DETERMINANTS OF VERTICAL SPECIALIZATION

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Abstract

The determinants of international outsourcing are analyzed using the O-ring theory of production and its predictions are explored empirically. The vertical specialization (VS) index suggested by Hummels et al. (2001) is estimated and regressed on variables related to lead time and product quality. It is found that tariff protection has a strong anti-VS bias and that market size, the effectiveness of ports, telephone density and control of corruption are the most important determinants of VS. Telecommunication developments explain an increase in the VS share of total exports over time.

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1 Introduction

Once upon a time Henry Ford invented a way of producing cars that made them affordable to ordinary American families. Furthermore, the workers were paid sufficiently high wages to create a mass market for the mass produced cars. Ford's idea was to break up the production process in as small and standardized units as possible and organize the activities sequentially along an assembly line. He had built factories into which steel entered at the one end and finished, standardized cars rolled off at the other end. Henry Ford is also famously associated with the statement that the colour of the car does not matter as long as it is black.

Modern manufacturing has changed a lot since Henry Ford's days. The assembly line has been replaced by different forms of flexible production such as quality circles, just-in-time delivery and flexible automation. On the demand side the modern consumer wants to have a choice. The idea of breaking up the production process in standardized units has, however, persisted and been reinvented as geographically dispersed production networks of specialized producers. The buzz-words of modern manufacturing are mass customization, outsourcing of non-core activities and supply chain management. In a number of industries the vertical stages of production differ widely in their factor intensity. Some stages are labour-intensive, others are capital-intensive while yet others use skilled labour intensively. Vertical specialization thus allows developing countries to enter labour-intensive stages in advanced industries and over time upgrade to more skills-intensive stages, while rich countries are able to retain jobs in skills-intensive stages of low-technology industries.

When supply chain management involves the minimization of time to market within a sequential production process, lead time becomes crucial at all stages of production. If expensive machinery and high-skilled workers are made idle waiting for an input from suppliers performing an earlier task in the production chain, that would involve big losses. By the same token, garments sell for a substantial discount simply because it is late in the season. Clothing has been the entry level sector for many poor countries in their industrialization process. However, the delivery time of fashion garment is now typically one week (Abertnathy et al., 1999) while in poor countries it may take as much as a month to get goods trough customs (Micco and Perez, 2002). Needless to say, poor infrastructure, corruption and ineffective border procedures may seriously impede poor countries in exploiting their comparative advantage for labour-intensive goods in an environment with increasingly time-sensitive vertical production networks.

A theoretical framework that captures the interdependence between production stages is the so-called O-ring production function suggested by Kremer (1993). A key feature of the O-ring theory is that quality of inputs cannot be substituted for quantity even when a lower quality fetches a significantly lower price. If a firm has chosen a high quality for n-1 stages in the production chain, it will also choose a high quality for the *n-th* stage. I find this framework useful for exploring the relationship between relative production costs, product quality and lead time in industries where vertical fragmentation has become important. To my knowledge exploring empirically the implications of this theory in the context of vertical specialization has not been done before.

The paper first presents the theoretical model and then makes some relevant adjustments in order to focus on the features of vertical specialization in an international context. I focus on two dimensions of quality, the fault rate of components and the timeliness of delivery. The Kremer model is simplified by abstracting from the use of capital in order to focus on the quality of inputs, and extended by including a supply function for quality.[2] The second part of the paper provides an empirical estimate of the determinants of vertical specialization in an international trade context using the vertical specialization index developed by Hummels et al. (2001). I regress this index on a number of variables which are likely to affect the extent to which firms engage in international vertical specialization using a panel of 52 countries and two periods (1997 and 2001). The rest of the paper is organized as follows: section two briefly discusses the nature and extent of vertical specialization. Section three presents the model, section four presents the empirical findings while section five concludes.

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[2] Kremer (1993) focuses on the quality of workers performing the tasks in the production chain and assumes that skills are distributed among workers according to an exogenous distribution function.

2 The nature and importance of vertical specialization

A recent study by Yi (2003) finds that at least half of the observed increase in world trade since the 1960s can be explained by means of a model of world trade that incorporates vertical specialization. The model mimics a dynamic process where technological and organizational innovations have made it possible to slice up the production process, while lower trade barriers create incentives for locating different stages of production in different countries.

In the empirical literature there is no consensus on exactly what vertical specialization is. Hummels et al. (2001) define it as the import content of a country's exports. They find that the share of vertical specialization in exports was about 20 percent in 1990, and that it had increased by 30 percent since 1970, using data for 13 OECD countries plus Taiwan; a sample which covered about 60 percent of world trade. Another measure of vertical specialization is intra-firm trade in intermediate inputs. Borga and Zeile (2003) find that during the period 1966-1999, exports of intermediate inputs by US parents to their foreign affiliates increased forty-fold, and the share of intra-firm exports of intermediate products in US total merchandise exports increased from 8.5 to 14.7 percent during the same period. Many argue that international outsourcing to external suppliers has increased faster than intra-firm trade in intermediates (e.g. Antras and Helpman, 2004). It is also worth noticing that while intra-firm trade as a share of world trade appears to have been fairly stable at about a third over the past two decades, intra-firm trade in intermediates has increased sharply, indicating that vertical multinational activity has increased relative to horizontal activity (Hanson et al., 2001; 2003).

These figures only cover trade in goods. In addition there is trade in services, where business services play an important role for vertical specialization providing logistics, matching suppliers and lead firms and assisting suppliers in meeting the quality standards of the lead firm. According to UNCTAD (2003), the inward stock of foreign direct investment in business services increased nine-fold during the period 1990-2001 worldwide; about 5-fold in developed countries and almost a 100-fold in developing countries. Moreover, the share of business services in total inward stock increased from 6 to 17 percent globally, and from less than 2 percent to almost a quarter in developing countries during the same period.

The nature of the linkages between the firms in the supply chain differs between sectors and market segments. Close coordination of and frequent communication between suppliers and the lead firm are common features in all production networks. However, the nature of the communication and coordination varies from automated procurement to joint R&D. Automated procurement is common in supply chains that are driven by retailers. Sales data are gathered in real time at the sales point, transmitted to distribution centres, which in turn are electronically connected to the suppliers. Inventory management and procurement are often computerized and in some cases automated such that the entire sequence of activities from production of parts and components to after-sales services is coordinated by means of electronic networks. Joint R&D and production planning are common in industries such as the car industry and the machinery sector.

Modern manufacturing equipment consists of flexible machine tools and production equipment that can be electronically programmed. Design and engineering are also computerized and can be fed directly into the programmable production equipment. This implies relatively small batch sizes, just-in-time delivery, quality control at source and consequently smaller inventories at all stages of production. Computer-assisted design (CAD) that feeds into computer-assisted manufacturing (CAM) is standard in many industries. Furthermore, the two (i.e. CAD and CAM) can be separated in space and between institutions through electronic transmission of design.[3] For example, even if manufacturing activities have relocated from Western Europe to emerging economies in Asia or more recently Eastern Europe, product development, product design and engineering activities have often remained in Western Europe either in specialized independent firms or as a main office function in multinationals.

Introducing modern, largely computerized technology at one stage in the production process often requires compatible technologies and computerization in the closest vertical stages as well in order for the system to operate smoothly. Suppliers in poor countries without access to electronic

[3] See Milgrom and Roberts (1990) for a seminal article on modern manufacturing practices, and Nordås (2004) for a case study.

networks rely on logistics firms that also match suppliers and downstream customers and provide quality control.[4]

To summarize this section, trade driven by vertical specialization accounts for at least a fifth of total world trade and it has perhaps been the most important source of trade growth during the past decade. Intra-firm trade accounts for a large part of this, but there is growing evidence that sourcing from foreign outside suppliers has gained in relative importance recently. The introduction of computer-assisted design and manufacturing and not least the possibility of integrating the control of production and logistics using ICT have been crucial for the proliferation of international vertical specialization.

3 The model

A model that captures the features of vertical specialization is Kremer's (1993) O-ring theory of production. The basic idea is that production consists of a number of tasks, and the value of the resulting output depends on the successful performance of all tasks. The production chain is as strong as its weakest link with the logical consequence that producers will choose to have all links equally strong. Kremer's production function reads:

$$Y = k^{\alpha}\left(\prod_{i=1}^{n} q_i\right) nB \qquad (1)$$

Y is final output, *n* is the exogenous number of tasks needed to complete the production process and it is assumed that each task is performed by one worker where $q \in (0, 1)$ represents the worker's ability to perform the task to perfection. B is the output per worker equipped with a single unit of capital if $q = 1$. Thus, the maximum output if all task are performed to perfection is $Y = k^{\alpha} nB$. Assume that all but one worker perform their task to perfection. If the lesser skilled worker's quality is 0.6, output

[4] See Feenstra et al. (2002) for a discussion of the role of Hong Kong logistic firms in mainland Chinese companies' trade performance.

will be reduced to $Y = 0.6 * k^{\alpha} nB$, or by the full 40 per cent lower ability of the lesser skilled worker.

In order to simplify the analysis and focus on the tasks undertaken in a vertically fragmented production chain, I set α = 0 and open the possibility that tasks can be delivered from outside suppliers. The production function then reduces to:

$$Y = \left(\prod_{i=1}^{n} q_i \right) nB \tag{2}$$

The variable *q* is now interpreted as the quality of input *i* measured relative to zero-faults and just-in-time arrival at the relevant production station, while B is a scalar that represents the output volume per unit of input if all inputs have zero faults and arrive on time. The price of an input is an increasing function of its quality. The profit maximizing lead firm chooses quality of the input according to the following maximization problem:[5]

$$\underset{q}{Max}\left[nB\left(\prod_{i}^{n} q_i \right) - \sum_{i=1}^{n} p(q_i) \right]$$

The first-order condition is

$$nB\left(\prod_{j \neq i}^{n} q_j \right) - p'(q_i) = 0 \tag{3}$$

The first term in this expression represents the marginal productivity of q_i. Following Kremer's argument, the derivative of the marginal product of the quality of the *i*th input with respect to the quality of all the other inputs;

$$\frac{d^2 Y}{dq_i d\left(\prod_{j \neq i} q_j \right)} = nB$$

is positive. This implies that the firm with the highest quality of the g -1 ($g \leq n$) input will place the highest value of quality of the *g-th* input and therefore be willing to pay the highest price for it. Thus, each firm will choose the same quality of all its inputs such that the first-order condition can be written as $p'(q) = nBq^{n-1}$. Assuming that the price of each input is a continuous function of its quality, we can find the relation between price and quality by integrating the first-order condition (3), which yields:

$$p(q) = \int nBq^{n-1}dq = Bq^{n} + c \tag{4}$$

The total unit cost of production will then be $nBq^{n} + nc$. The constant term, c, is zero if the lead firm operates in a competitive environment for its output, which is assumed. Equation (4) represents the inverse demand for quality. Turning to the supply of intermediate inputs, a cost function that has two elements is assumed; the cost of *producing* the input at the required time and with the required quality and the cost of ensuring that the input arrives at the customer's premises in time and with the quality intact. The first element is assumed to be a linear function of q while the second element is assumed to take an exponential form.

$$c(q) = aq + e^{\beta q} - 1 \tag{5}$$

The parameter a represents the marginal cost of production and may reflect the wage rate. The parameter β is a measure of the disadvantage of distance to the downstream producer in terms of lead time and damage during transit. Time to customer may vary substantially over similar distances depending on geographical characteristics, the quality of infrastructure and the effectiveness and cost of communication, transport services and customs procedures. A high β represents poor quality of infrastructure and services. We notice that if β is zero and hence the input is produced on the spot, the cost function consists of the linear term only. The producer of a particular input chooses quality level by maximizing profits as follows:

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[5] Final output is the numeraire in the model.

$\underset{q}{Max}\left\lfloor Bq^{n} - aq - e^{\beta q} + 1 \right\rfloor$, which yields the first-order condition:

$$nBq^{n-1} - a - \beta e^{\beta q} = 0 \qquad (6)$$

Consider two industries, high-technology and low-technology, where the two are distinguished by the number of inputs involved in producing the final output; $n_{hi} > n_{lo}$. Further, consider two different locations for the potential providers of the inputs; a high-wage location with good quality of infrastructure, indicated by subscript *r* and a low-wage location with poor infrastructure, indicated by subscript *p*; $\beta_p > \beta_r; a_p < a_r$. Figure 1 shows the market equilibrium in these two industries. MR depicts the first term in equation (6) which is the marginal revenue earned by the upstream supplier while MC represents his marginal cost, both as a function of quality. The marginal cost curve intercepts the vertical axis at *a*. The suppliers in the poor location have the lowest costs at low to medium quality levels, while the suppliers in the rich location have the lowest cost at high quality levels. The marginal revenue curve is more convex the larger is *n*. The high-technology sector firms are not willing to pay much for low-quality inputs, while the low-technology sector firms have a positive demand also for low-quality inputs. The figure illustrates a case where the low-technology sector will source all inputs from the poor location, while the high-technology sector will source all inputs from the rich location. This prediction will now be explored empirically.

4 Empirical estimates

In this section I provide some empirical evidence on the extent and determinants of international vertical specialization. I use the definition of vertical specialization suggested by Hummels et al. (2001) where vertical specialization in country *k*, sector *i* is given as:

$$VS_{ki} = \frac{\text{imported intermediates}_{\text{ki}}}{\text{gross output}_{\text{ki}}} \text{exports}_{\text{ki}}$$

The bracket expresses the intermediate import share of total gross output. This is multiplied by total exports from sector *i* of country *k*. Vertical specialization, hereafter denoted VS, can thus be seen as the import content of exports expressed in value terms. VS is estimated for a panel of 52 countries using the GTAP databases for 1997 and 2001. This database includes an input-output matrix for each country and the matrix distinguishes between local and imported intermediates. The sectors included in the analysis are electronics, motor vehicles and clothing. Electronics is the sector with the highest VS share among the manufacturing sectors included in the GTAP database. The motor vehicles industry is seen as a pioneer industry as far as management and industrial organization innovations are concerned. Clothing is often an entry level industry for developing countries that are in the process of industrializing, but empirical studies have found the fashion market to be increasingly time sensitive (Evans and Harrigan, 2003; 2004) and earlier studies have argued that the industry structure is characterized by international production networks (Abernaty et al. 1999, Gereffi 1999). The estimated VS shares are presented in annex table A.1.

Hummels et al. (2001) analyzed the development of the VS share of total trade, focusing on to what extent the structure of international trade is changing. I follow this approach to investigate what are the determinants of structural changes. In addition I want to investigate whether the determinants of VS are different from the determinants of exports in general, and therefore include a comparison of the level of VS and the level of total exports.

In the previous section I argued that the rate of faults and the time of delivery are the most important factors of competitiveness in vertical supply chains. Data on delivery time, fault rates and damage during transit can only be obtained at the firm level. However, both time in transit and damage during transit are likely to depend on access to good infrastructure, trade barriers and effective port handling and customs clearing. In order to explore the importance of these factors I regress the VS share on relevant variables organized into three groups; geography, policy and infrastructure. Starting with geography, distance to major markets is one important element. A proxy for this variable is the log of the latitude of the capital of the country in question. Since wealth is concentrated in the temperate zone of the world, the latitude is correlated with distance to major markets. Being landlocked or an island limits the choice of mode of transport and I therefore include dummies for island and landlocked in the regression. I expect the landlocked and island dummies to be negatively related to vertical specialization, while latitude is expected to have a positive effect.

The policy varible group contains tariffs and control of corruption. The tariff variable is the log of the tariff factor (1+ t_{ki}) where t_{ki} is the average applied rate for country *k* and sector *i*; the data are from the Trains database. Corruption has attracted much attention in recent years as an impediment to trade and growth. It is reasonable to assume that corruption, to the extent that it imposes an extra tax on transactions and in addition introduce uncertainty and delays, has a negative impact on vertical specialization. The control of corruption index is taken from Kaufman et al. (2002) and takes values between -2.5 and 2.5, the higher the value the better the control of corruption. In order to be able to take logs of this varible, I perform a linear transformation.

In the infrastucture variable group I have constructed indices of access to infrastructure, one for the entire panel and one covering the year 2001 only. The latter includes the density of roads, railways, airports and telephone lines (fixed plus mobile) and the quality of roads (the share that has been paved). Data availability limits the index that covers both periods to road density, road quality and telephone density.[6] Road and rail density are given as km per km^2 and airport density as number per km^2. I control for population density in the regressions including these infrastructure density variables as infrastructure in empty spaces are of little use. I also analyze the impact of each individual component of the index, the quality of ports, and time for customs clearance. Port efficiency is an index that takes values from 1 to 7, the higher the value the more effective are ports,

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[6] The individual indicators are first normalized such that they all have a common mean (one) and then the index is estimated by taking the average of these normalized indicators. This methodology is described in Limão and Venables (2001), but I do not raise the index to the power of -0.3 as they do. The regressions using the 2001 extended index are run on the entire sample (68 countries) included in the GTAP version 6.2 database. Data on road density and quality, rail density and airport density are from the World Bank's World Development Index, data on telephone density and cost of telephone conversations are from the ITU's World Telecommunication Indicators, while data on port efficiency and time through customs are from IMD.

and is based on surveys conducted by the IMD. Data on the time it takes to clear goods through customs are provided by the same source, but cover only 31 of the countries in the panel. Nevertheless, the sample should be reasonably representative as it includes countries on all continents, rich and poor, landlocked and coastal. Port efficiency in landlocked countries refers to ports of transit.

The expected sign on the infrastructure index is uncertain. Better behind the border infrastructure lowers lead time and reduces damage during transit both for internal and international trade. Good infrastructure could thus pursuade the lead firm in the supply chain and its suppliers to locate close to each other within the country. In addition many countries have established export processing zones (EPZ) with much better infrastructure and related services than average for the country in question. The quality of infrastructure for the country as a whole may therefore not always be a good proxy for the quality of infrastructure facing participants in international production networks.[7]

It is reasonable to believe that a larger part of the supply chain is located *within* the country in large countries compared to small countries. If $n = (n^h + n^f)$ in equation (2) where superscripts *h* and *f* respectively represent home and foreign, $n^h/(n^h + n^f)$ is larger the larger the country. I therefore control for market size represented by the log of GDP, and I expect that it has a negative impact on the VS share. Table A.1 indeed shows that small countries, both rich and poor have relatively high indices.

There is little reason to expect that the aggregate vertical specialization index is systematically related to income levels or wage levels. As indicated by Figure 1 above, producers in a poor country may participate vigorously in vertical specialization in low-technology industries.

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[7] The ILO (Singa Boyenge, 2003) has developed a database for export processing zones, which indicates that the share of total exports coming from such zones can be very high in certain developing countries (e.g. 61 percent in Morocco, 85 percent in Mozambique and 60 percent in Bangladesh), but the data are not sufficiently coherent to use as a control variable in the regressions.

Nevertheless, it is worth exploring the impact of the income level on vertical specialization, particularly whether the impact is different among sectors, and I include the log of GDP per capita to investigate this. Data on GDP and GDP per capita is taken from the World Development Indicators, while GDP for Taiwan is from Government of Thailand National Statistics and converted to USD using the market exchange rate.

GDP per capita is a measure of all the things, including good infrastructure, good institutions and human and physical capital that rich countries have and poor countries do not have. The impact of GDP per capita on vertical specialization therefore captures some of the effects of infrastructure and institutions when GDP per capita is included on its own. When included in the same regression as infrastructure and institutions, GDP per capita retains its significance in some regressions where it probably picks up the impact of relative factor endowments and comparative advantage. It contributes to the overall explanatory power without being significant in others and does not add anything to the analysis in yet other. I tested whether the insignificant variables are jointly significant in the regressions. If they are at a 10 percent significance level, they are retained, if not, they are dropped.

4.1 Total trade

I start with regressions on total trade. The left-hand side variable is the VS share while the right-hand side variables are income, geography, policy and infrastructure. I also included a time dummy (one if the observation is in 2001, zero if it is in 1997) in order to capture possible shifts over time in the determinants of vertical specialization. With shares on the left-hand side and logs of absolute levels on the right-hand side the appropriate estimation technique is weighted least squares estimates. I start by including measures of income and market size only, and it turns out that these variables alone explain two thirds of the variation. As expected, market size as measured by (the log of) GDP is negatively related to the VS share. The positive coefficicent on GDP per capita indicates that rich countries are more likely to engage in vertical specialization than poor countries. The time dummy is positive indicating that the VS share is about 1.15 times higher in 2001 than in 1997 when controlling for market size and income level.

The next column adds the geography indicators. The two dummies have the expected negative sign and are significant. In both island and landlocked countries the VS share is about 40 percent lower than in countries with both sea and land borders. Latitude is significant at the one percent level, but takes a negative sign, indicating that countries located close to the major markets participate less in international production networks when income and market size are controlled for. The elasticity of vertical specialization with respect to latitude is -0.17/0.27 = - 0.63.[8] Tariff protection appears to entail an anti-VS bias.

I finally add measures of the quality of infrastructure. The first column in this section presents the regression with the aggregated infrastructure index. It takes a positive sign, and the narrow measure indicates that an improvement of infrastructure by 10 percent would increase the VS share by about 9 percent and for the broader measure only available for 2001 by about 13 percent. Subsequent columns report regressions using the individual infrastructure indices. The last column presents the result of a regression where port efficiency and road density are interacted in order to capture the impact of containerized multi-modal transport. This regression provides the highest explanatory power of all regressions. We notice that the by far the most important infrastructure indicator is port efficiency. It is also worth noticing that the time dummy disappears when telephone density is included in the regression. This suggests that the increase in the VS share from 1997 to 2001 is due to the penetration of telephone lines in the economy. It is finally worth noticing the high adjusted R^2 for all the regressions.

Does vertical specialization differ from total trade when it comes to sensitivity to market size and infrastructure? In order to check this, I compare the determinants of the absolute level of VS and total exports, X. The major results are presented in Table 2. GDP and GDP per capita alone explain

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[8] The elasticity is found by dividing the estimated parameter by the mean of the vertical specialization share, which is 0.27.

76 percent of the variation in VS and 91 percent of total exports. The geographical indicators are jointly insignificant and omitted. Total exports are much more elastic to GDP than is VS but VS is much more sensitive to the quality of infrastructure than are total exports. It appears that tariff protection induces a strong anti-export bias which is particularly large for VS. We again notice that the time parameter disappears when telephone density is included in the regressions, indicating that changes over time in total exports as well as VS are driven by the proliferation of telecommunication connections. Table 2 thus indicates that there is clearly a difference between vertical specialization and exports in general.

4.2 Clothing

International trade in textiles and clothing is subject to an intricate system of quotas under the Multi-Fibre Agreement that was replaced by the Agreement on Textiles and Clothing (ATC) under the auspices of the WTO in 1995. The Europan Union, USA and Canada retained quotas under the ATC, and these are scheduled to be phased out by 2005. Quotas are allocated at a detailed level and are subject to changes over time and across items. The system is rather bureaucratic and it is hypothesized that the lack of flexibility it imposes on restricted producers constitutes an impediment to vertical specialization. I include two dummies taking the value of 0 if the country has no quotas under the MFA and 1 if it has a quota in the USA or EU respectively.[9]

Market size and income levels alone explain almost half of total variation in the VS share, and the richer the country the larger the VS share. The island and landlocked dummies are jointly insignificant and omitted. As expected, the quota dummy for the US is negative and highly significant reducing the VS share by more than half. It appears, however, that the quota system in the European Union if anything has a positive impact on the VS share. Protecting the domestic industry through tariffs is not significant, but a regression replacing corruption with an interaction term

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[9] Information on quotas is from the customs department in the US and from the System for the Management of Licenses for textiles (SIGL) in the EU.

between corruption and tariffs yielded a negative impact of tariffs and a positive impact of the interaction term (not reported).

Corruption in its own right appears to be a significant obstacle to vertical specialization in the clothing sector. A 10 percent improvement in the control of corruption index would increase the share of vertical specialization by about 70 percent. Turning to infrastructure, only port efficiency and road density have a significant effect with an elasticity with respect to the VS share of about 5 and 1.33 respectively. It is worth noticing that the VS share appears to have declined from 1997 to 2001 in the clothing sector. It probably follows that the supply chain is increasingly clustering around the producers of final output. The emergence of China as a major exporter has probably contributed to this, since China's textile and clothing sector can be characterized as a local, vertically integrated supply chain (Institute Français de la Mode, 2004).

The comparison of VS and total exports is presented in Table 4. We notice that VS is less elastic to domestic market size than is total exports. Further, we notice that better control of corruption has a large and significant impact on VS, but not on total exports. This result is robust, it appears in all pairs of regressions and supports the hypothesis that comparative advantage drives traditional trade in clothing, but vertical specialization requires an environment with low transaction costs and smooth flow of goods, services and information.[10] The elasticity to the quality of infrastructure is significantly higher for vertical specialization than for total exports for all the indicators included except for telecommunications where the elasticities are about the same.

[10] The quota dummies were significant and positive if included in the VS and X regressions, but quotas are probably imposed as a reaction to export performance rather than determining it. To test this, I applied a simultaneous equation system. Here the level of exports had a significant and positive impact on the probability of having a quota, while the resulting probability for having a quota was insignificant for VS and total exports.

4.3 Motor vehicles

Vertical specialization in the car industry appears to be largely explained by market size and the island dummy. The impact of the island dummy is dominated by Japan where the closely knit domestic supply chains are well documented. The island dummy is still negative, but insignificant when Japan is excluded. Japan is a major car producer and exporter, and its geographical circumstances probably have contributed to the structure of the industry. I therefore choose to retain Japan in the sample. The aggregate infrastructure index takes a *negative* and significant sign. Hence, it appears that good infrastructure tend to contribute to domestic clustering of the supply chain. The only individual infrastructure variables that are significant in the regressions are port efficiency and road density.[11] A 10 percent increase in the port effectiveness index would increase the share of vertical specialization in total exports by about 60 percent. We notice that the elasticity to market size is larger in absolute terms in the car industry than for the other sectors, suggesting that the supply chain in the car industry is more geographically clustered than the average.

Turning to a comparison of the level of VS and total exports in the sector, Table 6 presents the results. The infrastructure variables that had a significant impact on the level of vertical specialization were telephone density, the time for customs clearance and airport density. We notice that income, income per capita and latitude explains about two thirds of the variation in VS and almost 80 percent of the variation in total exports. As before VS is less elastic to GDP and more elastic to infrastructure than total exports. The landlocked dummy is always significant and positive and is probably driven by regional production networks in Europe and Africa. We finally notice that in the car industry tariff protection appears to have a large and positive effect on exports, if anything.

[11] The cost of a three minutes telephone call to the US has a strong and negative impact on vertical specialization in 1997, but data for these costs are not available for 2001.

4.4 Electronics

Market size is almost everything in the electronics sector. GDP explains most of the variation of the VS share while the VS level is income elastic in contrast to the other sectors. The regression results are presented in Tables 7 and 8. The VS share of exports is a negative function of GDP per capita when controlling for infrastructure and corruption, a result that indicates that low wages attract vertical specialization if infrastructure and control of corruption is good. Furthermore, the sector stands out with its significant and negative coefficient on latitude, a result that reinforces the impression that this is a sector where developing countries can become integrated in international production networks. Trade policy in terms of tariff protection appears to have little effect on the VS *share* of total exports, but a substantial negative effect on the *level* of both VS and total exports as shown in Table 8. Control of corruption, in contrast, has a relatively large and significant impact on the VS share as well as its level. The infrastructure indicators that turned out to be significant were telephone density, airport density, port effectiveness and time for customs clearance. We notice that port effectiveness has a significant and *negative* impact on the VS share, but a positive effect on the VS level. This probably indicates that production of electronics tend to cluster behind the border in countries with good infrastructure and effective ports.

Comparing the determinants of VS and total exports, we see from Table 8 that the pattern is the same as for the other two sectors, but the differences between VS and total exports are smaller. Income and market size explains about 60 percent of VS. The overall infrastructure index has a similar effect on VS and total exports, while telephone density has a stronger effect on VS. The results suggest that low-income countries are likely to participate in vertical specialization in the electronics sector if they refrain from tariff protection in the sector, control corruption and invest in infrastructure, particularly telecommunications.

5 Summary and Conclusions

This paper has first presented an analytical framework for studying the determinants of vertical specialization. The framework predicts that the more complex the production process, the more lead firms are willing to pay for high quality inputs and the less are they willing to pay for low-quality products. I focussed on two aspects of quality; the timeliness of delivery and the fault rate. While the quality of the product as it leaves the factory gate is under the suppliers' control, the timeliness of delivery might not be. Furthermore, the quality of the product when it enters the premises of the customer may also be beyond the control of the supplier if poor quality of infrastructure and related services results in damage during transit.

In order to assess the role of infrastructure for vertical specialization, I regressed the VS index on the quality of infrastructure, controlling for market size, trade policy and geography. The results largely support the hypotheses derived from the theory. In clothing, a labour-intensive industry with market segments of highly time-sensitive goods, VS is negatively related to income per capita. Nevertheless, low labour costs alone are not enough to engage in vertical specialization. In addition it takes adequate control of corruption and reasonably good infrastructure, particularly effective ports. The car industy in contrast resembles the high-technology industry represented by the high-quality, high price market equilibrium in Figure 1. In this sector VS is positively related to GDP per capita. Finally, the electronics sector has both high-technology and labour-intensive lower-technology segments. It is similar to the car industry when only GDP and GDP per capita are included in the regressions, but poor countries can exploit their comparative advantage for labour-intensive activities if they have good infrastructure, particularly effective ports and adequate telecommunications, if they have adequate control of corruption and refrain from tariff protection. The paper has also demonstrated that the relative importance of infrastructure, market size and institutions (represented by control of corruption) are different for VS compared to total exports. VS is less sensitive to market size and more sensitive to the quality of infrastructure, trade policy and the quality of institutions than are exports in general.

The VS share has increased from 1997 to 2001 when looking at total trade, but it has not changed in the car and electronics sectors and it has declined in the clothing sector. A possible explanation for this is that the industries where vertical specialization has been common for a long time tend to become more time-sensitive and cluster as the trade-off between lead time and production cost tip in favour of the former, while industries that have more recently embarked on VS appear to focus on cost savings.

The findings in this paper suggest that poor infrastructure and inefficient procedures related to the transfer of goods and services across international boundaries constitute a serious disincentive for local companies to invest in quality and thereby improve their ability to enter international production networks and improve productivity. VS is likely to contribute more to technolgy transfer than trade in general because the downstream firm has incentives to help its suppliers meeting quality standards, and barriers to vertical specialization may therefore represent lost opportunities for growth. Such implications are often overlooked in the trade and development debate. Opening up to trade and investment in logistics services could reduce lead time and damage during transit. Furthermore, given the large impact of time through customs in some of the regressions, a positive outcome of the negotiations on trade facilitation under the auspices of the WTO may prove a cost-effective way of easing some of the constraints facing entrepreneurs in poor countries.

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Figure 1. Market clearing, two industries, two locations

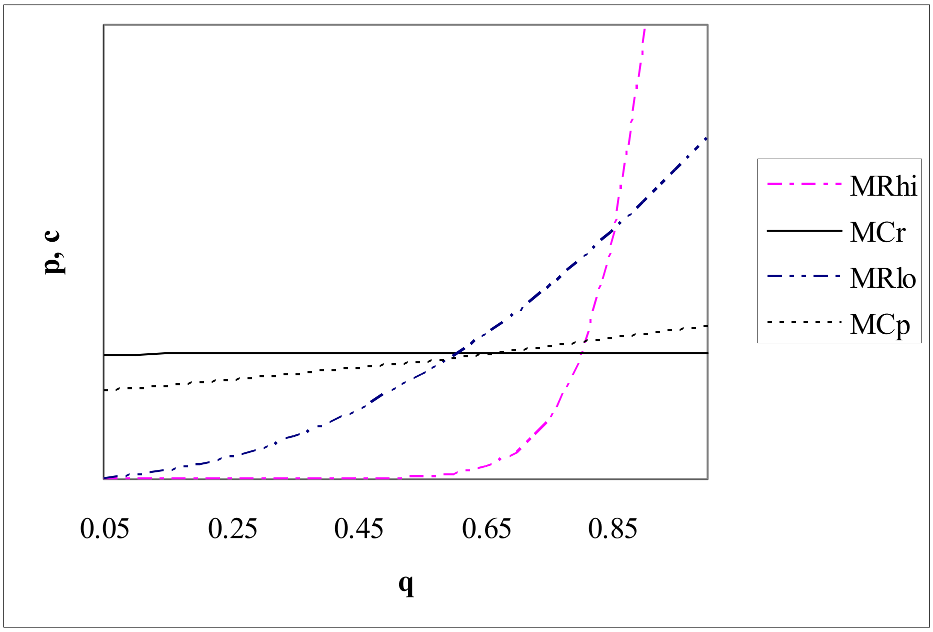

Table 1. VS share, total trade

				Infrastructure					
Variable	**Income**	**Geography**	**Policy**	**Aggregate3**	**Aggregate5**	**Tele**	**Roads**	**Ports**	**Road Port**
Log gdp	-0.49*** (-14.98)	-0.46*** (-14.01)	-0.45*** (-13.52)	-0.42*** (-13.94)	-0.39*** (-10.66)	-0.44*** (-13.67)	-0.44*** (-14.12)	-0.47*** (-13.32)	-0.44*** (-13.63)
Log gdp per capita	0.19*** (4.51)	0.22*** (5.89)	0.16** (2.21)				0.12* (1.78)		
Time	0.14* (1.67)	0.18** (2.31)	0.19** (2.41)	0.20*** (2.71)		0.07 (0.73)	0.20*** (2.81)	0.19** (2.32)	0.24*** (3.05)
Island		-0.51*** (-2.56)	-0.54*** (-2.67)	-0.52*** (-3.22)	-0.43*** (-2.64)	-0.43*** (-2.84)	-0.57*** (-3.06)	-0.40* (-1.81)	-0.57*** (-2.87)
Landlocked		-0.40** (-2.25)	-0.40** (-2.27)	-0.40** (-2.36)	-0.32* (-1.68)	-0.38** (-2.12)	-0.42*** (-2.56)	0.20 (0.47)	-0.32 (-0.87)
Latitude		-0.17*** (-3.83)	-0.16*** (-3.56)	-0.13*** (-3.22)	-0.15*** (-2.64)	-0.16*** (-3.47)	-0.15*** (-3.05)	-0.11** (-2.32)	-0.13*** (-2.91)
Log tariffs			-1.74 (-1.08)	-1.88* (-1.69)	-0.01 (-0.01)	-2.43* (-1.72)	0.66 (0.42)	-1.37 (-1.01)	-0.04 (-0.03)
Log infrastructure				0.24*** (3.74)	0.36*** (4.25)	0.18** (1.98)	0.16** (2.29)	0.85*** (3.37)	0.20*** (4.76)
Log population density							0.00 (0.09)		
n	102	102	101	101	68	104	101	76	76
Adj R square	0.69	0.76	0.76	0.78	0.76	0.75	0.80	0.80	0.82

Table 2. Comparing VS and total exports, total trade

	Aggregate		Tele-density		Port efficiency		Paved Roads	
Variable	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**
Log GDP	0.61*** (10.35)	0.82*** (23.98)	0.55*** (7.77)	0.78*** (19.17)	0.44*** (5.41)	0.71*** (15.96)	0.55*** (7.09)	0.77*** (17.57)
Log GDP per capita							0.16 (1.21)	0.11 (1.43)
Log tariffs	-6.28*** (-3.68)	-3.55*** (-3.62)	-3.80* (-1.68)	-2.06 (-1.58)	-6.13*** (-2.56)	-3.20** (-2.44)	-5.76** (-2.18)	-2.83* (-1.90)
Infrastructure	0.42*** (3.55)	0.25*** (3.60)	0.36*** (3.19)	0.21*** (3.28)	1.03** (2.11)	0.70** (2.59)	0.35*** (2.51)	0.23*** (2.95)
Time	0.24 (1.33)	0.19* (1.87)	-0.02 (-0.09)	0.04 (0.36)	0.23 (1.07)	0.20* (1.76)	0.17 (0.81)	0.17 (1.43)
n	102	102	103	103	76	76	89	89
Adjusted R square	0.76	0.92	0.75	0.91	0.55	0.85	0.74	0.91

Table 3. VS share, Clothing

Variable	Income only	Geography	Policy	Port-efficiency	Road-density
Log GDP	-0.43*** (-9.14)	-0.43*** (-8.76)	-0.43*** (-9.95)	-0.49*** (-8.28)	-0.41*** (-9.57)
Log GDP/capita	0.30*** (6.87)	0.30*** (6.34)	-0.11 (-1.00)	-0.05 (-0.34)	-0.18* (-1.71)
Time	-0.22* (-1.77)	-0.21* (-1.71)	-0.18 (-1.59)	-0.19 (-1.39)	-0.16 (-1.52)
Log latitude		0.05 (0.52)	-0.10 (-0.98)	0.09 (0.73)	-0.21** (-2.18)
Log tariff			-0.27 (-0.27)	-0.35 (-0.23)	0.64 (0.61)
Quota, US			-0.74*** (-3.99)	-0.65*** (-2.82)	-0.53*** (-2.91)
Quota, EU			0.27 (1.51)	0.03 (0.11)	0.40** (2.15)
log Corruption			1.91*** (4.59)		2.11*** (5.37)
Log Infrastr.				1.36*** (3.07)	0.36*** (3.81)
Log population density					-0.18*** (-2.88)
n	102	102	101	76	101
Adjusted R^2	0.48	0.47	0.61	0.57	0.66

Table 4. Comparing vertical specialization and total exports, Clothing

					Infrastructure							
	Income		**Policy**		**Aggregate**		**Tele**		**Paved Road**		**Port effect.**	
Variable	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**
Log GDP	0.63*** (4.06)	0.93*** (8.08)	0.74*** (4.67)	0.96*** (8.00)	0.68*** (5.25)	0.92*** (9.12)	0.71*** (4.55)	0.93*** (8.04)	0.69*** (4.54)	0.93*** (8.22)	0.44*** (2.51)	0.73*** (5.97)
Log GDP per capita	0.10 (0.55)	-0.30** (-2.29)	-0.50 (-1.63)	-0.49** (2.11)	-0.89*** (-3.51)	-0.78*** (-3.89)	-1.28*** (-3.02)	-1.20*** (-3.81)	-0.69** (-2.36)	-0.64*** (-2.96)	-0.51* (-1.88)	-0.59*** (-3.13)
Log latitude	0.55** (2.42)	0.50*** (2.94)	0.43* (1.87)	0.45** (2.63)	0.02 (0.09)	0.14 (0.85)	0.33 (1.48)	0.37** (2.19)	-0.02 (-0.11)	0.11 (0.64)	0.27 (0.77)	0.10 (0.50)
Log Corruption			2.98** (2.33)	0.98 (1.01)	2.51** (2.36)	0.73 (0.88)	3.24*** (2.59)	1.22 (1.31)	2.56** (2.12)	0.77 (0.85)		
Infrastructure					1.56*** (6.70)	1.08*** (5.95)	0.84*** (2.59)	0.77*** (3.17)	1.41*** (5.37)	1.00*** (5.97)	3.61*** (3.23)	1.75** (2.23)
N	102	102	102	104	102	101	102	102	89	89	76	76
Adj. R square	0.38	0.54	0.40	0.52	0.57	0.64	0.44	0.58	0.51	0.61	0.21	0.35

Table 5. VS share, Motor Vehicles

				Infrastructure		
Variable	**Income only**	**Geography**	**Policy**	**Aggregate**	**Port**	**Road-density**
Log GDP	-0.61*** (-10.71)	-0.63*** (-10.47)	-0.62*** (-11.26)	-0.59*** (-12.32)	-0.64*** (-11.11)	-0.56*** (-10.43)
Log GDP/capita	0.14 (1.52)	0.18 (1.48)			-0.40** (-2.46)	-0.05 (-0.26)
Island		-1.79*** (-3.78)	-1.58*** (-3.90)	-1.58*** (-3.76)	-1.35*** (-2.74)	-1.75*** (-3.95)
Landlocked		-0.33 (-1.09)	-0.34 (-1.17)			
Log latitude		-0.05 (-0.24)	-0.17 (-0.85)			
Log tariff			0.71 (0.35)			
log Corruption			1.01*** (2.62)	0.79*** (3.23)		0.39 (0.78)
Log Infrastr.				-0.15** (-2.22)	2.04*** (4.23)	0.19* (1.87)
Log population density						-0.21*** (-2.94)
n	102	102	103	102	76	101
Adjusted R^2	0.55	0.60	0.62	0.63	0.68	0.65

Table 6. Comparing vertical specialization and total exports, Motor vehicles

	Income		Geography		Policy		Tele		Time		Airport density	
Variable	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**
Log GDP	0.91*** (6.12)	1.19*** (10.16)	1.01*** (6.03)	1.30*** (9.99)	0.99*** (5.24)	1.23*** (8.78)	0.93*** (5.61)	1.24*** (9.62)	0.91*** (5.43)	1.12*** (8.19)	0.98*** (5.21)	1.19*** (7.94)
Log GDP per capita	0.79*** (4.98)	0.65*** (5.18)	0.67*** (4.03)	0.53*** (4.09)	0.91*** (2.72)	0.84*** (3.23)	-0.19 (-0.43)	-0.15 (-0.44)	0.94*** (3.48)	0.87*** (3.94)	0.59* (1.84)	0.44* (1.73)
Time	0.41 (1.02)	0.38 (1.23)	0.44 (1.12)	0.40 (1.32)	0.44 (1.12)	0.42 (1.37)	-0.40 (-0.83)	-0.26 (-0.69)	0.35 (0.96)	0.35 (1.15)		
Log latitude			0.27 (1.24)	0.26 (1.54)	0.26 (1.05)	0.31 (1.62)	0.19 (0.83)	0.22 (1.24)	0.31 (1.60)	0.32* (1.96)	0.19 (0.66)	0.30 (1.30)
Island			-0.77 (-0.98)	-0.49 (-0.81)	-0.79 (-0.99)	-0.44 (-0.72)	-0.72 (-0.94)	-0.44 (-0.75)	2.68* (1.81)	2.17* (1.78)	-0.55 (-0.72)	-0.44 (-0.72)
Landlocked			1.18* (1.85)	1.20** (2.42)	1.21* (1.88)	1.21** (2.44)	1.55** (2.46)	1.50*** (3.09)	1.63** (2.36)	1.55*** (2.73)	1.46** (2.02)	1.20** (2.06)
Log tariff					5.05 (1.45)	4.08 (1.51)	3.61 (1.07)	3.07 (1.18)	4.96 (1.54)	4.77* (1.81)	7.79** (1.92)	6.65** (2.05)
Log Corruption					-0.02 (-0.02)	-0.61 (-0.61)						
Infrastructure							1.19*** (2.84)	0.95*** (2.93)	-1.00** (2.17)	-0.65** (-1.73)	0.87** (1.98)	0.76** (2.19)
Log population density											-0.69** (-2.30)	-0.55** (-2.29)
N	102	102	102	102	101	101	101	101	61	61	67	67
Adj. R square	0.65	0.79	0.67	0.80	0.66	0.80	0.68	0.81	0.82	0.89	0.67	0.79

Table 7. VS share, Electronics

				Infrastructure		
Variable	**Income only**	**Geography**	**Policy**	**Time**	**Port**	**Airport-density**
Log GDP	-0.55*** (-15.10)	-0.47*** (-11.89)	-0.45*** (-12.41)	-0.28*** (-4.24)	-0.43*** (-9.42)	-0.46*** (-12.46)
Log GDP/capita	-0.02 (-0.048)	-0.00 (-0.06)	-0.30*** (-3.03)	-0.29** (-2.06)	-0.29** (-2.51)	-0.34*** (-3.24)
Time	0.06 (0.53)	0.12 (1.16)	0.14 (1.51)	0.06 (0.52)	0.13 (1.19)	
Island		-0.36 (-1.69)	-0.17 (-0.79)	1.05*** (2.59)	-0.34 (-1.31)	-0.07 (-0.36)
Landlocked		-0.16 (-0.50)	-0.22 (-0.76)	0.53 (1.12)	-0.38 (-0.69)	-0.39 (-1.52)
Log latitude		-0.22*** (-4.29)	-0.22*** (-4.48)	-0.36*** (-5.17)	-0.29*** (-4.34)	-0.10* (-1.84)
Log tariff			1.45 (0.63)	2.63 (0.86)	0.36 (0.13)	6.05*** (2.70)
log Corruption			1.54*** (4.42)	1.30*** (2.97)	2.13*** (4.28)	1.19*** (3.20)
Log Infrastr.				-0.43** (-2.33)	-1.05* (-1.93)	0.28*** (3.21)
Log population density						-0.07 (-1.20)
n	102	102	101	61	76	67
Adjusted R^2	0.72	0.77	0.81	0.85	0.82	0.85

Table 8. Comparing vertical specialization and total exports, Electronics

	Income		Geography		Policy		Aggregate		Tele density		Port	
Variable	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**	**Log VS**	**Log X**
Log GDP	1.10*** (6.46)	1.25*** (8.42)	1.13*** (5.70)	1.29*** (7.45)	1.28*** (7.48)	1.39*** (9.42)	1.23*** (7.42)	1.35*** (9.50)	1.22*** (7.34)	1.35*** (9.27)	0.89*** (4.31)	1.09*** (5.99)
Log GDP per capita	0.61*** (3.32)	0.55*** (3.49)	0.71*** (3.59)	0.62*** (3.63)	-0.39 (-1.03)	-0.35 (-1.06)	-0.49 (-1.33)	-0.45 (-1.43)	-1.16*** (-2.51)	-0.90** (-2.23)	-1.03** (-2.24)	-0.90** (-2.24)
Time	0.43 (0.95)	0.38 (0.96)	0.41 (0.89)	0.36 (0.89)								
Log latitude			-0.37 (-1.45)	-0.28 (-1.24)	-0.53* (-1.93)	-0.39 (-1.63)	-0.65** (-2.36)	-0.50** (-2.15)	-0.61** (-2.28)	-0.44* (1.89)	-0.39 (-1.16)	-0.33 (-1.13)
Island			0.28 (0.31	0.29 (0.36)								
Landlocked			-0.17 (-0.23)	-0.01 (-0.02)								
Log tariff					-16.75*** (-2.83)	-16.04*** (-3.14)	-14.61*** (-2.52)	-13.87*** (-2.81)	-12.25** (-2.06)	-12.81** (2.46)	-24.69*** (-3.53)	-22.34*** (-3.64)
Log Corruption					2.61* (1.86)	2.10* (1.73)	2.19 (1.60)	1.67 (1.43)	2.88** (2.11)	2.29* (1.93)	1.51 (0.93)	1.24 (0.87)
Infrastructure							0.78*** (2.60)	0.80*** (3.11)	1.01*** (2.73)	0.73** (2.23)	2.49* (1.78)	2.24* (1.83)
Log population density												
N	102	102	102	102	101	101	101	101	101	101	76	76
Adj. R square	0.60	0.69	0.59	0.69	0.64	0.72	0.66	0.75	0.66	0.73	0.44	0.54

Annex

Table A.1. Vertical specialization index, share of total exports

	1997				2001			
Country	**Total**	**Clothing**	**Cars**	**Electronics**	**Total**	**Clothing**	**Cars**	**Electronics**
Argentina	5.2	2.1	26.4	36.7	4.8	1.8	18.2	25.9
Australia	7.9	18.0	17.0	29.0	7.1	29.1	27.3	37.4
Austria	17.6	59.6	41.2	30.2	21.2	60.9	47.7	37.5
Bangladesh	6.7	23.8	12.3	10.1	5.5	13.5	13.4	9.9
Belgium	29.6	47.2	64.8	37.9	35.0	50.3	69.9	44.4
Botswana	24.4	72.8	39.6	28.8	33.7	79.7	65.6	41.3
Brazil	4.9	1.3	12.6	20.7	8.3	3.7	19.1	34.7
Canada	12.9	22.9	48.5	55.3	12.5	19.8	40.2	36.8
Chile	12.6	13.7	49.8	36.2	13.7	13.7	36.4	27.4
China	8.8	11.2	10.5	29.5	7.5	5.7	9.8	31.6
Columbia	7.8	9.4	28.8	11.5	9.7	19.9	40.6	23.3
Denmark	14.5	37.4	34.9	33.1	16.5	38.5	37.6	37.1
Finland	14.1	33.7	42.0	42.2	16.5	34.4	40.5	43.9
France	9.4	20.5	15.7	12.2	12.0	24.3	21.3	17.4
Germany	9.8	17.8	14.8	13.8	13.1	19.0	19.6	20.2
Greece	9.1	13.0	2.5	17.8	11.2	13.3	5.6	23.8
Hong Kong	14.2	28.8	21.6	56.1	7.7	13.0	9.1	41.6
Hungary	24.4	32.3	62.2	65.3	28.3	29.4	64.6	66.5
India	6.2	3.2	6.2	32.5	4.8	1.8	4.6	20.6
Indonesia	10.7	15.6	25.6	25.6	13.1	6.3	28.3	25.2
Ireland	24.8	56.2	13.6	56.7	26.8	54.0	17.0	54.9
Italy	10.3	11.9	20.8	19.5	11.9	13.5	25.1	23.8
Japan	4.0	7.9	1.4	5.7	4.3	7.8	1.6	8.2
Korea	14.0	17.0	11.8	33.0	15.2	15.9	10.5	36.3
Malawi	9.8	4.1	66.7	52.4	14.9	8.8	78.7	70.0
Malaysia	26.1	13.1	34.0	62.5	36.8	35.7	46.2	53.2
Morocco	12.0	27.9	21.7	22.9	14.5	6.5	37.6	43.1
Mexico	11.0	4.5	34.4	47.0	14.6	37.8	27.7	22.3
Mozambique	12.1	15.0	69.2	54.2	15.0	12.3	62.5	53.8
Netherlands	22.3	57.3	44.8	33.7	24.8	54.7	44.8	50.6
New Zealand	9.6	16.8	35.0	27.3	13.8	34.3	39.6	25.6
Peru	6.9	0.3	11.3	19.4	8.3	0.3	10.9	22.3
Philippines	26.0	39.7	54.0	89.8	30.6	38.4	46.9	71.6
Poland	26.0	32.2	51.7	28.6	13.2	21.5	38.3	28.8
Portugal	13.7	17.3	29.8	30.3	15.0	18.3	30.9	35.5
Singapore	43.4	65.7	50.8	78.7	48.3	46.5	47.1	79.4
Spain	11.5	26.9	32.9	23.9	13.2	29.7	38.5	28.4
Sri Lanka	22.0	48.6	36.6	65.5	23.4	43.0	24.9	61.7
Sweden	15.6	38.6	31.9	26.4	17.4	41.1	33.7	28.3
Switzerland	8.8	27.4	16.6	29.3	16.2	27.6	19.2	25.6
Taiwan	14.9	14.4	23.7	38.4	14.6	10.8	21.7	34.5
Tanzania	13.2	11.2	28.6	49.1	12.0	10.7	23.0	55.1
Thailand	18.0	4.2	31.3	26.8	26.3	14.3	46.5	65.1
Turkey	12.7	27.2	19.5	39.2	13.3	5.1	21.1	28.1
Uganda	9.5	8.9	24.0	40.9	14.1	11.6	34.1	44.2

UK	9.0	24.7	27.0	30.5	9.2	21.7	28.7	32.4
Uruguay	13.2	18.8	50.7	23.3	12.3	16.7	34.8	18.2
USA	4.6	13.2	12.1	15.2	4.5	13.8	12.3	14.2
Venezuela	10.4	9.9	38.9	51.0	8.8	8.9	34.4	45.9
Vietnam	22.7	68.5	54.1	52.5	16.4	40.4	39.6	40.5
Zambia	10.5	8.3	33.3	15.4	17.1	15.3	43.9	27.2
Zimbabwe	16.5	18.9	42.6	30.0	8.5	5.0	26.8	21.1