Technology Gap and International Knowledge Transfer: New Evidence from the Operations of Multinational Corporations[*]

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Abstract

Multinational corporations have long been recognized as both major creators of technology and as conduits of technology transfer. Technology transfer can happen directly, when the affiliate licenses the technology from the parent, or indirectly, when the affiliate imports intermediate goods with embodied technology. This paper estimates the effect of the affiliates' productivity relative to the frontier — the technology gap — on the choice of licensing the technology or importing it through intermediate goods. A novel measure of multinational technology transfer is employed using data on technology licensing payments versus imports from U.S. multinationals across many countries and industries. The main finding of this paper is that a large technology gap of an affiliate favors indirect knowledge transfer through imports. On average, a 10% increase in the technology gap decreases the share of licensing versus importing inputs embodying the technology by 5%. Considering that access to ideas and generation of new ones are crucial for long-run economic growth and convergence of a country, this study highlights the policy implications for countries to raise their productivity levels.

Keywords: Multinationals, technology transfer, productivity gap, intermediate inputs, royalties and license fees

JEL: F23, F1, O33, L24

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1 Introduction

There has been a significant increase in the levels of global trade in goods and services. Two components of this increase are noteworthy: currently, global trade in ideas is reaching annual levels of \$250 billion (World Development Indicators),[1] and trade in intermediate inputs comprises 57% of total trade in goods in OECD countries (Miroudot, Lanz and Ragoussis 2009).

The United States is a major seller of technology, accounting for around 50% of world royalties and license fee receipts (World Development Indicators), and trade in intermediate inputs in the U.S. accounts for half of total trade in goods (Miroudot et al. 2009). U.S. Multinational Corporations (MNC) are important conduits of technology transfer, with around two-thirds of royalties and license receipts coming from intra-firm transactions and approximately 60% of total trade within U.S. multinationals being trade in intermediate inputs (The U.S. Bureau of Economic Analysis).

A MNC can transfer its technology to foreign affiliates in *disembodied* form (know-how, industrial processes, computer software) or in *embodied* form (intermediate inputs). Flows of royalty and license receipts from affiliates to parents for the use of intangible technology is evidence of disembodied technology transfer, while exports of goods for further processing from parents to affiliates can indicate embodied technology transfer. It is well known that technology transfer is an important determinant of long-term cross-country income, economic growth and convergence of countries. However, the mode of technology transfer in embodied versus disembodied form has a differential impact not only on access to current knowledge and economic growth, but also on innovation, economic welfare, and convergence. The history of the soft drink "Fanta", which

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[1] Trade in disembodied ideas is measured by world receipts (or payments) of royalties and license fees.

was invented by the German affiliate of the Coca-Cola Company, offers one example. Possessing the recipe for Coca-Cola but lacking all the required ingredients due to a shortage in World War II-era Germany, Coca-Cola Deutschland invented this new soft drink by using the only available ingredients instead. In addition, the mode of technology transfer might also affect the degree of knowledge spillovers from multinational affiliates to domestic firms, which improves the productivity of the latter.[2]

What determines the mode of technology transfer within a MNC? This paper provides new evidence that the technology gap of U.S. MNC foreign affiliates, defined as their productivity compared to the productivity frontier, is associated with the decision of U.S. multinationals to export tangible goods versus intangible technology within the MNC. The example of Intel Corporation illustrates the hypothesis behind this paper. For 25 years, Intel Corporation has had plants in China where chips (intermediate goods) are shipped for assembly and testing. But in October 2010, the company announced the opening of a new wafer fabrication facility (fab) in China capable of using the blueprint to make the actual chips. At the same time, Intel announced the opening of a chip assembly factory in Vietnam (Takahashi 2010a; 2010b). One of the reasons why Chinese affiliates of Intel Corporation currently receive technology in the form of blueprints while Vietnamese affiliates receive technology in the form of intermediate goods might be that the former are currently closer to the productivity frontier, while the latter are farther from the frontier.

A panel data on the activities of U.S. multinationals in 45 host countries and across 7 manufacturing industries is employed to analyze the relationship between the affiliate's technology gap

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[2] See Keller (2010) for a survey of evidence on technology spillovers from international trade and foreign direct investment.

and the share of importing technology versus inputs. Focusing on the activities of U.S. MNCs is attractive as there is information on both the technology and input flows within firms. These data come from legally mandated benchmark surveys, conducted every five years by the Bureau of Economic Analysis (BEA), which enable the identification of U.S. parent-affiliate tangible and intangible technology transfers across FDI host countries and industries. The technology gap is measured as the deviation of the affiliate's labor productivity from the parent productivity in the same industry and year. The main finding of this paper is that the technology gap is negatively related to the share of disembodied versus embodied technology transfer, with a 10 percent increase in the technology gap on average decreasing the share of licensing versus importing inputs by 5 percent.

The significance of this paper stems from the realization that, based on industry patterns, MNCs tend to share know-how with country affiliates that are more productive, but export intermediate goods to the less productive ones. The fact that affiliates which are far from the frontier receive technology in the form of goods and not disembodied ideas, leads to policy implications that for developing less-productive countries the reduction in the technology gap would involve direct access to knowledge and ideas. This not only gives such countries access to current information, but also stimulates the creation of new knowledge which in itself is important for long-run economic growth and convergence.

The theory on multinational enterprises identifies horizontal and vertical directions for Foreign Direct Investment (FDI). Horizontal FDI arises when multinationals replicate their production in host countries to gain market access (Markusen 1984), whereas vertical FDI arises when different stages of production are fragmented to take advantage of differences in factor prices (Helpman 1984), intra-industry considerations (Alfaro and Charlton 2009), or international transaction costs (Keller and Yeaple 2012).[3] Country empirical studies have found that market sizes, country similarity, factor endowments, and barriers to trade are among the most important determinants of FDI, while country-industry studies find that these factors have a differential impact on FDI in various industries.[4]

This paper contributes to the growing body of literature on vertical production sharing within multinationals, where part of production takes place locally in affiliates while the other is imported from parents (Hanson, Mataloni and Slaughter 2005; Fouquin, Nayman and Wagner 2007; Keller and Yeaple 2013). Hanson and coauthors find that MNC foreign affiliate's demand for imported inputs is higher in affiliate countries with lower trade costs, lower wages for less-skilled labor, and lower corporate income tax rates (Hanson, Mataloni and Slaughter 2005). Keller and Yeaple (2013) formalize and empirically confirm that knowledge intensity is another important determinant for the location of intermediate input production, where it is more difficult to transfer technology in more knowledge-intensive industries.[5] This paper differs from the work of Hanson and colleagues and Keller and Yeaple by employing a direct measure which differentiates between transfer of tangible intermediate inputs versus intangible technology from U.S. parents to affiliates. Some new literature has emphasized the importance of especially intangible technology transfer in contrast to goods transfer within vertical production sharing (Atalay et al. 2014, Ramondo et al. 2015, and Cho 2015).

A second body of literature has documented the importance of productivity differences in

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[3] Ekholm, Forslid, and Markusen (2007) formalize "export-platform" FDI with both horizontal and vertical motivations.

[4] See Carr, Markusen and Maskus (2001), Bergstrand and Egger (2007), Brainard (1997) for country studies, and Helpman, Melitz and Yeaple (2004) and Awokuse, Maskus and An (2012) for country-industry studies.

[5] Keller and Yeaple (2008) provide key theoretical microeconomic foundations.

subsidiaries of foreign companies for knowledge flows within MNCs.[6] Bjorn and coauthors find that the larger the technology gap, the more important the foreign parent as a source of codified knowledge, defined as patents, licenses and R&D (Bjorn, Johannes and Ingmar 2005). Their study used survey data for foreign firms in Eastern European countries, but did not include knowledge embodied in intermediate goods.[7] A related study by Driffield, Love and Menghinello (2010), finds that Total Factor Productivity (TFP) of foreign affiliates in Italy is important for technology transfer from affiliates to parents (sourcing), but not important for technology transfer from parents to affiliates (exploiting).[8] Using data on French multinationals, Fouquin, Nayman and Wagner (2007) find that labor productivity of countries is positively associated with imported-input demand for affiliates in developed countries, but is negatively related for affiliates in developing countries.

This paper adds to the first body of literature a relative measure of embodied and disembodied technology to empirical analysis of multinationals' vertical production networks. In relation to the second body of literature, this paper explicitly identifies two forms of knowledge transfer within MNCs and highlights productivity differences of affiliates as an important factor in determining the mode of technology transfer. As the decision of transfer occurs within the firm, affiliate productivity may be endogenously determined by MNCs. This is addressed in the present study relying on a theory of trade, FDI, and technology transfer (Keller and Yeaple 2013). Furthermore, across country and across year variation in labor productivity of affiliates of

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[6] Martin and Salomon (2003) discuss general knowledge transfer capacities in multinational corporations.

[7] See also Gupta and Govindarajan (2000). Using country-level analysis, they find that knowledge flows within multinationals from home to host country are higher the lower the relative level of economic development of the host country (measured by GDP per capita).

[8] The survey used in Driffield et al. (2010) is based on a binary response to whether there was transfer of scientific and technological knowledge from parent to affiliate, which does not distinguish between tangible (intermediate goods) and intangible (patents, licenses, software) forms.

U.S. MNCs within the same manufacturing industry is used to identify not only the direction of the impact, but also parameter estimates. A limitation of this paper is the usage of aggregated country-industry level data due to inaccessibility of confidential firm-level data from the U.S. Bureau of Economic Analysis.

The remainder of the paper is organized as follows. The next section highlights the theoretical foundation. Section 3 presents the empirical estimation strategy and discusses estimation issues. Section 4 details data sources, variable construction, and descriptive statistics. The results are presented in section 5. Section 6 concludes.

2 Theoretical Foundation

The objective of this paper is to estimate whether there is a connection between the technological gap of MNC affiliates and the mode of international knowledge transfer from the multinational parents to affiliates across countries and industries. This paper focuses on one parent country's (the United States) affiliates abroad as it imposes certain homogeneity in terms of affiliate activities. Assume that U.S. multinationals decided where to locate their foreign affiliates.[9] The remaining decision involves the type of knowledge transfer, which is measured by the transfer of technology (know-how, industrial processes) versus intermediate goods from the U.S. parents to host country affiliates.[10] Direct measures of technology licensing payments and imports of goods for further processing are used to specifically pin down the share of disembodied versus embodied

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[9] Since the analysis in this paper is based on industry data, it prevents the study of questions related to the firm-level location decisions of the U.S. MNC affiliates abroad.

[10] This paper does not include arm's length technology transfer of U.S. multinational corporations to other unaffiliated domestic or foreign entities. Within-firm technology transfer in the form of intermediate inputs and ideas from U.S. parents to affiliates is the main focus of this paper. Other types of embodied technology might include capital goods and people, which are beyond the scope of this paper.

technology transfer from the U.S. parents to affiliates. The technology gap of an affiliate is measured by the deviation of its labor productivity from the parent's labor productivity in the same industry and year.

The approach for estimating the relationship between the technology gap and international knowledge transfer is as follows. I specify that the share of technology transfer (in intangible and tangible forms) to an affiliate country c in industry i, TT_{ci} is a function Φ of the technology gap of an affiliate country c in industry i, TG_{ci} and of other observed and unobserved determinants, Z_{ci}:

$$TT_{ci} = \Phi(TG_{ci}, Z_{ci,}\Theta), \tag{1}$$

where Θ is a vector of unknown parameters. Equation (1) can serve as a reduced-form of a model of technology transfer within multinational corporations. The theoretical model that motivates the empirical analysis that follows is based on Keller and Yeaple (2013). This model of trade, FDI, and international technology transfer builds on the transaction costs of international activities. There exist shipping costs to transfer intermediates that embody technological information from the U.S. parents to affiliates and communication costs to transfer disembodied technology. Shipping costs of moving goods across borders increase with distance from the parent, while communication costs of transferring disembodied technology are higher in more knowledge-intensive industries than in less knowledge-intensive industries.

According to this theory, it is harder to transfer technology in more knowledge-intensive industries because technology is tacit and hard to codify, which means it is best conveyed face-to-face.[11] In the absence of in-person communication, the technology transfer may be more imperfect the more knowledge-intensive the industry is. Multinational firms face a tradeoff between trade costs and technology transfer costs, which explains why there is a gravity of multinational sales, where affiliate sales fall with distance from the home country.

Since affiliate sales are positively related to productivity, this theory serves as a conceptual framework to explain what drives productivity differences across affiliate countries and industries. Trade costs and technology transfer costs increase with distance to the U.S., which is reflected in the lower productivity of affiliates. Furthermore, for a given distance from the U.S., a more knowledge-intensive industry, on average, receives lower affiliate sales (lower productivity). The theoretical framework suggests taking into account trade costs and technology transfer costs in driving productivity differences across host countries and industries. The following section discusses the empirical methodology.

3 Empirical Methodology

Based on the theoretical framework described above, the following estimation equation is employed:

$$Lic\_imp\_share_{cit} = \alpha + \beta TechGap_{cit} + \gamma X1_{cit} + \theta X2ct + \delta_c + \mu_t + \varepsilon_{cit}, \tag{2}$$

where c indexes affiliate countries, i indexes industries, t indexes time. Licensing-import share is defined as

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[11] For a discussion of the importance of face-to-face communication for transfering technology, see for example Koskinen and Vanharanta (2002) and Hovhannisyan and Keller (2015).

$$Lic\_import\_share_{cit} = \frac{Royalty\_license\_\ receipts_{cit}}{Royalty\_licence\_receipts_{cit} + Exports\_goods\_manuf_{cit}}, \tag{3}$$

where royalties and license receipts of the U.S. parents from the affiliates is a measure of payments for the usage of disembodied technology, and U.S. exports of goods for further manufacture from U.S. parents to affiliates is a measure of embodied technology in the form of intermediate goods.

Technology gap is defined as

$$TechGap_{cit} = \frac{ParentLabprod_{it} - Labprod_{cit}}{ParentLabprod_{it}} \tag{4}$$

where $ParentLabprod_{it}$ is parent labor productivity in an industry and year, and $Labprod_{cit}$ is affiliate labor productivity in a country, industry and year.

Based on theory described above (Keller and Yeaple 2013), the productivity of affiliates falls with distance from the United States due to increasing trade costs and technology transfer costs. Furthermore, technology transfer in more knowledge-intensive industries is more costly than in less knowledge-intensive industries. Thus, the labor productivity of affiliates is weighted by the relative distance of the affiliate country from the U.S., as well as the relative knowledge-intensity of the industry. The weighted labor productivity $Labprod_{cit}$ is constructed as

$$Labprod_{cit} = \frac{1}{Dist_c \times KI_{it}} \times \widetilde{Labprod}_{cit} \tag{5}$$

where $Dist_c$ is geographical distance between the U.S. and the affiliate country, KI_{it} is knowledge-intensity of an industry measured by parent R&D expenditures over sales (following Keller and Yeaple 2013), and $\widetilde{Labprod}_{cit}$ is unweighted labor productivity of affiliates.

Turning to remaining variables of equation (2), $X1$ is a vector of control variables at the country-industry-year level such as trade costs, $X2$ is a vector of control variables at the country-year level such as R&D expenditures, population, GDP per capita, and human and physical capital per worker, δ_c are country fixed effects, and μ_t are time fixed effects. It is expected that the coefficient on β will be negative, implying that the smaller the technology gap of an affiliates is (closer to frontier productivity), the more the affiliate will import technology directly (paying royalties and license fees) relative to importing goods for further processing.[12]

It is important to mention that licensing-import share is bounded between 0 and 1 with clusters of values at extreme points. We can employ a two-part Tobit model which is a widely used estimation method for censored data. Greene (2004) shows that maximum likelihood estimates of Tobit with fixed effects exhibit almost no bias, and incidental parameter problems do not need special adjustment. An alternative to Tobit is fractional logit model, suggested by Papke and Wooldridge (1996; 2008), where conditional mean is modeled as a logistic function. Before turning to the empirical analysis and results, the next section gives an overview of the data and descriptive statistics of the main variables.

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[12] In the robustness analysis, other measures of frontier will be employed as well.

4 Data

4.1 Main Variables

The primary data used in this paper are based on operations of U.S. MNCs abroad and come from the United States Bureau of Economic Analysis (BEA). The data cover 45 countries where U.S. multinationals have affiliates, span 7 NAICS manufacturing industries, and include 2 benchmark survey years (1999 and 2004). The manufacturing industries used in the analysis are food, chemicals, primary and fabricated metals, machinery, computers and electronic products, electrical equipment, appliances and components, and transportation equipment. The list of affiliate countries used in the analysis is given in Appendix 1. The analysis is restricted to the benchmark survey years because part of the data is available only in these surveys.[13] Additionally, industry classification has changed from SIC to NAICS, which prevents using earlier benchmark years.[14]

Licensing-Import Share is constructed using data on royalties and license fees received by U.S. parents and on U.S. exports of goods shipped to majority-owned affiliates for further processing. Royalties and license receipts, net of withholding taxes, received by U.S. parents from its affiliates comes from the balance of payments and direct investment position data in 1999 and 2004.[15,16] Data on royalties and license receipts offer an appropriate measure of

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[13] U.S. exports of goods for further manufacture, processing and assembly is only collected in benchmark survey years.

[14] The other benchmark survey years are 1989, 1994 and 2009. The publicly available data from BEA by country-industry are based on broadly defined industries. Due to a change in classification from SIC to NAICS, the Computers and Electronic Products manufacturing category was added, which would not allow direct comparison across industries with earlier benchmark years of 1989 and 1994. It is not possible to use 2009 benchmark survey because data on U.S. parents royalties and license fee receipts by industry was discontinued from 2006.

[15] A more precise measure would be royalties and license receipts by U.S. parents from its majority-owned foreign affiliates or payments to U.S. parents by its majority-owned foreign affiliates. Unfortunately, benchmark surveys of 1999 and 2004 do not provide that type of detailed data broken down by country-industry. Overall, around 90% of royalties and license fee receipts by U.S. parents from foreign affiliates are from majority-owned foreign affiliates.

[16] Using data on royalties and license fees which are net of withholding taxes, tax policy differences across

direct technology as these receipts are for the use or sale of intangible property or rights such as patents, industrial processes, trademarks, copyrights, franchises, manufacturing rights, and other intangible assets or proprietary rights (U.S. Direct Investment Abroad: Final Results from the 1999 Benchmark Survey, 2004).[17] Overall, approximately 50% of royalties and license fee payments from foreign affiliates to U.S. parents are for industrial processes which are most closely related to the payments for the usage of disembodied technology.[18]

Royalty and license receipts reflect the value of technology transfer, which could reflect changes in the volume of technology or changes in price. There are widely known difficulties with pricing and units of output of intangibles (Robbins 2009). Robbins notes that royalty payments for licensing of industrial processes often consist of a lump-sum payment and a royalty as a percentage of receipts.[19] In terms of price, transfer pricing is such that under U.S. law multinationals are required to charge the same price for intra-firm transactions on intangible assets as for unrelated arm's length transactions (Feenstra et al. 2010). Another difficulty with royalty and license receipts lies in the value of technology transfer that firms report, particularly coming from different countries. Branstetter and coauthors argue that under U.S. tax codes and the laws of foreign countries, there are restrictions on how U.S. multinationals make and value royalty payments. Furthermore, U.S. multinationals charge the same royalties for affiliates in different countries in order to avoid scrutiny from tax authorities (Branstetter et al. 2006).

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affiliate countries should be mitigated.

[17] See Howestine (2008) who describes various innovation-related data in the BEA international economic surveys.

[18] Data on royalties and license fees broken down by the type of intangible asset between affiliated parties is available starting from 2006. On average in the period 2006-2009, U.S. parents' receipts of royalties and license fees from affiliates included 50% of receipts for industrial processes, 30% for general use computer software, 15% for trademarks, and 5% for franchise fees, with the remainder to other categories.

[19] Vishwasrao (2007) explores the factors determining the type of payments (up-front fees, royalties, or a combination of both) for the technology transfer based on firm and industry characteristics for subsidiaries as well as for unaffiliated firms.

Data on the U.S. exports of goods comes from 1999 and 2004 benchmark surveys and is measured by the United States (either from the U.S. parent or another party) exports of goods shipped to majority-owned affiliates for further processing, assembly, or manufacture.[20,21] In 2004, exports for further processing from the U.S. parents to foreign affiliates were 60% of total exports and 90% within the manufacturing industry (BEA).

Technology gap is constructed using data on the gross product and number of employees of U.S. MNC parents and majority-owned foreign affiliates from the BEA. First, labor productivity of MNC parents is calculated as gross product (value added) divided by the number of employees for a given industry and year. It is taken as the frontier for a given industry and year. Then, labor productivity of majority-owned foreign affiliates is calculated as gross product (value added) divided by the number of employees for a given country, industry and year.[22] Finally, labor productivity of affiliates is weighted according to equation (5), where distance data is obtained from CEPII and R&D data from the BEA. The technology gap of a given affiliate is constructed as a relative difference from the frontier labor productivity (see equation 4). In this form, differences in productivity across industries are controlled for, and the identification of technology gap comes from variation across affiliate countries and years in a given manufacturing industry.

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[20] Although the U.S. exports of goods for further manufacture includes goods shipped from the U.S. parents or other U.S. entities, overall around 85% of imports by affiliates from the United States is from the U.S. parents.

[21] Because of non-disclosure and confidentiality, the BEA does not provide small portion of data for royalties and license fees and for U.S. exports of goods for further manufacture broken down by country and industry. Data given in a range [-$500,000; $500,000] is coded as $500,000; data is filled in with the same number for observations where country-industry data is available for one year and missing for another (11% for exports, and 3% for royalties).

[22] Due to confidentiality, a small portion of employment figures is given in ranges; in those cases, the midpoint of the range is taken.

4.2 Controls

Although the empirical analysis controls for country and year fixed effects, there may still be differences across host country affiliates over time, and across industries. One of the most important factors that will impact licensing-import share is trade costs, as it is costly to transfer goods across borders. Following the methodology of Hanson and colleagues (2005) and Keller and Yeaple (2013), ad-valorem trade costs at country-industry-year level are constructed as a sum of freight costs and tariffs:

$$\tau_{cit} = 1 + freight_{cit} + tariff_{cit}, \tag{6}$$

Freight costs are calculated as the ratio of import charges over customs value of imports.[23] Tariffs are obtained from the TRAINS database using WITS software of the World Bank.[24]

Research & Development expenditures (R&D) are considered an important determinant of technology transfer. To control for differences in country-level R&D, R&D expenditures as a percentage of GDP are employed from World Development Indicators.[25] Differences in R&D intensity across industries are captured in the analysis since labor productivity is weighted by the industry knowledge intensity, U.S. parent R&D expenditures/sales (see equation 5). Data on R&D expenditures of affiliates is not used in the analysis because of endogeneity concerns.

There are vast differences across affiliate countries in the level of development, size, factor

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[23] Using highly disaggregated data on U.S. imports in HS classification from www.internationaldata.org for 1999 and 2004, freight cost value is calculated as import charges (freight, insurance and other charges) over customs value of imports. To aggregate these figures to BEA industry classification, freight cost value is weighted by the relative importance of a given HS code in BEA code based on U.S. exports to that country.

[24] Weighted tariffs in 4-digit SIC classification are extracted from WITS software of the World Bank and matched to BEA classification.

[25] For the year where R&D expenditures were missing, data for a given country were linearly interpolated.

endowments and other economic factors that might drive differences in U.S. FDI. To control for host country's development level and size, population and GDP per capita are obtained from Penn World Tables (PWT 6.3). Intellectual Property Rights Protection (IPR) in affiliate countries might also be an important determinant for the transfer of technology from the U.S. parent to affiliate.[26] The IPR protection index is obtained from Park (2008). Physical capital per worker is constructed using capital and employment data from Penn World Tables 8.0 (Feenstra et al. 2015). Human capital per worker is proxied by human capital index available from Penn World Tables 8.0 (Feenstra et al. 2015), which is based on (Barro and Lee 2010) Educational Attainment Dataset.[27]

4.3 Descriptive Statistics

The final sample is an unbalanced panel of 45 countries, 7 manufacturing industries, and 2 years (1999 and 2004). Summary statistics of the main variables are presented in Table 1.[28] On average, exports of goods for further manufacture is around 8 times larger than royalties and license receipts.[29] Both royalties and license fees and exports of goods for further processing are quite dispersed with a large standard deviation. Licensing-import share, representing a technological measure of preference between imports of goods versus technology, is bounded between 0 and 1 by construction, with the smaller values representing a preference towards importing of inter-

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[26] Branstetter et al. (2006) find connection between stronger IPR and increased technology transfer within multinational corporations.

[27] In addition, there might be location-based differences and interdependencies in knowledge acquisition across affiliate countries (see e.g. Leonardi 2010), which are mitigated by including country fixed effects.

[28] In this analysis, I focus on positive numbers of technology gap, as my analysis does not apply to the case when weighted labor productivity of affiliates is larger than parent labor productivity. Since weighted labor productivity is based on distance, Canada is a large outlier which is dropped from the analysis.

[29] Feenstra et al. (2010) discuss various reasons for mismeasurement of international trade in ideas. Particularly, they note that the values of receipts from sales of intangible assets are relatively small because of possible underreporting of affiliates and/or high threshold values for mandatory reports.

mediates and the larger values preference towards licensing the technology. Figure 1 presents a histogram of licensing-import share which shows that around 30% of observations are close to zero, with 16% of values being strictly zero and 2% of values being 1.[30]

The empirical strategy controls for country and year fixed effects, so general differences across affiliate countries and across years are controlled. Additionally, since labor productivities differ across industries, technology gap compares labor productivities *within the same industry-year.*

The next section presents the empirical results.

5 Results

The goal of the empirical analysis is to estimate a relationship between the technology gap of U.S. multinationals foreign affiliates and licensing-import share: import of technology versus import of goods. Table 2 presents initial estimation results of the equation (2) using Ordinary Least Squares (OLS). All columns include country and year fixed effects, while in column 6 industry fixed effects are added as well. Robust standard errors, which allow for clustering by country-year, are shown in parentheses.[31] Column 1 shows that there is a strong negative correlation between affiliates' technology gap and their licensing-import share: within an industry, foreign affiliates with a large technology gap from parents import relatively less technology in the form of blueprints and designs and more in the form of intermediate goods.

The addition of trade costs in column 2 decreases the coefficient of technology gap only

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[30] Around 16% of royalties and license fees are zero, and around 2% of U.S. exports of goods for manufacture are zero, which by construction results in 16% of zero values and 2% of values of one in licensing-import share variable.

[31] Clustering by country-year is performed because some control variables do not vary by industry (e.g. IPR protection index), while both licensing-import share and technology gap vary by industry.

slightly from -0.179 to -0.154 while it remains highly significant at 5 percent. As expected, trade costs are estimated to be positive and significant, showing that import of goods is negatively related to trade barriers, resulting in a larger licensing-import share. In column 3 R&D expenditures as a percentage of GDP are added. The coefficient on R&D is positive and significant, meaning that affiliate countries with high R&D are licensing more disembodied technology rather than technology embodied in intermediate goods, which is what one would expect.

Additional country-year level controls are added in column 4. The coefficient on population is negative and significant, while GDP per capita has a positive effect on licensing-import share but it is not significant. The negative coefficient on population might imply that affiliates in countries with larger size receive a larger fraction of goods for further manufacture, assembly and processing. In column 5, IPR protection index and endowments of human and physical capital are added. As expected, IPR protection index is estimated to be positive and significant, implying that countries with strong protection of intellectual property receive more technology in the form of blueprints relative to intermediate goods. The coefficients on physical and human capital per worker are not significantly estimated. With the inclusion of all control variables, the coefficient of technology gap is around -0.15.

What is the magnitude of the estimated coefficient? The mean of licensing-import share is 0.24, while the mean of technology gap is 0.77 (see Table 1). Based on the estimated coefficient, this means that at the mean a 10% increase in the technology gap of a U.S. MNC affiliate, compared to the parent in the same industry, decreases the share of licensing versus importing inputs embodying the technology by 5%.[32] The magnitude of the estimated coefficient is economically

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[32] At the mean, the regression is $[0.24 = -0.15 * 0.77]$, thus a 10% increase in the right hand side is 0.0115, which lowers the licensing-import share by $0.0115/0.24 = 5\%$

sizeable.

To mitigate across-industry differences in technology gap and licensing-import share, industry fixed effects are added in column 6. The technology gap is still negative and significant at 10%, while the magnitude of the coefficient decreases only slightly from around -0.15 to around -0.13. However, trade costs, R&D expenditures and IPR protection cease to be significant. Overall, the results from table 2 indicate that there is a significant effect of technology gap on licensing-import share.

Although the OLS results reported in Table 2 provide important benchmark estimates, additional econometric models are estimated in Table 3. For convenience, column 1 repeats the OLS regression presented in Table 2 (column 5), while other econometric specifications are presented in columns 2 to 7. As mentioned previously, the dependent variable is a share with values strictly between 0 and 1 and around 16 percent of zeroes. The possible reason for the existence of zeroes is that data on both royalties and license receipts and exports of goods for further manufacture are recorded only when a certain threshold is passed. Therefore, equation 1 is estimated as a two-way censored Tobit model in column 2. Column 2 shows that technology gap has a negative and significant effect on licensing-import share, however the magnitudes of the estimates are not directly comparable with OLS. To compare OLS estimates with Tobit, in column 3, marginal effects at the mean of two-way censored Tobit model are presented. The coefficient on technology gap at the mean is -0.137 compared to -0.146 with OLS. In columns (4) and (5) Tobit and Tobit with marignal effects are estimated with the addition of industry fixed effects. The coefficient estimates are very close to OLS with industry fixed effects (table 2, column 6). As an alternative to Tobit model, the fractional logit estimates, which model conditional mean as a logistic function, are presented in column 6 and 7. In the fractional logit model as well, the coefficient on technology gap , -0.117, is close to OLS. On the whole, in all alternative econometric specifications, the technology gap variable is estimated negative and highly significant.

Licensing-import share is constructed by combining data on embodied and disembodied technological transfer. To understand the differences between these two types of technology transfer, decomposition of the dependent variable is performed in Table 4. For convenience, column 1 of Table 4 repeats the benchmark estimates of Table 2 (column 5) with licensing-import share as the dependent variable. In column 2, the dependent variable is intermediate goods import intensity, constructed as U.S. exports of goods for further manufacture divided by affiliate sales. As expected, the coefficient on technology gap is estimated to be positive and significant, implying that affiliates with a large technology gap on average import more intermediate goods. Additionally, the coefficient on trade costs is negative and significant, meaning that trade costs decrease intermediate goods import intensity consistent with previous literature. Turning to column 3, where the dependent variable is disembodied technology transfer intensity (royalty and license fees divided by affiliate sales), the coefficient is almost zero and not significant. One would expect the coefficient on disembodied technology transfer intensity to be negative. However, the fact that technology gap in this case is not significantly estimated probably has to do with small values of royalty and license fees and data limitations.

5.1 Robustness

The technology gap of affiliates is constructed using parent productivity as the frontier and is based on weighted labor productivity of affiliates (see equations 4 and 5). Table 5 presents results using alternative measures of technology gap. Column 1 repeats the benchmark estimates of Table 2 (column 5) for convenience. Recall that labor productivity is weighted by the relative distance of affiliate country and relative knowledge intensity of an industry (see equation 5). In column 2, technology gap is constructed based on unweighted labor productivity. The coefficient on technology gap is still negative and significant, however the magnitude of the coefficient decreases from -0.150 to -0.092. The weighted coefficient is larger, which shows that it is important to account for differences in proximity of affiliates of U.S. parents to home, as well as the knowledge-intensity of an industry.

Another feasible option for defining technology gap involves using a different frontier measure. To test the robustness of using parent productivity as a frontier, we can define the frontier as the most productive affiliate in the same industry and year, as it is possible that parents and affiliates perform different tasks. Then, the technology gap of a given affiliate is defined as a relative difference from the most productive affiliate in the same industry and year. It is important to note that in all cases, the frontier affiliate comes from a high-income country affiliate. The results of this exercise are reported in column 3 of Table 5. Using affiliate frontier, the coefficient on technology gap is estimated to be negative and significant and very close to the benchmark estimate of -0.146. Additionally, the signs and estimates of the controls are very similar to the benchmark estimates.

As an additional robustness check, technology gap is constructed based on frontier being

U.S. labor productivity using data from United Nations Industrial Statistics Database. Data on U.S. value added and employment by 3 and 4 digit Standard Industrial Classification (SIC) is obtained from INDSTAT4 database and matched to BEA industries. Then technology gap is constructed as weighted labor productivity differences of U.S. multinational affiliates from U.S. labor productivity. Using U.S. labor productivity in a given industry and year as a frontier instead of U.S. multinational parent labor productivity should eliminate potential endogeneity of the latter. The results of this exercise are presented in column 4 of table 5. The coefficient on technology gap is almost identical to the benchmark (-0.149 compared to benchmark -0.146) and is highly statistically significant. The coefficients and magnitudes of the control variables are also very similar. Overall, this table shows that the main results of this paper are not sensitive to the definition of frontier used in the construction of technology gap. In all 3 cases, technology gap is negatively associated with licensing-import share.

It is possible to argue that if U.S. affiliates have access to more disembodied technology (ideas), they can become more productive over time. To address the possibility of reverse causality, Table 6 performs a number of robustness checks by including lagged technology gap as well as lagged R&D. For convenience column 1 repeats the benchmark estimates of Table 2 (column 5). Because of industrial classification changes from SIC to NAICS in 1998, it is not possible to lag technology gap for 7 broadly defined manufacturing industries. Therefore, in column 2 technology gap value of 2004 is used for 1999 reducing the number of observations to 184. The coefficient on technology lag is still negative and highly significant, while the coefficient on 5 year lagged technology gap is almost zero and not significantly estimated.

To control for prior technological gap, in column 3 two year lagged technology gap is added.

The latter is constructed using U.S. labor productivity as the frontier in a given industry-year and proxying affiliates' productivity by a given country's industry-year labor productivity (data from United Nations INDSTAT4 database). The coefficient on technology gap is still negative and significantly estimated (-0.138 compared to benchmark -0.146), while the lagged technology gap is positive but not significant. To control for the past innovation effect, 3 year lagged R&D expenditures are included in column 4. The estimate on technology gap is still negative and significant, while the coefficient on lagged R&D is not significantly estimated.

To test whether including lagged technology gap is sensitive to the definition of the frontier, columns 5-7 use technology gap with frontier being U.S. labor productivity from United Nations INDSTAT4 data. Column 5 estimates are from table 5 column 4, while columns 6 and 7 include three and five year lagged technology gap respectively with frontier being the maximum labor productivity in a given industry-year from United Nations INDSTAT4 data. The coefficients on technology gap in columns 6 and 7 are very close to the benchmark estimates, but lagged variables are not significantly estimated. Overall, this table suggets that results are not driven by past technology gap or past innovation.

A number of additional robustness checks have been conducted (see table 7). In column 2 interaction of trade costs with R&D is included to address the possibility of differential effect of trade costs and R&D. The coefficient on interaction is not significant, while the coefficient on technology gap decreases slightly from -0.146 to -0.139 but remains significant. One might also argue that type of FDI matters for embodied versus disembodied technology transfer. If FDI is horizontal and market entry is the primary goal, affiliates might be replicating U.S. production abroad, so we would expect royalties to be higher. In the case of vertical FDI however, the main goal is further processing and assembly, so we would expect exports of goods for further processing to be higher. To test this hypothesis, the fraction of local affiliate sales to all affiliate sales for each country and year is calculated from BEA benchmark surveys. The results are shown in column 3. The results on technology gap are unchanged, while the coefficient on local to all sales is negative and significant suggesting that countries that sell more locally import more intermediate inputs than technology in disembodied form. This result is contrary to what we would expect but might be driven from the aggregated country-level nature of sales.

The next section offers concluding remarks.

6 Conclusions

Multinational corporations are the main mediators of the worldwide increase in technology trade. Intermediate inputs and know-how are the two forms of technology (tangible and intangible) transferred within multinational corporations that this paper has examined. This paper analyzed what determines the decision of multinationals on the form of technology transfer to its affiliates, using data on U.S. multinational activity in 45 countries, 7 manufacturing industries and 2 years. Detailed data on exports of goods for further processing, as well as royalties and license payments observed between U.S. MNC parents and their affiliates, enables us to specifically identify two types of knowledge transfer from parents to affiliates.

The main finding of this paper is that the technology gap, measured as the relative labor productivity difference from the frontier, is negatively related to the share of direct versus indirect transfer of knowledge from U.S. parents to affiliates. Relatively more productive affiliates get technology in the form of know-how, industrial processes, etc., while relatively less productive affiliates receive technology in the form of intermediate inputs. The magnitude of the effect is sizeable: a 10 percent increase in the technology gap of affiliates decreases the share of licensing versus importing inputs by 5 percent, on average. These results suggest that productivity of affiliates is an important determinant for knowledge transfer within multinational corporations.

The transfer of technology is central to modern economics because of its implications for long-term cross-country income, economic growth and convergence of countries. Access to knowledge and know-how are obtained by MNC affiliates from their parents, as well as via spillovers from those affiliates to domestic firms. Regardless of how such knowledge is gathered, it amounts to an avenue for innovation and income growth. Based on the results mentioned above, this study points to policy implications for countries to raise their productivity levels. Taking into account that the presence of MNC affiliates and the performance of those affiliates are contributing factors to the productivity levels of a country, policymakers should also think about creating more appealing atmosphere for MNCs, including such factors as favorable entry criteria and tax implications.

While this paper provides initial evidence on the relationship between the technology gap and the mode of technology transfer in multinational corporations, there are important extensions that should be considered in future work. First, obtaining firm-level or more disaggregated industry data will enable the examination of this question without potential aggregation bias. Second, it would be interesting to add a direct measure of technology, and explicitly model the process of innovation in the framework of technology transfer. Third, it would be useful to extend this analysis to other samples to see if the results continue to hold. A promising avenue involves the use of data on Swedish multinationals. Fourth, it would be interesting to analyze the type of technology transfer and its dynamic impact on economic growth. Finally, there are important questions on whether the type of FDI matters for the mode of technology transfer.

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Table 1: Descriptive statistics

Variable	Mean	Standard Deviation	Min	Max
Royalties & license receipts ($mln)	28.923	81.063	0	904
US exports of goods for manufacture ($mln)	226.545	555.678	0	4924
Licensing-Import share	0.237	0.282	0	1
Technology gap	0.767	0.254	0.001	1.940
Trade costs	0.127	0.105	0.009	1.120
R&D expenditures as a % of GDP	-0.077	1.033	-3.181	1.422
Population	10.317	1.536	8.202	14.077
GDP per capita	9.555	0.759	7.781	10.597
Intellectual property protection	1.256	0.308	0.207	1.541
Physical capital per person	12.722	1.457	8.574	18.136
Human capital per worker (index)	2.778	0.408	1.732	3.490

Note: Number of observations for all variables is 398. The sample includes 45 countries, 7 manufacturing industries and 2 years (1999 and 2004). Trade costs, R&D expenditures, population, GDP per capita, IPR and physical capital per worker are in natural logarithms.

Figure 1: Distribution of Licensing-Import Share

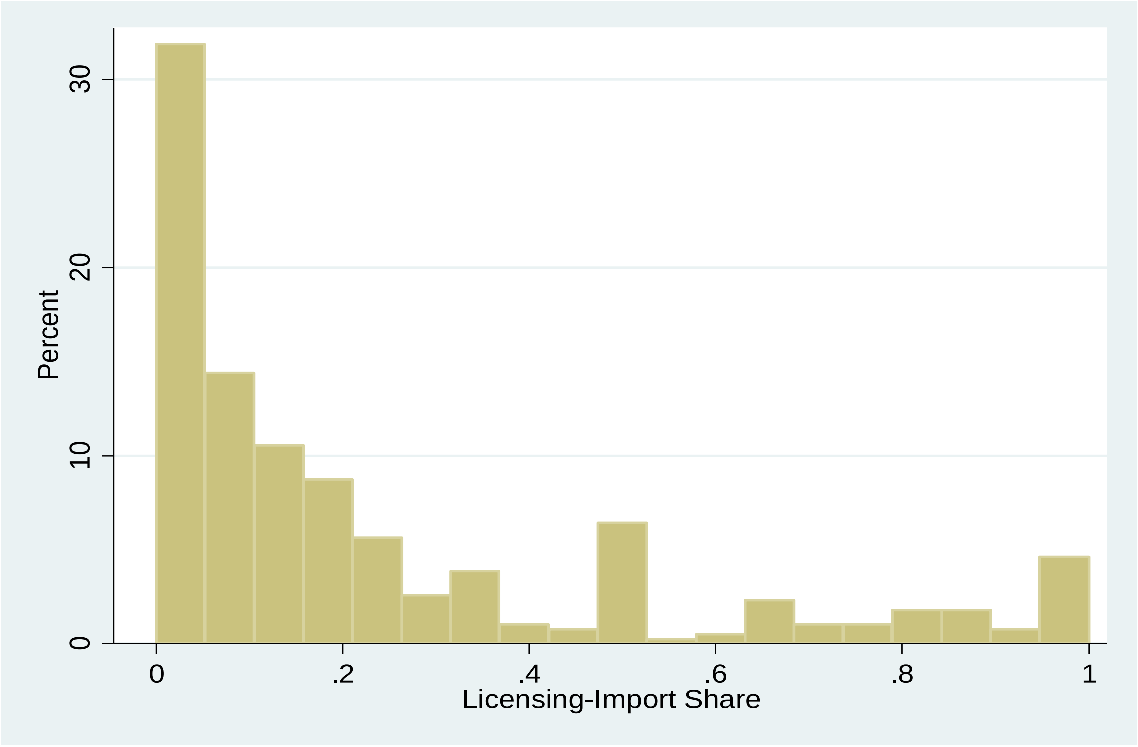

Table 2: Benchmark Regression

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Licensing-Import Share					
Technology gap	-0.179**	-0.154**	-0.152**	-0.145**	-0.146**	-0.133*
	(0.069)	(0.062)	(0.062)	(0.061)	(0.062)	(0.078)
Trade costs		0.448**	0.494**	0.532**	0.537**	0.004
		(0.200)	(0.202)	(0.212)	(0.216)	(0.223)
R&D			0.149**	0.124*	0.122*	0.026
			(0.060)	(0.073)	(0.073)	(0.072)
Population				-1.068***	-1.140***	-0.681*
				(0.403)	(0.421)	(0.404)
GDP per capita				0.130	0.143	0.267*
				(0.152)	(0.143)	(0.136)
IPR protection index				0.097**	0.110**	0.016
				(0.046)	(0.045)	(0.052)
Physical capital per worker					-0.002	0.005
					(0.013)	(0.013)
Human capital per worker					-0.202	-0.096
					(0.146)	(0.136)
Industry fixed effects	No	No	No	No	No	Yes
Observations	389	389	389	389	389	389
R-squared	0.354	0.367	0.369	0.374	0.374	0.436

Notes: All specifications include country and year fixed effects. Robust standard errors which allow for clustering by country-year are reported in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Various Econometric Specifications

	OLS	Tobit	Tobit-Marginal Effects	Tobit	Tobit-Marginal Effects	Fractional Logit	Fractional Logit-Marginal Effects
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable			Licensing-Import Share				
Technology gap	-0.146**	-0.178**	-0.137**	-0.175*	-0.135*	-0.943**	-0.117**
	(0.062)	(0.071)	(0.055)	(0.101)	(0.078)	(0.375)	(0.046)
Trade costs	0.537**	0.617**	0.078**	0.022	0.003	3.189**	0.065**
	(0.216)	(0.247)	(0.031)	(0.247)	(0.031)	(1.358)	(0.028)
R&D	0.122*	0.198**	-0.015**	0.091	-0.007	0.450	-0.006
	(0.073)	(0.087)	(0.007)	(0.085)	(0.007)	(0.436)	(0.005)
Population	-1.140***	-1.323***	-13.646***	-0.786*	-8.114*	-5.169**	-8.618**
	(0.421)	(0.504)	(5.204)	(0.467)	(4.821)	(2.202)	(3.674)
GDP per capita	0.143	0.175	1.668	0.310*	2.961*	1.106	1.707
	(0.143)	(0.181)	(1.727)	(0.166)	(1.583)	(0.773)	(1.194)
IPR protection index	0.110**	0.098*	0.123*	-0.009	-0.012	0.661*	0.134*
	(0.045)	(0.053)	(0.066)	(0.057)	(0.072)	(0.387)	(0.079)
Physical capital per worker	-0.002	-0.021	-0.272	-0.015	-0.187	-0.008	-0.016
	(0.013)	(0.017)	(0.215)	(0.017)	(0.211)	(0.083)	(0.170)
Human capital per worker	-0.202	-0.179	-0.497	-0.066	-0.183	-0.904	-0.406
	(0.146)	(0.179)	(0.496)	(0.166)	(0.460)	(0.875)	(0.393)
Industry fixed effects				X	X		
Observations	389	389	389	389	389	389	389
R-squared	0.374						

Notes: All specifications include country and year fixed effects. Robust standard errors which allow for clustering by country-year are reported in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Decomposition of Licensing-Import Share

Dependent variable	(1) Licensing-Import Share	(2) Intermediate Goods Import Intensity	(3) Royalty & License Fee Intensity
Technology gap	-0.146**	0.038***	0.002
	(0.062)	(0.014)	(0.003)
Trade costs	0.537**	-0.207***	0.009
	(0.216)	(0.069)	(0.012)
R&D	0.122*	-0.019	0.004
	(0.073)	(0.027)	(0.005)
Population	-1.140***	0.144	-0.032
	(0.421)	(0.175)	(0.020)
GDP per capita	0.143	0.041	-0.005
	(0.143)	(0.060)	(0.009)
IPR protection index	0.110**	-0.046**	0.003
	(0.045)	(0.020)	(0.003)
Physical capital per worker	-0.002	-0.000	-0.000
	(0.013)	(0.004)	(0.001)
Human capital per worker	-0.202	0.127**	-0.011
	(0.146)	(0.059)	(0.017)
Observations	389	343	343
R-squared	0.374	0.413	0.228

Notes: All specifications include country and year fixed effects. Robust standard errors which allow for clustering by country-year are reported in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Robustness-Alternative Measures of Technology Gap

	(1)	(2)	(3)	(4)
Dependent variable	Licensing-Import Share			
Technology gap (weighted)	-0.146**			
	(0.062)			
Technology gap (unweighted)		-0.092**		
		(0.042)		
Technology gap (affiliate frontier)			-0.146**	
			(0.070)	
Technology gap (weighted, frontier US labor productivity)				-0.149***
				(0.056)
Trade costs	0.537**	0.647***	0.871***	0.569***
	(0.216)	(0.242)	(0.240)	(0.209)
R&D	0.122*	0.143*	0.126	0.097
	(0.073)	(0.082)	(0.086)	(0.068)
Population	-1.140***	-1.363***	-1.171**	-1.058**
	(0.421)	(0.471)	(0.505)	(0.409)
GDP per capita	0.143	0.113	0.183	0.188
	(0.143)	(0.158)	(0.164)	(0.152)
IPR protection index	0.110**	0.141***	0.134**	0.118**
	(0.045)	(0.052)	(0.056)	(0.055)
Physical capital per worker	-0.002	0.004	0.003	-0.004
	(0.013)	(0.013)	(0.012)	(0.013)
Human capital per worker	-0.202	-0.237	-0.138	-0.156
	(0.146)	(0.144)	(0.117)	(0.142)
Observations	389	389	464	408
R-squared	0.374	0.371	0.325	0.368

Notes: All specifications include country and year fixed effects. Technology gap (weighted) is constructed using US MNC parent productivity in the same industry-year as the frontier and weighted labor productivity of affiliates. Technology gap (unweighted) is constructed using US MNC parent productivity in the same industry-year as the frontier and unweighted labor productivity of affiliates. Technology gap (affiliate frontier) is constructed using the most productive affiliate in the same industry-year and labor productivity of affiliates. Technology gap (weighted, frontier US labor productivity) is constructed using US labor productivity in the same industry-year as a frontier and weighted labor productivity of affiliates. Robust standard errors which allow for clustering by country-year are reported in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Robustness- Past Technology Gap and Past R&D

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable	Licensing-Import Share						
Technology gap (frontier-US parent labor productivity)	-0.146**	-0.223***	-0.138*	-0.149**			
	(0.062)	(0.077)	(0.070)	(0.062)			
Technology gap (frontier-US labor productivity)					-0.149***	-0.149**	-0.145*
					(0.056)	(0.065)	(0.075)
Trade costs	0.537**	0.869**	0.490*	0.533**	0.569***	0.596*	0.554
	(0.216)	(0.370)	(0.286)	(0.216)	(0.209)	(0.340)	(0.377)
R&D	0.122*	-0.085	-0.010	0.175**	0.097	0.131	0.243
	(0.073)	(0.099)	(0.131)	(0.087)	(0.068)	(0.177)	(0.157)
Population	-1.140***	0.041	-0.810	-1.132**	-1.058**	-0.603	-1.292**
	(0.421)	(0.064)	(0.632)	(0.431)	(0.409)	(0.617)	(0.525)
GDP per capita	0.143	-0.105	0.527*	0.132	0.188	0.144	0.237
	(0.143)	(0.181)	(0.312)	(0.139)	(0.152)	(0.422)	(0.334)
IPR protection index	0.110**		0.137*	0.103**	0.118**	0.134	0.875**
	(0.045)		(0.077)	(0.046)	(0.055)	(0.091)	(0.403)
Physical capital per worker	-0.002	-0.015	0.008	-0.001	-0.004	0.001	-0.017
	(0.013)	(0.017)	(0.014)	(0.013)	(0.013)	(0.014)	(0.015)
Human capital per worker	-0.202	0.518***	-0.271	-0.169	-0.156	-0.243	0.563
	(0.146)	(0.061)	(0.327)	(0.155)	(0.142)	(0.419)	(0.474)
Lagged technology gap (5 year)		-0.003					
		(0.056)					
Lagged technology gap - US frontier (2 year)			0.174				
			(0.122)				
Lagged R&D (3 year)				-0.047			
				(0.048)			
Lagged technology gap -maximum frontier (3 year)						-0.052	
						(0.102)	
Lagged technology gap -maximum frontier (5 year)							0.046
							(0.115)
Observations	389	184	310	387	408	322	266
R-squared	0.374	0.531	0.358	0.374	0.368	0.362	0.363

Notes: All specifications include country and year fixed effects. Lagged technology gap (5 year) is 5 year lagged technology with US MNC parent labor productivity as the frontier. Lagged technology gap US frontier (2 year) is 2 year lagged technology gap with US labor productivity as the frontier. Lagged R&D (3 year) is 3 year lagged R&D expenditures as a percentage of GDP. Lagged technology gap - maximum frontier (3 year/5 year) is 3 year/5 year lagged technology gap with frontier being the maximum labor productivity in a given industry-year. Robust standard errors which allow for clustering by country-year are reported in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Other Robustness Results

	(1)	(2)	(3)
Dependent variable	Licensing-Import Share		
Technology gap	-0.146**	-0.139**	-0.147**
	(0.062)	(0.061)	(0.062)
Trade costs	0.537**	0.675**	0.553**
	(0.216)	(0.295)	(0.217)
R&D	0.122*	0.051	0.160*
	(0.073)	(0.068)	(0.082)
Population	-1.140***	-0.895**	-0.827*
	(0.421)	(0.415)	(0.480)
GDP per capita	0.143	0.243*	0.117
	(0.143)	(0.139)	(0.150)
IPR protection index	0.110**	0.081*	0.128***
	(0.045)	(0.043)	(0.046)
Physical capital per worker	-0.002	-0.001	-0.001
	(0.013)	(0.013)	(0.013)
Human capital per worker	-0.202	-0.158	-0.270*
	(0.146)	(0.142)	(0.139)
Trade costs* R&D		0.135	
		(0.110)	
Local sales/All sales			-0.130*
			(0.068)
Observations	389	389	389
R-squared	0.374	0.376	0.377

Notes: All specifications include country and year fixed effects. Trade costs* R&D is the interaction of trade costs and R&D expenditures. Local sales/All sales is the fraction of local affiliate sales of all affiliate sales for each country and year. Robust standard errors which allow for clustering by country-year are reported in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table A1: Countries in the Sample

Argentina
Australia
Austria
Belgium
Brazil
Chile
China
Colombia
Costa Rica
Czech Republic
Denmark
Ecuador
Egypt
Finland
France
Germany
Greece
Honduras
Hong Kong
Hungary
India
Indonesia
Ireland
Israel
Italy
Japan
Korea: Republic of
Malaysia
Mexico
Netherlands
New Zealand
Norway
Peru
Philippines
Poland
Portugal
Russia
Saudi Arabia
Singapore
South Africa
Spain
Sweden
Switzerland
Turkey
United Kingdom