Openness to Ideas and Long Run Economic Growth

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Abstract

This paper studies the extent to which a country's total factor productivity (TFP), and thus income, depends not only on the level of openness to trade but also the level of "openness to ideas". First, we contribute to the literature an index of "openness to ideas" in order to determine how much TFP is explained by openness to ideas and how much is explained by openness to trade. Second, it is established that openness to trade plays a larger role than openness to ideas in increasing income. Finally, this paper suggests new evidence that openness to ideas and openness to trade are partial substitutes. This result has implications for development economics and policy.

Keywords: Growth, Trade, Technological Diffusion, Embodied and Disembodied Idea Flows
JEL Classification: F1, F43, O30, O33, O40

I. INTRODUCTION:

Theory suggests that both openness to ideas and openness to trade play a role in the diffusion of technologies across countries. In addition, both of these channels are seen to operate on long-run economic growth through total factor productivity (TFP). The fundamental question to ask, then, is how much of total factor productivity is explained by openness to trade and how much is explained by openness to ideas? By creating a new variable, or index, of openness to ideas using time-dependent data from both developed and developing countries we construct a comprehensive measure of this channel to understand how it affects income and thus economic growth.

In existing explorations of the relationship between trade, knowledge and TFP, emphasis is placed on the relationship between total factor productivity and a country's domestic R&D capital; furthermore, recent research has established that a country's total factor productivity growth depends not only on domestic R&D capital, but on foreign R&D capital as well. In light of this result, Coe and Helpman find that there is also evidence that beneficial effects of foreign R&D capital on domestic productivity become stronger the more open an economy is to trade (1995). From this work we can see that total factor productivity growth is intimately linked with technological diffusion. This paper goes beyond the previous literature, exploring the diffusion of disembodied technology by suggesting new evidence that "openness to ideas", measured in index form, acts as a major contributor to income through total factor productivity and is a partial substitute for openness to trade.

Coe and Helpman focus on developed countries in their analysis. One reason for this is there are just five countries that produce a majority of the world's innovations: the United States, Japan, Germany, England, and France (UNESCO, 1997). However, these are not the only countries with positive rates of long-term economic growth. If growth is driven by technological innovation, then technological diffusion between countries must be occurring, and we can track the diffusion of disembodied technology using these “top five” countries as an aggregate source of information transfer.

This paper will attempt to quantify a given country’s relative level of “openness to ideas” in index form and relate it to income, a measure that is important because the literature lacks a cohesive framework for understanding it. To achieve this goal, several variables thought to be proxies are tested individually for their relative importance as determinants of openness to ideas. Subsequently, a new variable is created to relate the proxies across time and throughout countries at all levels of development. Until now, this component has been unaccounted for within the literature. After analysis, an estimation of the amount of income explained by a country’s openness to ideas as a channel to the diffusion of technology is shown. Since this paper will also measure openness to trade, we compare the two measures for both developed and developing countries over time. Some countries might be strong in one dimension but not another, strong in both dimensions or weak in both dimensions. Depending on the state of openness of the countries to either ideas or trade, this could have significant real-world implications for development policy. For example, if a less developed country is not able to engage in a sufficient amount of embodied technology trade, it could instead attempt to “import” disembodied technology, for example by learning how to implement a new industry technique based on information gathered in an imported trade journal. Thus, this paper will also show if it is possible to substitute openness to ideas for openness to trade and vice versa, or whether diversifying by investing in both channels is most valuable for long term income levels and thus economic growth. In the end, we suggest that while openness to trade is overall more important for increasing income, based on the data available, openness to trade and openness to ideas are partial substitutes.

II. Literature Review:

An empirical understanding of the transmission mechanisms that link a country's productivity gains to economic developments in its trade partners has been pursued for quite some time, but was initially highlighted by Coe and Helpman in 1995. Their paper "International R & D Spillovers" revisited the fact that countries investing only in labor and capital are facing an upper bound in production and economic growth. Increases in solely these two inputs are not sustainable. To see this, consider a country investing in only labor and capital. The country can only employ so many workers and fill its production centers with so much capital before the inputs threaten to expand beyond the space available to produce. However, a country can achieve growth using its optimal level of inputs by improving productivity through increases in technology. For example, in the case of capital in the form of a computer, firms in the country can replace older computers with newer models or receive programming knowledge from a traveling consultant.

Recognizing this, Coe and Helpman empirically demonstrated the close link between productivity and R & D capital stocks (both domestic and foreign). However, Coe and Helpman did not account for the fact that knowledge spillovers may originate from non-trade channels. In fact, their results may be capturing an additional channel, for example, if trade is correlated with an omitted variable. Subsequent works building off of Coe and Helpman encounter the same limitation, such as Madsen's 2006 work in technology spillover through trade and TFP convergence. In fact, the variable, or index, created to measure openness to ideas in this analysis has a correlation of 0.9372 with openness to trade, as we will see.

Existing literature also details other channels of technological diffusion, such as foreign direct investment or direct knowledge spillovers. Wei-Kang Wong (2004) evaluates the relative importance of embodied versus disembodied ideas in capturing changes in income gaps and total productivity convergence. According to Wong, “Ideas are ‘disembodied’ if they are free to form a connection with any piece of equipment. Conversely, ideas are ‘embodied’ if their diffusion requires transfer of physical objects.”[1] In his analysis, telephone calls are a proxy for disembodied ideas, while trade is a proxy for embodied ideas. Since using trade and telephone calls may result in endogeneity problems, Wong constructs instruments for each of them using geographic, linguistic, and colonial components of countries’ overall trade and telephone call traffic abroad. He finds telephone call traffic, not trade, to be the main channel of technology transfer.

However, this paper has several weaknesses, the most important of which is that the instruments Wong uses for trade and telephone call traffic, such as geographic and linguistic components, may be capturing direct knowledge spillovers. Countries that are relatively closer in distance and/or countries that share a common language are more likely to exchange information directly through means other than trade. Furthermore, Wong only uses outgoing call traffic in his calculations. Using incoming call traffic and accounting for the level of technology in the conversation partner’s country could have also improved Wong’s analysis.

In 2003, Jungsoo Park explored the significance of international student flows as a channel for R & D spillovers. Park highlights the international movement of human capital, as

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[1] Wong (2004) p. 441
[2] Park (2004) p. 316
[3] Park (2004) p.316
[4] Sachs and Warner (1995)
[5] Note that the UNESCO publication came out during the year 1997, in the middle of the

well as physical capital and intermediate goods, that gives rise to technological diffusion across countries. He states, "As there exist bilateral student flows across economies, foreign students who acquire R & D induced technological knowledge through education and post-schooling job experience in their host country of study may contribute to the productivity increase in their home country when they return." [2]

Using methods espoused by Coe and Helpman (1995), Coe and Hoffmaister (1999), Keller (1998), and Edmond (2001), Park introduces several versions of foreign R & D stocks as alternates to his own, which defined foreign R & D stock as "…an outward student flow-weighted sum of other countries' R & D capital stocks which is then multiplied by the [originating] country's foreign-education intensity."[3] Foreign education intensity is defined as the ratio of students abroad to the domestic population. Although Park considers a five-year moving average of student flows and allows for lag time to study, work, and return, he does not account for the fact that some students may choose to permanently migrate to their host countries. This is a common gap in the literature due to the scarcity of data on the subject. More importantly, Park's measure of foreign R & D stocks does not reach its full potential of measurement capabilities. For example, Park could have just as easily weighted foreign countries' R & D by the population of business travelers. Doing so may have made his analysis of foreign R&D stock much stronger.

As we will be comparing openness to ideas against openness to trade, we would be remiss not to mention the seminal work of Sachs and Warner (1995). In an effort to "document the process of global integration and to assess its effects on economic growth in

[2] Park (2004) p. 316
[3] Park (2004) p.316

the reforming countries,"[4] Sachs and Warner explore to two main ways of looking at trade. The first is through so called "trade openness", in which one of the measures consisted of the sum of imports and exports over GDP. The second is based on trade restrictions, and involves the creation of a binary variable that serves as an index on the basis of data such as that from tariffs and restrictions that exist on current transaction payments. For the purposes of this paper, we will use the first option explored by Sachs and Warner, that of total imports and exports over GDP. Though this measure brings up worries of the presence of reverse causation, it is optimal for use in this paper due to lack of adequate data to replicate the Sachs and Warner trade "barriers" measure completely.

By testing measures of openness to ideas individually, and creating a time-variant index through a cross section of data from developed and developing nations, the paper builds off of the work of researchers such as Coe and Helpman (1995), Wong (2004) and Park (2003). However, the index will test a given country's level of openness to ideas in foreign technology independently of the established channel of trade. While openness to trade and openness to ideas both act as determinants of technological diffusion and adoption, by creating an index it will be possible to estimate their relative importance to total factor productivity, income and thus long-term economic growth. It will also be possible to determine whether the channels are substitutes or complements of each other.

III. THEORETICAL FRAMEWORK:

A. GROWTH ACCOUNTING

[4] Sachs and Warner (1995)

Basic growth accounting, championed by Robert Solow, tells us that economic growth can be explained through growth in labor, capital, and total factor productivity (TFP)– the measure of the current level of technology. It uses the basic Cobb Douglas production function:

$$Y = AK^{\alpha}L^{(1-\alpha)} \quad (1)$$

where Y is output, K is capital, L is labor, A is total factor productivity, α is capital's share and (1-α) is labor's share. Growth accounting subsequently breaks down the growth rate of aggregate output into the growth rate of inputs. In natural logarithmic form, for each country *i* equation 1 becomes,

$$\ln Y_{i,t} = \ln A_{i,t} + \alpha \ln K_{i,t} + (1-\alpha)\ln L_{i,t} \quad (2)$$

Growth regressions can be run on equation 2 using natural log differences, which can be seen in equation 3 below:

$$\ln Y_{i,t+1} - \ln Y_{i,t} = \left(\ln A_{i,t+1} - \ln A_{i,t}\right) + \alpha\left(\ln K_{i,t+1} - \ln K_{i,t}\right) + (1-\alpha)(\ln L_{i,t+1} - \ln L_{i,t}) \quad (3)$$

which can be transformed into

$$g_Y = g_A + \alpha g_K + (1-\alpha)g_L \quad (4)$$

where $g_A = \left(\ln A_{i,t+1} - \ln A_{i,t}\right)$ is total factor productivity growth. Total factor productivity growth is defined as the portion of output not explained by the amount of inputs used in production; it drives long-run growth in income in an economy with an aggregate neoclassical production function (Solow, [1956], Romer, [1990], Aghion and Howitt [1992]).

TFP as it is typically understood represents a development in technology. This is a misconception, however, as TFP is more accurately explained as the development of knowledge. For example, capital may become more efficient due to the use of new technologies; labor may become more efficient by improved education. TFP also captures efficiencies beyond the realms of capital and labor. For example, TFP growth may also result from improvements in institution design and business practices. The important thing to keep in mind, however, is that the common factor leading to TFP growth, and therefore economic growth, is knowledge. More specifically, it is the knowledge that increases efficiency, or innovation, that drives TFP growth. This explains why higher levels of efficiency from innovation can increase output without raising capital or labor inputs; however, like capital and labor, not all knowledge is distributed equally between countries, so not all countries are on the world technological frontier.

We can measure K, L, and Y through observation. However, total factor productivity is only measured as a residual, and thus captures a variety of components that play a role in changing the relation between the inputs and the output in addition to any measurement errors. Acknowledging the fact that not all countries are on the world technological frontier, and thus not all knowledge is distributed equally between countries, past research has attempted to estimate TFP by looking at proxies such as R&D patents; however, this analysis will attempt to show the respective impacts of openness to ideas and openness to trade on total factor productivity. For example, Connolly (2003) provides support for the finding that both foreign and domestic innovations contribute to GDP through total factor productivity. In her paper, "The Dual Nature of Trade," Connolly creates proxies for innovation with patent data and finds, "foreign technology embodied in imports plays a greater role in growth than domestic technology."

For the purposes of this paper, we consider the relation

(5) $$\ln A_{i,t} = f(\alpha T, \beta I, \delta R),$$

where T represents openness to trade, I represents openness to ideas, and D represents domestic R&D capital stock. In other words, we use the background that Solow has given us to estimate the level of TFP, and thus the level of income. By increasing any one of the three factors of TFP noted here, a country should be able to experience economic growth.

B. Models of Embodied and Disembodied Ideas

To determine which variables are to be part of the openness to ideas index and which measure openness to trade, we must first distinguish between embodied and disembodied ideas. As previously stated, embodied ideas can be found in the form of technological products themselves. The past few decades have seen the arrival of many embodied ideas – from computers and x-ray machines to cell phones and televisions. On the other hand, disembodied ideas are not encased within a specific product, and may diffuse through global society at a far smaller cost. In order to create a new variable for openness to ideas, we must focus on disembodied ideas. In 2002, Arora et al reported that existing studies fail to explain the mechanism that generates spillovers. For example, the relationship between productivity and foreign R&D, as determined by Coe and Helpman, simply supports the existence of diffusion effects, when it may really reflect knowledge transfers through markets. Arora et al also adds that the increasing efficiency of innovative labor adds to the growing market for technological goods. These spillovers, in the form of knowledge transfers, can be accounted for by exploring disembodied ideas.

III. Data

Now we turn to the task of defining the term "openness to ideas" empirically. We cannot fully understand the role that technological diffusion and knowledge transfers play in income or their implications for economic growth without looking at data covering bi-directional flows of goods and ideas. Following UNESCO's report that the United States, the United Kingdom, Germany, France, and Japan are the leaders in innovation, it is necessary to obtain aggregate data documenting these flows from the "top five" innovators to every other country in the world.[5] Proxy choice for openness to ideas, as well as the decision to engage in data reduction, is based on data availability. Only certain data for examples of embodied and disembodied flows are available for a large cross-section of countries. Panel data available for the openness to ideas index is comprised of several different bi-directional flow variables, including: foreign students studying abroad, international telephone call traffic, trade in books and newspapers, and patents filed by foreigners. Other data available includes the international branch office openings of top US consulting firms Bain and Boston Consulting Group (BCG) and the number of people with Internet connectivity per country.

Summary and sample statistics of the data sets can be found in Table 1 of the Appendix. In Table 1, "overall" refers to the whole dataset. "Between" refers to the variation of the means to each individual country (across time periods). "Within" refers to the variation of the deviation from the respective mean to each individual country. We see that nearly every variable varies more between countries than within countries, with the one exception being Internet users. Table 1 also contains the total number of observations (N), number of countries with observations (n) and average number of time periods for each country. Table 1 does not give and exact decomposition of the data: it converts sums of squares to variance using

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[5] Note that the UNESCO publication came out during the year 1997, in the middle of the timeframe of my dataset, which spans 1990-2008

different ‘degrees of freedom,’ therefore they are not comparable. It also reports square root (i.e. standard deviation) of these variances. Although the documentation is not exact, it is useful as a good approximation.

Data on foreign students studying abroad at the tertiary level was obtained from UNESCO’s Statistical Yearbooks, which show bilateral student flows between countries by year. In this analysis, we focus on student flows from both developed and developing countries to the top five innovating countries. Similarly we look at data from the top five innovating countries to the other countries. In this manner, we capture both the acquisition of knowledge from the top five developing countries (assuming that all students studying abroad return home). At the same time, we can capture knowledge spillovers from students from the top five innovating countries studying abroad. Along with the benefits, there are some drawbacks to using a variable measuring the number of students studying abroad. For example, like Park (2004) we do not have data available on the number of students that stay in their host countries versus returning homes after their studies are complete. Nor do we have weights for the number of contacts that returning students keep in their host countries. However, as Park (2004) postulated, by using a backward-looking five-year moving average of international student travels, we may be able to account for the time it takes for a student to study abroad, return home, and begin utilizing the innovative knowledge he or she obtained in his or her travels. Despite some of the drawbacks, the overarching theme of the international student data remains the same: through the UNESCO data, we can see an “import” of advanced knowledge by a given country.

Similarly, the international exchange of books and newspapers can be measured as a proxy of the exchange of ideas between countries. The UN Comtrade Database gives us the imports of books and newspapers from the top five innovators to the rest of the world. The number of books and newspapers that a given country receives from the top five innovators is one way to proxy how open it is to ideas from them. For example, an engineer in India may import a book from the UK on a topic in his or her field, and use the information he gains from that book in the creation of a new technological product. Alexopoulos and Chen (2009) explored this type of analysis by using the number of new technology manuals published in the United States to measure the United States' technological change in the years leading up to World War II. Their results provide us with an optimistic outlook for the significance of book imports because it suggests that [technological] books that are published in the top five countries and then imported by a given country i could also lead to technological change and economic growth. A drawback to this variable that the book trade data is not specific to titles in technology, and therefore may be unfavorably biased by books such as works of fiction. Note, however, that children's books are not included in this dataset, as UN Comtrade gives children's books a separate trade code. Newspaper imports, on the other hand, may account for the rapid spread of knowledge to the general public on advances in technology and opportunities in the field of technology.

Telegeography, a research division of Primetrica, Inc. provided the cross country bi-lateral flow data on number of telephone call minutes exchanged between a given country *i* and the top four innovating countries. Japan was not included due to a lack of sufficient observations required for analysis. A sum of outgoing and incoming call minutes was taken due to the fact that during a phone call, information is exchanged bilaterally almost instantaneously; the role of originating country is irrelevant. Wong (2004) showed the importance of this variable when he uses telephone traffic as a proxy for disembodied ideas and trade is a proxy for embodied ideas, finding that telephone traffic has a larger impact on income per worker and TFP than trade.

The World Intellectual Property Organization (WIPO) offers data on patent applications by country of origin. By selecting the top five innovating countries, the United States, the United Kingdom, France, Germany, and Japan, and aggregating their observations, we created a dataset detailing the number of patents filed by the "Top Five" in a given country i. Since every country has its own patent law, an inventor desiring foreign patent protection must file for it in a specific country, countries, or through a regional office. The presence of a foreign patent may inspire or even pressure domestic inventors to imitate the product by creating substitutes. Similarly, a foreign patent may inspire further innovation within the domestic industry.

We also look at the locations and opening years for foreign branch offices in the top US consulting firms. This data indicates that the host country has enough business to sustain an office. In other words, there are agencies in the host countries open to the ideas that a prestigious foreign consulting firm can provide and are willing to pay for them. BCG, and Bain were chosen as a representative sample of firms. Branch office information can be found on the respective company websites. BCG has 69 foreign branch offices and Bain has 33 foreign offices. McKinsey & Company was also considered for the sample, but unfortunately the company does not provide complete data on the opening years of its branch offices and thus had to be dropped.

The World Bank Online Database provided observations on the number of people with Internet connectivity, identified by country and year. Though this variable does not specifically describe the flow of information from one country to another, it is important as a proxy for tracking the flow of information through the Internet, including to and from foreign countries. This variable serves as a crucial inclusion for Internet data: without accounting for the spread of information through the Internet, arguably the best channel to transfer disembodied ideas, this analysis would not be as strong.

After investigating the various components of openness to ideas, we compare openness to ideas with openness to trade. As we saw previously, there are various methods of measuring openness to trade, but for the purposes of this paper we use the simple measure of the sum of total exports and imports for each country as provided by the World Bank Online Database. In addition, following the work of Coe and Helpman (1995) we use total R&D expenditure as a measure of domestic R&D capital stock. The World Bank Online Database provides R&D expenditures as a percentage of GDP, therefore it is necessary to divide the percentage by 100 and multiply the result by GDP to account for total R&D expenditures per country. Finally, it is important to mention that the central variable influencing economic growth in the traditional Solow (1956) model is the capital-labor ratio (CAP/L), a variable positively related to economic growth. In accordance with our empirical framework, we obtain data on total labor force and gross capital formulation from the World Bank Online Database to use as controls that explain a large portion of income and economic growth. Once all the variables are accounted for, we can begin the empirical analysis.

IV. EMPIRICAL SPECIFICATION

A. TESTING OPENNESS TO IDEAS PROXIES: EMPIRICAL FRAMEWORK

Before creating an index of openness to ideas we must estimate the ideas proxies' relative importance to total factor productivity and income. Variables must be tested individually for their relative importance as determinants of openness to ideas. The regression used to investigate the effect of an increase in a our proxies for openness to ideas on income is specified as follows:

(6) $$Y_{it} = \beta_0 + \sum \beta_j X_{it} + \sum \beta_j Z_{it} + \beta_j T_{it} + \beta_j R_{it}^d + \alpha_{it} + \boldsymbol{\varepsilon}_{it}$$

In this equation, the dependent variable, Y_{it}, is gross domestic product (GDP) by country *i* and year *j*. X_{it} represents a vector of control variables including the labor force and capital. T_{it} is the term for openness to trade, as measured by the sum of imports and exports, and R_{it}^d is the domestic capital stock. As previously discussed, past literature has suggested that T_{it} and R_{it}^d are positively linked with TFP (Griliches 1988; Coe and Helpman 1995). As our last estimate of TFP, the variable Z_i represents a vector of the independent "openness to ideas" variables. These include: telephone calls, the sum of calls *from* the top five innovating countries to a given country i and calls *to* the top five innovating countries from a given country i; student "imports", the number of students from the top five innovating countries studying abroad in country i in a given year; student "exports", the number of students from a given country i studying abroad in one of the top five innovating countries in a given year; book imports, the number of books exported from the top five countries to a given country i in a given year; newspaper imports (similar to book imports); the number of consulting company branches in a given country i in a given year; number of internet users; and number of patents filed in a given country i by the top five innovating countries. Finally, the error term is given by ε_{it} and fixed effects are represented by α_{it}. A full description of each of the variables and their sources can be found in Table 2 in the Appendix.

A natural log is taken of the dependent and independent variables in the regressions for two reasons. First, taking the natural log causes the coefficients on the independent control variables to become elasticity values. Consequently, a 1% increase in the independent variable will result in a percentage change in the dependent variable equal to the independent variable's coefficient. Second since logs are nonlinear, taking logs reduces the effect of outliers in the data.

As is exemplified in the empirical growth literature of Gregoriou and Ghosh (2009) and Acs et al (2006), a five-year simple moving average is taken of both dependent and independent variables. This technique has several advantages. A moving average smoothes out short-term fluctuations in the data such as shocks or business cycle changes so that the data reflects the long-term trends more clearly. It also allows the proxy variables to show their impact on income more clearly. For example, a five-year moving average accounts for the time it takes for knowledge transfers in the form of telephone calls or student travel to become innovation and impact income. One disadvantage of this method is that a five-year moving average is a lagging indicator. This means that the averages are slower to respond when there is a genuine change in the economy's direction. However, we are interested in long-term effects of openness to ideas on income their implications for economic growth over short-term effects. Another popular method of looking at annual data in empirical growth literature is to use averaged five-year period data. But, as is stressed by Soto (2002) and Attanasio et al. (2000), "the use of n-year averages is not suitable because of the lost of information that it implies and the arbitrariness of the length and the periods used for averaging."[6] Just as Soto (2002) and Attanasio (2000) pointed out, attempting to use data on five-year periods severely limited the number of observations to draw from in the data. This problem is particularly noticeable in our international student data, which would be reduced to two observations per

[6] Soto (2002) pg. 207

country using a five-year period analysis due to the fact that data on international students was only available between the years 2000 and 2008. One will also notice that of the two observations in the student data, one observation would be a period average of five years, while the other observation would be a period average of three years, thus it would be difficult to draw conclusive results form period data.

One last important point to mention in this section is that the panel data were estimated using fixed effects estimation. The decision to used fixed effects was a function of the need to control for omitted variables that differ between countries but are constant over time. The types of omitted variables referred to could potentially be numerous, and may include statistics such as institutional differences, cultural difference, frequency of bi-directional business travel or a more accurate representation of the transfer of disembodied goods over the Internet. Fixed effects also let us use the changes in the variables over time to estimate the effects of the independent variables on our dependent variable, GDP. One downfall of the fixed effects model is that it cannot be used to investigate time-invariant causes of the dependent variables. This would influence, for example, the decision to include a language or former colony dummy in the panel dataset to account for the fact that bi-directional flows of telephone calls and student travels are related to whether the country in question shares an official language or former governance with one of the top five innovating countries. Including a language or former colony dummy would be unfavorable in a fixed effects model because official language and independence of nearly all the countries in the dataset was established before the year 1990. Therefore the time-invariant characteristics of the countries would be perfectly collinear with the language and/or former colony dummy. We ran a Hausman test to give more conclusive input on the decision to use fixed effects. The null hypothesis of the Hausman test, that the preferred model is random effects, was rejected. Results for the Hausman test can be found in 4 in the Appendix.

The remaining sections of the empirical specification are laid out as follows. First, we test the relevance of our openness to ideas proxies by considering the output of all proxies individually in fixed effects estimation. Then we conduct a principal components analysis (PCA) to reduce our data and develop a new variable for openness to ideas. Finally, we test whether or not openness to trade and openness to ideas are substitutes or complements by estimating regressions to investigate whether the coefficient on openness to ideas is higher in high trade countries, suggesting complementarity, or higher in low trade countries, suggesting substitutability.

B. Testing Openness to Ideas Proxies: Initial Regression Results

The empirical analysis that follows uses a panel data set consisting of annual data from 213 countries and all years between 1990 and 2008 for which data are available. A list of the countries included in the analysis can be found in Table 3 in the Appendix.

The central conclusion that can be drawn from the results of the regression is that generally, increases in any of the proxies for openness to ideas results in an increase in GDP. For example, for a given country, a 1% increase in the number of internet users increases GDP by approximately 0.01%. The results of the F-test show that we can reject the null hypothesis that there is no difference between variances, and the p-value associated with the F-test supports the significance of this finding at the 1% level. Overall, the relationships between the independent and dependent variables are acting just as we predicted, based on previous growth literature and our results are optimistic. The full results of this regression can be found in Table 5 in the Appendix.

Two of the independent variables in this regression lack significance at the 10% level, namely telephone call traffic and book imports. This may to due to strong correlation between the independent variables, as we will address in the next section. Student exports and number of consulting branches have negative and significant coefficients, a result that was a bit surprising. The negative coefficient on student exports could be explained in the event that there may be many students who study abroad for long periods of time migrating to their host countries. In the case of the consulting firms, it may be the case the standard of taking the five-year moving average of the natural log of consulting branches skewed our regression output. Many countries did not host a BCG or Bain consulting firm branch until 2006, 2007, or even 2008. For those countries, observations of "0" are reported for over fifteen years. Even if in a case that a branch is built in earlier in the time period investigated, it is often the only branch built in the country, thus making the variable stagnant. In this case, the number of consulting branches would not rise with GDP. More importantly, although the coefficient on number of consulting branches was reported as significant, the variable does not have enough observations to carry through with our full analysis. Boston Consulting Group and Bain & Company have 69 and 33 foreign branches respectively, and most of these observations overlap in countries that are relatively well developed. When we carried out the next phase of the empirical specification, principal components analysis, our index of openness to ideas becomes subjected to the same limitations inherent in our consulting data. Therefore we are unable to estimate a regression of including the independent variables of openness to ideas and countries relatively closed to trade test due to lack of overlapping observations. As this impedes our ability to test whether openness to ideas and openness to trade are substitutes or complements, we drop the variable on number of consulting branches and re-run the initial regression.

The results of the new regression are similar to those of the first regression. The results are still optimistic, with many positive coefficients and a doubling of the included observations. However, now the coefficient on student exports is positive and significant at the 1% level, while the coefficient on book imports is negative and significant. Furthermore, student imports and newspaper imports have lost their significance, though their coefficients are positive. We suspect that while some of the change in significance has to do with the increase in observations, another part has to do with the fact that the variables are highly correlated, thus inducing multicollinearity. We explore this in the next section.

C. Data Reduction and Index Creation: Principal Components Analysis

Given that we have many variables to explain openness to ideas that are highly correlated (See Table 6 in the Appendix), principal components analysis (PCA) is the next logical step in data reduction and index creation because it can collapse our variables into a single new variable that reflects openness to ideas. Another benefit of using PCA is that it reduces data redundancy and prevents multicollinearity while accounting for the majority of the variance in the data within each new principal component.

PCA describes the variation in the data in terms of a set of uncorrelated components, where each component is a linear combination of the initial variables.

(7) $$PC_1 = a_{11}X_1 + a_{12}X_2 + \ldots + a_{1n}X_n$$
$$\vdots$$
$$PC_m = a_{m1}X_1 + a_{m2}X_2 + \ldots + a_{mn}X_n$$

In the equations above, $X_1 \ldots X_n$ are the observed variables and $PC_1 \ldots PC_m$ are the principal components. As Vyas and Kumaranyake (2006) state, "The higher the degree of correlation among the original variables in the data, the fewer components required to capture common information." The first coordinate, or principal component, holds the greatest variance by any projection of the data. The second greatest variance in the original data is on the second principal component, and so on. The weights for each principal component are given by the leading eigenvectors calculated in the eigen decomposition of the correlation matrix. The eigenvectors are in orthnormal form (meaning they are uncorrelated and normalized). The variance for each principal component is given by the eigenvalue of the corresponding eigenvector.

Thus we ran a PCA on our new set of openness to ideas proxies, including: telephone call traffic, student "exports", student "imports", book imports, newspaper imports, Internet users and foreign patent filings. One can see in Table 7 in the Appendix that the first component accounted for an overwhelming majority of the variation in in the original data, as is expected. The second component explains additional but much less variation than the first component and is uncorrelated with the first component. The weights for each principal component are given by the eigenvectors of the correlation matrix.

One of the characteristics of PCA is that interpretation is required to understand what the component outputs are measuring. However, in this case we can see from Table 7 that the first component accounts for approximately 40% of the variance in each of our openness to ideas proxies. Using the Kaiser Criterion, which suggests that one retain and interpret only those components with an eigenvalue greater than 1, we can use the first component as our index for openness to ideas (Kaiser 1960).

D. EMPIRICAL SPECIFICATION: TRADE AND IDEAS, SUBSTITUTES OR COMPLEMENTS?

Now that we have our "openness to ideas" variable, we can test it in a regression with openness to trade. The following equation is used to estimate the regression of openness to trade and openness to ideas on GDP:

$$Y_{it} = \beta_0 + \beta_1 L_{it} + \beta_2 K_{it} + \beta_3 R_{it}^d + \beta_4 T_{it} + \beta_5 I_{it} + \alpha_{it} + \varepsilon_{it}$$

where Y_{it} is GDP, L_{it} is total labor force, K_{it} is capital stock, R_{it}^d is a measure of R&D capital stock, T_{it} is a measure of openness to trade, and I_{it} is the measure(s) of openness to trade. Results are shown in Table 8 in the Appendix.

This regression yields more optimistic results, which can be seen in Table 8 in the Appendix. All coefficients are positive and significant, except for the coefficient on R&D capital stock, which is negative and insignificant. Note that the coefficient on openness to trade is much larger than the coefficient on openness to ideas. This suggests that openness to trade plays a larger role in economic growth than openness to ideas as we have defined it, contrary to the findings of Wong (2004)'s analysis of telephone call traffic and trade. However, two interpretations of this result exist. First, one could make the claim that since Wong was only considering telephone call traffic as a proxy for disembodied technology diffusion; his results were subject to the omitted variable bias. However, one must also take into account that four of the variables in this analysis, namely book and newspaper imports and exports are still at their core trade variables of physical goods, even though they act as a channel of disembodied technology. Therefore our results are technically double-counting a portion of the openness to trade variable, thus biasing the coefficients in favor of trade.

Finally, we can we can conduct a test to determine whether openness to ideas and openness to trade are substitutes. First we separated "openness to trade" into two new variables, countries with above average trade ("high trade") and countries with below average trade ("low trade"). Then we estimated two regressions on GDP – one including the "high trade" variable and one including the "low trade" variable. We expect a coefficient on openness to ideas that is higher in a regression with high trade countries suggests complementarity, but a coefficient on openness to ideas that is higher in a regression with low trade countries suggests substitutability. The results can be found in Table 9 in the Appendix.

All coefficients in both regressions are positive and significant, giving meaning to their interpretation. A few particular points should be noted. First, the coefficient on openness to ideas is higher in the regression with the low trade countries than it is in the regression with the high trade countries; this suggests that openness to trade and openness to ideas are substitutes. However, one must note that the coefficients on trade, whether high or low, al overall larger than the coefficients on openness to ideas, suggesting *partial* substitutability. In addition, the regression with high trade countries has seven times the observations of the regression with low trade countries. After examination of the data, we can see that in general, countries that engage in trade levels below average tend to be lower income (with a correlation of 0.89). On the other hand, most of the complete data reports are given by relatively higher income countries, which is a fact reflected in the openness to ideas observations. Thus, overlapping observations between low trade countries and our openness to ideas index are relatively scarce. The correlation between high trade countries and factor1 is 0.95, but the correlation between low trade countries and factor 1 is much lower in comparison, only 0.61[7].

Furthermore, we also see that the coefficients on R&D capital stock, labor, and trade are much higher in the regression with low trade countries, while capital has a relatively higher coefficient in high trade countries. From this we can suggest that low trade countries have a variety of options for trying to increase their income relative to low trade countries and spur continued economic growth. Openness to ideas is not the only important factor; investing in the labor force, R&D and trade opportunities will also have beneficial results.

V. CONCLUSION:

Innovative knowledge is not equally produced or shared. According to UNESCO, five developed countries are responsible for the bulk of easily measured innovation: the United States, the United Kingdom, France, Germany and Japan (1997). Furthermore, past literature has taught us that technological diffusion is a significant source of growth within the OECD countries and also between the OECD countries and developing countries (Coe, Helpman, Hoffmaister, 1997). With this knowledge in mind we explored the importance of the diffusion of disembodied technology relative to embodied technology in determining GDP in the developing world. We present a novel and compelling way to measure openness to ideas by consolidating a number of proxies for disembodied technology using principal components analysis.

However, we have run into several weakness associated with the work involved in this analysis. First, “imports and exports” of phone calls and students, as well as book and

[7] Note, however, that this is still a relatively high correlation, showing that Coe and Helpman, in 1995 did indeed suffer the problem of omitted variable bias.

newspaper trade may be capturing direct knowledge spillovers. As the work by Wong (2004) reflected, countries that are relatively closer in distance and/or countries that share a common language are more likely to exchange information directly through means other than trade, though we did double Wong's telephone traffic observations by summing incoming and outgoing calls. Second, we ran into a problem similar to that of Park (2004) in analyzing the student data. Though this analysis is similar to Park's in that both of our work involves the use of moving averages to smooth out the data and accounts for the time it takes student to go abroad, study, and return home, there is still no measure on the proportion of students who migrated to their host countries after their studies were complete. Third, we must realize that with proxies such as the ones used in this paper for openness to ideas, it's not just about getting knowledge, its about using the knowledge you get. Not every phone call or book import results in the birth of innovative technology and raises total factor productivity. This calls for a gaming component to be introduced in the theoretical literature. Finally, the proxies in this paper are limited in breath. However, this particular weakness leaves the door wide open for future research. For example, someone could expand on this framework by incorporating the number of international business travelers or an Internet measure that incorporates the bi-directional flow of disembodied technology. The only limitation is the data available.

We began our exploration with several tasks in mind. First, in order to determine how much TFP is explained by openness to ideas and how much is explained by openness to trade we first had to create a new variable, or index, of openness to ideas. This is where a large portion of the value added of this investigation came forth. Through principal components analysis, we can see that there is a clear measure of openness to ideas that can be used once the data is reduced. In addition, we determine that, while openness to trade is overall more important for increasing income, based on the data available, openness to trade and openness to ideas seem to be partial substitutes.

The results strongly suggest that increases in both openness to ideas and openness to trade result in the growth of income in a given country over time, though the larger coefficient on the natural of openness to trade suggests that openness to trade has a larger impact on GDP and thus on long term economic growth. Encouraged by these results, work in openness to ideas can be taken in many directions in the future. For example, more proxies for openness to ideas could be added or instrumentation techniques could be used for the ones presented here. Furthermore, this analysis encourages the reader to reflect on whether embodied ideas are found only in goods, as Wong (2004) assumes, or whether embodied ideas are found in people as well. Some of our strongest proxies, telephone call traffic, international student flows, and Internet users, all variables that are “disembodied” from goods, require this human component.

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World Intellectual Property Organization (2011). WIPO website: http://www.wipo.int/ipstats/en/

APPENDIX:

Table 1: Summary Statistics

Variable		Mean	Std. Dev.	Min	Max	Observations		
GDP	overall	22.96804	2.341325	17.66787	30.06067	N	=	3615
	between		2.32481	17.88152	29.79934	n	=	196
	within		0.2186059	21.71482	24.81306	T-bar	=	18.4439
Labor	overall	14.72268	1.884943	10.43115	20.45653	N	=	3477
	between		1.885335	10.49331	20.36958	n	=	183
	within		0.1301031	14.23051	15.38665	T	=	19
Capital	overall	21.89819	2.307075	16.89551	28.41689	N	=	2794
	between		2.330918	17.0079	28.05538	n	=	174
	within		0.3232914	19.89632	23.70133	T	=	16.0575
R&D Capital	overall	19.05359	2.972392	12.12078	26.43951	N	=	1229
Stock	between		3.00803	12.6603	26.26513	n	=	114
	within		0.2381243	18.23604	20.32152	T	=	10.7807
Openness to	overall	23.09673	2.143243	17.4167	28.79075	N	=	2849
Trade	between		2.205518	17.4167	28.26413	n	=	179
	within		0.3425163	21.54182	24.63032	T	=	15.9162
Telephone	overall	3.877886	2.354885	-4.815891	8.521951	N	=	2697
Traffic	between		2.227008	-1.425958	8.150354	n	=	200
	within		0.7918087	-0.9265137	7.412599	T-bar	=	13.485
Student	overall	4.967225	2.849551	0	11.12955	N	=	748
“Imports”	between		2.824565	0	11.07543	n	=	97
	within		0.4029022	2.248404	7.628304	T-bar	=	7.71134
Student	overall	7.385432	1.784416	1.124952	12.51505	N	=	2106
“Exports”	between		1.814115	1.463644	11.92852	n	=	194
	within		0.239452	6.102148	9.011636	T-bar	=	10.8557
Book	overall	11.88577	3.422043	5.638355	20.84526	N	=	3217
Imports	between		3.23681	5.638355	19.85492	n	=	199
	within		1.033978	4.372163	15.83575	T-bar	=	16.1658
Newspaper	overall	11.71808	3.236277	6.298949	19.49899	N	=	2180
Imports	between		3.006069	6.530878	18.86302	n	=	160
	within		1.018859	4.616215	15.45245	T-bar	=	13.625
Internet	overall	10.51753	3.132156	2.302585	19.17315	N	=	2894
Users	between		2.088614	5.839221	17.2763	n	=	203
	within		2.287732	2.385407	15.52916	T	=	14.2562
Foreign	overall	5.192056	2.338288	0	12.87424	N	=	1670
Patent Filing	between		2.333658	0.5493062	12.83184	n	=	141
	within		0.5727688	2.472105	8.068773	T	=	11.844

*All variable summary statistics given in terms of the five year moving average of the natural log of the variable.
**Std. Dev. is standard deviation

Table 2: Variable Details

Variable	**Description**	**Source**
Gross Domestic Product	Given in terms of Constant 2000 USD Reported by country i in year t Data Availability: 1990-2008	World Development Indicators Online Database
Total Labor Force	Total number of people in the labor force Reported by country i in year t Data Availability: 1990-2008	World Development Indicators Online Database
Gross Capital Formulation	Given in terms of Constant 2000 USD by country Reported by country i in year t Data Availability: 1990-2008	World Development Indicators Online Database
Openness to Trade	Calculated as (Imports + Exports) Total Imports and Exports are given in terms of Constant 2000 USD Reported by country i in year t Data Availability: 1990-2008	World Development Indicators Online Database
R&D Capital Stock	Total R&D expenditures Calculated by dividing the percentage of GDP spent on R&D by 100 and the multiplying the result by total GDP Reported by country i in year t Data Availability: 1990-2008	World Development Indicators Online Database
Telephone Calls	The sum of outgoing calls *to* the top five from a given country i in year t and incoming calls *from* the top five to a given country i in year t Data Availability: 1996-2008	Telegeography
Student "Exports"	The number of students from a given country i studying abroad in one of the top five in a given year t Data Availability: 2000-2008	UNESCO
Student "Imports"	The number of students from the top five studying abroad in country i in a given year t Data Availability: 2000-2008	UNESCO
Book Imports	The number of books imported by a given country i from the top five in a given year t Data Availability: 1990-2008	UN Comtrade Database
Newspaper Imports	The number of newspapers imported by a given country i from the top five in a given year t Data Availability: 1990-2008	UN Comtrade Database
Foreign Patents	Patents filed by top five in a given country t in year t	World Intellectual Property Organization
Consulting Firm Offices	The sum of Boston Consulting Group and Bain & Company office branches in a given country i during a given year t	Boston Consulting Group; Bain & Company
Internet Users	Number of people with Internet connectivity in a given country i in year t	World Intellectual Property Organization

* "Top five" refers to the top five innovating countries, as presented by UNESCO (1997): The United States, the United Kingdom, Germany, France, and Japan

Table 3: List of countries included in dataset

Afghanistan	Dominican Republic	Lesotho	San Marino
Albania	Ecuador	Liberia	Sao Tome and Principe
Algeria	Egypt, Arab Rep.	Libya	Saudi Arabia
American Samoa	El Salvador	Liechtenstein	Senegal
Andorra	Equatorial Guinea	Lithuania	Serbia
Angola	Eritrea	Luxembourg	Seychelles
Antigua and Barbuda	Estonia	China, Macao SAR	Sierra Leone
Argentina	Ethiopia	Macedonia, FYR	Singapore
Armenia	Faeroe Islands	Madagascar	Slovak Republic
Aruba	Fiji	Malawi	Slovenia
Australia	Finland	Malaysia	Solomon Islands
Austria	France	Maldives	Somalia
Azerbaijan	French Polynesia	Mali	South Africa
Bahamas	Gabon	Malta	Spain
Bahrain	Gambia, The	Marshall Islands	Sri Lanka
Bangladesh	Georgia	Mauritania	St. Kitts and Nevis
Barbados	Germany	Mauritius	St. Lucia
Belarus	Ghana	Mayotte	St. Vincent and the Grenadines
Belgium	Gibraltar	Mexico	Sudan
Belize	Greece	Micronesia, Fed. Sts.	Suriname
Benin	Greenland	Moldova	Swaziland
Bermuda	Grenada	Monaco	Sweden
Bhutan	Guam	Mongolia	Switzerland
Bolivia	Guatemala	Montenegro	Syrian Arab Republic
Bosnia and Herzegovina	Guinea	Morocco	Tajikistan
Botswana	Guinea-Bissau	Mozambique	Tanzania
Brazil	Guyana	Myanmar	Thailand
Brunei Darussalam	Haiti	Namibia	Timor-Leste
Bulgaria	Honduras	Nepal	Togo
Burkina Faso	China, Hong Kong SAR	Netherlands	Tonga
Burundi	Hungary	Netherlands Antilles	Trinidad and Tobago
Cambodia	Iceland	New Caledonia	Tunisia
Cameroon	India	New Zealand	Turkey
Canada	Indonesia	Nicaragua	Turkmenistan
Cape Verde	Iran, Islamic Rep.	Niger	Turks and Caicos Islands
Cayman Islands	Iraq	Nigeria	Tuvalu
Central African Republic	Ireland	Northern Mariana Islands	Uganda
Chad	Isle of Man	Norway	Ukraine
Channel Islands	Israel	Oman	United Arab Emirates
Chile	Italy	Pakistan	United Kingdom
China	Jamaica	Palau	United States
Colombia	Japan	Panama	Uruguay
Comoros	Jordan	Papua New Guinea	Uzbekistan
Congo, Dem. Rep.	Kazakhstan	Paraguay	Vanuatu
Congo, Rep.	Kenya	Peru	Venezuela, RB
Costa Rica	Kiribati	Philippines	Vietnam
Cote d'Ivoire	Korea, Dem. Rep.	Poland	Virgin Islands (U.S.)
Croatia	Korea, Rep.	Portugal	West Bank and Gaza
Cuba	Kosovo	Puerto Rico	Yemen, Rep.
Cyprus	Kuwait	Qatar	Zambia
Czech Republic	Kyrgyz Republic	Romania	Zimbabwe
Denmark	Lao PDR	Russian Federation	
Djibouti	Latvia	Rwanda	
Dominica	Lebanon	Samoa	

Table 4: Hausman Test

	Coefficients			
	(b) Fixed	(B) Random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Labor	0.3211132	0.2940939	0.0270193	0.0471282
Capital	0.2163956	0.2324228	-0.0160272	.
Openness to Trade	0.2374355	0.274022	-0.0365865	.
R&D Capital Stock	0.0747998	0.1439698	-0.06917	.
Telephone Call Traffic	0.00544	0.0170137	-0.0115736	.
Student "Exports"	0.0276785	-0.00035	0.0280285	.
Student "Imports"	-0.003718	0.0045763	-0.0082943	.
Book Imports	-0.0168498	-0.0013541	-0.0154957	.
Newspaper Imports	0.0039738	0.0110056	-0.0070319	.
Internet Users	0.0183847	-0.0070252	0.0254099	.
Foreign Patent Filings	0.0112514	0.0234583	-0.0122069	.

Note: All variables given in terms of the five year moving average of the natural log
b= consistent under Ho and Ha; obtained from xtreg
B=inconsistent under Ha, efficient under Ho; obtained from xtreg
Test: Ho: Difference in coefficients not systematic
Chi2(11) = 547.55
Prob>Chi2 = 0.0000

Table 5

Dependent Variable Gross Domestic Product	(1)	(2)
Labor Force	.2728175***	.3211132***
	(.065617)	(.0517331)
Capital	.1749833***	.2163956***
	.0176929)	(.0146343)
Trade Openness	.2581543***	.2374355***
	(.022299)	(.0215351)
R&D Capital Stock	.0864373***	.0747998***
	(.0178815)	(.0141545)
Telephone Call Traffic	-.0065092	.00544
	(.0065595)	(.0061734)
Student "Exports"	-.0210818*	.0276785***
	(.0111312)	(.0105576)
Student "Imports"	.0081439*	-.003718
	(.0043798)	(.0052678)
Book Imports	.0032885	-.0168498***
	(.0058401)	(.0049295)
Newspaper Imports	.0069184**	.0039738
	(.0029045)	(.0025464)
Internet Users	.01196***	.0183847***
	(.0039668)	(.0044647)
Foreign Patent Filings	.0127594***	.0112514***
	(.0041619)	(.0029169)
Consulting Offices	-.0468936***	
	(.0124315)	
Constant	8.797439***	7.30054***
	(.8586719)	(.7861577)
R^2 Overall	0.9492	.9589
Observations	252	426

Standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Note: All variables given in terms of the five year moving average of the natural log

Table 6: Correlation Matrix

	Telephone Call Traffic	Student "Exports"	Student "Imports"	Book Imports	Newspaper Imports	Internet Users	Foreign Patent Filings
Telephone Call Traffic	1						
Student "Exports"	0.7522	1					
Student "Imports"	0.8032	0.5342	1				
Book Imports	0.7775	0.6293	0.8053	1			
Newspaper Imports	0.7681	0.6245	0.7585	0.8808	1		
Internet Users	0.8028	0.7391	0.728	0.7769	0.7309	1	
Foreign Patent Filings	0.5541	0.5854	0.538	0.5484	0.4634	0.7042	1

Table 7

Principal Components Analysis

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	5.1729	4.48478	0.7390	0.7390
Comp2	.688113	.239375	0.0983	0.8373
Comp3	.448738	.169034	0.0641	0.9014
Comp4	.279704	.101536	0.0400	0.9414
Comp5	.178168	.05054	0.0255	0.9668
Comp6	.127628	.0228765	0.0182	0.9850
Comp7	.104752		0.0150	1.0000

Table 7 Continued: Eigenvectors

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7
Telephone Call Traffic	0.4015	-0.0894	-0.2293	-0.5132	0.02	-0.6378	-0.3282
Student “Exports”	0.3543	0.3481	-0.7207	0.0286	0.2971	0.366	0.1042
Student “Imports”	0.3804	-0.3054	0.3739	-0.5416	0.2205	0.4365	0.2996
Book Imports	0.3992	-0.2974	0.1313	0.4002	0.0462	0.2858	-0.7007
Newspaper Imports	0.3856	-0.3946	-0.0404	0.5121	0.123	-0.3683	0.53
Internet Users	0.4014	0.1937	0.012	0.0001	-0.8756	0.1214	0.1405
Foreign Patent Filings	0.3151	0.7042	0.5189	0.1418	0.2806	-0.1917	0

Table 8

Gross Domestic Product	(1)
Labor Force	.496403***
	(.0452797)
Capital	.2297418***
	(.0145754)
Openness to Trade	.2762534 ***
	(.0173119)
R&D Capital Stock	-1.14 e-13
	(3.48 e-13)
Openness to Ideas	.039705***
	(.0070465)
Constant	5.190986***
	(.6668459)
Observations	374
R^2 Overall	0.9351

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Note: All variables given in terms of the five year moving average of the natural log

Table 9

Gross Domestic Product	(1)	(2)
Labor Force	.3355332 ***	.6432011*
	(.032514)	(.3253396)
Capital	.2058175 ***	.1294416**
	(.0109886)	(.0624719)
R&D Capital Stock	.0523036 ***	.1595937***
	(.0107365)	(.050994)
Openness to Ideas	.0062536**	.0817152***
	(3.48 e-13)	(.0188166)
High Trade	.276041 ***	
	(.0131197)	
Low Trade		.3040516*
		(.1599014)
Constant	7.288984 ***	1.81208
	(.4842875)	(2.986272)
Observations	370	56
R^2 Overall	.9479	.3774

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Note: All variables given in terms of the five year moving average of the natural log