The Determinants of Offshoring: the Role of Infrastructure and Quality of Institutions

by Gamberoni Elisa, Lanz Rainer, Piermartini Roberta

1

Draft prepared for the ETSG 2008 Conference Warsaw 11-13 September

01 September 2008

Abstract

Despite a rapidly expanding body of literature, empirical evidence on offshoring is very limited and, given the lack of data it principally relies on case studies. Based on the newly available OECD Input-Output database, this paper is the first systematic empirical study on the determinants of offshoring for a broad set of countries and industries. Our study covers 34 countries and 18 manufacturing industries for 1995 and 2000.

Quality of institution and quality of infrastructure have been highlighted as important sources of comparative advantage in the recent literature of offshoring. The aim of the paper is to estimate the relevance that these factors have in determining the level and the location of offshoring. Measuring offshoring as the share of imported inputs over total inputs, we estimate two sets of regressions. One, based on country level information, aims at identifying the country characteristics that determine which countries offshore the most in which sector. The other one, relying on the calculations for the index of offshoring by country-pairs, aims at explaining the decision of where to source inputs according to comparative advantage.

We find a more important role of skill endowment than capital endowment in determining comparative advantage in offshoring decisions. Air transport infrastructure and to a lesser extent communication infrastructure are important sources of comparative advantage. These results hold even when we control for air-transport and communication as determinant of transport costs. We do not find robust evidence of a role of institution as a source of comparative advantage. On the contrary we sometimes find that differences in the quality of institutional quality are negatively correlated with offshoring. We claim that one possible explanation may be that to solve the hold-up problem associated with offshoring both good institutions in the importing and in the exporting country are needed. On this issue the next efforts of our research will focus.

I. INTRODUCTION

An important phenomenon over the last half century has been the significant increase in trade in parts and components. Over the last two decades trade in intermediate has increased at a faster pace than trade in final goods, explaining a large part of the superior growth of trade compared to GDP (Figure 1). This rapid growth is related to the rapidly developing phenomenon of vertical specialization and offshoring, that is the sourcing of input goods or services from a foreign country. This includes sourcing from a foreign affiliate through foreign direct investment (FDI) and sourcing from a foreign

1 Gamberoni Elisa is economist at the World Bank and PhD student at HEI. Lanz Rainer is economist at the OECD and PhD student at the University of Munich. Roberta Piermartini is counsellor in the Research and Statistics Division of the World Trade Organization (WTO), 154 Rue de Lausanne, 1202 Geneva, Switzerland. This paper reflects the opinion of the authors and cannot be attributed to the international organizations the work for or their Members.
non-affiliate through arm's-length contracts. Hummels et al. (2001) estimate that between 1970 and 1990 vertical specialization grew by almost 30 per cent on average for the 14 countries\footnote{These are Australia, Canada, Chinese Taipei, Denmark, France, Germany, Japan, Korea, Ireland, Italy, Mexico, Netherlands, United Kingdom, United States.} under examination and accounted for 30 per cent of world export growth.

Chart 1

**Trends in world trade of total merchandise, intermediate goods and GDP, 1988-2006**

A rapidly expanding literature introduces elements from industrial organization and contract theory in trade theory to explain international outsourcing. The main answer to the question as to why firms offshore is that offshoring allows the advantage of location to be exploited. That is, the traditional law of comparative advantage holds, but it applies at the level of components. It may be the case that the various stages of production require different types of technology or skills, or they may require inputs in different proportions. Under these conditions, the benefit of fragmenting production across countries is that the firm can locate different stages of the production process in the country where there is relative abundance of the type of skill or input used relatively more intensively in that stage of production. In so doing, the firm can lower costs of production.

Together with the traditional factors of comparative advantage (such as factor prices and skills availability), this new literature on offshoring has highlighted new sources of comparative advantages as determinants of the decision of where to offshore what. These new sources include quality of institutions and quality of infrastructures. Quality of institutions matters because institutions are a crucial determinant of the effectiveness of contract enforcement. This is essential to solve the hold-up problem arising between the supplier of intermediate good and the producer of a final good.\footnote{See Williamson (1985), Grossman and Hart (1986) Hart and Moore (1990).} To the extent that the production of intermediate goods requires investment specific to the relationship supplier-buyer to customize the input to the production of final good, there is an incentive for the supplier to under-invest ex-ante because the value of the input is less outside the relationship. If institutions are good, the contract between the final good producer and the supplier of the intermediate
good is enforceable ex post, and this reduces the risk that the quality of the input good does not correspond to standard required by the producer of the final good.

Quality of infrastructure matters because it is an important determinant of transport and communications costs. Advancements in communication technologies have allowed the development of an effective multi-modal transport system. This has helped to reduce both time of delivery and uncertainty of delivery. The use of radio frequency identification tags, the internet and transponders on product packages allows factories and warehouses to keep track of where a product is at any time. Sharing information among terminal operators, shippers and customs brokers can help manufacturers and logistic contractors to manage the supply chain and fulfil the need of just-in-time delivery, thus fostering international fragmentation of production.

Quality of institution and infrastructure also matter in the decision of which sector to offshore. Some sectors are more institutional-intensive than other. Empirical literature focusing on offshoring has focused on the degree of complexity of the production process of the final good and the degree of standardization of intermediate goods required in the production of the final good as factors affecting the degree of institutional dependency. Intuitively, institutions will be more important in sectors characterised by more complex production processes, where the final producer needs to set up relationship with a multiplicity of producers of intermediate goods. This is simply because there are more relationships that are potentially affected by the contracting imperfection (Levchenko, 2007). Institutions are also particularly important in sectors that make intensive use of inputs that require relation-specific investments, that is customised inputs. The intuition is that if imports are standardised then the market for this input is thick and there is therefore limited scope for the hold-up problem to emerge (Nunn, 2007).

Similarly, for infrastructure some products are more infrastructure-intensive than others. In particular, different type of infrastructure (communication infrastructure and transport infrastructure) matter for determining comparative advantage in different sectors. For example, recent research suggests that quality of road infrastructure is particularly important for specializing in the production of textile and apparels (Yeaple and Golub, 2007).

To sum up, the degree of standardization, geographical separability as well as time sensitiveness of components are key factors determining the prevalence of offshoring in particular areas of activity and in determining the patterns of comparative advantages.

However, fragmentation of production also carries costs. Separate production stages need to be coordinated and monitored. Furthermore, offshoring implies incurring transportation and communication costs and other connecting services costs. These costs are higher between countries where people do not speak the same language or have very different historical background. In addition these costs are higher in countries where the quality of institutions and the quality of infrastructure are low. The decision of whether to offshore and where is driven by the trade-off between the advantage of lower production costs due to the exploitation of comparative advantages and the disadvantage of incurring these other types of costs.

In this paper, we provide the first systematic evidence on the empirical determinants of offshoring based on Input-Output tables. While there is a rich, dynamic and evolving theoretical literature on the fragmentation of production, empirical studies on the determinants of offshoring is scarce. In particular, existing research either focuses on specific countries for which firm level data on imported inputs used for production exist (Hanson et al. (2006) Feinberg and Keane (2005?)) or uses standard trade statistics classifications to distinguish trade data between trade in final goods and trade in intermediate goods (Bergstrand and Egger, 2008). While presenting the advantage of a wide coverage, trade data are not collected to match the economic definition of offshoring. That is, they do

---

4 This is what determines comparative advantages.
5 Most literature focuses on the determinants of intra-firm versus arms'-length trade in intermediates.
not distinguish whether a product is consumed as final good or is used as intermediate input in the production of a final goods. Data recorded in Input-Output tables overcome this limitation.

Based on the latest OECD Input-Output database (the 2006 edition), that covers 35 countries and 48 industries for 1995 and 2000, we measure offshoring as the share of imported inputs over total inputs. Following Feenstra and Hanson (1999), we calculate this index according to two definition of offshoring: a broad definition that includes all imported inputs in the definition of offshoring and a narrow definition that limits the imported inputs to those falling in the same sector as the importing sector. We use both definitions as the latter definition is closer to public perception of offshoring (commonly, the purchase of steel by a carmaker would not be considered offshoring but the purchase of car parts would), but form a theoretical point of view the broad definition matters too.

On the basis of the index of offshoring, we run two type of analysis. First, using a logistic transformation of this variable, we estimate the importance that quality of infrastructure and quality of institution have on a country's decision of how much to offshore in each sector. Second, relying on the assumption that import composition by trading partner is the same for intermediate and final goods in each sector, we calculate bilateral offshoring measures. We then use this measure to estimate a model of offshoring whereby the location decision of where to offshore depends on the host country quality of infrastructure, quality of institution and relative endowment of capital and skilled labour. [Finally we assess whether institutions and infrastructure play a more important role in determining comparative advantage in offshoring than in determining patterns of trade.]

The rest of the paper is structure as follows. The next section reviews the relevant theoretical and empirical literature. Section III provides some stylised facts. Section IV describes the empirical model by specifying the empirical equation and defining the variable used and their expected effects. Section V reports the results of the regression analysis. Section VI concludes.

II. LITERATURE REVIEW

1. Theoretical literature on the determinants of offshoring

Traditional models of trade assume that production takes place within the boundaries of a firm. Therefore they do not explain offshoring, whereby different stages of production are unbundled across countries. A rapidly expanding literature introduces elements from industrial organization and contract theory in trade theory to explain international outsourcing. Most of this has focussed on the choice between offshoring at arm's-length or through FDI. In this paper, we focus on the decision to offshore irrespective of whether it is by sourcing input from an affiliated or an unaffiliated firm.

A simple model explaining why firms decide to offshore has been developed by Jones and Kierzkowski (1990 and 2001). They provide a very simple explanation for the increasing fragmentation of production. They argue that the various stages of production may require different types of technology/skills or inputs in different proportions. In these conditions, the benefit of fragmenting production across countries is that the firm can locate different stages of the production process in the country where there is a relative abundance of the type of skill/input used relatively more intensively in that stage of production. In doing so, the firm can lower costs of production.

---

6 For example, the tyre of a car can be either an input in the production of cars by the automotive sector or a consumption good if purchased by the consumer to change the old tyres of his car.

7 The model of trade in intermediate developed by Feenstra and Hanson (1996) makes a similar point. They assume a continuum of intermediate goods and a single final good, where trade in intermediates occurs on a basis of factor-proportion theories. The South is assumed to be unskilled-labour abundant. Intermediate goods can be costlessly assembled in the North. In this set up, inputs that are relatively less intensive are offshored from the North to the South. General predictions are that: offshoring is less likely in the inputs of goods that make intensive use of the factor for which the offshoring country is relatively more abundant (skilled labour in this case), an increase in the relative supply in the South increases offshoring (eg. an increase in
However, production fragmentation is costly. Separate production stages need to be coordinated and monitored. Furthermore, this implies incurring transportation and communication costs, insurance costs and other connecting services costs.

In this set-up, the decision of where to source inputs from will be driven by both comparative advantage in a particular sector and by the costs of services links. The latter are strongly affected by production scale - as production scale increases, fixed costs related to services can be spread over a larger output, thus implying lower costs per unit of output – and by the quality of infrastructure (as well as regulatory barriers to service trade). Quality of infrastructure is in fact an important determinant of the costs and the quality of services links such as transport and communication costs (Jones, 2000).

Similar conclusions on the importance of infrastructure can be drawn from Antràs and Helpman (2004). In their paper, authors assume that firms vary in their productivity and they have two decision to take about how to source their input: (i) they can either offshore or source domestically their inputs, (ii) they can choose to outsource or vertically integrate production. For the purpose of this paper we will only focus on the first type of decision. In Antràs and Helpman's model the decision to offshore depends on the trade off between higher fixed costs to source inputs abroad than domestically (because of search costs for example) and the lower variable costs of sourcing input in the South where wages are lower than in the North. When inputs are sourced abroad, profits increases associated with more productive firms are more rapid than when inputs are sourced domestically. As a consequence, the more productive firms are more likely to offshore. A general prediction of this model is that the larger the wage gap between the home and the foreign country, the larger the share of firms that will choose to offshore. This is because lower wages abroad will make it easier for domestic firms with lower productivity to cover the fixed costs of offshoring. A related general conclusion of this model is that as trade costs fall, offshoring (both at arm's length and through FDI) increases. This implies that whatever factor reduces trade costs (like when infrastructure improves), it will cause an increase in offshoring.

Other factors that in the model of Antràs and Helpman (2004) will lead to more offshoring are: an average increase in firms' productivity and a lowering of fixed costs for offshoring. That is, offshoring will be higher in countries with higher average productivities and countries where fixed costs of offshoring are lower will be the preferred location where to offshore. From an empirical point of view a number of factors can determine the magnitude of these fixed costs. For example, search costs for a supplier are one these factors. They are higher when the supplier is located in a country that is culturally different from the country where the buyer is located offshore (e.g. different languages, different laws and practices) and they will be in general high for a buyer that has not the language and knowledge skills required to search for an appropriate supplier abroad. Communication costs and time costs of trade can also account for larger fixed costs if offshoring.

How does the quality of the institutional framework affect the decision to offshore? Quality of institutions matters because the contract between the final good producer and the supplier of the intermediate good needs to be enforceable. Otherwise the risk of outsourcing may be too high. When two private parties set up a production relationship, a certain fraction of their investment will be specific to their relationship and cannot be recovered by entering in another relationship if the first does not go to good end. As a consequence of the irreversibility of this investment, parties are reluctant to enter in the relationship. The solution is to write binding contract, but for these to be enforceable quality of institutions matter a great deal.

Note communication and time costs to trade have both a fixed cost and a variable cost component.

There are two alternative approaches in which economic theory has modelled the role of quality of institutions in determining the patterns of trade. One approach is to model institutions as Ricardian technology differences across countries. That is, worse institutions yield productivity losses in the production of capital or a technological improvement), if the unit cost of all activities were lower at home, then there would be no offshoring (this can be the case if the technological gap between two countries is very large).
In a model with different types of firms and with varying types of possible contracts across industries and countries, Antràs and Helpman (2008) show that better institutional frameworks for contracting in the South increase the likelihood of offshoring, but may reduce the relative prevalence of either FDI or foreign outsourcing. In general, economic theory assumes that the risk related to entering in a production relationship is higher when sourcing occurs through arm's-length trade (in this sense institutions are an important determinant of the choice between outsourcing or insourcing), but it also exist when input are sourced from a foreign affiliate.

In particular, the quality of institutions will determine from which country a firm chooses to source its inputs (Grossman and Helpman, 2005). In countries with a good quality of institutions, there will be less under-investment. Thus, the costs of producing customized intermediate inputs will be lower than in countries with a poor institutional environment.

The institutional framework matters, in particular, for the production of non-standardized inputs. Therefore, countries with a good institutional environment have a comparative advantage in the production of intermediate goods that require a specific investment (less standardized products) by the supplier to customize the product to the needs of the producer of the final good.

Yi (2003) and Markusen and Venables (2007) highlight the importance of trade costs (transport and communication costs as well as tariffs and other non-tariff barriers) in determining offshoring. When production is fragmented a reduction in trade costs produces a double advantage: it decreases the price of imported components and increases the return from exported final output. Therefore, imports of components will increase both for the higher demand of those firms that export assembled products and for the higher demand of those firms that assemble for the local market only. In addition, when trade costs fall it may become efficient to fragment production. Therefore, trade in intermediate also increases at the extensive margin because more firms will choose to offshore. For this reason, trade in intermediate increases faster than trade in final goods. In particular, the increase in the extensive margin of trade in intermediate can generate a non-linear response of trade (especially trade in intermediates) to falling trade costs.

2. Empirical Literature

Two branches of the empirical literature are relevant for this study: (i) empirical evidence on the determinants of offshoring (arms'-length trade plus intra-firm trade); (ii) empirical literature on the importance of infrastructure and institution for trade.

(a) the determinants of offshoring

As we already mentioned, because of lack of data, empirical analysis on the determinants of offshoring is quite rare. Existing studies that rely on US firm level data have found evidence that trade costs, low wages for unskilled workers and low corporate income taxes as a determinant of trade in intermediates for further processing within multinationals (Hanson et al., 2006). In particular, focussing on trade between US multinational corporations and their Canadian affiliates in the period intermediate good. The other approach is to model institutions in a setting of incomplete contract theory, where contracts are more incomplete in countries with worse institutions. The implications of these two modelling approach are significantly different, as recently showed by Levchenko (2007) in the first set up theory predicts that all gain from trade, in the second set up less developed countries may not gain from trade.

10 Using firms level data, most empirical studies on offshoring focus on the determinants of intra-firm versus arm's length trade imports in total imports. See, for example, Antás, 2003; Yeaple 2006 and Nunn and Trefler, 2008, Corcos et al., 2008.

11 Hansen et al. (2006) measure offshoring as the share of the cost of imports on total costs (proxied by revenues for lack of data)
1984-1995, Feinberg and Keane (2005) highlight that the largest contribution to the growth in intra-firm trade did not arise as a consequence of tariff reduction, but rather followed the improvements in just-in-time delivery and the reduction in inventory costs.

A limitation of these studies is that they only reflect intra-firm trade for US multinationals. Offshoring is a much wider phenomenon. Extensive amount of empirical analysis on the incidence of offshoring shows that the US is not the main driver of the offshoring phenomenon (Hummel et al, 1998 and 2001; Campa and Goldberg, 1997). Furthermore, intra-firm trade is only a small percentage of trade in intermediate. Recent evidence based on a sample of over 4000 French firms shows that most trade in intermediate inputs occurs at arm's-length (Jabbour, 2007).

At a more aggregated sectoral level, evidence that offshoring is driven by trade costs and comparative advantage is also found by Egger and Egger (2003) for Austria. Building a panel of 9 years and 20 industries from Austrian Input-Output tables, they find that lower tariffs and lower unit labour costs in Eastern Europe significantly increased offshoring from Austria to Eastern Europe. Nordas (2005) focuses on the role that infrastructure quality. Relying on the GTAP database, Nordas calculates the index of vertical specialization developed by Hummels et al. (2001) for 52 countries and 5 sectors. Vertical specialization is found to be significantly affected by trade barriers and infrastructure quality.

A recent paper by Bergstand and Egger (2008) estimates a gravity model of trade in intermediate for 160 countries from 1990 to 2000. Contrary to expectations they find that most trade in intermediate is between developed countries rather than between developed and developing countries. The problem with using the UN classification by broad economic category to distinguish trade in intermediates by trade in final goods is that this classification is quite arbitrary. Indeed a good can be an intermediate input or a final product depending on the buyer. For example, the tyre of a car - that falls in the category parts and components and that it is typically classified as an input in trade statistics-, is an input if used in the production of cars by the automotive sector, but is a final product if purchased by the consumer that change the old tyres of his car for wear and tear.

(b) infrastructure and institutions

A number of empirical studies that have looked at the importance of infrastructure as a determinant of trade flows and comparative advantage. (Clark et al., 2004; Limão and Venables, 2001, Fink et al., 2002; and Nordas and Piermartini, 2004). All these studies have found a positive and significant impact of quality of infrastructure on trade. In particular, using an overall index of the quality of infrastructure, Limão and Venables (2001) find that improving the overall quality of infrastructure so as to move from the median country to the top 25th percentile in the distribution of infrastructure enhances trade by 68 per cent, moving down to the bottom 75th percentile reduces trade by nearly 30 per cent. Using a direct measure of communication costs (the bilateral cost of making a telephone call) in a gravity model, Fink et al. (2002) "find that the cost has a significant and negative impact on bilateral trade flows. Furthermore, supporting the idea that the cost of telecommunications affect search costs, "they find that the bilateral cost of telecommunications have a larger effect on trade flows for differentiated than for homogenous products.

Distinguishing across a number of infrastructure variables (road, airport, port and telecommunication), Nordas and Piermartini (2004) look at the impact of different types of infrastructure on total bilateral trade and on selected sectors. Consistently with the evidence that the bulk of trade occurs via sea, they find that port efficiency is the most important determinant of trade costs. Among individual sectors, the automotive sector appears to be most communication-sensitive. Nordas and Piermartini explain the finding with the fact that the automotive sector is characterized by just-in-time production technology, differentiated products and intra-industry trade both in
components and finished cars. Just-in-time production requires coordination, which in turn is communication-intensive.

A study by Yeaple and Golub (2007) finds that differences in the quality of public infrastructure between countries can explain differences in total factor productivity. Furthermore, since sectors differ in how intensively they use services related to infrastructure and how dependent they are on good infrastructure, the impact of quality of infrastructure on total factor productivity differs between sectors. For example, Yeaple and Golub (2007) find that the quality of road infrastructure appears to be particularly important for productivity growth in the transportation equipment sector and in the production of textile and apparels. Hence, the quality of infrastructure has an impact on patterns of specialization and international trade.

Institutional differences are found to be an important determinant of trade flows in a number of recent studies. Using a gravity model of trade, Anderson and Marcouiller (2002) and de Groot et al. (2004) show that quality of institutions significantly affects bilateral trade volumes and that better institutions are associated with higher volumes of trade. At the sectoral level, Ranjan and Lee (2007) show that institutional quality has a more important role in determining the volume of trade in institution-intensive sectors.

More recently, Levchenco (2007) and Nunn (2007) test whether institutions are a source of comparative advantage in the same way as skill and capital abundance. Using data on 1998 US bilateral imports at the 4 digit SIC classification and relying on the empirical model developed by Romalis (2004), Levchenco shows that US imports from countries with better institutions tend to concentrate in industries more dependent on institutions. As a proxy for institutional dependency Levchenco uses a measure of a good’s complexity calculated as the herfindal index of inputs used in production. To this purpose he uses US I-O Tables and assumes that US sector intensities apply to all countries.

Using a specification of the empirical model similar to Levchenco’s but on countries total exports to the rest of the world, Nunn reaches a similar result: quality of institutions is a source of comparative advantage. His study however focuses on the quality of contract enforcement as a measure of the quality of institution and, therefore, measures the degree of sectoral institutional intensity with the proportion of intermediate inputs that require relationship-specific investments. On the basis of the Rauch (1999)’s classification, Nunn constructs two indexes of contract intensity across industry. One index classifies as contract intensive inputs that are neither sold on an organised exchange nor can be reference priced in trade publications, the other one classifies as contract intensive only those inputs that are not sold on an organised exchange. The assumption is that goods that can be sold on an organised exchange (an to a less extent those than can be reference priced) are only marginally affected by the hold-up problem, because if the buyer attempts to negotiate lower prices for the input, the seller can sell it to another buyer. Like in Levechenko’s study, sectoral institutional intensity is calculated for the US input structure and it assumed to apply to all countries.

To our knowledge the only attempt to measure the importance of institutions for total offshoring is the paper by Nunn and Trefler (2007). In this paper, the authors measure the contractability of inputs of from foreign suppliers with the export price to the US (the assumption is that the degree of contract incompleteness is increasing with the complexity or quality of the goods) and use US I-O tables to construct an indicator for final goods (when less than 50 per cent of goods in the industry are used as inputs). Then, they estimate an equation for the change in imports as a function of the degree of contractual completeness, where by means of an indicator of final goods (that equals one if less than 50 per cent of goods are used as input in the industry), they allow for a different impact of improved contracting on final and intermediate goods. Their results suggest that improved contracting results in

---

12 That is, they have a higher trade share in that sector relative to average trade share of the country in US imports.
an increase in total offshoring, while it is not an important determinant of the volume of imports of final goods.

III. MEASURING OFFSHORING

A major problem with measuring the magnitude and the trend of offshoring is that the economic definition of offshoring does not easily match officially collected data.

Economic literature suggests a number of ways in which offshoring may be measured. A rough measure of offshoring can be obtained using trade statistics. For manufactured goods, trade in intermediates is commonly used as a proxy measure for offshoring. The trade classification broad economic categories (BEC) groups goods according to their end use into capital, intermediate and consumption goods. A similar approach has been adapted by Yeats (2001) by defining trade in certain SITC product categories (those which have the words "parts" or "components" in their description) as trade in intermediates. The advantage of using these measures is that they provide information for a wide range of countries and years.

The problem with using statistics on trade in intermediates to measure offshoring is the arbitrariness of the definition of product groups. A good might be either final or intermediate depending on the context. For instance, software programmes reported under the category "computer and information services" can be demanded both as final products by consumers and as intermediates by firms. Trade statistics do not allow a distinction to be drawn between these two uses.

In this study, we calculate offshoring on the basis of the third edition (2006) edition of the OECD input-output database. The advantage of using input-output tables over trade data is that they allow goods/services used as intermediate inputs to be distinguished from those used for final consumption. Furthermore, they identify both domestic and imported inputs used by an industry in its production process. This consolidated input-output database provides the most extensive coverage of comparable data available up to now for imported intermediate goods used as input for further processing. It contains input-output tables of 35 countries covering 48 industries and the years 1995 and 2000 mostly. Since the focus of this paper is on goods offshoring, we drop services industries and energy industries. Furthermore, we have to aggregate some industries in order to obtain comparable data across countries. Our final sample includes 34 countries and 18 non-energy goods industries.

(a) Narrow offshoring

Input-output tables allow us to calculate the so-called narrow measure of offshoring as defined by Feenstra and Hanson (1999): Narrow offshoring is the ratio of imported own-industry inputs to total own-industry inputs used in production. Hence, this ratio limits the imported inputs in the definition of the index to those falling in the same sector as the importing sector e.g. engines/brakes used by the car industry. Analytically, the narrow measure is calculated as:

\[
\frac{\text{imported inputs}_k}{\text{domestic-imported inputs}_k} \quad \text{for } s=1,\ldots,18
\]

where \(s\) denotes inputs. We do not present results for the broad measure since our quantitative analysis uses the narrow measure only. Typically, broad offshoring is a bit lower than narrow offshoring.

---

13 We follow OECD (2007) in using the aggregation.
14 Differently, the broad offshoring measure (Feenstra and Hanson, 1996) considers all non-energy inputs \(s\) used by industry \(k\), e.g. steel used by the car industry. For a sector \(k\) the broad measure is defined as:

\[
\alpha_{s_k,\text{broad}} = \frac{\sum_{s} \text{imported inputs}_s}{\sum_{s} \text{domestic-imported inputs}_s} \quad \text{for } s=1,\ldots,18
\]
Generally, the definition of offshoring involves two dimensions, i.e. the geographic dimension and a firm dimension. By using input-output tables we can only distinguish the geographic dimension but we cannot disentangle the firm dimension, i.e. we cannot say whether imported inputs stem from an affiliate or from an outside suppliers.

(b) Bilateral Offshoring

An important limitation of input-output data is that offshoring measures can only be constructed at the multilateral level. While for each sector data on imports from all other sectors are available, imports are aggregated across all countries. That is, data on imported inputs are not bilateral. This allows empirical research to analyse the determinant of the total amount of offshoring at the country level and by sector, but does not allow to answer the question of what determines the location of offshoring. In order to address this problem, in our study, we also calculate a measure of bilateral offshoring. Bilateral offshoring is obtained by combining narrow offshoring with trade data. More precisely, the narrow offshoring measure ($os_{ki}$) of reporter country $i$ is multiplied by the import share ($m_{kij}$) of partner country $j$ in industry $k$. The implicit assumption is that that the composition of final goods and intermediate goods imports is the same across partner countries $j$, i.e., if German imports in the car industry consist by 30% of intermediates, then German car imports from both US and the Slovak Republic are assumed to consist to 30% of intermediates too.

Define $m_{kij}$ as the share of imports the partner country $j$ has in overall industry imports of reporter country $i$, i.e. $m_{kij} = \frac{\text{imports}_{kij}}{\sum_j \text{imports}_{kij}}$

Subscript $k$ indicates the industry, $i$ the reporter/importing country and $j$ the partner/exporting country.

Bilateral offshoring from reporter country $i$ to partner country $j$ in industry $k$ is then:

$$os_{kij} = os_{ki} \cdot m_{kij}$$

Hence, $os_{kij}$ is the share of inputs imported from country $j$ in total own-industry inputs used by industry $k$ in country $i$. 

\[
os_{k,narrow} = \frac{\text{imported inputs}_{kk}}{\text{domestic+imported inputs}_{kk}}
\]
IV. STYLIZED FACTS

This section examines the evidence on trends, patterns and the size of offshoring on the basis of the raw data.

1. The incidence of offshoring

Table 1 reports the measure of narrow offshoring index for the 34 countries in our sample for the years 1995 and 2000. We calculate offshoring at the country-level as the output weighted average of the industry measures. Countries are sorted top-down according to their offshoring measure in 2000.

Three facts emerge from Table 1. First, in line with the findings of Hummels et al. (2001)\(^{15}\), large countries tend to offshore less than small countries. The United States, Japan, China, Brazil and India present the lowest incidence of offshoring, while small countries such as Belgium, Ireland and Hungary offshore the most. A possible explanation is that large countries find it easier to exploit economies of scale: Since large countries are more abundant in labour and/or capital than small countries, they are able to achieve increasing returns to scale in different stages in production and across many sectors. Conversely, small countries will bundle their production factors in a smaller number of stages of production and import more inputs. Second, there are substantial differences in the extent to which countries rely on offshoring. Offshoring in the top offshoring country (Belgium, 77.7 percent) is seven times more than in the bottom offshoring country (India, 10.2 percent). Third, offshoring has increased for almost all countries between 1995 and 2000. Especially strong has been the increase for Eastern European countries, i.e. for the Czech Republic from 39 to 58.1 percent, for the Slovak Republic from 39.7 to 56.1 percent and for Poland from 18.6 to 40 percent. Only the Netherlands, France, Brazil and India experienced modest declines in their offshoring measure. Hence, this increase in offshoring for most countries over five years documents well the ongoing phenomenon of the international fragmentation of production.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|l|c|c|}
\hline
\hline
Belgium & 63.6 & 77.7 & Norway & 35.7 & 38.3 \\
Ireland & - & 77.7 & Germany & 30.7 & 36.4 \\
Hungary & 60.8 & 64.9 & Finland & 30.5 & 32.7 \\
Austria & 55.2 & 63.3 & Korea & 31.4 & 32.3 \\
Czech Republic & 39.0 & 58.1 & New Zealand & 29.1 & - \\
Slovak Republic & 39.7 & 56.1 & Greece & 27.9 & 29.0 \\
Switzerland & - & 55.9 & Australia & 26.1 & 27.3 \\
Canada & 40.5 & 51.5 & France & 28.3 & 25.8 \\
Portugal & 34.1 & 49.5 & Russia & 21.7 & 23.8 \\
Sweden & 42.0 & 47.7 & Turkey & 22.0 & 22.5 \\
Denmark & 41.0 & 46.5 & Indonesia & 17.8 & 22.4 \\
Netherlands & 45.2 & 44.9 & Argentina & 20.9 & - \\
United Kingdom & 38.9 & 43.0 & United States & 16.6 & 19.8 \\
Italy & 35.0 & 42.9 & Japan & 11.7 & 14.9 \\
Israel & 42.1 & - & China & 9.0 & 13.9 \\
Poland & 18.6 & 40.0 & Brazil & 10.9 & 10.5 \\
\hline
\end{tabular}
\end{table}

Offshoring measures for 18 non-energy goods industries in the years 1995 and 2000 are presented in Table 2. At first sight, it becomes clear that the reliance on offshoring differs substantially not only across countries but also across industries. While top offshoring industries ‘Office accounting and computing machinery’ and ‘Radio, television and communication equipment’ imported 50 and 42.7 percent of their own-industry inputs in 2000 respectively, industries at the bottom of the list, i.e. ‘Fabricated metal products’ and ‘Agriculture, hunting, forestry and fishing’ offshored only 11.8 and 6.2 percent respectively. Over time most industries have increased offshoring of own-industry inputs, however, the increase in offshoring seems more evenly distributed across industries as for countries. The increment in offshoring has been especially high in the industries ‘Radio, television and communication equipment’ (from 31.2 to 42.7 percent), ‘Manufacturing nec, recycling (include furniture)’ (28.1 to 36.9), ‘Machinery and equipment, nec’ (25.9 to 32.1) and ‘Wood and products of wood and cork’ (15.8 to 21.9).  

16 Hummels et al. (2001) estimate that the machinery and chemicals industries accounted for three quarters in the growth of vertical specialization for most countries in their sample between 1960 to 1990.
Besides describing the size of offshoring across countries and industries, we further ask to which extent countries are similar in their offshoring pattern. In order to do so, we follow Campa and Goldberg (1997) and calculate Spearman rank correlations of offshoring in non-energy goods industries between pairs of four countries (Canada, Japan, United Kingdom and the United States) as shown in Table 3.\textsuperscript{17} A higher correlation indicates that the ranking of industries according to offshoring is similar for a country pair, i.e. that two countries have a high or low offshoring measures in the same industries. While Campa and Goldberg (1997) find significant differences across countries in the degree at which different industries rely on imported inputs in production, we find a more homogenous pattern for offshoring. We observe that no correlation is negative for any country pair.\textsuperscript{18} Offshoring in Japanese industries is weakly correlated to offshoring in industries of the Canada and the United States, but a bit more to offshoring in the United Kingdom. Over time the United States and Great Britain became more similar in their offshoring pattern across industries (from 0.61 to 0.69). Differently, the United States and Canada experienced a large drop in their rank correlation of offshoring industries, i.e. from 0.82 in 1995 to 0.5 in 2000. Generally, Spearman rank correlations of our offshoring measures are far higher than correlations of imported input shares in Campa and Goldberg (1997)\textsuperscript{19}, especially between Japan and other countries as well as for Canada and Great Britain.

<table>
<thead>
<tr>
<th>Year: 1995</th>
<th>Canada</th>
<th>Japan</th>
<th>UK</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>0.1225</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>0.4191</td>
<td>0.429</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>0.82</td>
<td>0.29</td>
<td>0.61</td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year: 2000</th>
<th>Canada</th>
<th>Japan</th>
<th>UK</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>0.3284</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>0.7549</td>
<td>0.5441</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>0.50</td>
<td>0.29</td>
<td>0.69</td>
<td>1.00</td>
</tr>
</tbody>
</table>

2. The direction of offshoring

Economic theory suggests that offshoring takes place to exploit comparative advantage. We should therefore expect that most offshoring take place between developed and developing countries. What is the evidence on the patterns of offshoring? Table 4 shows for each of the 34 countries in our sample the share of intermediate inputs in total inputs sourced from high and middle-low income countries, respectively. We follow the World Bank classification to distinguish these two income groups.\textsuperscript{20}

\textsuperscript{17} Campa and Goldberg (1997) calculate Spearman rank correlations for the export share, import share and imported input share for Canada, Japan, United Kingdom and the United States for the years 1974, 1984 and 1993.

\textsuperscript{18} Spearman rank correlations for other country pairs in our sample are also almost all positive.

\textsuperscript{19} The OECD input-output data allow us to overcome the limitations in Campa and Goldberg. One problem with their study is that the series are not fully comparable across countries: for Canada and Japan their measure include inputs from agriculture and raw material as well as manufacturing inputs, while the measure of offshoring for the United States and United Kingdom only includes manufacturing inputs. To a certain extent these differences reflect different endowments in raw materials.

\textsuperscript{20} See Appendix I for the classification of reporter countries.
TABLE 4
Offshoring (narrow measure) to high and middle-low-income countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Income Group</th>
<th>Overall</th>
<th>High</th>
<th>Medium/Low</th>
<th>Overall</th>
<th>High</th>
<th>Medium/Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td></td>
<td>77.7</td>
<td>66.7</td>
<td>11.0</td>
<td>Norway</td>
<td>38.3</td>
<td>32.3</td>
</tr>
<tr>
<td>Ireland</td>
<td></td>
<td>77.7</td>
<td>69.8</td>
<td>7.9</td>
<td>Germany</td>
<td>36.4</td>
<td>27.9</td>
</tr>
<tr>
<td>Hungary</td>
<td></td>
<td>64.9</td>
<td>49.8</td>
<td>15.1</td>
<td>Finland</td>
<td>32.7</td>
<td>25.7</td>
</tr>
<tr>
<td>Austria</td>
<td></td>
<td>63.3</td>
<td>52.9</td>
<td>10.3</td>
<td>South Korea</td>
<td>32.3</td>
<td>23.0</td>
</tr>
<tr>
<td>Czech Republic</td>
<td></td>
<td>58.1</td>
<td>45.4</td>
<td>12.7</td>
<td>New Zealand</td>
<td>29.1</td>
<td>24.0</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td></td>
<td>56.1</td>
<td>37.1</td>
<td>19.0</td>
<td>Greece</td>
<td>29.0</td>
<td>23.3</td>
</tr>
<tr>
<td>Switzerland</td>
<td></td>
<td>55.9</td>
<td>51.4</td>
<td>4.5</td>
<td>Australia</td>
<td>27.3</td>
<td>20.3</td>
</tr>
<tr>
<td>Canada</td>
<td></td>
<td>51.5</td>
<td>44.6</td>
<td>6.9</td>
<td>France</td>
<td>25.8</td>
<td>21.6</td>
</tr>
<tr>
<td>Portugal</td>
<td></td>
<td>49.5</td>
<td>44.5</td>
<td>5.0</td>
<td>Russia</td>
<td>23.8</td>
<td>13.0</td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td>47.7</td>
<td>42.4</td>
<td>5.3</td>
<td>Turkey</td>
<td>22.5</td>
<td>16.1</td>
</tr>
<tr>
<td>Denmark</td>
<td></td>
<td>46.5</td>
<td>39.8</td>
<td>6.7</td>
<td>Indonesia</td>
<td>22.4</td>
<td>13.6</td>
</tr>
<tr>
<td>Netherlands</td>
<td></td>
<td>44.9</td>
<td>35.6</td>
<td>9.3</td>
<td>Argentina</td>
<td>20.9</td>
<td>11.6</td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
<td>43.0</td>
<td>34.9</td>
<td>8.1</td>
<td>United States</td>
<td>19.8</td>
<td>11.9</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td>42.9</td>
<td>33.9</td>
<td>9.0</td>
<td>Japan</td>
<td>14.9</td>
<td>8.1</td>
</tr>
<tr>
<td>Israel</td>
<td></td>
<td>42.1</td>
<td>37.2</td>
<td>5.7</td>
<td>China</td>
<td>13.9</td>
<td>8.3</td>
</tr>
<tr>
<td>Poland</td>
<td></td>
<td>40.0</td>
<td>31.1</td>
<td>8.9</td>
<td>Brazil</td>
<td>10.5</td>
<td>6.9</td>
</tr>
<tr>
<td>Spain</td>
<td></td>
<td>39.4</td>
<td>33.5</td>
<td>5.9</td>
<td>India</td>
<td>10.2</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Notes: Numbers indicate percent. Country offshoring is calculated as output weighted average of offshoring measures of non-energy goods industries.

As we discussed above, I-O tables only provide figures for the overall imports of intermediate from all other countries in the world. Table 3 is calculated using bilateral trade shares to decompose overall offshoring into a bilateral measure of offshoring. Figures reported in Table 3 suggest that offshoring from high-income countries prevails. In fact, no country in our sample imported relatively more from medium/low income countries than from high income countries. Although this is partially the result of using trade shares to bilateralise offshoring, recent evidence based on UN BEC of trade in intermediates shows a similar pattern: trade in intermediate occurs mainly among developed countries (Bergstrand and Baier, 2008).

At the sectoral level, Table 4 shows that at the exception of textile most imported inputs are sourced by high-income countries from high-income countries. Furthermore, middle-low income countries also import a large share of their inputs from high income countries. This pattern is particularly evident in electrical machinery, while textiles and agriculture represent two exceptions.

TABLE 4
Allocation of Bilateral Offshoring: Shares of Country Group Pairs in Overall Offshoring

<table>
<thead>
<tr>
<th>Industry</th>
<th>Narrow OS</th>
<th>High-High</th>
<th>High-Low</th>
<th>Low-High</th>
<th>Low-Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office, accounting &amp; computing machinery</td>
<td>53.1</td>
<td>47.1</td>
<td>35.0</td>
<td>11.0</td>
<td>6.9</td>
</tr>
<tr>
<td>Radio, television &amp; communication equipment</td>
<td>43.4</td>
<td>47.2</td>
<td>38.4</td>
<td>10.1</td>
<td>4.3</td>
</tr>
<tr>
<td>Ships, Aircraft and Railroad equipment</td>
<td>38.6</td>
<td>80.8</td>
<td>11.9</td>
<td>6.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Electrical machinery &amp; apparatus, nec</td>
<td>38.5</td>
<td>37.0</td>
<td>21.3</td>
<td>31.4</td>
<td>10.3</td>
</tr>
<tr>
<td>Medical, precision &amp; optical instruments</td>
<td>37.7</td>
<td>75.8</td>
<td>16.1</td>
<td>7.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Manufacturing nec; recycling (include furniture)</td>
<td>37.2</td>
<td>43.1</td>
<td>41.6</td>
<td>9.8</td>
<td>5.5</td>
</tr>
</tbody>
</table>
### Table 1: Sectoral Composition of Trade (in percent)

<table>
<thead>
<tr>
<th>Industry</th>
<th>Exports</th>
<th>Total Exports</th>
<th>Imports</th>
<th>Total Imports</th>
<th>Value Added</th>
<th>Exports</th>
<th>Total Exports</th>
<th>Imports</th>
<th>Total Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals and pharmaceuticals</td>
<td>36.3</td>
<td>73.2</td>
<td>9.3</td>
<td>11.5</td>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinery &amp; equipment, nec</td>
<td>32.7</td>
<td>70.0</td>
<td>14.4</td>
<td>13.2</td>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Metals</td>
<td>29.8</td>
<td>52.4</td>
<td>27.4</td>
<td>10.1</td>
<td>10.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor vehicles, trailers &amp; semi-trailers</td>
<td>26.9</td>
<td>77.4</td>
<td>12.1</td>
<td>8.8</td>
<td>1.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Textiles, textile products, leather and footwear</td>
<td>25.5</td>
<td>29.1</td>
<td>41.5</td>
<td>14.0</td>
<td>15.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood and products of wood and cork</td>
<td>22.1</td>
<td>57.9</td>
<td>29.3</td>
<td>5.8</td>
<td>7.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulp, paper, paper products, printing and publishing</td>
<td>21.2</td>
<td>73.9</td>
<td>9.1</td>
<td>11.3</td>
<td>5.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubber &amp; plastics products</td>
<td>18.2</td>
<td>63.4</td>
<td>20.4</td>
<td>12.1</td>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food products, beverages and tobacco</td>
<td>16.9</td>
<td>59.9</td>
<td>22.3</td>
<td>9.6</td>
<td>8.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other non-metallic mineral products</td>
<td>12.2</td>
<td>56.6</td>
<td>21.7</td>
<td>15.7</td>
<td>6.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fabricated metal products</td>
<td>12.0</td>
<td>60.7</td>
<td>25.4</td>
<td>10.8</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture, hunting, forestry and fishing</td>
<td>6.3</td>
<td>41.5</td>
<td>33.2</td>
<td>10.5</td>
<td>14.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Numbers indicate percent.

### V. THE EMPIRICAL METHODOLOGY

#### 1. the estimated equations

Our aim is to study the role that transport infrastructure and quality of institution have in determining the patterns of offshoring by affecting overall trade costs and determining comparative advantage.

We test these hypotheses by estimating two equations: One explores the determinants of offshoring at the country and sectoral level. The second one turns to the distribution patterns of offshoring across partner countries.

First of all at the multilateral level, we estimate the following equation of offshoring:

\[
\ln\left( \frac{o_{isk}}{1 - o_{isk}} \right) = \alpha + \beta_1 (q_k * Q_{RoW} / Q_i) + \beta_2 (comm_k * \ln Comm_{RoW} / Comm_i) + \beta_3 (airtr_k * \ln AirTr_{RoW}) + 21 \\
\beta_4 (k_k * \ln K_{RoW} / K_i) + \beta_5 (h_k * \ln H_{RoW} / H_i) + \delta_i + \mu_k + \xi_i + \epsilon_{sit}
\]

where \( o_{isk} \) is the offshoring index of country \( i \) in sector \( k \) (calculated as country \( i \)’s imports of intermediate (non-energy) inputs from all other countries in the world. In equation (1) offshoring is explained by the interaction of industry characteristics with country characteristics.\(^{21}\) Our variables of interest are \( Q, Comm, AirTr \) which denote the quality of institutions, communication and air-transport infrastructure respectively. Country \( i \)’s endowments of physical and human capital are denoted by \( K \) and \( H \), respectively. Subscript \( RoW \) denote that the variable is calculated as the average across all potential partners of country \( i \). \( q \) is a measure of the contract-intensity of industry \( k \), \( airtr \) is a measure of air transport intensity, \( h \) denotes skill-labour intensity, and \( k \) capita intensity, \( \delta_i \), \( \xi_i \), and \( \mu_k \) denote time, country and industry fixed effects.

\(^{21}\) The specification is based on Romalis (2004) who uses interaction terms to test the importance of factor endowments as source of comparative advantage.
Recent empirical studies (Nunn, 2007 and Levchenko, 2007) have looked at the role of institutions in determining comparative advantages in total trade, that is trade in final and intermediate goods. Following this literature we look at the importance of institution and infrastructure in determining comparative advantage in offshoring. If a country has a comparative advantage in institutional intensive sectors, for example, we should expect that it will recur less to offshoring in institutional intensive sectors. Institutional intensive sectors are more subject to hold-up problems and this is more likely to be a problem (due to difference in languages, laws and practice) across countries than within a country. In general, the local price of a factor is lower if the factor is abundant in the home country. This reduces the incentive to offshore driven by lower factor prices abroad. We therefore expect a positive coefficient on the interaction terms.

Focussing on transport infrastructure, available data on the prevailing mode of transport by sector has showed that although sea transport is the most used means of transport especially for bulk commodities, air transport is the preferred mode for high commodities characterised by high value/weight ratios (eg. electronics) and for long distance travels (Harrigan, 2005). Since air transport is more expensive than sea transport, this evidence shows that industries are willing to pay a premium to reduce the time transport. Good quality of air infrastructure will provide a comparative advantage in time sensitive goods. We test this hypothesis by assuming that time sensitive sector (or air transport-intensive sectors) are sectors characterised by a high value to weight ratio.

Equations (1) is based on the index of offshoring of a country from all other countries in the world. Multilateral offshoring does not allow to study the empirical relevance of different factors in determining the location decision of where to offshore. To address this question, we rely on the bilateral estimates of offshoring that we calculated by using bilateral trade shares. We then estimate a gravity type equation of offshoring for an unbalanced panel of 34 reporter country across all their trading partners.

The equation we estimated for bilateral offshoring is the following:

$$\ln \left( \frac{os_{ijt}}{1 - os_{ijt}} \right) = \alpha + \beta_1 \ln(dist_{ijt}) + \beta_2 \ln(d_{ijt}) + \beta_3 \ln(lang_{ijt}) + \beta_4 \ln(rgdp_{ij}^* * \ln(rgdp_{ij}^* + \beta_5 \ln(rgdp_{ij}^* * \ln(rgdp_{ij}^* + \beta_6(k_i \ln(H_{ij}^* / K_{ji}^*)) + \beta_7(k_h \ln(H_{ij}^* / K_{ji}^*)) + \beta_8(q_k \ln(Q_{ij}^* / Q_{ji}^*)) + \beta_9(airTr_{ij} \ln(AirTr_{ij}^* / AirTr_{ji}^*)) + \beta_{10}(Comm_{ij} \ln(Comm_{ji}^* / Comm_{ij}^*)) + \beta_{11}AirTr_{ij} + \beta_{12}Comm_{ij} + \beta_{13}FTA_{ij} + \beta_{14} \ln(remoteness_{ij}^*) + \beta_{15} \ln(remoteness_{ji}^*) + \mu_i + \delta_j + \xi_i + \zeta_j + \epsilon_{ijt}$$

(2)

where $\xi_i$ and $\zeta_j$ are reporter and partner fixed effects.

In this bilateral specification we introduce the standard gravity model variable to measure trade costs. These include distance, common colonial link, adjacency and common language. Additionally we bilateralize the indexes of Transport and Communication quality. That is we build a variable that denotes the average quality of institutions as an indication of average bilateral transport costs. The reason is that offshoring costs related to monitoring and intensity of communication are higher the worse the quality of infrastructure in the two countries. We then introduce a set of variables that aim specifically at capturing the exploiting comparative advantage nature of offshoring. We model this in terms of relative factor abundance and use sectoral intensity to account for sectoral differences.

Regressions for the logistic specification above are run using the generalised linear model. There are however numerous zeros in the database. Zeros arise both because of zero bilateral trade flows and
because of zero offshoring. In order to account for the zeros, we also use the Poisson estimation method.

2. Data and measurements

A complete description of the variables used for this paper is provided in the Appendix. This section focuses on the variables related to infrastructure and institutions.

A higher quality of infrastructures reduces the cost of transport and allows a faster delivery of products. Just-in-time production represents a key component in the splitting up of the value chain. We therefore expect that quality of infrastructure matters for the decision to offshore. In particular, since logistic services for just-in-time delivery are provided through the combination of alternative modes of transport and the intensive use of communication technologies, we expect that trade costs are lower the better the quality of infrastructure for all types of transport infrastructure and the better the quality of communication infrastructure.

Following Limao and Venables (2001), the indexes for the quality of transport and communication infrastructure are calculated as the normalised average across components. We measure the overall quality of transport infrastructure of a country as an average of the quality of road, rail, ocean and air transport. In particular, we calculate the index of the overall quality of transport infrastructure using information on the number of airport with paved railways over 3047 meters, the density of railways, the percentage of paved roads and an index of port efficiency. In order to construct the index of the quality of communication infrastructure, we consider the density of internet users per 1000 people; the number of mobile phone subscribers per 1000 people and the number of telephone mainlines per 1000 people. Both for transport and for communication infrastructure a higher value of the index denotes better quality.

The effectiveness of contract enforcement is a key element in determining the extent of the hold-up problem connected to offshoring. In order to measure the quality of institution in terms of their ability to enforce contract we follow existing empirical literature (Nunn, 2007) and use the indicator for "rule of law" developed by Kaufman et al (2003). This index is calculated on the basis of individuals' perception of the effectiveness of the judiciary system and of contract enforcement. The index ranges between -2.5 (lowest institutional quality) to 2.5 and is taken from the World Bank (2007) Governance Indicator database.

<table>
<thead>
<tr>
<th>TABLE 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSPORT</td>
</tr>
<tr>
<td>TOP 5</td>
</tr>
<tr>
<td>1995</td>
</tr>
<tr>
<td>Denmark</td>
</tr>
<tr>
<td>Netherlands</td>
</tr>
<tr>
<td>France</td>
</tr>
<tr>
<td>Austria</td>
</tr>
<tr>
<td>Spain</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BOTTOM 5</th>
</tr>
</thead>
</table>

\[22\] Data on the number of airport with paved railways over 3047 meters is taken from the CIA fact book. The density of railways, the percentage of paved roads, the density of internet users per 1000 people; the number of mobile phone subscribers per 1000 people and the number of telephone mainlines per 1000 people are taken form the World Bank (2007) World Development Indicator. The port efficiency index is taken from the IMD World Competitiveness year book. This index is build on the basis of a questionnaire and reflects answers to the question of whether water infrastructures meet business requirements. Interviewed people judge based on a scale that varies from 1 to 10. The scale reflects the level of agreement with the statement.
Turning to sectoral intensities, as Levchenko (2004) and Nunn (2007) we follow Romalis (2004) approach. As a proxy for sectoral institution intensity, we use one minus the Herfindahl index of intermediate inputs used in the production of the final good in the USA during 1997. This measure increases in the variety of inputs used in production and is a proxy for the complexity of goods. More complex good are considered more institutional intensive than goods that require a lower number of inputs, because, given the higher number of relationships involve, they are likely to face a more important hold up problem.

Transport intensity is proxied by the average unit value of each sector. There is a large body of evidence that shows that while the preferred means of transport for trade in bulk commodities (characterised by a high weight to value ratio) is ocean shipping, air transport is largely used for transport of products characterised by high value to weight. We take the inverse of the unit values as a proxy for the value to weight ratio and assume that sectors characterised by a higher weight to value are more transport intensive (especially sea transport intensive) than sectors characterised by a low weight to value ration (air transport intensive). Unit values are taken from the CEPII BACI database, which reports these values at the six digit level of the 1992 Harmonised System.

Communication intensity is build in conformity with the findings of Fink et al (2002). The authors find that communication costs are more important for differentiated rather than homogeneous goods. Following their findings, we proxy communication intensity by the share of lines of differentiated products in each sector, where in order to identify differentiated products we follow the Rauch (1999) classifications.

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Average unit value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining and quarrying</td>
<td>0.0861902</td>
</tr>
<tr>
<td>Coke, refined petroleum products and nuclear fuel</td>
<td>0.1562566</td>
</tr>
<tr>
<td>Food products, beverages and tobacco</td>
<td>0.3088696</td>
</tr>
<tr>
<td>Other non-metallic mineral products</td>
<td>0.3845591</td>
</tr>
</tbody>
</table>
VI. ESTIMATION RESULTS

Table 7 reports the results for the estimates of equation (1). The results focus on the narrow measure of offshoring because, as we discussed above, this is the measure that more strictly corresponds to the notion of offshoring. The results show that skilled labour endowment and the quality of air transport infrastructure are important determinant of comparative advantage. On average a country tend to offshore skilled labour intensive products the higher the average relative endowment of skilled labour of the rest of the world. By the same token, the higher the relative average quality of air transport of the rest of the world the higher the level of offshoring in air-transport intensive products. We do not find significant coefficients for quality of institutions and quality of communication as determinant of comparative advantage in the regressions for multilateral offshoring. This result is robust to the use of both the inverse of the Herfindal index as a measure of sectoral institutional intensity (the measure used by Levchenko (2007)) and the measure of the degree of sectoral differentiation as measured according to the Rauch classification – as done by Nunn (2007).

Table 7: The importance of quality of institutions and infrastructure in offshoring

<table>
<thead>
<tr>
<th></th>
<th>narrow offshoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactions institutions, q*lnQrow/Q</td>
<td>1.22</td>
</tr>
<tr>
<td>Interactions air transport,.airtr*lnAirTrrow/AirTr</td>
<td>-.004***</td>
</tr>
<tr>
<td>Interaction communication, comm*lnCommrow/Comm</td>
<td>-.078</td>
</tr>
<tr>
<td>Interactions skill labour, h*lnHrow/H</td>
<td>8.72***</td>
</tr>
<tr>
<td>Interactions capital, k*lnKrow/K</td>
<td>.24</td>
</tr>
</tbody>
</table>

Table 7 reports the results for the estimates of equation (1). The results focus on the narrow measure of offshoring because, as we discussed above, this is the measure that more strictly corresponds to the notion of offshoring. The results show that skilled labour endowment and the quality of air transport infrastructure are important determinant of comparative advantage. On average a country tend to offshore skilled labour intensive products the higher the average relative endowment of skilled labour of the rest of the world. By the same token, the higher the relative average quality of air transport of the rest of the world the higher the level of offshoring in air-transport intensive products. We do not find significant coefficients for quality of institutions and quality of communication as determinant of comparative advantage in the regressions for multilateral offshoring. This result is robust to the use of both the inverse of the Herfindal index as a measure of sectoral institutional intensity (the measure used by Levchenko (2007)) and the measure of the degree of sectoral differentiation as measured according to the Rauch classification – as done by Nunn (2007).
Turning to the estimation of equation (2), the results are reported in Table 8. In order to account for the fact that our dependent variable is a fraction between 0 and 1, Column (1) and (2) reports the results for the logistic transformation of the measure of offshoring estimated using the generalised linear model of estimation with a binomial probability function. In Column (3) and (4), we consider for each reporter in the database the complete set of partners. We therefore include all bilateral zero trade in the matrix of bilateral trade. For this reason and to correct for heteroscedasticity, we estimate the offshoring model using Poisson estimation. Both traditional factors of comparative advantage – capital and skill labour endowment- and quality of air transport and communication infrastructure appear significant and with the correct sign. When significant also institutional quality show the correct sign as a source of comparative advantage, but it is in general not significant. A possible explanation is that institutional quality is not a form of comparative advantage as other factors of production. It is necessary that the importer as well as the exporter exhibit a certain minimum level of institutional quality in order for the hold-off problem arising between the supplier of the inputs and the producer in the downstream sector to be solved. It is only when this threshold is reached that comparative advantage kicks in.

Table 8: The determinants of offshoring: where to offshore

<table>
<thead>
<tr>
<th></th>
<th>GLM-Logistic</th>
<th>Poisson including zeros</th>
</tr>
</thead>
<tbody>
<tr>
<td>narrow offshoring</td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Interactions</td>
<td>Interactions</td>
<td>Interactions</td>
</tr>
<tr>
<td>institutions, q*lnQ</td>
<td>-.009</td>
<td>.15</td>
</tr>
<tr>
<td>Interactions</td>
<td>Interactions</td>
<td>Interactions</td>
</tr>
<tr>
<td>airtransport, airtr*lnAirTr</td>
<td>.003***</td>
<td>0.002***</td>
</tr>
<tr>
<td>Interaction</td>
<td>Interaction</td>
<td>Interaction</td>
</tr>
<tr>
<td>communication, comm*lnComm</td>
<td>.045#</td>
<td>.04**</td>
</tr>
<tr>
<td>Interactions</td>
<td>Interactions</td>
<td>Interactions</td>
</tr>
<tr>
<td>skill labour, h*lnH</td>
<td>8.58***</td>
<td>7.22***</td>
</tr>
<tr>
<td>Interactions</td>
<td>Interactions</td>
<td>Interactions</td>
</tr>
<tr>
<td>capital, k*lnK</td>
<td>-.041</td>
<td>.20§</td>
</tr>
</tbody>
</table>

average good airtransport
average good communication

standard gravity variables

<table>
<thead>
<tr>
<th></th>
<th>GLM-Logistic</th>
<th>Poisson including zeros</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>-.61***</td>
<td>-.60***</td>
</tr>
<tr>
<td>Colony</td>
<td>.10**</td>
<td>.14***</td>
</tr>
<tr>
<td>Contiguity</td>
<td>.46***</td>
<td>.38***</td>
</tr>
<tr>
<td>Language</td>
<td>.37***</td>
<td>.40***</td>
</tr>
<tr>
<td>FTA</td>
<td>.28***</td>
<td>.34***</td>
</tr>
<tr>
<td>GDP i*GDPj</td>
<td>.58***</td>
<td>.56***</td>
</tr>
<tr>
<td>Remoteness i</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Remoteness j  

<table>
<thead>
<tr>
<th></th>
<th>yes</th>
<th>yes</th>
<th>yes</th>
<th>yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>time fixed effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>industry fixed effects</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>country fixed effects</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

Number of observations  

<table>
<thead>
<tr>
<th></th>
<th>90270</th>
<th>77473</th>
<th>156840</th>
<th>156840</th>
</tr>
</thead>
<tbody>
<tr>
<td>log pseudolikelihood</td>
<td>-1754.52</td>
<td>-1639.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-square</td>
<td>0.26</td>
<td>0.33</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ***, **, * denote 1, 5, 10 per cent significance level

VII. CONCLUSIONS

This paper tests the extent to which offshoring is driven by comparative advantage. Together with traditional sources of comparative advantage, we test for new sources of comparative advantage highlighted in the literature on offshoring, namely quality of infrastructure and quality of institutions. In particular, we distinguish between communication infrastructure and transport infrastructure. Indeed, economic literature highlights a different role for the two types of infrastructure. While transport, especially air transport, is an important component in determining comparative advantage in time-sensitive goods, communication infrastructure are important to address the information asymmetry associated with trade in differentiated goods. Institutions are crucial in providing a comparative advantage in the decision to offshore of goods that require an important upfront investment to customise the input to the requirements of the downstream sector. Consistently with the results of the empirical literature on total trade, we find a more important role of skill endowment than capital endowment in determining comparative advantage, that tend to be not significant although in general present the right sign. Air transport infrastructure and to a lesser extent communication infrastructure are important sources of comparative advantage. These results hold even when we control for air-transport and communication as determinant of transport costs. We do not find robust evidence of a role of institution as a source of comparative advantage. On the contrary we sometimes find that differences in the quality of institutional quality are negatively correlated with offshoring. We claim that one possible explanation may be that to solve the hold-up problem associated with offshoring both good institutions in the importing and in the exporting country are needed. On this issue the next efforts of our research will focus.
References


APPENDIX A: Data and sources

Industry intensity data and sources

- **Share of lines, by industry, of differentiated product according to the Rauch (1999) classifications.** The classification is taken from the John Havemann, International Trade data website, available at: www.macalester.edu/research/economics/page/haveman/trade_resources/TradeData.html. The Rauch (1999) classification identifies each product according to one of the following categories: traded on an organized exchange (homogeneous goods), with referenced price and differentiated goods. The classification used is the SITC rev.2 classification at the 4 digit level. We first match the SITC rev.2 into industries. This was done by matching the SITC rev2 at the 4 digit level with the HS6 1988/1992 and then matching the HS6 1988/1992 with the ISIC rev.3 at the 4 digit data. Thus, data was aggregated by industry. Conversion files were taken from WITS (2008) Integrated database. The measure was constructed by counting the number of lines classified as differentiated goods by industry. This amount was then divided by the total number of lines of present in each industry.

- **Unit values** are taken from the CEPII (2008) BACI database. Data is reported according to the 1992 Harmonised System classification at the six digit level of aggregation. Data for 1994 was not available and thus 1995 values were used. The conversion of the data from the HS6 level to the ISIC rev.3 t the 4 digit was done using the conversion file provided by CEPII (2008) BACI database.

- **Capital intensity.** It is proxied by one minus the share of total compensation in value added. Data on total wage compensation and value added at the industry level was taken from the OECD Input/Output Table.

- **Skill intensity.** It is constructed by multiplying the ratio of non-production worker wages to total wages of the United States during 1996 with the share of total labour compensation in value added. The source of non-production worker wages to total wages is Bartelsman and Gray (1996). The data was taken from the Nunn (2006) database, available at: http://www.econ.ubc.ca/nnunn/contract_intensity_data.htm. Data is classified according to the 1997 Bureau of Economic Analysis Input Output classification. We converted this classification into the 1997 Harmonised System at the 10 digit level using the conversion Table provided by the BEA. The 10 HS Harmonized system was converted into the 1996 HS at the 6 digit level and then to the ISIC rev3 using the Conversion Table provided by WITS (2008) Integrated database. The variable is the simple average of the values by industry.

- **The Herfindahl index** is taken from the Nunn (2007) database. It is calculated by summing the squared share of intermediate inputs used in the production of the final good. Nunn (2006) constructs this measure using the 1997 United States Input – Output Table. As for the skill intensity variable, data was coverted into the ISIC rev3 classification. The variable is the simple average of the values by industry.

- **Transport Infrastructure Index.** The index is build using the following variables:
b) The number of airports with paved runways over 3,047 m. Source: CIA Factbook, various years.
c) A port efficiency index (1-10). Source: IMD World Competitiveness Yearbook, various years. The question asked is: “Do water infrastructures (harbour ...) meet business requirements?

• **Communication Infrastructure Index.** The Index is built using the following variables:
  a) Internet users per 1000 people.
  b) Mobile phone subscribers per 1000 people.
  c) Telephone mainlines per 1000 people.

• **Institutional Endowment** is proxied with the rule of law as in Kaufman et al. (2003). Source: World Bank (2008), Governance database. Missing years were replaced using data on the next year. Data on the next year was used to replace the missing years. The index ranges between -2.5 (lowest institutional quality) to 2.5.
APPENDIX B
To be added: Summary statistics at the industry level and at the country level.

APPENDIX C
Reporter Countries Grouped according to World Bank Income Classification

<table>
<thead>
<tr>
<th>High Income Countries</th>
<th>Medium and Low Income Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Brazil</td>
</tr>
<tr>
<td>Austria</td>
<td>Czech Republic</td>
</tr>
<tr>
<td>Belgium</td>
<td>Hungary</td>
</tr>
<tr>
<td>Canada</td>
<td>Korea, Rep.</td>
</tr>
<tr>
<td>Denmark</td>
<td>Poland</td>
</tr>
<tr>
<td>Finland</td>
<td>Slovak Republic</td>
</tr>
<tr>
<td>France</td>
<td>Turkey</td>
</tr>
<tr>
<td>Germany</td>
<td>China</td>
</tr>
<tr>
<td>Greece</td>
<td>Russia</td>
</tr>
<tr>
<td>Ireland</td>
<td>India</td>
</tr>
<tr>
<td>Italy</td>
<td>Indonesia</td>
</tr>
<tr>
<td>Japan</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
</tr>
<tr>
<td>Switzerland</td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td></td>
</tr>
</tbody>
</table>

Note: *Data for Argentina, Israel and New Zealand is available for the years 1997, 1995 and 1996 only. They are not used in the calculations for Table 2 and Table 4 because years are too distant from 2000. Partner Countries are also grouped according to the classification of the World Bank. Partner countries that are not classified by the World Bank are assigned to the medium and low income group.*