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Accounting for Quality Differences in Human Capital And Foreign Direct Investment

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Abstract

In this paper, I empirically investigate how cross-country differences in the quality of human capital, as they are captured by the conventional measures of international test score differences, influence the patterns of foreign direct investment. Using panel data covering 32 countries and the period between 1985 and 2004, I find that a host country's quality of educational attainment plays an independent role in attracting foreign direct investment. In particular, I find empirical evidence in support of the idea that the quality of human capital influences horizontal foreign direct investment even after accounting for the roles of skill and factor endowments, trade costs, investment costs and country-size and income effects.

Keywords: labor skills, international test scores, horizontal FDI, vertical FDI.
JEL Codes: F21, F23, J24, O15

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1. Introduction

There exists a vast literature on the determinants of foreign direct investment, which typically documents that differences in human capital attainment play a significant role in influencing the patterns of foreign direct investment across countries over time.[1] At the same time, a strand in the human capital and growth literature has long emphasized how differences in human capital quality can influence economic growth. According to this body of work, measures of human capital based on attainment and enrollment data only are not sufficient for explaining cross-country differences in economic growth and accounting for quality differences in human capital can be important.[2] Despite these findings, the existing literature on foreign direct investment (FDI) has ignored quality differences in human capital as an important country characteristic that could influence patterns and flows of FDI.

This paper focuses on the role of quality of human capital and its differential impact on vertical and horizontal FDI. In particular, it focuses on whether and to what extent international differences in educational achievement as measured by variations in cognitive test scores across countries over time have power to identify the determinants of foreign direct investment.

Using panel data covering 32 countries and the period between 1985 and 2004, I find that a host country's quality of educational attainment plays an independent role in attracting foreign direct investment. In particular, I find empirical evidence in support of the idea that the quality of human capital influences horizontal FDI even after accounting for the roles of skill and factor endowments, trade costs, investment costs and country-size and income effects. Quantity of skilled labor abundance influences vertical FDI. Accounting for quality of educational attainment and quantity of skilled labor abundance strengthens both horizontal and vertical FDI to rise endogenously.

Following Hanushek and Kimko (2000), I measure the endowment of labor force quality by using international comparative test scores of mathematics and science. I embed quality of human capital into the knowledge capital model of the multinational enterprise (MNE) and examine it empirically. Carr, Markusen and Maskus (2001) estimate the knowledge capital model (KK). By estimating the quality-adjusted knowledge capital model, I find that an increase in a small host country quality endowment will increase the real affiliate sales of the parent country in the host country. Ceteris paribus, an improvement in standardized test scores in the host country by one standard deviation of test scores differences between the home and host country can account for

[1] See Borensztein et al. (1998) who wrote that a minimum threshold of human capital stock is required for the higher productivity of FDI.
[2] See Hanushek (1992), Hanushek and Kimko (2000), and Hanushek and Woessmann (2007).

$13.4 billion increase in horizontal FDI flows which is 49% relative to average FDI flows per country.

2. Literature Review

Many theoretical and empirical papers study FDI and its determinants. The general equilibrium trade theory of multinational firms is based upon the traditional competitive, constant return model of international trade. The trade theory from the 1980s allows the industrial organization approach and builds upon the increasing returns to scale and imperfect competition. It generates the two branches of the "Vertical" and "Horizontal" model. The vertical model explains that the differences in factor endowments among countries are main determinants of FDI and firms geographically fragment the production by stages (Helpman, 1984, Helpman and Krugman, 1985). Vertical FDI prevails when differences between country characteristics are significant and horizontal FDI dominates when countries have similar country characteristics. The horizontal model shows that firms produce the same goods or services in multiple countries (Markusen, 1984, Markusen and Venables, 1998). Markusen (1997, 2002) combines the vertical and horizontal model. The KK model provides the framework in which firms choose among domestic, vertical and horizontal stages. Carr, Markusen and Maskus (2001) estimate the KK model of the multinational firms to predict the direction and volume of trade and FDI. Blonigen et al. (2003) change the terms measuring differences in human capital abundance of the KK model and find that horizontal FDI dominates vertical FDI motives. Bergstrand and Egger (2005) develop a "Knowledge-and-physical-capital model." They extend the two countries (home, host), two goods (skilled and unskilled labor intensive good), and two factors (skilled and unskilled labor) knowledge capital model to three countries (home, host, the rest of the world), three goods (skilled, unskilled labor intensive good, intermediate good), and three factors (skilled labor, unskilled labor, physical capital) case. The addition of physical capital to the modern knowledge-capital model helps to resolve several puzzles in the international trade and investment literatures.

There exist a number of economic literatures that explore the role of quality of human capital in the economic growth of nations. Becker (1993) defines that human capital is any skill that has market value. It can be augmented through investing in a person's knowledge and skills. Barro and Lee (1993) first measured national stocks of human capital by computing the number of years of educational attainment achieved by average person in each country. But this is a crude measure of skill differences. It does not account for quality differences in human capital across countries.

Hanushek and Kimko (2000) use the measure of comparative test scores of mathematics and scientific skills as an alternative measure of quality differences. They develop a single measure of labor force quality by combining all the information about international mathematics and science tests available for each country from 1964 through 1991. They find that labor force quality has a consistent, stable and strong relationship with economic growth by conducting various analytical specifications. A series of indirect investigations of causal structure indicate there is no reverse causality from growth through schooling resources to quality of human capital. Cognitive test scores are not significantly affected by the pupil-teacher ratio, total expenditure on education per GDP and so on. The results are not driven by the high performances of East Asian countries either. By looking at the relation between the quality measure and immigrant earnings differences in the United States, authors find that international quality difference are positively correlated with productivity differences.[3] Therefore, accounting for quality differences in human capital significantly improves the ability to explain economic growth.

In this paper I merge these two strands in the literature. If I consider FDI model driven by Heckscher-Ohlin considerations only or one in which horizontal motives of FDI only, then the role of quality of human capital and its differential impact on FDI outweigh either horizontal or vertical FDI to rise endogenously. Thus, I choose the KK model which integrates vertical and horizontal FDI. The quality measure of human capital is drawn from the role of the quality of human capital in economic growth. The impact of augmenting quality of human capital in FDI can be analyzed by estimating the significance of an independent role of human capital quality in the KK model.

The remainder of the paper is organized as follows: In section 3, I discuss the data and empirical methodology and present basic results. In section 4, I discuss econometric issues and robustness. In section 5, I interpret the main results. Section 6 concludes.

3. The Data and Empirical Strategy

3.1 The Data

The choice of a proxy for the quality of human capital is crucial to shed light on the independent role of quality of labor force in FDI. By following Hanushek and Kimko (2000), I choose the

[3] The cultural background, family support and social norms of the immigrants those who get quality of human capital only from their home country are not significantly related with their earning differences in USA. The significant role of immigrant quality differences that identifies their earning differences in USA suggests that there is no endogeneity in the quality of human capital as a measure of productivity differences. Large effect of quality of human capital on economic growth is not because of omitted variable bias. The causal impact of quality on growth appears large. Hanushek and Kimko (2000) calculate that one standard deviation in measured cognitive skills generates one percent difference in average annual real growth rates.

international test scores of primary and secondary school student achievement in math and science which were conducted over the last three decades as a measure of the comparison of cognitive achievement across countries. International comparison tests of educational achievement in math and science are conducted by the International Association for the Evaluation of Educational Achievement (IEA), the International Assessment of Educational Progress (IAEP), and the Program for International Student Assessment (PISA). The Trends in International Mathematics and Science Study (TIMSS), conducted every four years by IEA, is an assessment of fourth-graders, eighth-graders and twelfth-graders in mathematics and science. The advantage of test scores for younger students is that more of the population is still in school. But it misses differences in skill associated with better secondary or post-secondary schooling. Also, it does not account for differences resulting from immigration. In 1995, TIMSS collected data for 4th and 8th graders. In 1999, TIMMS collected data for 8th grade only. With the 2003 data collection, TIMSS offers the first international trend comparisons in mathematics and science at grades four and eight. In 2003, the United States and a number of other countries participated in data collection at two grade levels:

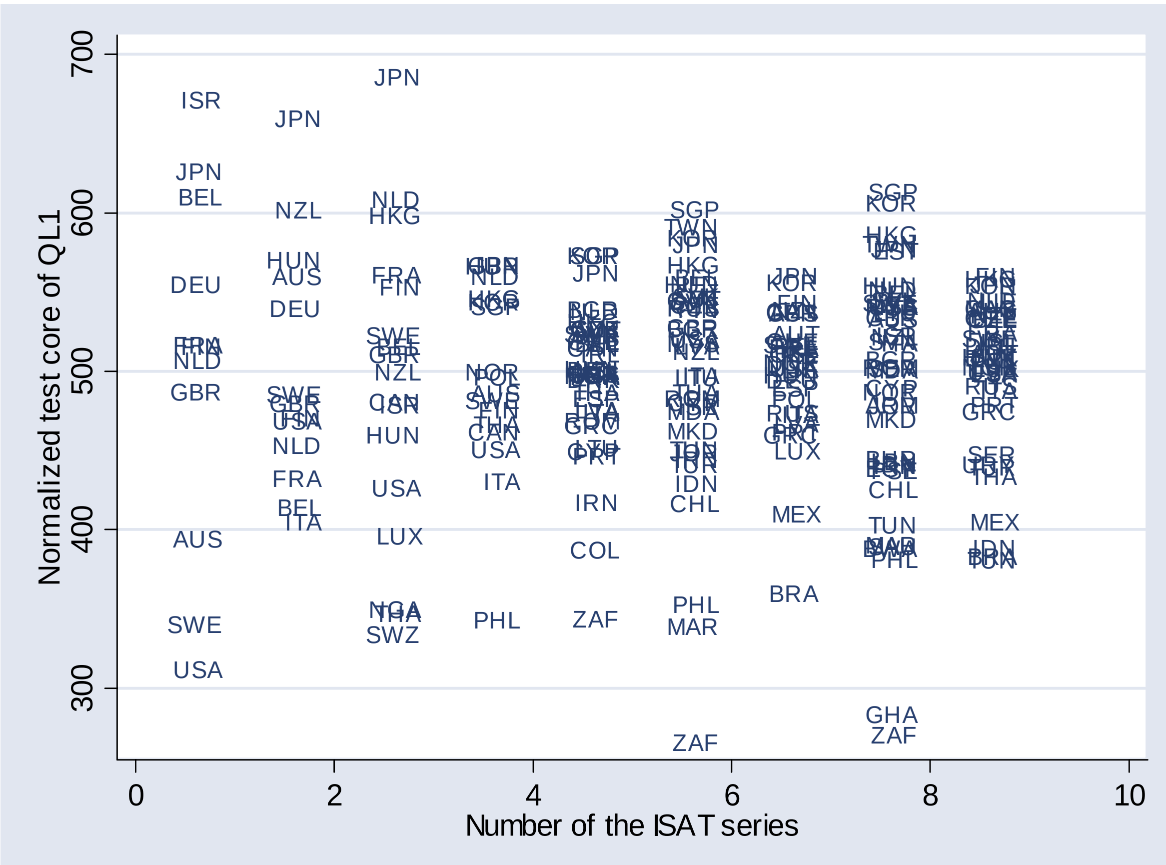

Figure 1. The Normalized International Student Achievement Test Score from 1964 to 2003.

25 nations collected data on fourth-graders and 46 nations collected data on eighth-graders. In Table A, I summarize the international student achievement test (ISAT) scores. My quality of human capital data methodology is detailed in Appendix 1.

There are several features in my quality of human capital data, illustrated in Figures 1 through 4.

The normalized test score is generated by combining the math and science test score over the different age groups in a given period of time. Figure 1 shows how the normalized ISAT score of each country is distributed within a specific test series and over the different test series. In Figure 1, 73 countries have at least one observation in the normalized ISAT series. Seven countries score high consistently. Japan, Korea, Hungary, Nederland, Hong Kong, Singapore, and Taiwan are the countries in which more than 40% of test scores is higher than 550 which is in the top 16 percent. Seven countries score low consistently. Philippines, South Africa, Brazil, Chile, Morocco, Mexico and Tunisia are the countries in which more than 50% of test scores is less than 430 which is in the bottom 16 percent.

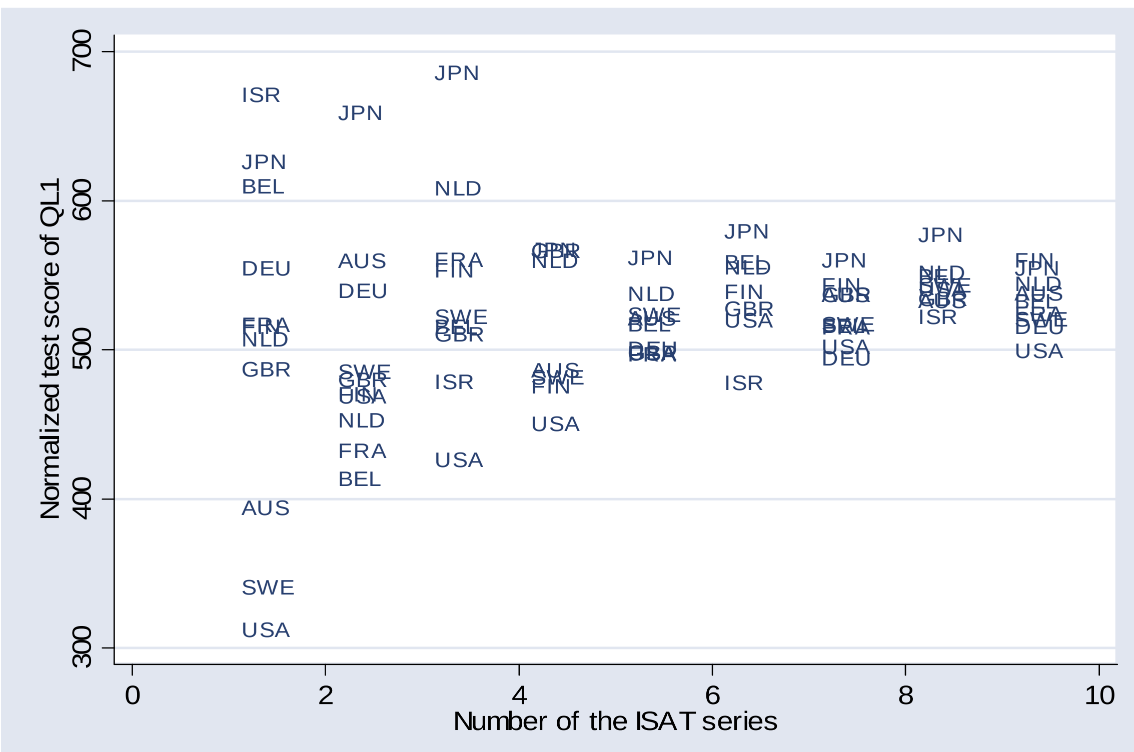

Figure 2. A Convergence of the ISAT scores in the developed countries.

Focusing only on 11 countries from 1964, I draw Figure 2 by arranging number of the ISAT series with respect to time on the horizontal axis. I find that there is a convergence of the ISAT score around 530 over time in the developed countries. Israel, Japan, Belgium, Germany, France, Nederland, United Kingdom, Austria, Sweden, USA, and Finland are the developed countries in Figure 2. There exists a convergence of the quality of human capital among the developed countries. Quality differences in human capital between the developed countries get relatively smaller over time.

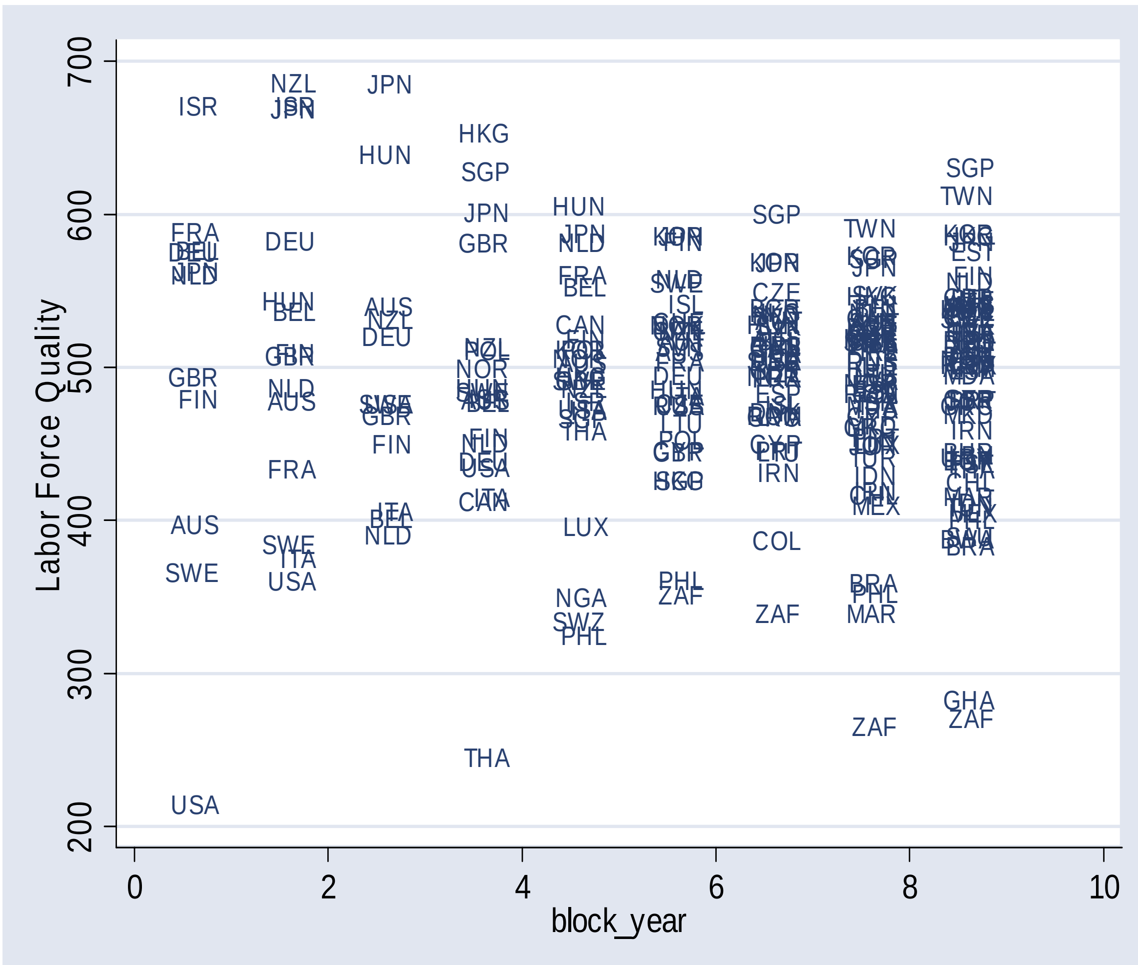

Figure 3. The lagged normalized International Student Achievement Test Score.

I assume that changes in the quality of the population of primary school students today will apply to new entrants in the labor force over age fifteen 10 years later, while the changes at secondary school level become effective for the labor force over age fifteen 5 years later. Figure 1 does not take into account these effects. Thus, I give 10 year lags for the international test score of 4th graders, 5 year lags for the international test score of 8th graders, and no lag for 12th graders. Then I construct block years for 5 year periods from 1965 to 2004. I have 8 different block years.[4] I use this data as a proxy for quality of labor force.[5] I find that a standard deviation of the ISAT score becomes greater as I consider the delay at which the younger students enter the labor force. Japan, Korea, Spain, Singapore, and Taiwan are the countries in which more than 40% of test scores is higher than 566 which is in the top 16 percent. Philippines, South Africa, Brazil, Botswana, Columbia, Ghana, Morocco, Mexico, Nigeria are the countries in which more than 50% of test scores is less than 422 which is in the bottom 16 percent. Quality differences in human capital in Figure 3 are greater than those of Figure 1.

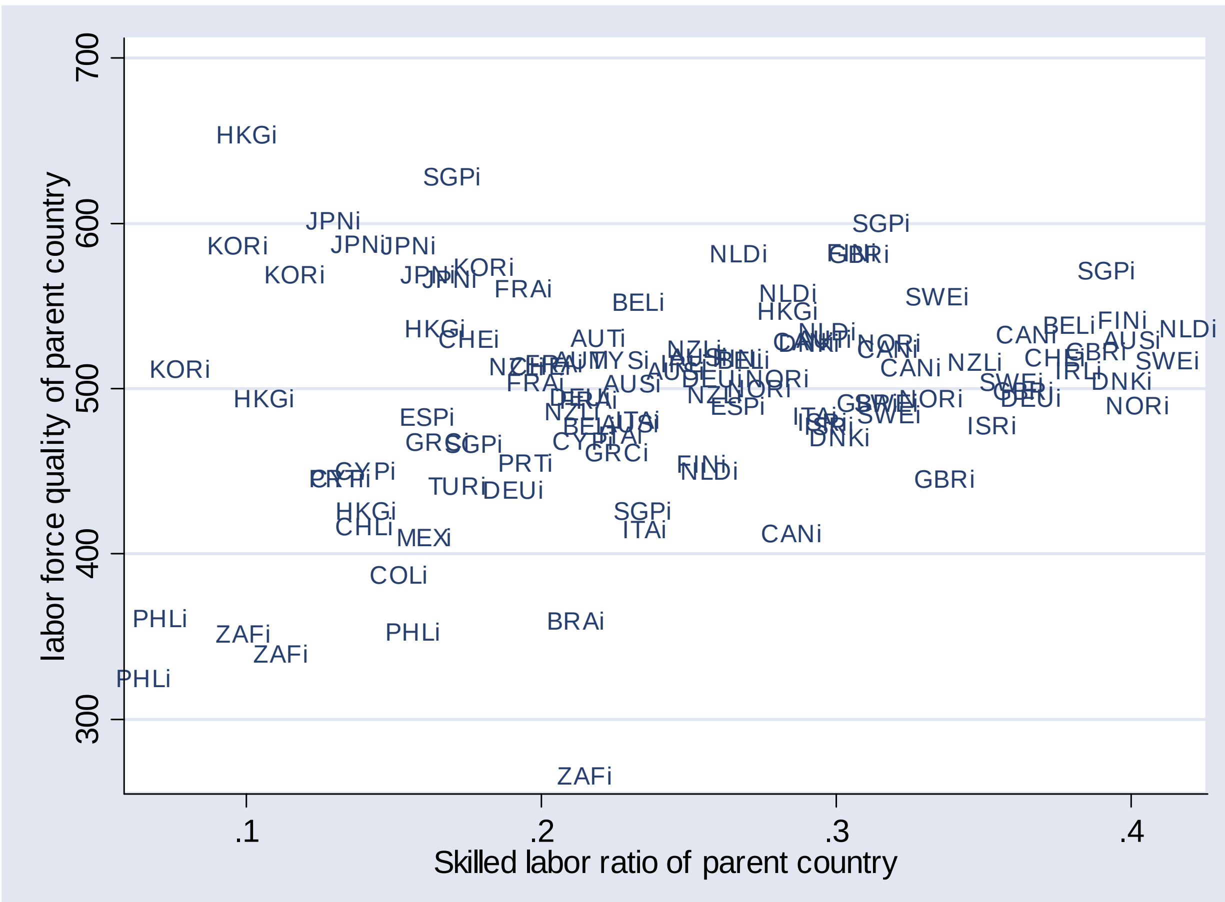

Figure 4. The correlation between labor force quality and skilled labor ratio in parent country i

Both the quality of human capital and quantity of skilled labor endowment can be used as one of

4 Given time lags, the 9th block year is generated. The 9th block year data covers 2005-2009. I drop it. 4 block years are used for the estimation of the role of quality of human capital in FDI.

5 I only take the lagged normalized ISAT score block years from 5 to 8 into the estimation of the role of quality of human capital in FDI: 1985-1989, 1990-1994, 1995-1999, 2000-2004.

the independent variables which determine the magnitude of FDI of home country in the host country. If these variables are highly correlated then the independent role of quality of human capital may be doubtful because of the possibility of multicollinearity. I use the lagged normalized ISAT scores to draw Figure 4. Skilled labor endowment of each country is obtained by the ratio of skilled occupations in employment to total employment. By observing the correlation between quality of human capital and skilled labor ratio of parent country i in which headquarter is located, I can find some extent of substitutability and complementarity of quality of human capital and quantity of skilled labor endowment. On the one hand, the observations along the 45 degree line of Figure 4 can support the complementarity of quality of human capital and quantity of skilled labor endowment. Canada, Denmark, Finland, Great Britain, Sweden, and Switzerland are countries that have relatively equal proportion of skilled labor ratio and quality of human capital. On the other hand, the observations in the north-west corner of Figure 4 indicate that some countries can compensate the relative scarcity of skilled labor by improving the quality of human capital. Hong Kong, Japan, and South Korea are countries that have lower level of skilled labor ratio but higher quality of human capital. In sum, while Figure 4 shows a strong positive correlation between the two measures of human capital, the association is far from perfect and there is a lot of heterogeneity across countries.

I have annual data on foreign affiliate sales from 1985 to 2004. It is the real sales volume of nonbank manufacturing affiliates in each country. The United States Department of Commerce provides the foreign affiliated sales data of the USA owned MNE and the USA affiliate sales data of foreign owned MNE. The data are bilateral with the USA. If the USA is home country then the rest of the world is host country and vise versa. I combine the real foreign affiliate sales by averaging them for every five years and building 4 block years: 1985-1989, 1990-1994, 1995-1999, 2000-2004. If real sales total data within a block year is only one observation for a country then I drop it. Annual sales are reported in millions of US$ and are converted from local currencies using exchange rates from the *International Financial Statistics* (IFS) publication of the International Monetary Fund. The United States GDP deflator is applied to the data to obtain the 1995 real GDP. There are 32 countries in addition to the United States for which I have at least two complete data in one block year. This data is used for the dependant variable, which measures the intensity of foreign-owned firms' business activity in a given country over every half decade in the data.

Real GDP is measured in billions of 1995 US$ for each country. Annual real GDP values in local currencies are converted by using the exchange rate provided by the IFS. US GDP deflator is used to convert to real GDP.

Skilled labor share is defined by the ratio of the International Labour Organization (ILO) occupation categories: 0/1 for professional, technical and related workers, 2 for administrative and managerial workers in employment to total employment in each country. Since the ILO adjusted the classification code after the year 2000, the skilled labor ratio from 2000 to 2004 is calculated by using categories 1, 2, and 3 to total employment.

Trade cost is based on the World Competitive Report (WCR) before the year 2000. After the year 2000, the source becomes the Global Competitive Report (GCR). Trade cost index measures on the scale of 0 to 100. The index 100 indicates most restrictive trade. Investment cost is also obtained from the WCR before the year 2000 and the GCR after the year 2000. It also ranges from 0 to 100 and 100 is the highest investment cost. Distance is measured in kilometers from Washington D.C. to the capital city of each country. Summary statistics are reported in Table B.

3.2 Empirical Strategy

3.2.1 Empirical methodology

Carr et al. (2001) uses the following regression equation to examine the empirical impacts of foreign direct investment determinants on real sales volume:

$$\begin{aligned} RSALES_{ij} = {} & \beta_o + \beta_1 * (GDPSUM) + \beta_2 * (GDPDIFSQ) + \beta_3 * (SKDIFF) \\ & + \beta_4 * ([GDPDIFF]*[SKDIFF]) + \beta_5 * (INVCJ) + \beta_6 * (TCJ) \\ & + \beta_7 * ([TCJ]*[SKDIFFSQ) + \beta_8 * (TCI) + \beta_9 * (DIS) + u_{ij} \qquad (1) \end{aligned}$$

This specification (1) relates the real volume of affiliate sales ($RSALES_{ij}$) of either US-owned manufacturing affiliates abroad or foreign-owned manufacturing affiliates in the US to fundamental country characteristics. Variables and the expected signs of coefficients are listed and defined in Table C. $RSALES_{ij}$ is the dependent variable. GDPSUM is a joint market size measure as proxied by the sum of the two countries GDP. GDPDIFFSQ is squared differences in country size. All the differences in equation (1) are obtained as a home country variable minus a host country variable. SKDIFF is skill endowment differences; GDPDIFF*SKDIFF is interaction between the difference in country size and skill difference; INVCJ is the investment costs into the host country; TCJ is the trade costs of exporting to the host country; TCJ*SKDIFFSQ is interaction between the trade cost to the host country and the squared differences in skill endowment; TCI is the trade cost of exporting to the parent country; DIS is the distance between home and host country.

Table C. The definition of variables and the expected signs of the coefficients

Variables	Definition	Coefficients
$RSALES_{ij}$	Real foreign affiliate sales of country i in country j	
GDPSUM	Sum of real GDP of countries i and j	$\beta_1 > 0$
GDPDIFFSQ	Squared value of the GDP difference between county i and country j	$\beta_2 < 0$
SKDIFF	Skilled endowment difference between county i and country j	$\beta_3 > 0$
GDPDIFF*SKDIFF	Interaction between GDP difference and Skill difference	$\beta_4 < 0$
INVCJ	Investment cost of country i to country j	$\beta_5 < 0$
TCJ	Trade cost of country i to country j	$\beta_6 > 0$
TCJ*SKDIFFSQ	Interaction between trade cost host and squared skill differences of country i and j	$\beta_7 < 0$
TCJ	Trade cost of exporting to the parent country i from host country j	$\beta_8 < 0$
DIS	Physical distance from Washington D.C. to the capital city of a country	$\beta_9 \gtrless 0$

Expected signs of coefficients are following[6]: β_1 is positive because GDP sum of the parent and host country increases the real affiliate sales of the parent country in the host country since a joint market size is positively related with the affiliate sales; β_2 is negative because real affiliate sales volume has an inverted U-shaped relationship with differences in market size; β_3 is positive because the headquarters of firms is located in the relatively skill abundant country; β_4 is negative because the KK model implies the vertical firms prevail in which the home country is small and skill abundant; β_5 is negative because the foreign affiliate sales volume is adversely affected by the cost of investing in the host country; β_6 is positive for which the trade cost in exporting to the host country increases the foreign affiliates sale in the host country; β_7 is negative because the horizontal firms prevail as the trade cost into host country increases given the skill difference between the home and host country is relatively small; β_8 is negative due to the fact that the trade cost for the shipment back to the home country discourages the incentive to build plants in the host country; β_9 is ambiguous because distance is related with the costs of export, investment and

[6] For more details of the expected signs of coefficients, please see Carr et al. (2001).

monitoring.

[TABLE 1 HERE]

By using 165 observations for the 32 countries from 1985 to 2004, I replicate the Carr et al. model with the GDP difference term. I conduct Breusch & Pagan test (1979) for heteroskedasticity which verifies that there exist significant heteroskedasticity. I model the multiplicative heteroskedasticity in (1.1), and do the feasible GLS, and estimate the equation by weighted least squares.

$$Var(u \mid x) = \sigma^2 \exp(\delta_0 + \delta_1 x_1 + \delta_2 x_2 + \ldots + \delta\ x_k) \qquad (1.1)$$

In Table 1, I report heteroskedasticity corrected results from Carr et al. (2001) estimation model.

The sum of host and home country GDPs is significant at the 1% level and it is positively related to real foreign affiliate sales of parent country in host country. GDP difference is positive and significant at the 1% level. GDP difference squared is negative and significant at the 1% level. Marginal effect of GDP difference on real FAS total is inverted-U shaped but its optimal level of GDP difference that maximizes real FAS total is skewed slightly to the right side. This is because the GDP difference coefficient is positive and statistically significant. Skill difference is negative and significant at the 5% level. Interactions between GDP difference and Skill difference are negative, but this coefficient is statistically insignificant. Investment cost in host country is statistically insignificant but the sign of the coefficient is negative. Trade cost for host country is negative and significant at the 1% level. Interaction between trade cost and squared skill difference is positive and significant. Trade cost for parent country is negative. In short, GDP sum, GDP difference, GDP difference squared, interaction between GDP difference and skill difference, Investment cost in host country, and trade cost for parent country has consistent sign with the prediction of the KK model. But the signs of skill difference, trade cost for host country and interaction between squared skill difference and trade cost for host country are not consistent with the KK model.

Based on the KK model and the stylized facts of the quality of human capital, I hypothesize that when the USA is a parent country, an increase in the host country labor force quality increases U.S. affiliates production in the host country. If the USA is a host country, an increase in parent-country labor force quality increases the parent country's affiliate production in the USA. By observing the correlation between quality of human capital and skilled labor ratio of parent country i in which headquarter is located, I assume some extent of substitutability and complementarity of quality of human capital and quantity of skilled labor endowment. My hypotheses are based on the strong substitutability of the two measures of human capital.

To control for unobserved country specific differences that do not change over time, I use a fixed-effects estimation approach. I add dummy variables for the host country and parent country in the equation (1).[7] I also employ robust regression methods that correct for outlier biases using Cook's D-test.[8] I conduct the substitution of total years of schooling for skilled labor ratio and the comparison of the results including GDP difference with excluding GDP difference for the sensitivity test by following Levine and Renelt (1992). The equation (1) and Table 1 replicate Carr et al. model and the following equation (2) and Table 2 incorporate quality of human capital differences.

In addition to baseline estimation equation (1), I add GDP difference, Quality difference, interaction between GDP Difference and Quality difference, and interaction between Trade Cost Host and Quality difference Squared and build estimation equation (2) for the quality-adjusted KK model.

$$
\begin{aligned}
RSALES_{ij} = \beta_0 &+ \beta_1 * (GDPSUM) + \beta_2 * (GDPDIFF) + \beta_3 * (GDPDIFFSQ) \\
&+ \beta_4 * (SKDIFF) + \beta_5 * ([GDPDIFF] * [SKDIFF]) \\
&+ \beta_6 * (QDIFF) + \beta_7 * ([GDPDIFF] * [QDIFF]) \\
&+ \beta_8 * (INVCJ) + \beta_9 * (TCJ) + \beta_{10} * ([TCJ] * [SKDIFFSQ]) \\
&+ \beta_{11} * ([TCJ] * [QDIFFSQ]) + \beta_{12} * (TCI) + \beta_{13} * (DIS) + u_{ij} \qquad (2)
\end{aligned}
$$

GDPDIFF is differences in country size and obtained by parent country real GDP minus host country real GDP. QDIFF is a measure of quality differences of human capital abundance in parent county i relative to host county j. GDPDIFF*QDIFF is interaction between GDP difference and quality difference. TCJ*QDIFF is interaction between trade cost into host country and quality difference.

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[7] Carr et al. (2001) include only dummy variables for the host country because they assume that fixed effects exist only for the recipient country. But I expect that fixed effects exist not only in the host country but also in the parent country. I exclude dummy variable for the Unites States and expect that the addition of country-specific effects not to change the results very much. I compare the results obtained from equation (2) and a fixed effects approach with the corresponding results conducted by Carr et al. (2001).

[8] These regressions eliminate outliers, observations for which Cook's D > 1, and iteratively select weights for the remaining observations to reduce the absolute value of the residuals.

I expect $\beta_2 = 0$, $\beta_6 < 0$, $\beta_7 > 0$, $\beta_{11} > 0$ in the results of estimation of equation (2) and all the other coefficients signs are same as Carr et al. model. I expect $\beta_2 = 0$ because real sales total is inverted U shape with respect to the GDP difference between parent and host country. Given $\beta_2 = 0$ and $\beta_3 < 0$, the real sales total is maximized at which the GDP difference is zero. β_6 is negative. As the host country quality endowment increases, it will attract the foreign affiliate sales (FAS) of the home country in the host country. β_7 is positive. If there is similarity between the home country and host country in size, a decrease in quality difference between the home country and host country will increase the total affiliate sales of parent in the host country. Therefore the coefficient of interaction between GDP difference and quality difference should be positive. β_{11} is positive: As trade cost into the host country increases, the home country affiliate sales in the host country increase only if there is an increase in quality difference when skill endowment is identical.

I expect that labor force quality difference has negative effects on FAS. If quality difference increases, then FAS of home country in host country decreases. If quality difference decreases, then FAS of home country in host country increases. This negative relationship may be reflecting a quantity-quality substitution. I expect that the results imply that the omission of labor force quality is not trivial. The horizontal firm is important when the relative quality of factor endowments is similar but the vertical firm dominates when the relative endowment of skilled labor is much different. Accounting for quality of educational attainment and quantity of skilled labor abundance strengthens both horizontal and vertical FDI motives.

[TABLE 2 HERE]

3.2.2 Basic results

I compare Carr et al. estimations with the quality-adjusted model. I expect that the quality of human capital is a significant factor in the knowledge capital model (KK) of multinational firms. GDP sum of home and host countries are statistically significant and have positive relation with volume of foreign affiliate sales of headquarter located in home country and plants in the host country. In Table 2 column (1), I add quality endowment variables such as quality difference, interaction between GDP difference and quality difference, and interaction between trade cost and squared skill difference. Column (2) is the robust regression version of column (1). In column (3), I report results from quality adjusted model with WLS. Additional 35 observations are complete, except that no foreign affiliate sales data are reported. I assume that the missing real FAS data are truncated at a certain point. Thus, I replace those latent real foreign affiliate sales total data of parent country in host country with zeros. I estimate equation (2) with a Tobit regression in column (4). Coefficients in Tobit model are the marginal effect on the unconditional expectation ($\partial E(y|x)/\partial x_j$). I also calculate the marginal effect on the conditional expectation of the expected value of y for the subpopulation where y is greater than zero: ($\partial E(y|y>0, x)/\partial x_j$). The marginal effect of conditional expectation is relatively smaller than the marginal effects of unconditional expectation. Thus, I use the marginal effect of unconditional expectation and do not report results with conditional expectation here. Skill difference is positive and significant in column (2). In those quality adjusted models in (2) and (4), the coefficients of skill difference are positive. After I adjust for heteroskedasticity, it becomes insignificant and the direction of sign is changed in (3). Quality difference is positive and statistically insignificant except WLS at (3). After I control quality difference, the coefficient of skill difference in (1), (2), (3) and (4) becomes smaller relative to the basic Carr et al. estimation in terms of an absolute value of the coefficients. I expect that sign of quality difference is negative but empirical results do not meet the expected sign. Interaction between trade cost and squared quality difference is positive and insignificant except with the OLS in (1). I find that quality difference in the quality-adjusted KK model has a positive sign over all specifications.

4. Econometric Issues and Robustness

4.1 Endogeneity

Hanushek and Kimko (2000) show that the labor force quality are exogenous to the third factors that might influence growth. Using immigration earning regressions on the test score of the three different age groups, they show that the immigrant earnings in the USA are not affected by cultural factors, family behaviors, and the market efficiency of the their home country but by quality of education alone. Quality data of immigrants who get education only in their home country is not correlated with any other factor that is related to the omitted variable which has significant role in immigrant earning in the USA. Results suggest that the quality of the immigrants who get education only in their home country have strong and significant effects on their earnings in the USA. And this effect is much stronger compared to the immigrants who get some education in the USA. The effect of school quality on the US earning of immigrants shows that schooling location, whether it is on home country or home country and US or US only, generates significantly different effects on the immigrants earning in US. This indicates that schooling quality dose not contain any other third factor that affects growth. I implement same kind of strategy here in the KK model.

4.2 Selection Bias

One may argue that international test scores in math and science are not a good measure of skilled labor force quality. There may be some potential problems. Countries which participate in the IEA test may have selection bias. Many developing countries have cheating problems. There will be testing issues related to whether students are prepared directly for the test in the curriculum. Language of testing may also be a problem.

Countries participating in the TIMSS vary from less-developed countries to developed countries. Each country voluntarily chooses to participate. Since the participation rate and the variation of GDP per capita for those participating countries are high, the entry to take TIMSS is exogenous. From 1981 to 2003, 62 countries took part in TIMSS at least once.

In IEA studies, the target populations for all countries are known as the international desired population. The international desired population is categorized to population 1, for 9 years old or 4th grade, and population 2, for 13 years old or 8th grade. TIMSS expects all participating countries to define their national desired populations to correspond as closely as possible to its definition of the international desired populations. TIMSS participants are expected to ensure that the national defined populations include at least 95 percent of the national desired populations. The TIMSS standard for sampling precision requires a minimum of 4,000 students for each target population.

Under this sampling design, TIMSS test scores are simple random samples and they provide unbiased estimates for the entire population. TIMSS test scores represent students' cognitive skill. Translation for the TIMSS data collection instruments are provided in English and translated into 34 languages. Language of testing also does not matter.

4.3 Measurement Issues

Skilled labor share is obtained by the ratio of skilled labor force in employment to total employment. This specification is based upon the assumption that all the workers have identical productivity. There are some missing parts. Skill differences do not entirely rely on either number of workers or man-hours to characterize labor input. Pure quantity of schooling, while important, is a crude measure of skill differences. Endowment of cognitive skills of skilled workers is better proxy for the skill differences. But there is a data shortcoming. I use the international test scores as a proxy for the average labor force quality in a country. I expect that cognitive skill differences between home and host country are a better proxy than skilled labor ratio differences.

4.4 Unbalanced panel data

Real foreign affiliate sales of parent country i in host country j data is an unbalanced panel. Home countries that do not have the foreign affiliate sales (FAS) data in the USA may have corresponding USA affiliate sales data in the home country. In these cases, number of observations of parent country i real FAS data in host country j is not same as the number of observations of real FAS of country j in country i. The regression of real FAS total of county i in country j on the independent variables includes some cases that only have one way data even though the regression focuses on the bilateral response. To solve this problem, I exclude the real FAS total data if there is only real USA FAS data in the host country but not the corresponding real FAS data of that country as a parent in the USA. I call this the unbalanced data. With the exclusion of the unbalanced data, total number of observations is 128 in 25 countries. Excluding the unbalanced data weakens the effects of all independent variables on real FAS. The results are not reported here. Another way to solve this problem is to replace real FAS total data which do not have parent country affiliates sales in the USA with zeros and use a Tobit regression specification to handle a censored regression. Doing this brings the pairs of the included countries into balance and extends the data set. These data have the same number of real FAS of i in j and real FAS of j in i. There is an even number of observations in the Tobit regression. The Tobit regression results are included in all tables.

[TABLE 3 HERE]

4.5 Random effects or fixed effects

I perform Hausman's (1978) specification test in the basic quality adjusted model of column (2) in Table 3. I reject the null hypothesis that there is no systematic difference between fixed-effect estimates and random-effect estimates. Therefore I choose the fixed effect estimator which is a consistent estimator in both null and alternative hypotheses.

Quality difference data which range from -252 to 252 are measured as a home country international comparative test score minus a host county test score and have some variation within country over time. The standard deviation of quality difference data is 66 from the mean overall and 34.3 from the within variation over time. Compared with skill difference at which within variation is about 1/3 of overall variation, the quality difference within variation is relatively higher. Except the USA I use dummy variables for recipient (Host) countries when the USA is parent (Home) country and parent countries when the USA is host country to control for all the fixed effects that do not change over time within a country. In Tables 3 and 4, each equation contains such dummy variables. I include dummy variables for only host countries in column (1). There may exist fixed effects in parent country also. Thus, I contain all dummy variables for home countries and host countries in (2). Columns (3) and (4) are robust regressions of (1) and (2). Coefficients of GDP sum and GDP difference squared are statistically significant and consistent with the predictions of the KK model in Table 3. The sign of the skill difference coefficient is changing with respect to the inclusion of parent country dummy variables. When I control for parent country fixed effects in addition to host country, the sign of skill difference changes from positive to negative. The skill difference coefficient is statistically insignificant except in the robust OLS regression (4). The interaction between GDP difference and skill difference is negative and significant under the robust regression specification. The coefficient of quality difference is negative and significant at the 5% significance level in column (2) and it becomes even stronger and significant compared with the coefficient value obtained in (1) at which the parent country dummy variable is excluded. The interaction between the GDP difference and the quality difference is positive and insignificant in (2) and (4). The coefficient of investment cost host is insignificant and positive in (1) and (2). The host country's trade cost is negative and significant in (2) when all parent and host country dummy variables are included. The interaction between the host country's trade cost and the squared quality difference is negative and insignificant but it is changed to positive significant in (3).

[TABLE 4 HERE]

In Table 4, I conduct the fixed effect estimation with WLS and Tobit specifications. GDP sum and GDP difference squared are statistically significant and the signs are consistent with the prediction of the KK model. GDP difference becomes negative and significant in the Tobit regression of columns (3) and (4). Skill difference is positive and significant at the 1% level in WLS in column (2). The Interaction between the GDP difference and the skill difference is negative and statistically significant except in column (1) and this effect is even stronger when parent and host country dummy variables are included. Quality difference is negative and statistically significant at the 1% level in columns (2) and (4). This effect is stronger compared with (1) and (3). The interaction between the GDP difference and the quality difference is positive and significant at the 10% level in column (2). The coefficient of investment cost of the host is positive over all specifications and statistically significant in WLS. The signs of trade cost host and investment cost host are opposite to the KK model. The interaction between trade cost host and squared skill difference are negative and statistically significant at the 10% level in (2). The interaction between trade cost into host country and squared quality difference is positive but insignificant in (2). When the parent country dummy variables are included, the sign of coefficient in the parent country's trade cost changes from negative to positive. I choose the results in columns (2) and (4) from Table 4 to interpret the independent role of quality differences in FDI because they are heteroskedasticity corrected results and obtained from the censored normal regression model even after accounting for fixed-effects. I also conduct the fixed effect estimation of Carr et al. model for OLS, WLS and Tobit. The results are similar and not reported here.

4.6 Modified sample

[TABLE 5 HERE]

I substitute the skilled labor ratio in the sample with the average years of schooling obtained by the average person in each country and construct the quantity difference instead of the skill difference. I call this the modified sample. Barro and Lee (2000) upgrade the educational attainment data that is calculated from 20 years old up to 65 by including young age worker from 15 years old. In developing countries young high school graduates or high school drop outs start work when they are 15 years old. This is a good proxy for the stock variable of the quantity of human capital. This can be a counterpart of the quality of human capital and educational achievement. I use block year data in 1985-1989, 1990-1994, 1995-1999 and 2000-2004. The average years of schooling data from 2000 to 2004 are an estimation. I conduct regressions with modified sample for all Tables (1) to (4) and get similar results. In Table 5, I only report the results of fixed effect estimation of WLS and Tobit with modified sample. The coefficient of quantity difference is positive in all columns and significant at the 10% level in (3). When parent and host country dummy variables are included, the interaction between GDP difference and quantity of human capital endowment difference are positive and significant at the 5% level in column (4). The fixed-effect estimates of the quality difference are negative and statistically significant at the 1% level if I include parent and host country dummy variables in column (4) and they are consistently negative in all columns. The interaction between GDP difference and quality difference is positive when controlling for all country dummy variables in columns (2) and (4). The interaction between the trade cost to host country and squared quality difference are positive in WLS. In short, the magnitude and signs of quality difference in the fixed effect estimations are similar compared with the results in Table 4.

4.7 Inclusion of GDP differences

[TABLE 6 HERE]

In Table 1, I get the result that GDP difference is statistically significant and positive. I conduct the regression of Table 1 in the exclusion of GDP difference variable and find that excluding the GDP difference in the estimation equation generates the omitted variable bias. In Table D, the correlation between GDP difference and Skill difference is 52.4% but the correlation between GDP difference and quality difference is -6.46%. If I exclude the GDP difference variable then Skill difference has a positive bias and quality difference has a negative bias. Since the correlation between GDP difference and skill difference is high, the size of the bias in skill difference is high. This result is not reported here. Because of the positive and negative bias associated with the skill differences and quality differences, I prefer the estimations which include GDP difference to those which exclude it. In Table 6, I estimate equation (2) excluding GDP Difference variable from Table 4. Main differences between including GDP difference and excluding it in the fixed effect estimation of quality adjusted model are the relative changes in the effects of skill difference and quality difference on the real FAS. Excluding GDP difference in Table 6 increases the coefficient of skill difference in Tobit. But it decreases the coefficients of quality difference in Tobit. Though there is negative bias in quality difference in (3) and (4), the expected sign and significance of quality difference are very similar to the results shown in Table 4.

5. Interpretation of the Coefficients

Since the KK model is nonlinear, I analyze partial derivatives here and interpret the findings. In doing so, I choose the coefficients from columns (2) and (4) in Table 4 and use the average values of the variables in the entire data set.

5.1 Impact of Host-Country Trade Costs

Partial derivative: (∂Sales/∂Trade cost host)

= B9 + B10 (squared skill difference) + B11 (Squared quality difference)

= -1772.3 -28,658.8*(squared skill difference) + 0.009*(Squared quality difference) < 0 iff quality difference < 477.7 (WLS).

= -453.9 -127.1*(squared skill difference) -0.005* (Squared quality difference) < 0 (Tobit).

Quality difference is between -251.9 and 251.9. For all levels of quality differences, as the host country's trade costs increase the real FAS decreases. If the squared skill difference is zero and the host country's trade costs increase, the real FAS decreases for all level of quality differences. Given the identical skill endowment in home and host country, an increase in quality difference can offset the effect of host country's trade costs (WLS). Given squared quality difference is zero, as the host country's trade costs increase, the real FAS decreases for all levels of skill difference.

Result 1: As host country's trade costs increase home country affiliate sales in host country increase only if there is an increase in quality difference when skill endowment in home and host country are identical.

5.2 Impact of Bilateral Trade Costs

Partial derivative: (∂Sales/∂Trade cost)

= B9+B10(squared skill difference)+B11(Squared quality difference)+B12

= -1772.3 -28,658.8*(squared skill difference) + 0.009*(Squared quality difference) +661< 0 iff quality difference < 393.4 (WLS). For all level of quality differences, as bilateral trade costs increase the real FAS decreases.

= -453.9 -127.1*(squared skill difference) -0.005* (Squared quality difference) +399.1 < 0 (Tobit). For all level of quality differences, as bilateral trade costs increase the real FAS decreases.

Result 2: When bilateral trade costs increase, total affiliate sales decrease. Trade and investment are complements (Tobit). When bilateral trade costs increase, total affiliate sales increase only if quality difference increases and skill endowment in home and host country is identical. Trade and *investment are substitutes (WLS).*

5.3 Impact of Difference in GDP

Partial derivative: (∂Sales/∂GDP diff)

= B2 +2*B3*(GDP difference) +B5(skill difference) +B7(quality difference)

= 0.1-0.002* 2*(GDP difference) -26.8*(skill difference)+0.03*(quality difference) (WLS).

= -1.756-0.001*2*(GDP difference)-6.755*(skill difference)+0.003*(quality difference) (Tobit).

At the average value of skill difference and quality difference, if GDP difference < -76.8 then the real FAS increase. If GDP difference = -76.8 then the real FAS are maximized. If GDP difference > -76.8 then the real FAS decrease. GDP difference is between -9304 and 9349. It is slightly skewed to the left (76 out of 9304 is 0.8%). If skill difference = 0 and quality difference = 0 then the real FAS increase when GDP difference is less than 30.5. The real FAS volume is maximized when GDP difference is 30.5 and the real FAS decrease if GDP difference is greater than 30.5. When two countries' skill and quality endowment are identical, real FAS will be maximized if home country GDP is 0.3% greater than host country GDP.

In the Tobit regression specification, the optimal level of GDP difference to maximize the real FAS total is skewed to the left side when I use the average level of skill difference and quality difference. As GDP difference is less than -878, an increase in GDP difference increases the real FAS total. The real FAS total is maximized when GDP difference is -878 and decreases as GDP difference is greater than -878.

If a country is small (GDP difference < 0) and skilled labor scare (Skill difference < 0) and quality abundant (Quality difference > 0), then an increase in GDP difference will increase its FAS (WLS and Tobit). In the data set, there are 29 observations in 15 countries that meet these conditions.[9]

Result 3: As a country i converge to the income (GDP) in the USA, it will increase the level of affiliate sales in both direction conditional on a parent country quality endowment is abundant and parent country skilled labor is scarce.[10]

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[9] Australia, Austria, Belgium, Denmark, France, Germany, Hong Kong, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Singapore, Switzerland.

[10] An increase in the difference variables (GDPDIFF, SKDIFF, QDIFF) is not necessarily a convergence or divergence, it just depends because the signs of those variables change depending on whether the home or host country is bigger, etc. This is what Blonigen et al. (2003) point out.

5.4 Impact of Difference in Skill Endowment

Holding quality difference constant, I obtain the following partial derivatives

(∂Sales/∂Skill difference)

= B4 +B5*(GDP difference) +B10*2*(trade cost host)*(Skill difference) = 172205-26.8*(GDP difference)-28658.8*2*(trade cost host)*(Skill difference) (WLS).

= B4 +B5*(GDP difference)+B10*2*(trade cost host)*(Skill difference) = -7917-6.8*(GDP difference)-127.1*2*(trade cost host)*(Skill difference) (Tobit).

If two countries are similar in size (GDP diff = 0) and skill endowment (Skill difference = 0), then an increase in the skill endowment abundance of home country relative to host country increases total FAS of home country in host country (WLS). The effects will be decreased as the skill difference increases more (Skill difference > 0) and GDP difference is larger (GDP diff > 0). Put differently, an increase in the host country skill endowment (Δskill diff < 0) will increase real FAS of country i in country j if parent country is large (GDP difference > 0) and parent country is skilled labor abundant (Skill difference > 0). At the average values of the variables, (∂Sales/∂Skill difference) = 128826.6 (WLS) and (∂Sales/∂Skill difference)= -15173.8 (Tobit). As skill endowment in home country increases, total FAS of home country in host country increases (WLS). In Tobit specification, for all level of skill endowment in the data set, an increase in skill difference decreases the real FAS of home country in host country.

5.5 Impact of Difference in Quality Endowment

Holding skill difference constant, I obtain the following partial derivatives

(∂Sales/∂Quality difference)

= B6 +B7*(GDP difference) +B11*2*(trade cost host)*(Quality difference)

= -232.1 +0.028*(GDP difference) +0.009*2*(trade cost host)*(quality difference) < 0 iff
quality difference < 426.5 (WLS).

= B6 +B7*(GDP difference)+B11*2*(trade cost host)*(Quality difference)

= -76.1+0.003*(GDP difference)-0.005*2*(trade cost host)*(quality difference) < 0 iff
quality difference > -276.6 (Tobit).

If two countries are similar in size (GDP diff = 0) and quality endowment (quality difference = 0) then an increase in the host country quality endowment (Δquality difference < 0) will increase the real FAS of country i in country j. This empirical evidence supports the idea that the quality of human capital influences horizontal foreign direct investment. At the average values of GDP difference (= 1064.6 million $), trade cost host (= 26.4) and all levels of quality difference, as host country quality endowment increase the real FAS of home country in host country increases. Thus, if host country is small (GDP difference > 0) and quality of human capital abundant (quality difference < 0) then a small host country can overcome the relative scarcity of skilled labor by increasing quality of human capital to attract foreign affiliate sales. (WLS, Tobit).

This effect will be weakened as the quality difference increases more (quality difference > 0) if parent country is small (GDP difference < 0) and trade cost to host country is large (trade cost host > 0). In other terms, an increase in the parent country quality endowment (Δquality difference > 0) will increase the real FAS of country i in country j if home country is small (GDP difference < 0), trade cost to host is large (trade cost host > 0) and quality of human capital abundant (quality difference > 0) (WLS).

At the mean of quality difference (= -1.42) and GDP difference, trade cost host, I get (∂Sales/∂Quality difference) = -203 in WLS and (∂Sales/∂Quality difference) = -72.5 in Tobit specification. Ceteris paribus, an increase in the host country quality endowment by one standard deviation of quality difference (66.1) (Δquality difference < 0) will increase the real FAS of home county in host country by $13.4 billion which is 49% relative to average FDI flows per country (WLS).[11]

There are 59 observations in 20 host countries in the data set at which the host country has greater quality endowments and smaller country sizes than the USA.[12] The 20 countries satisfy the following result 4. These host countries have high enough quality endowment relative to the USA to attract US affiliate sales in those countries.

Result 4: If the USA is a parent country then an increase in host country quality endowment will increase the US real affiliate sales in host country (WLS, Tobit).

There are 45 observations in 20 parent countries in the data set at which the parent country has greater quality endowments and smaller country size (GDP) than the USA. But no parent country has high enough quality endowment or trade cost to host country to increase the FAS in the host county.

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[11] (∂Sales/∂Quality difference)= -203. ΔQuality difference=-66.05. Δ Sales =(203*66.05)=13408.15.

[12] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Singapore, Sweden , Switzerland, United Kingdom.

6. Conclusion

Based upon the estimation results, the quality-adjusted KK model suggests that quality of human capital should be taken into account. I find that the role of quality of human capital is statistically significant in the KK model of MNE. Using panel data covering 32 countries and the period between 1985 and 2004, I find that a small host country can overcome the relative scarcity of skilled labor by increasing quality of human capital to attract foreign affiliate sales or to increase outward FDI. I also find empirical evidence in support of the idea that the quality of human capital influences horizontal foreign direct investment, even after accounting for the roles of skill and factor endowments, trade costs, investment cost and country-size and income effects. Ceteris paribus, an increase in the host country quality of human capital by one standard deviation of quality difference increases FDI flows from home country to host country by $13.4 billion which is 49% relative to average FDI flows per country. Accounting for quality of educational attainment and quantity of skilled labor abundance strengthens both horizontal and vertical FDI to rise endogenously.

Predications come from the KK model and the stylized facts of quality differences between countries over time. A new model that embeds quality endowment of human capital into the KK model will enhance the identification of the determinants of FDI. Further research can embed the quality-adjusted KK model in a general equilibrium setting.

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Table A: The International Student Achievement Tests[13]

	Abbr.	Study	Year	Subject	Age	Countries
1	FIMS	First International Mathematics Study	1963-1967, 1964(C)	Math	13, FS	11
2	FISS	First International Science Study	1968-1972, 1970-1971(C)	Science	10, 14, FS	11, 12, 12
3	SIMS	Second International Mathematics Study	1977-1981	Math	13, FS	17, 12
4	SISS	Second International Science Study	1982-1986, 1983-1984(C)	Science	10, 14, FS	15, 17, 13
5	TIMSS	Third International Mathematics and Science Study	1993-1997, 1994-1995(C)	Math/Science	9(3+4), 13(7+8), FS	24, 38, 21
6	TIMSS-Repeat	TIMSS-Repeat	1997-2001, 1998-1999(C)	Math/Science	14(8)	38
7	PISA 2000/02	Programme for International Student Assessment	2000	Math/Science	15	31
8	TIMSS 2003	Trends in International Mathematics and Science Study	2001-2004, 2002-2003(C)	Math/Science	9(4), 13(8)	25, 46
9	PISA 2003	Programme for International Student Assessment	2003	Math/Science	15	40

[13] In the age column, FS stands for Final years in secondary education. Year (C) indicates the collected year. This table uses the information in Hanushek and Woessmann (2007).

Table B. Summary statistics (basic sample; N=165, n=59, T=2.8)

Variable		Mean	Std. Dev.	Min	Max
Realsaletot	O	27035	37554	57	163579
GDP sum	O	8442	1597	5385	13202
GDP Difference	O	1065	7367	-9304	9349
GDP difference squared	O	55076784	22292396	6710249	87410736
Skill Difference	O	0.017	0.098	-0.208	0.208
	B		0.104	-0.191	0.194
	W		0.034	-0.087	0.120
Skill Difference Squared	O	0.010	0.012	0.0000002	0.043
	B		0.012	0.0001	0.038
	W		0.004	-0.010	0.022
Quality Difference	O	-1.42	66.05	-251.87	251.87
	B		73.96	-251.87	187.61
	W		34.28	-169.58	105.04
Quality Difference Squared	O	4338	9390	0.0001	63438
	B		11074	0.01	63438
	W		5379	-19774	41618
Quantity Difference	O	0.62	3.30	-7.17	7.17
	B		3.79	-7.17	7.17
	W		0.38	-0.54	2.99
Quantity Difference Squared	O	11.20	11.80	0.005	51.34
	B		14.10	0.04	51.34
	W		1.99	5.08	21.03
Investment Cost Host	O	29.60	8.34	17.72	57.24
Trade Cost Host	O	26.36	9.34	9.84	66.74
Trade Cost Parent	O	25.67	7.88	9.84	54.73
distance	O	8455	3998	734	15958

N: Total number of observations. n: Average number of between country (cross country) observations
T: Average number of within country observation (time period).
O: overall, B:between, W:within

Table D. Correlation Matrix (basic sample; N=165)

	rsaletot	gdpsum	gdpdiff	gdpdifsq	skdiff	skdifsq	qlodiff	qlodifsq	tyrdiff	tyrdifsq	invcj	tcj	tci	dist
Real Sales Total	1													
GDP sum	0.408	1												
GDP Difference	-0.006	-0.121	1											
GDP Diffference Squared	-0.229	0.456	-0.039	1										
Skill Difference	-0.121	-0.120	0.524	-0.020	1									
Skill Difference Squared	-0.151	0.142	0.094	-0.038	0.224	1								
Quality Difference	0.055	0.144	-0.065	0.128	0.015	0.076	1							
Quality Difference Squared	-0.169	-0.063	0.023	0.002	0.071	0.313	-0.132	1						
Quantity Difference	-0.042	-0.160	0.835	-0.060	0.657	0.143	0.021	0.070	1					
Quantity Difference Squared	-0.163	0.014	0.098	0.083	0.168	0.280	0.079	0.408	0.234	1				
Investment Cost Host	-0.116	-0.132	0.511	-0.121	0.514	0.352	0.169	0.060	0.559	0.283	1			
Trade Cost Host	-0.079	-0.265	0.064	-0.451	0.311	0.334	0.089	0.161	0.113	0.066	0.511	1		
Trade Cost Parent	0.040	-0.257	0.043	-0.520	-0.220	0.310	-0.084	0.201	-0.005	0.038	0.042	0.223	1	
distance	-0.367	-0.071	0.014	0.023	0.037	0.206	-0.088	0.215	0.020	0.105	-0.078	0.036	-0.006	1

Table E. Countries (basic sample, number of countries = 32)

Frequency (frequency of the participation in the ISAT)											
1	Colombia	Turkey									
2	Brazil	Greece	Israel	Malaysia	Mexico	Philippines	Portugal				
3	Cyprus	South Africa									
4	Finland	Ireland	Spain								
6	Austria	Belgium	Denmark	Germany	Italy	Switzerland					
7	Korea										
8	Australia	Canada	France	Hong Kong	Japan	Netherlands	New Zealand	Norway	Singapore	Sweden	United Kingdom

Table1- Replication for CMM Model of Real Sales Volume of Affiliates in the Inclusion of GDP Difference: WLS

Variable	WLS
GDP sum	9.305*** (1.609)
GDP difference	1.122** (0.530)
GDP difference squared	-0.001*** (0.000)
Skill Difference	-120,849.738** (48,879.096)
GDP difference* Skill Difference	-7.284 (7.537)
Investment Cost Host	-200.906 (595.182)
Trade Cost Host	-1,421.571*** (523.014)
Trade Cost Host* SquaredSkillDifference	30,311.415*** (11,110.936)
Trade Cost Parent	-100.738 (576.778)
distance	-8.808*** (0.962)
Intercept	105,890.381** (40,710.131)
Observations	165
Adjusted R-squared	0.53

Standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table2- Basic Results of Real Sales Volume of Affiliates with Quality of Human Capital:OLS, WLS and Tobit

Variable	(1) OLS	(2) Robust OLS	(3) WLS	(4) Tobit
GDP sum	14.570*** (1.628)	20.733*** (0.774)	9.130*** (1.547)	13.535*** (12.18)
GDP difference	0.785** (0.388)	0.300 (0.185)	1.301** (0.527)	0.840*** (3.00)
GDP difference squared	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (6.94)
Skill Difference	-9175.763 (29,987.338)	24,016.387* (14,257.670)	-70243.628 (47,730.955)	10452.847 (0.52)
GDP difference* Skill Difference	-7.185 (5.472)	-4.755* (2.602)	-8.915 (7.659)	-5.067 (1.30)
Quality Difference	29.082 (32.950)	0.407 (15.666)	153.661*** (44.204)	17.163 (0.76)
GDPdifference*Quality Difference	0.006 (0.006)	0.001 (0.003)	0.015 (0.010)	-0.000 (0.11)
Investment Cost Host	-550.873 (391.169)	-77.287 (185.984)	-735.230 (585.289)	-378.669 (1.31)
Trade Cost Host	-88.708 (378.469)	-130.129 (179.946)	-1,379.038*** (495.402)	68.827 (0.25)
Trade Cost Host* SquaredSkillDifference	-6134.026 (9,117.025)	-3912.206 (4,334.748)	14844.815 (11,562.343)	-9244.761 (1.45)
Trade Cost Host* SquaredQualityDifference	-0.003 (0.010)	0.006 (0.005)	0.007 (0.014)	0.002 (0.31)
Trade Cost Parent	-242.931 (368.415)	-187.604 (175.165)	-423.398 (558.474)	-157.839 (0.68)
distance	-2.519*** (0.565)	-0.133 (0.269)	-8.124*** (0.989)	-1.742*** (4.39)
Intercept	10175.876 (27,359.790)	-60,391.528*** (13,008.386)	146,908.914*** (39,506.500)	-26338.676 (1.45)
Observations	165	165	165	200
Adjusted R-squared	0.51	0.87	0.55	
Log Likelihood				-1930.80

Standard errors in parentheses in OLS and WLS. In Tobit, Absolute value of z statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table3- Fixed Effect Estimation of Quality Adjusted Model: OLS, Robust OLS

	OLS		Robust OLS	
	(1)	(2)	(3)	(4)
Variable	Host country only	Home and Host country	Host country only	Home and Host country
GDP sum	18.831*** (1.795)	24.292*** (3.201)	19.070*** (0.537)	7.160*** (0.293)
GDP difference	1.155 (1.647)	-1.148 (1.389)	0.714 (0.493)	0.014 (0.127)
GDP difference squared	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.0004*** (0.000)
Skill Difference	67,791.82 (40,955.888)	-2,925.06 (38,801.722)	6,145.64 (12,249.490)	-8,175.256** (3,557.376)
GDP difference* Skill Difference	-7.297 (5.265)	-7.354 (5.058)	-5.297*** (1.575)	-1.700*** (0.464)
Quality Difference	-82.859* (42.920)	-96.495** (39.842)	13.362 (12.837)	-4.767 (3.653)
GDPdifference*Quality Difference	-0.001 (0.005)	0.003 (0.006)	0.002 (0.002)	0.001 (0.001)
Investment Cost Host	618.657 (694.570)	485.081 (481.346)	-22.334 (207.739)	-24.777 (44.130)
Trade Cost Host	-534.928 (429.059)	-550.268* (303.328)	40.109 (128.327)	-0.123 (27.809)
Trade Cost Host* SquaredSkillDifference	-487.644 (8,428.264)	-281.334 (6,733.862)	1,964.37 (2,520.808)	-948.268 (617.366)
Trade Cost Host* SquaredQualityDifference	-0.013 (0.010)	-0.011 (0.010)	0.005* (0.003)	-0.001 (0.001)
Trade Cost Parent	-93.497 (269.624)	639.523* (382.489)	-337.145*** (80.642)	-5.279 (35.067)
distance	-1.595*** (0.609)	2.229 (1.598)	-0.194 (0.182)	0.151 (0.147)
Intercept	-36,469.21 (31,830.256)	-163,424.528*** (42,268.551)	-54,650.813*** (9,520.106)	-29,238.907*** (3,875.218)
Observations	165	165	165	164
Adjusted R-squared	0.77	0.89	0.98	1

Standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table4- Fixed Effect Estimation of Quality Adjusted Model: WLS and Tobit

	WLS		Tobit	
	(1)	(2)	(3)	(4)
Variable	Host country only	Home and Host country	Host country only	Home and Host country
GDP sum	22.372*** (2.501)	32.215*** (3.520)	20.075*** (16.79)	24.090*** (10.45)
GDP difference	4.361 (3.197)	0.122 (2.188)	-1.341 (1.20)	-1.756* (1.90)
GDP difference squared	-0.001*** (0.000)	-0.002*** (0.000)	-0.001*** (10.89)	-0.001*** (6.32)
Skill Difference	219,456.992** (84,432.245)	172,204.673*** (58,090.859)	53,352.142* (1.74)	-7916.880 (0.29)
GDP difference* Skill Difference	0.805 (10.919)	-26.804*** (9.702)	-6.757* (1.69)	-6.755* (1.89)
Quality Difference	-223.978** (95.597)	-232.134*** (79.177)	-31.339 (1.02)	-76.096*** (2.81)
GDPdifference*Quality Difference	-0.014 (0.012)	0.028* (0.016)	-0.004 (1.00)	0.003 (0.83)
Investment Cost Host	2,902.136* (1,750.527)	2,993.654*** (1,085.238)	472.409 (0.89)	402.089 (1.16)
Trade Cost Host	-1467.952 (1,031.140)	-1,772.276*** (583.248)	-246.948 (0.77)	-453.862** (2.11)
Trade Cost Host* SquaredSkillDifference	6640.974 (16,119.058)	-28,658.798* (16,113.177)	-2228.872 (0.36)	-127.065 (0.03)
Trade Cost Host* SquaredQualityDifference	-0.005 (0.016)	0.009 (0.022)	-0.001 (0.13)	-0.005 (0.72)
Trade Cost Parent	-347.426 (296.880)	661.037 (495.374)	-189.222 (1.04)	399.084* (1.71)
distance	-1.764** (0.788)	6.300 (56.427)	-1.370*** (3.21)	2.080* (1.81)
Intercept	-60000.868 (65,557.079)	-256338.593 (879,948.114)	-82,036.750*** (3.76)	-161,189.620*** (5.58)
Observations	165	165	200	200
Adjusted R-squared	0.74	0.88		
Log Likelihood			-1841.52	-1745.15

Standard errors in parentheses in WLS. In Tobit, Absolute value of z statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table5 - Fixed Effect Estimation of Quality Adjusted Model with Modified sample: WLS and Tobit

	WLS		Tobit	
	(1)	(2)	(3)	(4)
Variable	Host country only	Home and Host country	Host country only	Home and Host country
GDP sum	21.637***	27.840***	19.170***	22.038***
	(2.400)	(3.415)	(16.59)	(10.44)
GDP difference	6.336*	-2.941	-0.55	-1.600*
	(3.220)	(2.806)	(0.49)	(1.81)
GDP difference squared	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(11.28)	(6.53)
Quantity Difference	6,640.81	6,857.41	3,537.507*	438.584
	(9,308.980)	(13,017.959)	(1.76)	(0.20)
GDP difference* Quantity Difference	0.575	0.554	0.236	0.560**
	(1.012)	(1.219)	(0.91)	(2.19)
Quality Difference	-331.635**	-112.777	-46.364	-78.579***
	(132.561)	(100.205)	(1.42)	(2.89)
GDPdifference*Quality Difference	-0.033*	0.027	-0.003	0.003
	(0.017)	(0.018)	(0.84)	(0.69)
Investment Cost Host	8.535	2,374.353*	95.037	473.734
	(1,583.330)	(1,269.527)	(0.19)	(1.42)
Trade Cost Host	-576.607	-1,343.760*	0.494	-348.721
	(888.709)	(724.074)	(0.00)	(1.62)
Trade Cost Host* SquaredQuantityDifference	-22.585	20.554	-14.736	0.58
	(24.895)	(47.125)	(1.59)	(0.07)
Trade Cost Host* SquaredQualityDifference	0.007	0.04	-0.003	-0.004
	(0.018)	(0.026)	(0.34)	(0.62)
Trade Cost Parent	-635.921**	1,264.263***	-519.360***	592.670***
	(320.467)	(459.922)	(3.24)	(2.65)
distance	-2.271***	4.368	-1.704***	10.588**
	(0.716)	(9.093)	(4.21)	(2.03)
Intercept	23,767.45	-299,004.122*	-48,948.463**	-291,043.186***
	(62,902.790)	(169,442.347)	(2.33)	(3.78)
Observations	167	167	202	202
Adjusted R-squared	0.71	0.85		
Log Likelihood			-1863.52	-1764.35

Standard errors in parentheses in WLS. In Tobit, Absolute value of z statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table6- Fixed Effect Estimation of Quality Adjusted Model in the Exclusion of GDP Difference: WLS and Tobit

	WLS		Tobit	
	(1)	(2)	(3)	(4)
Variable	Host country only	Home and Host country	Host country only	Home and Host country
GDP sum	24.482***	30.449***	19.715***	23.983***
	(2.798)	(3.528)	(17.26)	(10.37)
GDP difference squared	-0.002***	-0.002***	-0.001***	-0.001***
	(0.000)	(0.000)	(11.52)	(6.49)
Skill Difference	206,355.830**	164,758.076***	69,855.872**	24,172.96
	(84,282.574)	(49,182.901)	(2.55)	(1.10)
GDP difference* Skill Difference	-1.928	-22.139**	-5.202	-7.332**
	(10.929)	(9.471)	(1.37)	(2.06)
Quality Difference	-135.956	-251.337***	-46.624*	-99.984***
	(97.734)	(55.341)	(1.66)	(4.16)
GDPdifference*Quality Difference	-0.005	0.025*	-0.004	0.004
	(0.013)	(0.015)	(1.15)	(0.93)
Investment Cost Host	4,297.522**	2,836.558***	419.791	390.969
	(1,857.633)	(1,019.489)	(0.79)	(1.12)
Trade Cost Host	-1,870.877*	-1,654.439***	-187.887	-404.145*
	(1,125.272)	(568.904)	(0.60)	(1.89)
Trade Cost Host* SquaredSkillDifference	8,090.60	-24,399.167*	-1,565.76	-1,160.77
	(17,547.426)	(14,571.944)	(0.26)	(0.24)
Trade Cost Host* SquaredQualityDifference	0.005	0.007	-0.001	-0.007
	(0.017)	(0.020)	(0.20)	(1.08)
Trade Cost Parent	-549.175*	755.113	-189.557	294.761
	(300.308)	(482.015)	(1.05)	(1.31)
distance	-2.130***	7.751	-1.327***	2.089*
	(0.801)	(43.344)	(3.14)	(1.81)
Intercept	-111,292.96	-265,667.32	-72,358.239***	-134,539.740***
	(71,702.654)	(676,184.935)	(3.60)	(5.39)
Observations	165	165	200	200
Adjusted R-squared	0.75	0.88		
Log Likelihood			-1842.24	-1747

Standard errors in parentheses in WLS. In Tobit, Absolute value of z statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix 1

A. Methodology of the data set

Originally there are 26 raw test series. I follow the normalization method of Hanushek and Kimko (2000). The normalization method in detail is following. First step, I convert each test series to the mean of 500 by multiplying 500/(mean of the test). This is based on the assumption of random sampling such that each country is assumed to be randomly drawn and take the test. Each country's test score at a given time period is normally distributed within the test series. The random sampling assumption is problematic, because the mean of the each test does not vary over time, and the score of the different time period can not be comparable. It only tell us how the ranking of the country's test score is changing but the magnitude of the change in the each country test score can not be accounted. Second step, I use the NAEP USA data to solve this problem. I use the NAEP USA test score to drift the mean of the each test score. USA NAEP score can be keyed to the international test score of the USA because NAEP USA test score has used absolute measure to compare how USA math and science cognitive skills change over time. I use the relation between USA ISAT score and NAEP score. I match the data between USA ISAT score and NAEP score by comparing closest time, age group and subtest. By doing so, I get the drift and apply this drift to the mean of the each test series. In short, I construct a normalized score and let the mean of each test drift according to the relative drift of the USA ISAT score with respect to NAEP score The First International Mathematics Study (FIMS) in 1963 and 1964 does not have NAEP comparison, because FIMS is predated in NAEP. I substitute the FIMS test for NAEP in 1963 and 1964. The NAEP adjustment process helps us to account different level of quality over different test. Third step, transforming raw test score by following the first and second steps, I finally use the standard error of each country test score to combine different subtests (math and science) over the same age group in a given period of time. I use weighted averages. Weight is a reciprocal of standard deviation of each country test score in a given test series. I call the data built by applying 1st and 3rd step without conducting 2nd step Quality of Labor force 1(QL1). I call the data obtained by taking 1st, 2nd and 3rd steps Quality of Labor force 2(QL2).

B. Construction of quality stock variable

Hanushek and Kimko (2000) point out the problem of using ITS as a proxy for the labor force quality. By combining all the different test series together, they construct one integrated measure to explain cross country variations of economic growth. But using panel quality data may not be a good proxy for the entire labor force, because labor force quality is a stock variable and it contains all different level of age groups as well as heterogeneity of labor quality within the same age group. To solve this problem, I match the test score data with the educational attainment of labor force by adjusting time lags of test scores, because the achievement change in the observed test performance of current students affect the future labor force quality.

Barro and Lee (2000) construct the data on the average years of schooling achieved by the average person at the various levels and of all levels of schooling combined. Measures of schooling years are obtained by combining the data on the distribution of educational attainment among adult population with the average duration of school at each level. It is a stock variable. The data on the distribution of educational attainment among adult population is the fraction of the adult population for whom the highest level of attainment fell into the seven classifications such as no schooling, primary school attained, primary school complete, secondary school attained, secondary school complete, higher school attained, and higher school complete.

Following the perpetual inventory method, Barro and Lee (2000) construct current flows of adult population that are added to the benchmark stocks of schooling attainment. I use this schooling attainment stock variable to convert the quality flow to the quality stock variable. Since schooling attainment data is the fraction of the adult population who get the certain level of education, I adjust the quality of different levels of education to the schooling quality of the entire population who already finished up to the specific level of education. I multiply the quality of specific level of education to the fraction of adult labor force population who finished at the very level of education. Thus, it can be used as a stock of the schooling quality at each education level.

Let fij be the fraction of the adult population who has finished the jth level of education in country i. Let qij be the quality of the jth level of education in country i. The proxy for qij is the weighted averages of math and science test score at the jth level in a given year for country i. Then Qij, the stock variable for schooling quality, is obtained by

$$\mathrm{Q}_{\mathrm{ij}} = \mathrm{f}_{\mathrm{ij}} * q_{ij} \qquad \text{for } i = 1,\ldots,142,\ j = 1,2,4,6.$$

i is the countries who have the ISAT score and j is the seven classifications such as no schooling(1), primary school attained(2), primary school complete(3), secondary school attained(4), secondary school complete(5), higher school attained(6), and higher school complete(7). Schooling complete level (fi3, fi5, fi7) is the subset of the some schooling attained level (fi2, fi4, fi6). Thus, Out of 7 different levels, I use 3 levels of quality data, qi2, qi4, qi6 to match with fi2, fi4, fi6. For the no school level fi1, qi1, I assume that those who have no schooling (1) have same lowest level of quality across countries.

I set the scale of Qij from 0 to 1000 and normalize the quality of the no schooling level (1) to 100 out of 1000. That means the quality of the no schooling is equal to 100 out of 1000. I assume that changes in the quality of schooling at primary level today will apply to new entrants in the population over age 15 in 10 years later, while the changes at secondary level become effective for the population over age 15 in 5 years. That is, I give 10 year lag for the international test score at primary level, 5 year lag for the international test score at secondary level, and no lag for secondary graduation level. I use the 4^{th} grade international test score as a proxy for the primary school quality, the 9^{th} grade international test score as a proxy for the secondary school quality, and the 12^{th} grade international test score as a proxy for the higher education quality. There are some missing quality data for primary, secondary and higher education level. I make weighted average for missing data for primary, secondary and higher education level from 1964 to 2003. I use this 40 years period combined data as a proxy for missing data for three different levels. All countries have a combined data for secondary level but some countries do not have primary or higher education level data, so I do the cross country regression to predict missing data for primary and higher education data. I regress primary quality data on secondary level data and regress higher level on secondary quality level. This interpolation may cause a bias. But matching quality and educational attainment with missing data also generate a bias. Fraction of adult population who has some primary education is relatively high compared with the fraction of some secondary school attained. The fraction of adult population gets smaller along with the increase in the education attainment. If some level of educational attainment is not taken into account, then the stock of quality will be fairly smaller than that of other countries who take into account all level of educational attainment. By using predicted quality level, I can alleviate this bias. But still there exists certain degree of bias.

After this data combination, I construct Qij, the quality stock variable. Each of Quality of labor force 3 (QL3) and Quality of labor force 4 (QL4) is educational attainment adjusted quality stock variable corresponding to QL1 and QL2.

The panel spans the year 1965 to 2004, and I divide it into eight sub periods: 1965-1969, 1970-1974, 1975-1979, 1980-1984, 1985-1989, 1990-1994, 1995-1999, 2000-2004. To combine the different levels of quality stock at country i in five year period, I use weighted averages in which Wijt is a reciprocal of standard deviation of quality at each level j divided by the sum of the reciprocal of standard deviation of quality at each level j in a given time t. I multiply the weight

Wijt with each quality stock Qijt and sum up for the different grade levels of quality stock at country i in five year period. If t stands for eight sub-periods, p goes from the beginning year to ending year in the sub-periods. For example, if t is sub-period 2 then the year variable, p, goes from 1970 to 1974. σ_{ijt} is the standard deviation of the international test score at level j in time period t for country i.

$$\text{Wijt} = \frac{\frac{1}{\sigma_{\text{ijt}}}}{\sum_{p}\sum_{j=1}^{6}\frac{1}{\sigma_{\text{ijp}}}} \qquad \text{for } i = 1,\ldots,142, \quad j = 1,2,4,6.$$

QL1 is the normalized ISAT scores, QL2 is NAEP drift adjusted ISAT and QL3 and QL4 are the corresponding stock adjusted test score of QL1 and QL2. QL1 and QL2 generate similar results. QL3 and QL4 generate similar results. But there are some differences between the results of QL1, QL2 and those of QL3, QL4. In my paper, I use the lagged QL1 to report the results. The results of QL2, QL3, and QL4 are not reported.