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Publication date:
2006

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Dalgaard, C-J. L., & Andersen, T. B. (2006). Cross-Border Flows of People, Technology Diffusion and Aggregate Productivity. Cph.: Department of Economics, University of Copenhagen.

DISCUSSION PAPERS
Department of Economics
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06-04

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Cross-Border Flows of People, Technology Diffusion and Aggregate Productivity*

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February 15, 2006

Abstract

A number of empirical studies have investigated the hypothesis that cross-border flows of goods (international trade) and capital (FDI) lead to international technology diffusion. The contribution of the present paper consists in examining an as yet neglected vehicle for technology diffusion: cross-border flows of people. We find that increasing the intensity of international travel, for the purpose of business and otherwise, by 1% increases the level of aggregate total factor productivity and GDP per worker by roughly 0.2%.

Keywords: Technology diffusion, Productivity, IV estimation.
JEL Classification codes: O33, O47, C21

*We would like to thank Phil Abbott and David Weil for comments and discussions. The usual disclaimer applies. We also thank Fransesco Alcalá and Antonio Ciccone for sharing their data. Contact: thomas.barnebeck.andersen@econ.ku.dk, or carl.johan.dalgaard@econ.ku.dk. The activities of EPRU (Economic Policy Research Unit) are supported by a grant from The Danish National Research Foundation.

1 Introduction

It is well documented that the bulk of observed differences in GDP per worker can be accounted for by the variation in aggregate total factor productivity (TFP).[1] A leading theoretical explanation for aggregate TFP differences is that some countries are closer to the technological frontier than others, as a result of higher rates of technology adoption.[2] This theoretical work has been supplemented by empirical studies of the international diffusion process. In particular, it has been argued that cross-border flows of goods (international trade) and capital (FDI) are important vehicles for the diffusion of technology across the globe.[3] The underlying logic of why international trade and FDI are expected to enable diffusion of technology is that (intermediate) goods and machinery embody leading-edge technological knowledge. At the same time, however, it is well recognized that flows of goods and capital also proxy other aspects of global interaction. Indeed, in the influential study by Frankel and Romer (1999), which examines the relationship between trade and productivity, the authors observe that perhaps (p. 393)

> The literal shipment of goods between countries does not raise income. Rather, trade is a proxy for the many ways in which interactions between countries raise income – specialization, spread of ideas, and so on. Trade is likely to be highly, but not perfectly, correlated with the extent of such interactions. Thus, trade is an imperfect measure of income-enhancing interactions among countries.

In particular, Frankel and Romer emphasize (p. 381) "[the] exchange of ideas through communication and travel" as an important income-enhancing mechanism. To our knowledge, no aggregate studies have explicitly explored the strength of this mechanism empirically.[4]

The contribution of the present paper lies in examining the importance of cross-border flows of people for aggregate productivity. We examine the hypothesis that societies more

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[1] See e.g. Klenow and Rodriguez-Clare (1997), Hall and Jones (1999) and Caselli (2004).

[2] The pioneering theoretical contribution is Nelson and Phelps (1966). Recent notable contributions include Lucas (1993), Howitt (2000) and Eaton and Kortum (2002).

[3] The literature is surveyed in Keller (2004).

[4] Gambardella et al. (2003) pursue the matter using regional data. The authors find a significant relationship between the annual number of airplane passengers (embarked and disembarked) in regions of Europe and regional average labor productivity.

exposed to foreign influence, as measured by the temporary in- and outflows of travellers, will be able to obtain useful technologies, ideas and organizational strategies from abroad. Once implemented the acquired knowledge should stimulate aggregate TFP (productivity) and overall GDP per worker (labor productivity). Accordingly, higher "travel intensity" will increase TFP and thereby GDP per worker.

Empirically we find strong support for this hypothesis. Increasing the intensity of travel (defined as the ratio of international arrivals plus departures to the size of the labor force) by 1% increases the level of TFP by roughly 0.2%. Consistent with the diffusion hypothesis, the impact on labor productivity is about the same, suggesting that the travel/GDP per worker association can be accounted for entirely by the travel/TFP link. Globalization, to the extent that it is associated with an intensified cross-border flow of people, therefore seems to be strongly related to economic outcomes. This finding is robust to the inclusion of other fundamental determinants of productivity such as (measures of) institutional quality and key climate related circumstances.[5] Further, we document that once travel is controlled for, international trade holds no additional explanatory power vis-a-vis productivity. This finding suggests that the main reason why trade stimulates productivity is by enabling knowledge diffusion, and not that trade instigates specialization and intensified competition.

The notion that interaction of individuals matters for international diffusion of knowledge is of course not new. Contributions to the theory of endogenous growth has already incorporated this mechanism. Lucas (1993) develops a model where human capital spillovers ensure international convergence in income per worker. In the article Lucas emphasize learning-by-doing as a form of human capital accumulation, which could be relevant in trying to understand the East Asian growth miracle. Irwin and Klenow (1994) provide empirical evidence on learning in the semi-conductor industry. In particular, they find evidence of international knowledge spillovers stemming from learning-by-doing, thus supporting the spillover mechanism in Lucas' model. It is hard to believe that diffusion of tacit knowledge like that acquired through learning-by-doing could occur without any personal interaction, which then almost inevitably must involve cross-border flows of people.

Personal interaction may be crucial for diffusion of technological knowledge more generally. The reason is that even technological knowledge is not always fully codified since this

[5] That the institutional make-up of a country empirically is a key determinant of long-run productivity was originally demonstrated in important contributions by Hall and Jones (1999) and Acemoglu et al (2001). Sachs (2003) argues convincingly that some aspects of climate also matters directly for aggregate productivity.

would be extremely costly. Aspects of technological knowledge remains tacit in nature and may only be transferred fully via personal interaction, preferably face-to-face (Keller, 2004). This could especially be true for knowledge spillovers between researchers, commonly assumed to exist in idea-based endogenous growth models (Romer, 1990; Aghion and Howitt, 1992, and many others).

That personal contacts could be key in the diffusion process was pointed out early on by Arrow (1969); an assertion which more recently has received strong empirical support (Foster and Rosenzweig, 1995).[6] Furthermore, Arrow (1969, p. 34) argues that a relative lack of personal contacts outside a country may be an important impediment to the adoption of valuable technological knowledge from abroad. Accordingly, international travel (whether for the purpose of business or pleasure) ought to facilitate the diffusion of technological knowledge by allowing people to build personal relationships across borders.

As a concrete historical case of travel-induced spread of technology, in the broadest sense, one may refer to the "the age of discovery". During this period (starting late in the 15th century) European explorers brought many new crops back from their excursions, which subsequently became important agricultural produce for European farmers. The list includes the Potato, Corn, many varieties of beans and the Tomato. The motivating force behind European discoverers was undoubtedly the desire to establish new trade routes, and to obtain luxuries such as silk, spices and gold. In retrospective, however, the bringing back of agricultural crops may have been more important for long-term development in Europe (by enhancing calorie intake in the population at large) than the gold the explorers brought back. Yet, the former was an altogether unexpected beneficial innovation from travelling to new continents.

Finally, contemporary cases of knowledge spillovers through personal (international) interaction can also be provided. One example concerns the creation of the so-called "Desh Garment Company" in Bangladesh, which was founded on interaction with Korean Daewoo, and turned out to be a resounding success. As described by Rhee (1990, p.336)

> The collaboration agreement, which was to run five years, involved several key

[6] Foster and Rosenzweig present survey results deriving from a questionnaire circulated in 186 Indian villages around the time of the "Green Revolution". Over a third of the respondents claimed to have received most of their information regarding cropping practices from friends and neighbours, rather than through campaigns orchestrated by government agencies. Similar results emerge from another survey conducted among farmers in the Philippines.

elements: six months of training for Desh workers in Korea: start-up activities to involve certain purchases of machinery by Desh from Daewoo, which would then handle the installation, supervise and advise on the actual start-up; production, to be managed by Desh with consultation and supervision provided by Daewoo.

Hence the in- and outflow of people to (and from) Bangladesh was an important ingredient in establishing this new endeavour, and thereby in its ultimate success.[7]

The paper proceeds as follows: Section 2.1 lays out a simple framework which conceptually forms the basis for our empirical analysis of cross-country technology diffusion. Aside from motivating our empirical specification this discussion also allows us to contrast our work with previous studies in a transparent way. Section 2.2 presents our empirical specification, and Section 2.3 describes our data. Section 2.4 documents the partial correlation between travel intensity and productivity. In Section 2.5 we lay out our identification strategy, and in Section 2.6 we present IV estimates. Section 2.7 provides a direct test of our key exclusion restriction. Section 3 concludes.

2 Empirical Analysis

2.1 A Conceptual Framework

Consider the following Solow (1956) model, slightly modified to allow for human capital and technology transfer. The production function is Cobb-Douglas, exhibiting constant returns to capital and labor input. Labor is augmented by technology, A_t (which grows at the rate g_t), but also by human capital, h. Along a steady state trajectory GDP per worker, y_t^*, is then given by

$$y_t^* = \left(\frac{s}{n + \delta + g_t} \right)^{\frac{\alpha}{1-\alpha}} A_t h, \tag{1}$$

where s is the savings/investment rate, n is the rate of labor force growth, δ is the rate of capital depreciation, and α is capital's share. This equation, in its log form, was estimated by Mankiw, Romer and Weil (1992). Their cross-section analysis invoked the identifying assumption that A is a random variable with a constant mean.[8] However, more recent work

[7]For other cases and further references, see Rauch (2001).

[8]They also allowed human capital to be accumulated. To capture this, equation (1) could be restated as $(s/n + \delta + g_t)^{\frac{\alpha}{1-\alpha}} A_t h^*$, where h^* is the steady state stock of human capital per worker.

has deemed this assumption suspect. As a result, we will instead entertain the idea that countries, to varying extent, tap into a "world technology frontier", A_t^w. In the spirit of Nelson and Phelps (1966) we assume that local technology is characterized by the following first-order linear differential equation

$$\dot{A}_t = \phi \cdot (A_t^w - A_t), \tag{2}$$

where $\phi > 0$ parameterizes the rate of technological diffusion. The parameter ϕ can therefore be thought to capture adoption, or knowledge spillovers from abroad. To complete the model we assume the world technology frontier expands over time at a constant rate of technological progress: $\dot{A}_t^w = g^w A_t^w$. The evolution of technology in the economy over time is fully described by $\dot{A}_t^w = g^w A_t^w$ and equation (2). A steady state for this system is a A_t^w / A_t-ratio such that the rate of (local) technological progress is equal to the frontier rate: $\dot{A}_t / A_t = g_t = \dot{A}_t^w / A_t^w = g^w$. It is easy to show that this ratio, which is unique and can be interpreted as the steady state distance to the frontier, is determined by ϕ,

$$A_t = \frac{\phi}{\phi + g^w} A_t^w. \tag{3}$$

If equation (3) is substituted into equation (1) (along with $g_t = g^w$) we are left with a complete solution for the long run level of GDP per worker as a function of the parameters of the model.

While simple, this structure holds several implications which are useful for the empirical examination of international technology diffusion. As should be clear, the model implies that growth differences between countries should be temporary in nature. In the long run, differences in growth of labor productivity, y, as well as productivity, A, disappear. In addition, persistent differences in productivity are due to differences in ϕ.[9]

With this sort of framework in mind, explaining observed differences in the levels of A (and y), rather than differences in growth rates, is a sensible focus for the empirical analysis. The reason is that the former reflects persistent variation whereas the latter is a transitional phenomenon. In the present study we essentially examine, by way of cross-section regression

[9] Howitt (2000) develops a multi-country Schumpeterian growth model, which contains similar reduced form properties. In Howitt's model g^w is determined by global R&D effort and ϕ is endogenously determined as well.

analysis, the hypothesis that cross-border flows of people influences the size of ϕ. If so, it should impact on A, or, its empirical proxy, the level of TFP.

In contrast, the existing literature on aggregate knowledge spillovers typically use panel data. In effect, these studies take a log-differenced version of equation (3) to the data, thereby examining the determinants of TFP growth ($\dot{A}_t/A_t$). The right hand side variable is R&D expenditures in leading economies, weighted by either trade shares (Coe and Helpman, 1995; Coe et al., 1997) or FDI shares (de la Potterie and Lichtenberg, 2001). A few observations regarding the difference in empirical strategy and specification, compared with the present paper, are worthwhile.

First, while the existing literature attempts to resolve the problem of endogeniety of trade/FDI (if at all) by invoking internal instruments, the levels specification allows us to invoke an external instrument for travel. Second, since we employ a pure cross-section analysis, adding accumulated global R&D investment (to proxy A^w) would not make much sense. If bilateral travel flows were available one could generate a variable involving weighted accumulated R&D investment for the purpose of estimation, thereby mimicking the independent variable from existing panel studies. We do not follow this track since bilateral travel flows are (to the best of our knowledge) not available, and because we do not wish to limit attention to R&D spillovers *per se* but rather examine knowledge diffusion more generally. As a result, we opt for a parsimonious specification which involves regressing A on travel (and other plausible determinants of the rate of diffusion) so as to capture the influence from ϕ. Third, panel data allows for country specific intercepts in the regression; this is infeasible in a cross-section analysis. Instead, we add controls for other potentially "deep" determinants of ϕ, aside from global interaction via travel, and carefully try to instrument these when relevant.

Finally, an important implication of the model is that ϕ only affects y via A.[10] As a result, we expect that the impact of travel intensity on y can be accounted for entirely by the association between travel and productivity. That is, if indeed our travel variable only captures the technology diffusion channel.

[10] In theory this is still true if s and n are endogenously determined in a standard growth framework. See e.g. the discussion in Mankiw, Romer and Weil (1992, p.411).

2.2 Specification

On the basis of the conceptual framework outlined in the previous section, the empirical strategy is as follows. Contingent on data for TFP (proxy for A), our empirical specification is a regression model of the form ("i" refers to countries):

$$\log(A_i) = \gamma_1 + \gamma_2 TRAVEL_i + \mathbf{X}_i' \cdot \boldsymbol{\gamma}_3 + \varepsilon_i, \tag{A}$$

where TRAVEL is the cross-border flow of people, $\mathbf{X}_i$ is a vector of controls and ε_i captures omitted factors and noise. In choosing relevant controls, $\mathbf{X}_i$, we follow the approach taken in the recent literature on "deep determinants" of productivity (Hall and Jones, 1999; Acemoglu et al., 2001; and others). In particular, following Rodrik et al. (2004) the set of variables to be included in $\mathbf{X}_i$ can be partitioned into three main subsets: "institutions", "integration" (participation in the world economy) and "geography". The rationale for adopting these controls, in the specific context of technology diffusion, is as follows.

At the fundamental level there are two sorts of reasons why countries do not adopt new technologies from abroad. First, there may be a lack of "willingness" to adopt. That is, the incentive structure may discourage adoption of foreign technologies. This would be the case absent well-established property rights. Related, powerful groups in society may attempt to block innovations if they stand to loose economic or political influence (Parente and Prescott, 1999; Acemoglu and Robinson, 2000). We try to take these kinds of barriers to adoption into account by controlling for the institutional environment. Second, there could be a lack of "access" to foreign technology. Such lack of access could be geographically founded. For example, Diamond (1999) argues convincingly for the difficulty in transferring (agricultural) technologies across climate zones. To capture considerations along these lines we include a set of geo-controls. But a lack of access could also be caused by a lack of global integration, which we control for via the TRAVEL variable. Hence, although TRAVEL is singled out in equation (A), and in the analysis to follow, we fully recognize that it conceptually captures "integration".

Our central tests involve equation (A). But we also run regressions involving labor productivity:

$$\log(y_i) = \beta_1 + \beta_2 TRAVEL_i + \mathbf{X}_i' \cdot \boldsymbol{\beta}_3 + \epsilon_i. \tag{Y}$$

The reason why we run the regression displayed in equation (Y) is that by comparing the size of our estimates of γ_2 with those for β_2 we get a sense of whether the full effect of TRAVEL runs through TFP. This would be the case if TRAVEL only drives knowledge spillovers (matter for ϕ but not for investment rates).

2.3 Data

In calculating the key dependent variable, the level of TFP, we follow the literature on development accounting by invoking an aggregate Cobb-Douglas production function, which exhibits constant returns to the principal rival factors of production: capital and human input.[11] Specifically, following Klenow and Rodriguez-Clare (1997) we use that GDP per worker can be written as

$$y_i = A_i \left(\frac{k_i}{y_i} \right)^{\frac{\alpha}{1-\alpha}} h_i,$$

where A_i is productivity (TFP), $k_i \equiv K_i/L_i$ is capital per worker, and h_i is human capital per worker. Assuming markets are competitive, α can be identified by the share of capital in national accounts. We assume α is 1/3 for all countries.[12] Contingent on data for y, k and h we can then calculate A as the residual. Data for real (PPP) GDP per worker, y, the capital stock per worker, k, and the stock of human capital per worker, h, are those used by Caselli (2004). These data, which are based on Penn World Tables, version 6.1 (Heston et al., 2002), and on Barro and Lee (2001), enable us to construct a productivity measure dating from the mid-90s. Specifically, data on real GDP per worker and capital are from 1996, whereas human capital figures are from 1995.

Focusing on mid-90s is important since data on cross-border flows of people is only available from 1990 onwards. In particular, we proxy the flow of people by the sum of yearly international arrivals and departures, taken from World Development Indicators (2004) (WDI). This variable measures arrivals and departures of people traveling to, and staying in, places outside their usual place of residence for no more than one consecutive year for business, leisure, and other purposes not related to an activity remunerated from within the place visited.[13] In particular, we use (the log of) the average sum of yearly arrivals and departures

[11] See Caselli (2004) for a survey of the literature.

[12] This is the conventional assumption in the literature. The study by Gollin (2002) suggests it is not an unreasonable approximation.

[13] The labelling of the underlying variables in WDI is slightly misleading in that it describes the raw data as "international tourist departures" and "international tourist arrivals", respectively. As the WDI background

over the 1990-1996 period divided by the size of the workforce. We denote this variable TRAVEL.[14]

Our institutional measure is the index of government anti-diversion policies, proposed by Hall and Jones (1999). The index is rather broad, combining indicators of bureaucratic quality, law and order, corruption, risk of expropriation, and the likelihood of government repudiation of contracts. We denote this variable INSTITUTIONS.[15]

Turning to measures of geography, continent dummies (America, Asia & Oceania, Europe, and Africa) have been widely employed in the empirical growth literature. As argued by Sachs (2003), however, adding continent dummies to the regression is likely to be an incomplete way of controlling for the influence of geography on development. Indeed, most geographical analyses stress several other factors such as geographic isolation and the disease environment. To capture the impact of geography more fully we therefore invoke three additional geo-controls in our regressions: (i) a dummy variable which takes on a value of 1 if the nation is landlocked (henceforth LANDLOCK); (ii) the absolute latitude of the country (LATITUDE); and (iii) the fraction of land area in the tropics (TROPICS). The source of LANDLOCK and TROPICS is Gallup et al (1999); LATITUDE is taken from Hall and Jones (1999).

Finally, we need a measure of trade openness to motivate our IV strategy. For this purpose we shall rely on the real openness measure of Alcála and Ciccone (2004). They define REAL OPENNESS as the ratio of imports plus exports to PPP GDP. The data source for this measure is WDI.

2.4 Partial Correlations

In order to examine the influence of TRAVEL on productivity a cross-plot is a natural starting point. As is visually obvious from Figure 1, the two variables have a high positive

notes make clear, however, tourism is only a subset of the annual departures and arrivals.

[14] Allowing the number of arrivals to enter into TRAVEL implies that we run the risk of a spurious positive correlation between TRAVEL and GDP per worker. The reason is that arrivals increase GDP by national accounts convention (export of services). Of course, this problem is no greater than that of the trade literature. Still, to resolve the problem one could measure TRAVEL solely by departures. Reassuringly, the correlation between these two alternative TRAVEL series is 0.94.

[15] A number of different measures of institutional quality have been used in the literature. The advantage of using this precise index is that Hall and Jones (1999) provide instruments, which we shall invoke below. In any case, different measures of institutional quality are highly correlated.

correlation.[16] This is confirmed in Table 1 (Panel B), which reports the correlation matrix associated with our key variables. The correlation between TRAVEL and productivity is 0.67.

> Figure 1 about here <

> Table 1 about here <

In Table 2 we report results from OLS regressions involving equation (A) (Columns (1)-(4)) and equation (Y) (Column (5)). Column (1) shows that TRAVEL and a constant (i.e. the line in Figure 1) can account for as much as 46% of the variation in productivity across countries. As we move from left to right in Table 2 we progressively add additional controls to test the robustness of the partial correlation between TRAVEL and productivity. The important message from the regressions is that TRAVEL is estimated with high precision in all columns. Moreover, we cannot reject the null hypothesis that the coefficient on TRAVEL is the same across columns. It is also worth noting that TRAVEL, INSTITUTIONS and geography account well for the variation in labor productivity, with a R^2 of 0.86.

> Table 2 about here <

As a final check of the partial correlations reported above we have done a series of LAD (median) regressions to check robustness.[17] The results, which are available upon request, show that the partial correlations between TRAVEL and productivity are not driven by outliers. Indeed, TRAVEL remains significant in all the specifications from Table 2 (typically at the 1% level) when re-estimated by LAD .

Overall, the above results document that TRAVEL is robustly correlated with productivity. While this is encouraging, it does not prove causality. The latter is the issue to which we now turn.

2.5 Identification

TRAVEL is likely to be endogenous in equations (A) and (Y). Countries whose productivity is high for reasons unrelated to international travel may simply experience a higher intensity

[16]The figure has two clear outliers: (LSO) Lesotho and (ROM) Romania. Lesotho is a small monarchy completely encapsulated by South Africa. In particular, some 40% of all male Basotho are migrant workers in South Africa. Romania, on the other hand, has a large Romany population with a long tradition of crossing borders and living in caravans.

[17]This method of estimation is much more resistant to outliers than OLS (see Deaton, 1997).

of international travel. In order to address this potential endogeneity problem we need to instrument TRAVEL.

As argued in the seminal paper by Frankel and Romer (1999), certain geographic characteristics are important determinants of the extent to which a given country is engaged in international trade. Since a country's level of productivity does not affect these geographic characteristics, i.e. they are exogenous, the information contained in geography is a candidate instrument for international trade. This insight can also be used in the present context since international trade leads to more business travel (see e.g. Keller, 2004, p. 756-57), which in turn may instigate leisure travel. Figure 2, which provides a cross plot of REAL OPENNESS against TRAVEL, indicates that this is not an unreasonable conjecture. Consequently, the same geographic characteristics that are candidate instruments for international trade should work for TRAVEL. The maintained exclusion restriction, in the analysis to come, is that once we control for TRAVEL, REAL OPENNESS should have no effect on productivity. We test this both indirectly (using over-identifying restrictions in Section 2.6) and directly (relying on tests of non-nested models in Section 2.7). In both cases, we find strong evidence in favour of the validity of the exclusion restriction.

> Figure 2 about here <

We will use the trade instrument devised by Frankel and Romer (1999). This instrument is constructed in two steps: First, fitted bilateral trade shares are constructed by regressing bilateral trade shares on factors such as distance, size, common border, etc.. Second, fitted bilateral trade shares are then aggregated in order to construct the geographic component of countries' overall trade. We rely on the updated and expanded version of the Frankel-Romer instrument computed by Alcalá and Ciccone (2004). Figure 3, which plots the fitted (aggregate) trade share against TRAVEL, provides visual evidence of the quality of this instrument.

> Figure 3 about here <

In order to instrument the INSTITUTIONS variable, we adopt a two-pronged strategy. Firstly, we rely on two language variables: the fraction of the population speaking English as first language and the fraction speaking one of the major European languages (English, French, German, Portuguese or Spanish) as first language. These language instruments, which were originally proposed by Hall and Jones (1999), allow us estimate the full OLS sample using IV methods. However, secondly, we rely on the celebrated settler mortality instrument proposed by Acemoglu et al. (2001). This instrument, which is widely accepted (see e.g. Rodrik et al., 2004), is arguably the strongest instrument around, but it reduces our sample considerably.

2.6 Instrumental Variables

In Table 3 we re-estimate the specifications in Table 2 using 2SLS. Instruments consist of the fitted trade share and the two language variables.

> Table 3 about here <

Several features of the table stand out. First, TRAVEL is highly significant in all specifications. Second, the coefficient estimate associated with TRAVEL is remarkably stable despite the progressive inclusion of additional control variables. In fact, a quick look at the standard errors reveals that in a statistical sense the point estimates associated with TRAVEL are the same across columns in the table. Third, the impact of TRAVEL on GDP per worker is insignificantly different from the impact of TRAVEL on TFP. This is consistent with the hypothesis that TRAVEL induces knowledge spillovers, thereby increasing labor productivity. It is also noteworthy that the data, judged by Columns (3) to (5), do not reject the over-identifying assumption that the fitted trade shares only influence productivity, and labor productivity, through TRAVEL. We further explore the validity of the exclusion restriction in Section 2.7.

To gauge the quality of our instruments we rely on the framework provided by Stock and Yogo (2004). This framework provides a multivariate generalization of the well-known Staiger-Stock "rule-of-thumb", the so-called Cragg-Donald statistic and associated critical values.[18] The null being tested is that instruments are weak in the sense that inference based on IV estimates is plagued with size distortions. The Cragg-Donald statistic reported in Table 3 must be above the relevant critical value reported in Stock and Yogo (2004) for instruments to be strong.[19] The critical values allow one to perform four tests, viz. that

[18]The rule-of-thumb is that strong instruments require a F-value above ten in the first-stage regression. The Cragg-Donald value equals the F-value when there is just one endogenous variable.

[19]Since Stock and Yogo assume homoskedasticity in deriving critical values, we have provided a test for the null of homoskedasticity in Table 3. We cannot reject the null at any conventional levels. However, all re-

the size distortion is at least 5, 10, 15 or 20 percent, respectively. Note that with one endogenous variable and 3 excluded instruments, the rule-of-thumb, which is widely used in the literature, deems instruments strong if the maximal size distortion is less than 15 percent (see Stock and Yogo, 2004, Table 2).[20]

If we look at Column (4) in Table 3, our preferred specification, the Cragg-Donald value is 5.33. This is below the lowest critical value in Stock and Yogo (2004, Table 2), and it means that with a nominal size of 0.05 we cannot reject that the actual size is at least 0.25. In other words, weak instruments result in a size distortion of at least 0.2. To address this problem, Stock and Yogo recommend using the Limited Information Maximum Likelihood estimator (LIML), which is superior to 2SLS when instruments are weak.

Consequently, in Table 4 we report estimates using LIML.[21] With a Cragg-Donald value of 5.33 we can now conclude that the maximal size distortion is below 10 percent, since the critical values for the Cragg-Donald statistic are different under LIML estimation (see Stock and Yogo, 2004; Table 4). Hence with LIML we are able to control the size distortion to a level acceptable by the standards of the rule-of-thumb.[22] We can however do better, as we show next.

> Table 4 about here <

Table 5 reports results from 2SLS using (the log of) settler mortality as instrument for INSTITUTIONS. Unfortunately, this implies a non-trivial reduction in sample size. Yet, in a statistical sense, results are the same as in Tables 2-4. In addition, the Cragg-Donald value of 8.81 in Column (3) implies that the maximal size distortion is below 5 percent. Hence, using strong instruments, we get similar results as reported in Tables 2-4 above.

> Table 5 about here <

ported t-statistics are robust since under the null of homoskedasticity this makes no difference asymptotically. For completeness, non-robust t-statistics give the same results as robust ones.

[20] An alternative way of viewing the rule of thumb (with one endogenous variable and three excluded instruments) is that it deems instruments strong if the null of a maximal bias (relative to OLS) of at least 10 percent is rejected.

[21] Note that with just-identification 2SLS and LIML coincide, which is why Column (1) in Table 3 is omitted.

[22] In addition, the joint test of both endogenous variables being zero is rejected at one percent using the Anderson and Rubin (1949) test (not reported). This test is fully robust to weak instruments but may experience low power.

Our results suggest that TRAVEL has a substantial impact on productivity: an (exogenous) increase in TRAVEL by 1% leads to an increase in productivity by roughly 0.2%. To get a sense of what this elasticity implies, in terms of predicted TFP differences, one may begin by observing that moving from the 10th percentile to the 90th percentile in the TRAVEL distribution (in the sample of Tables 2-4) involves increasing TRAVEL by roughly 3 yearly departures/arrivals per worker. Using the elasticity of 0.2, this difference in TRAVEL predicts a difference in the level of TFP by roughly a factor of 2.2. Moving from the 10th to the 90th percentile in the TFP distribution (in the same sample) involves a difference of roughly a factor of 5. Hence the economic significance of TRAVEL is substantial, but not implausible.

2.7 Flows of People Versus Flows of Goods

In Section 2.6 we reported tests of the exclusion restriction that once we control for TRAVEL, exogenous trade shares should have no effect on productivity. While the data do not allow us to reject this assumption some doubts may remain.

Even accepting that TRAVEL is a stronger measure of technology diffusion than trade, it is also clear that trade may matter for the level of productivity through other channels as well. In particular, exposure to international trade may induce an intensified state of competition and lead to specialization in production. It is plausible that this also matters for A. However, in theory specialization and competition will not necessarily stimulate productivity. Consider specialization, it is clear that if an economy ends up specializing in less innovative sectors overall productivity could suffer, at least in the medium term.[23] Naturally, specialization could also give rise to dynamic benefits, aside from the static efficiency gain. But *a priori* the impact is ambiguous. The same goes for competition. On the one hand, in a large market firms may try harder to innovate so as to "escape competition". But, on the other hand, in more competitive markets profits tend to be lower, which in turn reduces the incentives to innovate. The net effect of competition is therefore also ambiguous *a priori*.[24] To be sure,

[23] See Matsuyama (1992) and Galor and Mountford (2004) for growth theories which explicitly shows how this outcome could be the result of trade liberalisation

[24] See Aghion and Griffith (2005) for a thorough theoretical and empirical discussion of this issue. In particular, the authors present evidence of a hump-shaped association between measures of competition and productivity growth using micro-data, thereby corroborating the theoretical prediction of an ambiguous effect of competition on productivity.

whether trade should have an impact on productivity above and beyond what is captured by TRAVEL is an empirical issue. Below we address this important issue more directly than is allowed for by OID tests.

We start by comparing the predictive power of TRAVEL and REAL OPENNESS in the OLS setting. In Table 6 we add REAL OPENNESS to all columns of Table 2, which amounts to a test of two non-nested models by construction of a hybrid "supermodel". REAL OPENNESS is highly insignificant in all columns. Accordingly, TRAVEL dominates REAL OPENNESS as a (log-linear) predictor of productivity and labour productivity.

> Table 6 about here <

A direct test, relying on a supermodel in the IV setup, is not feasible. The reason is that the high correlation between TRAVEL and REAL OPENNESS induces weak identification, which in turn renders the test unreliable.

As a result, we employ the so-called J test, developed by Davidson and MacKinnon (1981) and MacKinnon et al. (1983), which partly allows us to circumvent this problem. The J test chooses between two non-nested models. In our case:

$$\begin{aligned} H_0 &: \log(A_i) = \gamma_1 + \gamma_2 TRAVEL_i + \mathbf{X}_i' \cdot \boldsymbol{\gamma}_3 + \varepsilon_i, \\ H_1 &: \log(A_i) = \delta_1 + \delta_2 REAL\ OPENNESS_i + \mathbf{X}_i' \cdot \delta_3 + \nu_i. \end{aligned}$$

The set of excluded instruments, Z, is required to be the same in the two models. The test works as follows. We begin by estimating the alternative model (H_1) by 2SLS. The obtained parameter vector is $\widehat{\delta} = \left[\widehat{\delta}_1, \widehat{\delta}_2, \widehat{\delta}_3\right]$. Next, we proceed to calculate the predicted values of $\log(A_i)$ using $\hat{\delta}$, $\log(A_i, \widehat{\delta})$. Finally, the following model is estimated by 2SLS:

$$\log(A_i) = \gamma_1 + \gamma_2 TRAVEL_i + \mathbf{X}_i' \cdot \boldsymbol{\gamma}_3 + \alpha_J \log(A_i, \widehat{\delta}) + \mu_i. \tag{4}$$

If H_0 is true we should not be able to reject the null of $\alpha_J = 0$.[25] The test for $\log(y_i)$ is conducted in the same way.

[25] Note that under the null $\alpha = 0$, we need not take into account that $\log(A_i, \widehat{\delta})$ is a generated regressor in (4) since $\widehat{\delta}$ is obtained using IV and $\log(A, \widehat{\delta})$ is linear. Formally, $E(\nabla_\delta \log(A, \widehat{\delta})'\mu) = \mathbf{0}$ and $\alpha = 0$ suffice (see Wooldridge, 2002, Appendix 6A).

Table 7 reports the J test on the main specifications in Tables 3 and 5. The row with $\log(A, \widehat{\delta})$ performs the J test with productivity as the dependent variable, whereas the row with $\log(y, \widetilde{\delta})$ performs the J test with labour productivity as the dependent variable.

> Table 7 about here <

Inspection of the table shows that we cannot reject $\alpha_J = 0$ in any column. Moreover, except for Column (3), i.e. labour productivity in the large sample, TRAVEL remains significant. Yet instrument weakness is a concern throughout Columns (1) to (4). In Columns (5) and (6), however, we do fine by the standards of the rule-of-thumb. Hence the J test provides the same conclusion as the OID tests, namely that the exclusion restriction is valid.[26]

Overall, this suggests that trade has no statistically significant effect on productivity once we control for cross-border flows of people. Accordingly, we cannot reject a view which holds that the net effect of trade-induced specialization and competition on aggregate productivity is negligible. At the same time our findings are fully consistent with trade affecting productivity indirectly, i.e. through its influence on cross-border flows of people.

3 Concluding Remarks

Theoretically, observed differences in TFP levels can (at least in part) be motivated by differences in technology adoption rates. But why do some countries adopt technology more

[26] Godfrey (1983) has also proposed a test of non-nested models in an IV setting. The idea is to compare a weighted sum of the squared residuals from H_0 and H_1. Godfrey derives both a direct test and an indirect regression-based test; asymptotically they are equivalent. The regression-based test is carried out in the following way: First we estimate $\widehat{\gamma} = [\widehat{\gamma}_1, \widehat{\gamma}_2, \widehat{\gamma}_3]$ from H_0 using 2SLS with instruments Z. The next step is to generate predicted values, $\widehat{TRAVEL}$, $REAL\ \widehat{OPENNESS}$ and $INSTI\widehat{TUTIONS}$, of $TRAVEL$, $REAL\ OPENNESS$ and $INSTITUTIONS$, respectively, by regressing each on the vector of instruments, Z. Third, partition $\widehat{X}$ and $\widehat{\gamma}_3$ as $\widehat{X} = [INSTI\widehat{TUTIONS} : \widehat{W}]$ and $\widehat{\gamma}_3 = [\widehat{\gamma}_{INSTITUTIONS} : \widehat{\gamma}_W]$, and then generate $\widehat{a}_i = \widehat{\gamma}_1 + \widehat{\gamma}_2 \widehat{TRAVEL}_i + [INSTI\widehat{TUTIONS}_i : \widehat{W}_i] \cdot [\widehat{\gamma}'_{INSTITUTIONS} : \widehat{\gamma}'_W]$. Fourth, regress $\widehat{a}$ on a constant, $REAL\ \widehat{OPENNESS}$ and $\widehat{X}$. Let $\widehat{G}$ be the residual vector from this regression. Finally, use OLS on $\log(A_i) = \gamma_1 + \gamma_2 TRAVEL_i + \mathbf{X}'_i \cdot \boldsymbol{\gamma}_3 + \alpha_G \widehat{G}_i + \mu_i$. If H_0 is true we should not be able to reject the null of $\alpha_G = 0$. Since the Godfrey test requires over-identification, it cannot be performed in the small sample using the settler mortality instrument. However, in the large sample, where the INSTITUTIONS variable is instrumented by the two language variables, it strongly supports the validity of the exclusion restriction. That is, the null of $\alpha_G = 0$ is never rejected at a 10 percent level in the samples associated with Columns (1) to (3) in Table 7. Results are available upon request.

readily than others? In the present paper we have examined the hypothesis that integration, as manifested in cross-border flows of people, facilitates the spread of technological knowledge.

There are many reasons why the direct interaction between individuals may be crucial. Tacit knowledge almost inevitably needs to be communicated person-to-person. Even general technological knowledge is often not completely codified, which implies that it can only be transmitted fully if individuals meet in person. Many growth theories build on the idea that spillovers between individuals exist and are substantial.

Our empirical analysis shows that a compelling case can be made for the existence of cross-border spillovers using aggregate data. The intensity of travel is a strong predictor of aggregate productivity levels, even controlling for measures of the institutional infrastructure and key climate related circumstances. The estimated causal effect of travel on productivity is statistically and economically significant. Moreover, the association between international travel and GDP per worker can be fully accounted for by the association between international travel and TFP. Taken together, these findings suggest that cross-border flows of people is an important vehicle for knowledge diffusion.

Finally, our analysis reveals that international trade has no impact on productivity once we control for travel. This finding suggests that the impact of international trade on productivity is due to knowledge diffusion, whereas trade-induced competition and specialization bear no effect on productivity.

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A Figures and Tables

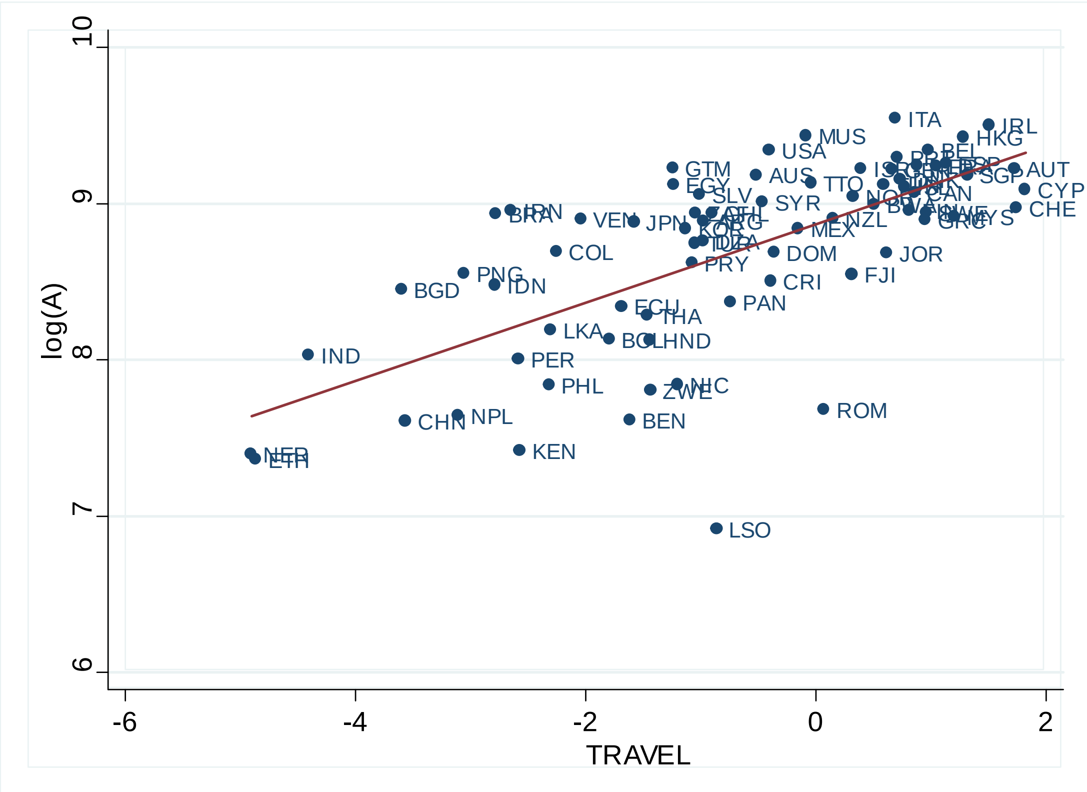

Figure 1. TRAVEL vs. log(A) (72 countries).

Notes: (AGO) Angola, (ARG) Argentina, (AUS) Australia, (AUT) Austria, (BDI) Burundi, (BEL) Belgium, (BEN) Benin, (BGD) Bangladesh, (BOL) Bolivia, (BRA) Brazil, (BWA) Botswana, (CAN) Canada, (CHE) Switzerland, (CHL) Chile, (CHN) China, (CIV) Cote d'Ivoire, (COL) Colombia, (CRI) Costa Rica, (CYP) Cyprus, (DNK) Denmark, (DOM) Dominican Republic, (DZA) Algeria, (ECU) Ecuador, (EGY) Egypt, (ESP) Spain, (ETH) Ethiopia, (FIN) Finland, (FJI) Fiji, (FRA) France, (GBR) United Kingdom, (GRC) Greece, (GTM) Guatemala , (HKG) Hong Kong, China, (HND) Honduras, (HUN) Hungary, (IDN) Indonesia, (IND) India, (IRL) Ireland, (IRN) Iran, (ISL) Iceland, (ISR) Israel, (ITA) Italy, (JOR) Jordan, (JPN) Japan, (KEN) Kenya, (KOR) Korea, Rep., (LKA) Sri Lanka, (LSO) Lesotho, (MAR) Morocco, (MDG) Madagascar, (MEX) Mexico, (MUS) Mauritius, (MYS) Malaysia, (NER) Niger, (NGA) Nigeria, (NIC) Nicaragua, (NLD) Netherlands, (NOR) Norway, (NPL) Nepal, (NZL) New Zealand, (PAN) Panama, (PER) Peru, (PHL) Philippines, (PNG) Papua New Guinea, (PRT) Portugal, (PRY) Paraguay, (ROM) Romania, (SGP) Singapore, (SLV) El Salvador, (SWE) Sweden, (SYR) Syrian Arab Republic, (TCD) Chad, (THA) Thailand, (TTO) Trinidad and Tobago, (TUN) Tunisia, (TUR) Turkey, (TZA) Tanzania, (USA) United States, (VEN) Venezuela, (ZAF) South Africa, (ZWE) Zimbabwe.

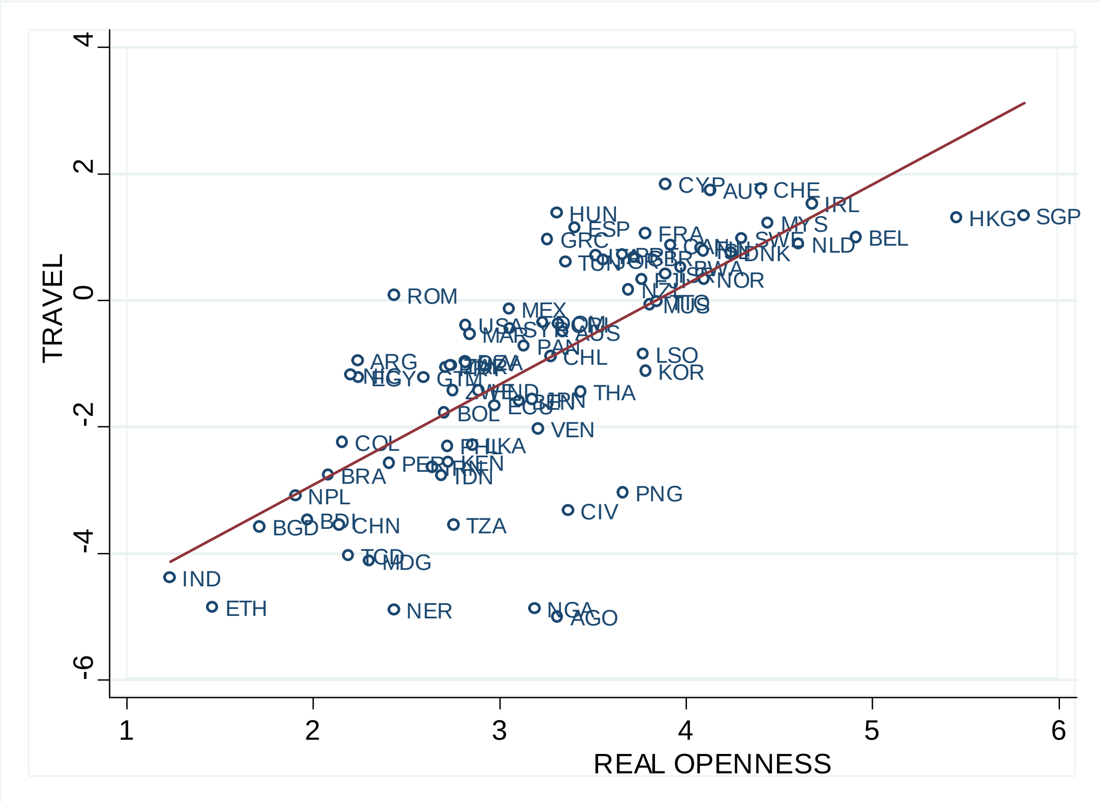

Figure 2. REAL OPENNESS vs. TRAVEL (72 countries).

Notes: See Figure 1 for the key to country codes.

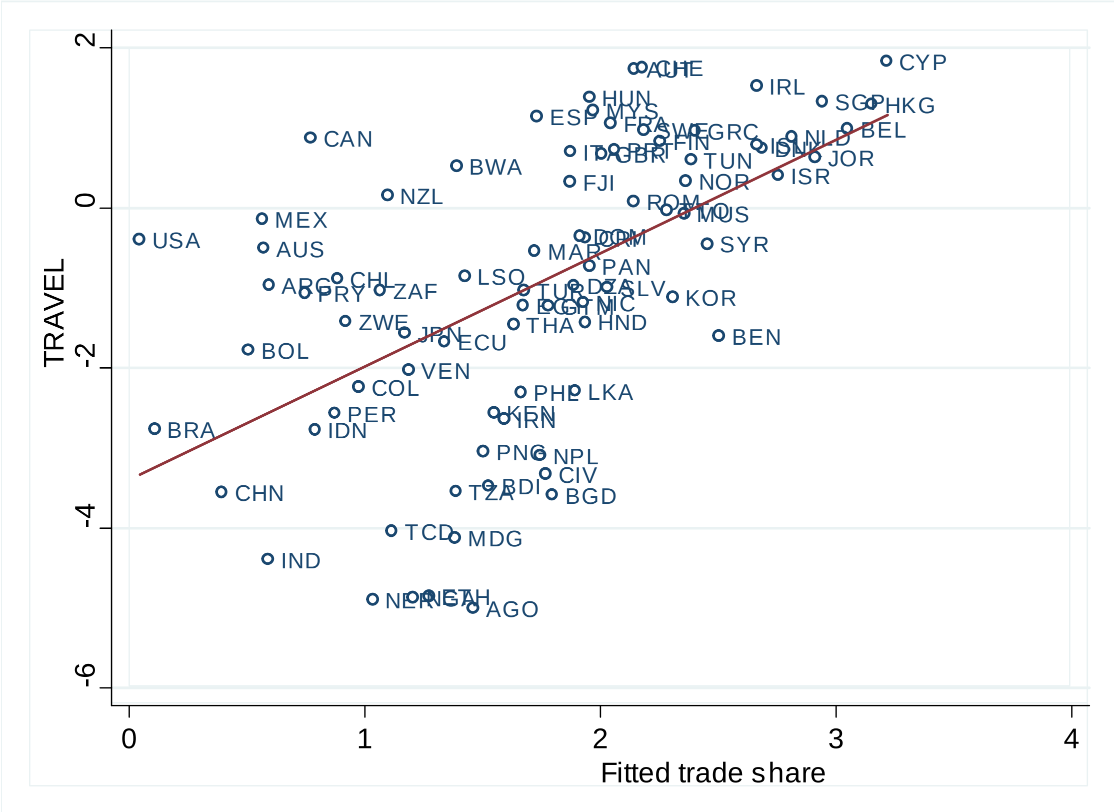

Figure 3. Fitted trade share vs. TRAVEL (72 countries).

Notes: See Figure 1 for the key to country codes.

Table 1: Summary Statistics for Selected Variables

			Panel A				
Variable	Observations	Mean	Median	Std. Dev.	Min	Max	
TRAVEL	72	−0.72	−0.62	1.64	−4.9	1.83	
log(A)	94	8.48	8.72	0.75	6.01	9.54	
log(y)	94	9.38	9.56	1.14	6.45	10.96	
INSTITUTIONS	93	0.63	0.58	0.21	0.23	1	
LANDLOCK	89	0.18	0	0.38	0	1	
TROPICS	89	0.19	0.03	0.27	0	1	
LATITUDE	92	0.27	0.22	0.19	0	0.72	
			Panel B				
			Correlation Matrix				
TRAVEL	1						
log(A)	0.67	1					
log(y)	0.79	0.90	1				
INSTITUTIONS	0.65	0.56	0.76	1			
LANDLOCK	−0.11	−0.35	−0.33	−0.08	1		
TROPICS	−0.44	−0.42	−0.46	−0.39	−0.07	1	
LATITUDE	0.57	0.44	0.60	0.70	−0.05	−0.70	1

Notes: Correlations are calculated for the 72-country sample where TRAVEL is available. Panel A provides standard summary statistics, whereas Panel B provides the correlation matrix. All variables are explained in the main text.

Table 2: OLS Regressions

	(1)	(2)	(3)	(4)	(5)
Dependent variable	log(A)	log(A)	log(A)	log(A)	log(y)
TRAVEL	0.251***	0.190***	0.167***	0.165***	0.254***
	(0.026)	(0.039)	(0.040)	(0.041)	(0.041)
INSTITUTIONS		0.688**	0.918*	0.918*	2.071***
		(0.319)	(0.463)	(0.471)	(0.354)
LANDLOCK			−0.547***	−0.459**	−0.460***
			(0.200)	(0.193)	(0.161)
TROPICS			−0.780***	−0.760***	−0.630**
			(0.239)	(0.222)	(0.273)
LATITUDE			−0.804	−0.687	−0.188
			(0.501)	(0.485)	(0.522)
CONSTANT	8.868***	8.369***	8.591***	8.558***	8.651***
	(0.049)	(0.254)	(0.273)	(0.403)	(0.307)
CONTINENTS	No	No	No	Yes	Yes
Observations	72	71	68	68	68
R-squared	0.46	0.48	0.59	0.61	0.86

Notes: Ordinary Least Squares estimates. The dependent variable in Columns (1) to (4) is the log of productivity in 1996; in Column (5) it is the log of real GDP (PPP) per worker in 1996. Variables are described in the main text. CONTINENTS refers to whether the model was estimated with continental dummies (Africa, America, Asia & Oceania and Europe) included. All standard errors (reported in parenthesis) are heteroskedasticity robust. Asterisks ***, **, * indicate significance at a 1%, 5% and 10% level, respectively.

Table 3: 2SLS Regressions

Dependent variable	(1) log(A)	(2) log(A)	(3) log(A)	(4) log(A)	(5) log(y)
TRAVEL	0.202***	0.195***	0.162***	0.177***	0.203***
	(0.048)	(0.060)	(0.048)	(0.056)	(0.065)
INSTITUTIONS		1.045*	1.624**	1.352**	2.255***
		(0.628)	(0.664)	(0.563)	(0.499)
LANDLOCK			−0.536***	−0.451**	−0.483***
			(0.190)	(0.183)	(0.159)
TROPICS			−0.896***	−0.784***	−0.718***
			(0.197)	(0.206)	(0.277)
LATITUDE			−1.394**	−0.977**	−0.248
			(0.579)	(0.497)	(0.489)
CONSTANT	8.833***	8.133***	8.368***	8.323***	8.573***
	(0.057)	(0.467)	(0.355)	(0.433)	(0.371)
CONTINENTS	No	No	No	Yes	Yes
OID (p-value)		0.05	0.16	0.24	0.43
Pagan-Hall test (p-value)	0.50	0.53	0.47	0.56	0.43
Cragg-Donald statistic	36.2	3.04	2.77	5.33	5.33
Observations	72	71	68	68	68
R-squared	0.44	0.48	0.59	0.61	0.86

Notes: Two-Stage Least Squares estimates. The dependent variable in Columns (1) to (4) is the log of productivity in 1996; in Column (5) it is the log of real GDP (PPP) per worker in 1996. TRAVEL is instrumented by the fitted trade share, whereas INSTITUTIONS is instrumented by the two European language variables. The Cragg-Donald statistic can be used to test the strength of instruments; critical values are supplied by Stock and Yogo (2004). The Pagan-Hall test is a test of the null of homoskedasticity. All variables are described in the main text. CONTINENTS refers to whether the model was estimated with continental dummies (Africa, America, Asia & Oceania and Europe) included. All standard errors (reported in parenthesis) are heteroskedasticity robust. Asterisks ***, **, * indicate significance at a 1%, 5% and 10% level, respectively.

Table 4: LIML Regressions

	(1)	(2)	(3)	(4)
Dependent variable	log(A)	log(A)	log(A)	log(y)
TRAVEL	0.182^{**}	0.158^{***}	0.177^{***}	0.203^{***}
	(0.079)	(0.050)	(0.057)	(0.066)
INSTITUTIONS	1.301	1.754^{**}	1.372^{**}	2.256^{***}
	−1.001	(0.795)	(0.584)	(0.505)
LANDLOCK		-0.535^{***}	-0.451^{**}	-0.483^{***}
		(0.191)	(0.184)	(0.159)
TROPICS		-0.919^{***}	-0.786^{***}	-0.718^{***}
		(0.207)	(0.206)	(0.278)
LATITUDE		-1.494^{**}	-0.990^{*}	−0.249
		(0.664)	(0.506)	(0.491)
CONSTANT	7.951^{***}	8.313^{***}	8.312^{***}	8.572^{***}
	(0.733)	(0.407)	(0.443)	(0.374)
CONTINENTS	No	No	Yes	Yes
OID (p-value)	0.07	0.26	0.43	0.60
Pagan-Hall test (p-value)	0.57	0.45	0.56	0.58
Cragg-Donald statistic	3.04	2.77	5.33	5.33
Observations	71	68	68	68
R-squared	0.44	0.56	0.60	0.85

Notes: Limited Information Maximum Likelihood estimates. The dependent variable in Columns (1) to (3) is the log of productivity in 1996; in Column (4) it is the log of real GDP (PPP) per worker in 1996. TRAVEL is instrumented by the fitted trade share, whereas INSTITUTIONS is instrumented by the two European language variables. All variables are described in the main text. CONTINENTS refers to whether the model was estimated with continental dummies (Africa, America, Asia & Oceania and Europe) included. The Cragg-Donald statistic can be used to test the strength of instruments; critical values are supplied by Stock and Yogo (2004). The Pagan-Hall test is a test of the null of homoskedasticity. All standard errors (reported in parenthesis) are heteroskedasticity robust. Asterisks ***, **, * indicate significance at a 1%, 5% and 10% level, respectively.

Table 5: 2SLS Regressions

Dependent variable	(1) log(A)	(2) log(A)	(3) log(A)	(4) log(y)
TRAVEL	0.168***	0.152**	0.187***	0.247***
	(0.064)	(0.059)	(0.060)	(0.062)
INSTITUTIONS	1.314**	1.539***	1.487**	3.028***
	(0.608)	(0.526)	(0.594)	(0.736)
LANDLOCK		−0.258	−0.190	−0.319
		(0.194)	(0.179)	(0.205)
TROPICS		−0.864***	−0.753***	−0.599**
		(0.219)	(0.226)	(0.286)
LATITUDE		−1.084*	−0.938	−0.484
		(0.584)	(0.649)	(0.786)
CONSTANT	8.016***	8.335***	8.192***	7.884***
	(0.459)	(0.334)	(0.448)	(0.579)
CONTINENTS	No	No	Yes	Yes
Pagan-Hall test (p-value)	0.18	0.57	0.77	0.71
Cragg-Donald statistic	9.41	7.95	8.81	8.81
Observations	45	44	44	44
R-squared	0.52	0.60	0.60	0.82

Notes: Two-Stage Least Squares estimates. The dependent variable in Columns (1) to (3) is the log of productivity in 1996; in Column (4) it is the log of real GDP (PPP) per worker in 1996. TRAVEL is instrumented by the fitted trade share, whereas INSTITUTIONS is instrumented by the log of settler mortality. All variables are described in the main text. CONTINENTS refers to whether the model was estimated with continental dummies (Africa, America, Asia & Oceania and Europe) included. The Cragg-Donald statistic can be used to test the strength of instruments; critical values are supplied by Stock and Yogo (2004). The Pagan-Hall test is a test of the null of homoskedasticity. All standard errors (reported in parenthesis) are heteroskedasticity robust. Asterisks ***, **, * indicate significance at a 1%, 5% and 10% level, respectively.

Table 6: OLS Regressions

Dependent variable	(1) log(A)	(2) log(A)	(3) log(A)	(4) log(A)	(5) log(y)
TRAVEL	0.241***	0.211***	0.164**	0.155**	0.266***
	(0.061)	(0.063)	(0.067)	(0.066)	(0.063)
REAL OPENNESS	0.023	−0.064	0.008	0.024	−0.028
	(0.118)	(0.118)	(0.116)	(0.041)	(0.106)
INSTITUTIONS		0.766**	0.903*	0.878*	2.118***
		(0.313)	(0.472)	(0.459)	(0.393)
LANDLOCK			−0.548***	−0.464**	−0.453***
			(0.196)	(0.187)	(0.154)
TROPICS			−0.784***	−0.773***	−0.614**
			(0.266)	(0.235)	(0.285)
LATITUDE			−0.796	−0.662	−0.216
			(0.501)	(0.506)	(0.544)
CONSTANT	8.785***	8.543***	8.628***	8.494***	8.725***
	(0.433)	(0.457)	(0.416)	(0.602)	(0.448)
CONTINENTS	No	No	No	Yes	Yes
Observations	72	71	68	68	68
R-squared	0.46	0.48	0.59	0.61	0.86

Notes: Ordinary Least Squares estimates. The dependent variable in Columns (1) to (4) is the log of productivity in 1996; in Column (5) it is the log of real GDP (PPP) per worker in 1996. Variables are described in the main text. CONTINENTS refers to whether the model was estimated with continental dummies (Africa, America, Asia & Oceania and Europe) included. All standard errors (reported in parenthesis) are heteroskedasticity robust. Asterisks ***, **, * indicate significance at a 1%, 5% and 10% level, respectively.

Table 7: J Test using 2SLS Regressions

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	log(A)	log(A)	log(y)	log(A)	log(A)	log(y)
TRAVEL	0.342***	0.415*	0.214	0.437**	0.440**	0.513***
	(0.129)	(0.236)	(0.203)	(0.200)	(0.186)	(0.174)
$\text{Log}(A, \hat{\delta})$	−2.653	−1.280		−2.103	−1.039	
	(−1.741)	(−1.145)		(−1.428)	(0.638)	
$\text{Log}(y, \tilde{\delta})$			−0.048			−1.077
			(0.886)			(0.679)
INSTITUTIONS	9.003*	2.705*	2.495	7.070*	3.683**	6.288**
	(5.281)	(1.604)	−2.343	(4.219)	(1.854)	(2.821)
LANDLOCK	−2.090**	−0.835**	−0.505	−0.529***	0.007	−0.662***
	(1.065)	(0.389)	(0.461)	(0.200)	(0.260)	(0.201)
TROPICS	−2.661**	−0.946***	−0.763	−1.951**	−1.017***	−1.244**
	(1.221)	(0.262)	(0.688)	(0.841)	(0.324)	(0.541)
LATITUDE	−4.347*	−0.538	−0.346	−2.317*	−1.168	−1.004
	(2.355)	(0.653)	(0.593)	(1.239)	(0.744)	−1.004
CONSTANT	27.875**	18.339**	8.915	23.878**	15.627***	16.373***
	(12.631)	(8.680)	(7.389)	(10.323)	(4.306)	(4.953)
CONTINENTS	No	Yes	Yes	No	Yes	Yes
OID (p-value)	0.98	0.54	0.34			
Pagan-Hall test (p-value)	0.63	0.85	0.99	0.56	0.82	0.90
Cragg-Donald statistic	4.66	1.18	1.13	2.67	5.52	5.52
Observations	68	68	68	44	44	44
R-squared	0.53	0.51	0.85	0.53	0.57	0.82

Notes: J Test using Two-Stage Least Squares estimates. The dependent variable in Columns (1), (2), (4) and (5) is the log of productivity in 1996; in Columns (3) and (6) it is the log of real GDP (PPP) per worker in 1996. TRAVEL is instrumented by the fitted trade share. INSTITUTIONS is instrumented as in Table 4 in Columns (1) to (3) and as in Table 5 in columns (4) to (6). $\text{Log}(A, \hat{\delta})$ and $\text{Log}(y, \tilde{\delta})$ are calculated as explained in the text (see equations H_0, H_1 and (4)). All variables are described in the main text. CONTINENTS refers to whether the model was estimated with continental dummies (Africa, America, Asia & Oceania and Europe) included. The Cragg-Donald statistic can be used to test the strength of instruments; critical values are supplied by Stock and Yogo (2004). The Pagan-Hall test is a test of the null of homoskedasticity. All standard errors (reported in parenthesis) are heteroskedasticity robust. Asterisks ***, **, * indicate significance at a 1%, 5% and 10% level, respectively.