a]	(3)[b]
Obs	10100	8079	10100
Year	1994	1994	1994
$\ln(dist_{ij})$	-1.538	-1.353	-1.738
	-0.041	*-0.032*	*-0.043*
$bord_{ij}$	0.976	1.042	0.917
	-0.195	*-0.141*	*-0.179*
Country dummies	yes	yes	yes
Partner dummies	yes	yes	yes
Estimation	OLS	OLS	Tobit
F(@)	249.63	159.67	-
Prob > F	0	0	-
R-squared	0.789	0.786	-
Root MSE	2.214	1.688	-
Log Likelihood	-	-	-20306.379
LR P^2(206)	-	-	15231.38
Prob > P^2	-	-	0
Pseudo R^2	-	-	0.273

Notes: [a] Huber-White heteroscedasticity robust standard errors in parentheses. [b] 2021 left-censored observations # 0, 8079 uncensored observations.

Table 2: Market access and GDP per capita[(a)]

ln*(GDP per capita)*	(1)[(b),(c]	(2)[(b),(c]	(3)[(b),(c]	(4)[(b),(c]	(5)[(b),(c]
Obs	*101*	*101*	*101*	*101*	*101*
Year	*1996*	*1996*	*1996*	*1996*	*1996*
$\ln(FMA_i)$	0.476	-	-	-	0.316
	-0.066				*-0.066*
	[0.076]				*[0.088]*
$\ln(MA_i) = \ln(DMA_i(1)) +$	-	0.558	-	-	-
		-0.042			
		[0.064]			
$\ln(MA_i) = \ln(DMA_i(2)) +$	-	-	0.479	-	-
			-0.044		
			[0.063]		
$\ln(MA_i) = \ln(DMA_i(3)) +$	-	-	-	0.373	-
				-0.022	
				[0.032]	
$\ln(DMA_i(3))$	-	-	-	-	0.141
					-0.037
					[0.059]
Estimation	OLS	OLS	OLS	OLS	OLS
R^2	0.346	0.642	0.61	0.727	0.584
F(@)	52.76	174.46	121.21	299.9	47.78
Prob>F	0	0	0	0	0

Notes: [(a)] first stage estimation of the trade equation using Tobit (column (3) in Table 1).
[(b)] Huber-White heteroscedasticity robust standard errors in parentheses. [(c)] Bootstrapped standard errors in square parentheses (200 replications).

Table 3: Instrumental variables estimation, foreign market access and GDP per capita[(a)]

	(1)[(b),(c),(d)]	(2)[(b)]	(3)[(b)]
Obs	98	98	98
Year	1996	1996	1996
		Dependent variables	
Regressors	ln(GDP per capita)	ln(MA_i(3))	ln(GDP per capita)
ln(FMA_i)	0.447	-	-
	[0.089]		
ln(Distance from USA)	-	-1.102	-0.619
		-0.112	*-0.18*
ln(Distance from Belgium)	-	-1.007	-0.401
		-0.054	*-0.079*
ln(Distance from Japan)	-	-0.848	-0.604
		-0.092	*-0.23*
OLS estimate	0.49	-	-
	[0.078]		
Hausman test (*p*-value)	0.316	-	-
	(Accept)		
Sargan test (*p*-value)	0.713	-	-
	(Accept)		
Estimation	IV	OLS	OLS
R^2	0.362	0.88	0.278
F(@)	32.65	165.06	10.14
Prob>F	0	0	0

Notes: (a) first stage estimation of the trade equation using Tobit (column (3) in Table 1).
(b) Huber-White heteroscedasticity robust standard errors in parentheses. (c) Bootstrapped standard errors in square parentheses (200 replications). (d) Endogenous variable: ln(FMA_i); Exogenous variables: ln(Distance from USA), ln(Distance from Belgium), and ln(Distance from Japan).

Table 4: Foreign market access and GDP per capita[(a)]

ln*(GDP per capita)*	(1)[(b)]	(2)[(b)]	(3)[(b)]	(4)[(b)]	(5)[(b)]
Obs	79	79	101	101	101
Year	1996	1996	1996	1996	1996
ln(FMA_i)	0.425	0.307	-2.962	-2.29	0.467
	[0.081]	*[0.074]*	*[0.365]*	*[0.312]*	*[0.076]*
Full sample			yes	yes	yes
Non-OECD	yes	yes			
Incorrect Distance			yes		
Colonial Links				yes	yes
Estimation	OLS	OLS	OLS	OLS	OLS
R^2	0.248	0.152	0.021	0.14	0.323
F(@)	33	20.64	1.08	13	48.33
Prob>F	0	0	0.302	0	0

Notes: (a) first stage estimation of the trade equation using Tobit (column (3) in Table 1).
(b) Bootstrapped standard errors in square parentheses (200 replications).

Table 5: Supplier access and the relative price of Machinery and Equipment[(a)]

ln*(Mach and equip relative price)*	(1)[(b)]	(2)[(b)]	(3)[(b)]
Obs	46	46	45
Year	1985	1985	1985
ln(FSA_i)	-0.15	-	-
	[0.060]		
ln$(SA_i = DSA_i(3) + FSA_i)$	-	-0.066	-0.079
		[0.029]	*[0.024]*
Estimation	OLS	OLS	OLS
R^2	0.26	0.184	0.273
F(@)	19.31	13.57	29.32
Prob>F	0	0	0

Notes: (a) first stage estimation of the trade equation using Tobit (column (3) in Table 1).
(b) Bootstrapped standard errors in square parentheses (200 replications).

Table 6: Market access, GDP per capita, and physical geography[(a)]

ln(*GDP per capita*)	(1)[(b)]	(2)[(b)]	(3)[(b),(]	(4)[(b)]	(5)[(b)]	(6)[(b),(]
Obs	99	99	91	99	99	91
Year	1996	1996	1996	1996	1996	1996
ln(FMA_i)	-	-	-	0.475	0.264	0.208
				[0.067]	*[0.073]*	*[0.062]*
ln$(MA_i = DMA_i(3) + FMA_i)$	0.363	0.281	0.231	-	-	-
	[0.031]	*[0.030]*	*[0.055]*			
ln(Hydrocarbons per capita)	0.04	0.03	0.03	0.04	0.04	0.03
	[0.022]	*[0.021]*	*[0.023]*	*[0.020]*	*[0.017]*	*[0.017]*
ln(Arable Land Area)	-0.1	-0.11	-0.1	-0.21	-0.18	-0.1
	[0.071]	*[0.066]*	*[0.076]*	*[0.058]*	*[0.055]*	*[0.057]*
Number of Minerals	0	0	0	0.06	0.05	0.03
	[0.018]	*[0.017]*	*[0.016]*	*[0.018]*	*[0.015]*	*[0.010]*
Fraction Land in Geog. Tropics	-	-0.35	-0.33	-	-0.26	-0.19
		[0.192]	*[0.268]*		*[0.244]*	*[0.252]*
Prevalence of Malaria	-	-0.73	-0.77	-	-1.17	-1
		[0.315]	*[0.396]*		*[0.262*	*[0.291*
Socialist Rule 1950-95	-	-	-0.1	-	-	-0.27
			[0.220]			*[0.203]*
External War 1960-85	-	-	0	-	-	0
			[0.238]			*[0.170]*
Protection of Property Rights	-	-	-0.16	-	-	-0.41
			[0.129]			*[0.096]*
Estimation	OLS	OLS	OLS	OLS	OLS	OLS
R^2	0.75	0.837	0.839	0.503	0.634	0.776
F(@)	81.18	101.4	65.1	22.18	43.25	46.68
Prob>F	0	0	0	0	0	0

Notes: [(a)] first stage estimation of the trade equation using Tobit (column (3) in Table 1).
[(b)] Bootstrapped standard errors in square parentheses (200 replications).

Table 7: Market access, GDP per capita, and social infrastructure [(a)]

ln*(GDP per capita)*	(1)[(b)]	(2)[(b)]	(3)[(b)]	(4)[(b)]
Obs	86	86	86	86
Year	1996	1996	1996	1996
$\ln(FMA_i)$	-	-	0.528	0.232
			[0.085]	*[0.103]*
$\ln(MA_i) = \ln(DMA_i(3) + FMA_i)$	0.392	0.312	-	-
	[0.033]	*[0.040]*		
Distance from Equator, (0,1) scale[(c)]	-	1.556	-	2.546
		[0.612]		*[0.794]*
Fraction pop. speaking English	-	0.01	-	0.409
		[1.044]		*[0.330]*
Fraction pop. speaking a European language	-	0.558	-	0.752
		[0.197]		*[0.181]*
Estimation	OLS	OLS	OLS	OLS
R^2	0.746	0.821	0.361	0.537
F(·)	310.78	84.2	53.5	32.83
Prob>F	0	0	0	0

Notes: [(a)] first stage estimation of the trade equation using Tobit (column (3) in Table 1).
[(b)] Bootstrapped standard errors in square parentheses (200 replications). [(c)] Distance from the Equator is measured, as in Hall Jones (1998), by |latitude|/90.

Table 8: Market access, GDP per capita, and regional effects[(a)]

ln(*GDP per capita*)	(1)[(b)]	(2)[(b)]	(3)[(b)]	(4)[(b)]
Obs	101	101	101	101
Year	1996	1996	1996	1996
$\ln(FMA_i)$	-	-	0.476	0.202
			[0.076]	*[0.062]*
$\ln(MA_i) = \ln(DMA_i(3) + FMA_i)$	0.373	0.328	-	-
	[0.032]	*[0.053]*		
Africa	-	-0.784	-	-1.974
		[0.367]		*[0.231]*
Latin America and Carribean	-	-0.213	-	-1.003
		[0.270]		*[0.185]*
South East Asia	-	-0.802	-	-0.382
		[0.284]		*[0.309]*
Other Asia	-	-1.06	-	-2.015
		[0.470]		*[0.211]*
Eastern Europe and former USSR	-	-0.06	-	-1.213
		[0.279]		*[0.149]*
Middle-East	-	-0.325	-	-1.192
		[0.578]		*[0.556]*
Estimation	OLS	OLS	OLS	OLS
R^2	0.727	0.83	0.346	0.673
F(@)	299.9	62.51	52.76	53.45
Prob>F	0	0	0	0

Notes: [(a)] first stage estimation of the trade equation using Tobit (column (3) in Table 1).
[(b)] Bootstrapped standard errors in square parentheses (200 replications).

Table 9: Market access, supplier access and GDP per capita.[a]

ln*(GDP per capita)*	(1)[b]	(2)[b]	(3)[b]	(4)[b]	(5)[b]	(6)[b]
Obs	101	101	101	101	101	101
Year	1996	1996	1996	1996	1996	1996
"		0.5	0.5		0.5	0.5
F		8	10		8	10
$\ln(FMA_i)$	-	0.319	0.32	-	-	-
$\ln(FSA_i)$	0.532	0.182	0.178	-	-	-
	[0.114]	*[0.040]*	*[0.039]*			
$\ln(MA_i(3))$	-	-	-	-	0.235	0.236
$\ln(SA_i(3))$	-	-	-	0.345	0.134	0.131
				[0.032]	*[0.012]*	*[0.011]*
Estimation	OLS	OLS	OLS	OLS	OLS	OLS
R^2	0.377	0.361	0.36	0.687	0.726	0.726
F(@)	57.05	54.6	54.56	254.37	290.7	291
Prob>F	0	0	0	0	0	0

Notes: [a] first stage estimation of the trade equation using Tobit (column (3) in Table 1).
[b] Bootstrapped standard errors in square parentheses (200 replications).

Table 10: Foreign market access, supplier access, and implied values of the structural parameters of the model

"	0.4	0.5	0.6
F = 6	0.495 (*n_2=0.337*)	0.531 (*n_2=0.314*)	0.569 (*n_2=0.293*)
F = 8	0.364 *(n_2=0.343)*	0.393 *(n_2=0.318)*	0.417 (*n_2=0.300*)
F = 10	0.291 *(n_2=0.344)*	0.308 *(n_2=0.325)*	0.330 *(n_2=0.303)*

Notes: the table reports values of the labour share ($) implied by the estimated coefficients on foreign market and supplier access for different values of intermediate share (") and demand elasticity (F). The values of $ are derived from the formula for n_2 in equation (21). Column (2) of Table 8 presents the full estimation results for values of "=0.5 and F=8, while column (3) of Table 8 presents the full estimation results for values of "=0.5 and F=10.

Table 11: Market access, supplier access and income per capita

ln*(GDP per capita)*	(1)(b)	(2)(b)	(3)(b)	(4)(b)	(5)(b)	(6)(b)
Obs	98	98	98	98	98	98
Year	1996	1996	1996	1996	1996	1996
"		0.5	0.5		0.5	0.5
F		8	10		8	10
$\ln(FMA_i)$	0.556	0.348	0.349	-	-	-
	[0.057]					
$\ln(FSA_i)$	-	0.199	0.194	-	-	-
		[0.028]	*[0.027]*			
$\ln(MA_i(3))$	-	-	-	0.525	0.32	0.322
				[0.071]		
$\ln(SA_i(3))$	-	-	-	-	0.183	0.179
					[0.017]	*[0.017]*
Estimation	OLS	OLS	OLS	OLS	OLS	OLS
R^2	0.565	0.579	0.579	0.744	0.737	0.737
F(@)	141	146.2	146.1	315.8	297.3	297.7
Prob>F	0	0	0	0	0	0

Notes: First stage estimation of the trade equation using Tobit (column (3) in Table 11). Bootstrapped standard errors in square parentheses (200 replications). The smaller number of observations than in Table 9 reflects the fact that the Sachs and Warner (1995) openness variable used in the trade equation estimation is unavailable for Panama, Saudi Arabia, and Yemen.

Table 12: Economic Magnitudes

	Variable				
Country	-1 Access to Coast	-2 Loss of Island Status	-3 Becom Open[(a)]	-4 Distance (50% closer to all	-5 Distance (Central Europe)
Australia		6.12%		73.73%	
Mauritius		6.12%		73.73%	307.92%
Madagascar		6.12%	75.48%	73.73%	302.90%
Central African Republic	64.29%		75.48%	73.73%	218.57%
Hungary	64.29%		71.73%	73.73%	
Paraguay	64.29%		68.05%	73.73%	188.51%
Zimbabwe	64.29%		75.48%	73.73%	286.68%

Notes: [(a)] actual values for the Sachs and Warner (1995) openness index are 1 in Australia, 0 in Central African Republic, 0.038 in Hungary, 1 in Mauritius, 0.077 in Paraguay, and 0 in Zimbabwe.

Table 13: The Effect of Removing a Common Border

Removal of Common Border	Effect on Per Capita Income	
Germany - Czech Republic	Germany	Czech Republic
	- 0.18%	- 49.37%
U.S. - Mexico	U.S.	Mexico
	- 1.20%	- 51.92%
Central Afr. Republic - Chad	Central Afr. Republic	Chad
	- 0.01%	- 0.004%

Appendix A: Data

Bilateral Trade: data on bilateral trade flows are from the World Bank COMTRADE database. This provides information for the 101 countries listed in Table A1 during 1992-6.

GDP per capita: data on current price (US dollars) GDP and on population are from the World Bank. These data are also available for the 101 countries listed in Table A1 during 1992-6.

Geographical variables: data on bilateral distance, internal area, arable land area, existence of a common border, and whether a country is an island or land-locked are from the World Bank. These data are available for the 101 countries listed in Table A1.

Colonial dummy: a variable which is 1 if one country is a former colony of another and 0 otherwise. Source: Fieldhouse (1982) and Grier (1999).

Manufacturing wage per worker: data on number of employees and wages and salaries (current price US dollars) in total manufacturing are from the UNIDO Industrial Statistics Database. Information is available for the 62 countries indicated in Table A1 during 1992-6.

Relative price of machinery and equipment: data on the price of machinery and equipment and GDP in local currency units per US dollar are from Phase V of the United Nations International Comparisons Project (United Nations (1994)). The data are available for the 46 countries indicated in Table A1 and are for 1985.

Number of Minerals: the total number of minerals of which a country has reserves from the list of 44 main minerals compiled by Parker (1997).

Property Rights Protection: on a scale from 1 to 5, where a higher score indicates weaker protection of property rights. Source: Holmes, Johnson, and Kirkpatrick (1997). These data are unavailable for Central African Republic, Guatemala, Kazakhstan, Kyrgyz Republic, Madagascar, Macedonia, Mauritius, and Chad.

Physical Geography and Institutional, Social, and Political Characteristics: data on hydrocarbons (deposits of petroleum and natural gas) per head, fraction of land area in the geographical tropics, prevalence of Malaria, socialist rule, and the occurrence of an external war are from Gallup, Sachs, and Mellinger (1998). Information is available for all 101 countries in our dataset, except for the data on hydrocarbons per capita which are unavailable for Moldova and Yemen. The data can be downloaded from: http://www2.cid.harvard.edu/ciddata.

Social Infrastructure: data on distance from the equator, the fraction of the population speaking English, and the fraction of the population speaking a European language are from Hall and Jones (1999). Information is available for 86 of the countries listed in Table A1. Data are unavailable for the following countries: Albania, Armenia, Czech Republic, Estonia, United Germany, Croatia, Kazhakhstan, Kyrgyz Republic, Lithuania, Latvia, Moldova, Macedonia, Russia, Slovak Republic, and Slovenia. The data can be downloaded from: http://www.stanford.edu/~chadj/datasets.html.

International Openness: data on international openness are from Sachs and Warner (1995). Information is available for 98 of the countries listed in Table A1. The countries for which data are unavailable are Panama, Saudi Arabia, and Yemen. The data can be downloaded from http://www2.cid.harvard.edu/ciddata.

Africa: Algeria, Central African Republic, Cote d'Ivoire, Cameroon, Congo Republic, Egypt, Ethiopia, Gabon, Kenya, Madagascar, Mozambique, Mauritius, Malawi, Morocco, Sudan, Senegal, Chad, Tanzania, Tunisia, South Africa, Zambia, and Zimbabwe.

Latin America and the Caribbean: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, Paraguay, El Salvador, Trinidad and Tobago, Uruguay, and Venezuela.

South East Asia: China, Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, and Taiwan.

Other Asia: Bangladesh, India, Sri Lanka, Mongolia, Nepal, and Pakistan.

Eastern Europe and the former USSR: Albania, Armenia, Bulgaria, Czech Republic, Estonia, Croatia, Hungary, Kazakhstan, Kyrgyz Republic, Lithuania, Latvia, Moldova, Macedonia, Poland, Romania, Russia, Slovak Republic, and Slovenia.

Middle-East: Israel, Jordan, Saudi Arabia, Syria, and Yemen.

Table A1: country composition and availability of wage / machinery and equipment relative price data

1. Albania (ALB)	(w)		28. Estonia (EST)		
2. Argentina (ARG)	(w)		29. Ethiopia (ETH)	(w)	(g)
3. Armenia (ARM)			30. Finland (FIN)	(w)	(g)
4. Australia (AUS)		(g)	31. France (FRA)	(w)	(g)
5. Austria (AUT)	(w)	(g)	32. Gabon (GAB)	(w)	
6. Bangladesh (BGD)	(w)	(g)	33. UK (GBR)	(w)	(g)
7. Bulgaria (BGR)			34. Greece (GRC)		(g)
8. Belg./Lux (BLX)	(w)	(g)	35. Guatemala (GTM)		
9. Bolivia (BOL)	(w)		36. Hong Kong (HKG)	(w)	(g)
10. Brazil (BRA)	(w)		37. Honduras (HND)		
11. C Afr. Rp. (CAF)	(w)		38. Croatia (HRV)	(w)	
12. Canada (CAN)	(w)	(g)	39. Hungary (HUN)	(w)	(g)
13. Switzerl. (CHE),			40. Indonesia (IDN)	(w)	
14. Chile (CHL)	(w)		41. India (IND)	(w)	(g)
15. China (CHN)			42. Ireland (IRL)	(w)	(g)
16. Cote d'Ivoire (CIV)		(g)	43. Israel (ISR)	(w)	
17. Cameroon (CMR)	(w)	(g)	44. Italy (ITA)	(w)	(g)
18. Congo Rep. (COG)		(g)	45. Jamaica (JAM)	(w)	
19. Colombia (COL)	(w)		46. Jordan (JOR)	(w)	
20. Costa Rica (CRI)	(w)		47. Japan (JPN)		(g)
21. Czech Rep. (CZE)			48. Kazakhstan (KAZ)		
22. Germany (DEU)		(g)	49. Kenya (KEN)	(w)	(g)
23. Denmark (DNK)	(w)	(g)	50. Kyrgyz Rp. (KGZ)		
24. Algeria (DZA)	(w)		51. Korea, Rp. (KOR)	(w)	(g)
25. Ecuador (ECU)	(w)		52. Sri Lanka (LKA)		(g)
26. Egypt (EGY)		(g)	53. Lithuania (LTU)	(w)	
27. Spain (ESP)	(w)	(g)	54. Latvia (LVA)		

Notes: (w) indicates that data on manufacturing wages per worker are available; (g) indicates that data on the relative price of machinery and equipment are available

Table A1 (cont): country composition and availability of wage / machinery and equipment relative price data

55. Morocco (MAR)	(w)	(g)	82. Singapore (SGP)		
56. Moldova (MDA)			83. El Salvador (SLV)		
57. Madagasc. (MDG)		(g)	84. Slovak Rep. (SVK)		
58. Mexico (MEX)	(w)		85. Slovenia (SVN)	(w)	
59. Macedonia (MKD)	(w)		86. Sweden (SWE)	(w)	(g)
60. Mongolia (MNG)			87. Syria (SYR)		
61. Mozambiq. (MOZ)	(w)		88. Chad (TCD)		
62. Mauritius (MUS)	(w)	(g)	89. Thailand (THA)	(w)	(g)
63. Malawi (MWI)	(w)	(g)	90. Trinidad/T. (TTO)	(w)	
64. Malaysia (MYS)	(w)		91. Tunisia (TUN)	(w)	(g)
65. Nicaragua (NIC)			92. Turkey (TUR)	(w)	(g)
66. Netherlands (NLD)	(w)	(g)	93. Taiwan (TWN)	(w)	
67. Norway (NOR)	(w)	(g)	94. Tanzania (TZA)	(w)	(g)
68. Nepal (NPL)	(w)		95.Uruguay (URY)		
69. New Zeal. (NZL)	(w)	(g)	96. USA (USA)	(w)	(g)
70. Pakistan (PAK)	(w)	(g)	97. Venezuela (VEN)	(w)	
71. Panama (PAN)			98. Yemen (YEM)		
72. Peru (PER)			99. South Afr. (ZAF)	(w)	
73. Philippines (PHL)	(w)	(g)	100. Zambia (ZMB)	(w)	(g)
74.Poland (POL)		(g)	101. Zimbabwe (ZWE)	(w)	(g)
75. Portugal (PRT)		(g)			
76. Paraguay (PRY)					
77. Romania (ROM)	(w)				
78. Russia (RUS)					
79. Saudi Arab. (SAU)					
80. Sudan (SDN)					
81. Senegal (SEN)		(g)			

Notes: (w) indicates that data on manufacturing wages per worker are available; (g) indicates that data on the relative price of machinery and equipment are available

References

Acemoglu, D., Johnson, S. and Robinson, J. (2000), 'The Colonial Origins of Comparative Development: An Empirical Investigation', NBER Working Paper, 7771.

Anderson, J. and van Wincoop, E. (2000), 'Gravity with Gravitas: a Solution to the Border Puzzle', Boston College, mimeograph.

Benhabib, J. and Spiegel, M. (1994), 'The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-country Data', Journal of Monetary Economics, 34, pp.143-173.

Davis, D. and Weinstein, D. (1998), 'Market Access, Economic Geography, and Comparative Advantage: An Empirical Assessment', NBER Working Paper, 6787.

De Long, B. and Summers, L. (1991), 'Equipment Investment and Economic Growth', Quarterly Journal of Economics, 106(2), pp.445-502.

Dicken, P. and Lloyd, P. (1977), *Location in Space*, Harper and Row: New York.

Eaton, J. and Kortum, S. (2000), 'Trade in Capital Goods', paper presented at CEPR European Workshop in International Trade, Copenhagen.

Efron, B. (1979), 'Bootstrap Methods: Another Look at the Jackknife', Annals of Statistics, 7, pp.1-26.

Efron, B. (1981), 'Nonparametric Estimates of Standard Error: The Jackknife, The Bootstrap, and Other Resampling Methods', Biometrika, 68, pp.589-599.

Efron, B. and Tibshirani, R. (1993), *An Introduction to the Bootstrap, Monographs on Statistics and Applied Probability*, Chapman & Hall: New York.

Fieldhouse, D. (1982), *The Colonial Empires: A Comparative Survey from the Eighteenth Century*, Macmillan: London.

Frankel, J. (1997), 'Regional Trading Blocs in the World Trading System', Institute for International Economics, Washington DC.

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

Fujita, M., Krugman, P. and Venables, A.J. (1999), *The Spatial Economy: Cities, Regions, and International Trade*, MIT Press.

Gallup, J., Sachs, J. and Mellinger, A. (1998), 'Geography and Economic Development', Proceedings of World Bank Annual Conference on Development Economics, World Bank: Washington.

Grier, R. (1999), 'Colonial Legacies and Economic Growth', Public Choice, 98(3-4), pp.317-335.

Hall, R. and Jones, C. (1999), 'Why Do Dome Countries Produce So Much More Output per Worker than Others?', Quarterly Journal of Economics, February, 83-116.

Hanson, G. (1998), 'Market Potential, Increasing Returns, and Geographic Concentration', NBER Working Paper, 6429.

Harris, C. (1954), 'The Market as a Factor in the Localization of Industry in the United States', Annals of the Association of American Geographers, 64, pp.315-348.

Holmes, K., Johnson, B. and Kirkpatrick, M. (1997), *1996 Index of Economic Freedom*, The Heritage Foundation and The Wall Street Journal, Washington DC and New York.

Hummels, D. (1995), 'Global Income Patterns: Does Geography Play a Role?', Chapter 2 of Phd Thesis, University of Michigan.

Hummels, D. (1999), 'Towards a Geography of Trade Costs', University of Chicago, mimeograph.

Knack, S. and Keefer, P. (1997), 'Does Social Capital Have an Economic Payoff?', Quarterly Journal of Economics, 112, pp.1251-1288.

Krugman, P. and Venables, A.J. (1995), 'Globalisation and the Inequality of Nations', Quarterly Journal of Economics, 110(4),pp. 857-880.

Leamer, E. (1997), 'Access to Western Markets and Eastern Effort', in S. Zecchini, (ed), Lessons from the Economic Transition, Central and Eastern Europe in the 1990s, Dordrecht: Kluwer Academic Publishers, pp.503-526.

Limao, N. and Venables, A.J. (2001), 'Infrastructure, Geographical Disadvantage, Transport Costs, and Trade', World Bank Economic Review, forthcoming.

McArthur, J. and Sachs, J. (2001), 'Institutions and Geography: Comment of Acemoglu, Johnson, and Robinson (2000)', NBER Working Paper, 8114.

McCallum, J. (1995), 'National Borders Matter: Canada-US Regional Trade Patterns', American Economic Review, 85(3), pp.615-623.

Mankiw, G., Romer, D. and Weil, D. (1992), 'A Contribution to the Empirics of Economic Growth', Quarterly Journal of Economics, 107(2), pp.407-437.

Pagan, A. (1984), 'Econometric Issues in the Analysis of Regressions with Generated Regressors', International Economic Review, 25(1), pp.221-247.

Parker, P. (1997), *National Cultures of the World: A Statistical Reference, Cross-Cultural Statistical Encyclopedia of the World, Volume 4*, Greenwood Press: Westport, CT.

Radelet, S. and Sachs, J. (1998), 'Shipping Costs, Manufactured Exports, and Economic Growth', paper presented at the American Economic Association Meetings, Harvard University, mimeo.

Redding, S. and Venables, A. (2000), 'Economic Geography and Measured Productivity', London School of Economics, mimeo.

Sachs, J. and Warner, A. (1995), 'Economic Reform and the Process of Global Integration', Brookings Papers on Economic Activity, 0(1), pp.1-95.

Temple, J. and Johnson, P. (1998), 'Social Capability and Economic Growth', Quarterly Journal of Economics, 113(3), pp.965-990.

United Nations (1994), *World Comparisons of Real Gross Domestic Product and Purchasing Power, 1985: Phase V of the International Comparisons Programme,* United Nations: New York.

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