Foreign Direct Investment and Exports of Services

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Abstract: The paper augments a standard export demand function in order to examine the impact of outward foreign direct investment (FDI) on United States export performance in services. It uses several panel data estimators: mean group, pseudo pooled mean group, and one-way and two-way fixed effects. It finds that the results are very sensitive to the exact empirical specification. While FDI is found to have a negative effect overall, for given levels of world demand and relative prices, this hides the presence of heterogeneity among different categories of services. Allowing for heterogeneity, it is possible to identify some arms-length categories of services in which exports are reduced as a result of higher levels of outward investment. In contrast, other types of service exports, notably receipts of royalties and affiliated services, are raised as a result of FDI.

Key words
Foreign direct investment, exports of services, panel data estimation.

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I. Introduction

International trade in services has risen markedly over the past two decades, with the value of trade in services now equivalent to around one-quarter of total merchandise trade. This expansion in cross-border service transactions reflects the increasing importance of service industries within national economies, as well as technological improvements in telecommunications and transportation and the ongoing liberalisation of national markets resulting from the General Agreement on Trade in Services (GATS, 1995), administered by the World Trade Organisation (WTO), and continued in the GATS 2000 negotiations that started in February 2000.

Firms face a number of choices as to the way in which they try to exploit new market opportunities. They can produce at home and export abroad, or move abroad directly. Thus, FDI and exports can be seen as alternative ways of supplying foreign markets. At other times a foreign market presence may be essential for transactions to take place at all. So outward investments to establish a foreign market presence may facilitate trade in services and raise parent company sales, but equally they may raise affiliate sales, with the parent company no longer exporting services but instead receiving remitted profits.

The growth in international trade over the past 15 years has coincided with strong growth in worldwide FDI, leading to a growing policy interest in the relationship between trade and foreign direct investment (WTO, 1996). Pain and Wakelin (1998) and Fontagné and Pajot (2000) provide detailed overviews of the extant literature. To date, most of the studies of the impact of FDI on trade are concerned with trade in manufactures. However, there are several aspects of services trade that mean that the impact of FDI in service sectors may be different to the impact of FDI in manufacturing on manufactures trade. Thus the objective of this paper is to utilise and extend the approach used by Pain and Wakelin (1998) to explore whether production relocation also affects trade in services. We use a detailed panel data set for the United States over the period 1986-2000 which allows us to model the determinants of six different categories of services.

We employ a number of different econometric techniques, and find that the relationship between FDI and exports of services is sensitive to the precise empirical specification adopted. Whilst it appears that FDI does have an effect on the volume of exported services, the impact of changes in service sector FDI and FDI in other sectors is found to differ at

times, and the direction of the relationship with exports is difficult to pin down after allowing for world demand, the relative price of US produced services and other controlling factors. Indeed, there is evidence of considerable heterogeneity in the size and significance of the coefficients across individual categories of exports.

These results support the argument originally made by Pain and Wakelin (1998), namely, that in a time series context it makes little sense to ask whether trade and investment are complements or substitutes, especially at an industry level, as it is clear that both trend upwards over time. Instead, what matters is export performance, i.e. whether additional FDI changes the level of exports for a given level of world demand and relative prices.

The structure of the remainder of this paper is as follows. In Section II we provide a review of the existing literature on the impact of FDI on trade. Most of the papers discussed deal with manufacturing issues rather than with those related to services, but we include some papers that have sought to model trade in services at the end of the section. Section III provides a discussion of the definitional and measurement issues encountered when using data on services. It discusses the specific nature of the relationship between trade and FDI for services in the context of the US data set that we use and includes some descriptive statistics. The econometric approach is laid out Section IV. The main empirical results are in Section V, and the final section contains some brief concluding comments.

II. Foreign direct investment and international trade

The theoretical literature on international trade and the behaviour of multinational firms fails to give a clear indication as to whether foreign production acts as a complement to or a substitute for international trade. This is explained, in part, by the separate development of models of trade and models of foreign investment based on the behaviour of individual firms. We start by discussing theoretical models of the relationship between trade and foreign investment, and then consider some of the issues raised by recent papers on the determinants of foreign investment. Finally, we review a number of existing empirical studies of the relationship between trade and FDI. However, as the literature has largely ignored the services sector, most papers discussed below will relate to the manufacturing sector.

II.1 Theoretical issues

In the traditional 2x2x2 Heckscher-Ohlin (H-O) model, trade in goods is brought about by international differences in relative factor endowments, and therefore differences in relative factor prices. The conventional framework assumes perfectly competitive markets, identical constant returns to scale (CRS) production functions, and zero transportation costs. Factor price equalisation can be achieved either through movement of factors (such as FDI), or movement of goods embodying the services of those factors (international trade). The movement of factors equalises the relative endowments and the return to factors, and thereby reduces trade. Trade and factor movements can, therefore, be seen as substitutes.

However, when the assumptions of this model are relaxed, and imperfections are allowed for, trade and factor movements may act as complements. Markusen (1983) uses the traditional factor proportions model as a starting point, but removes the usual H-O motivation for trade by assuming that relative endowments are equal and fixed (as well as total factor supplies), and subsequently relaxes the H-O assumptions[1] one by one. This leads to complementarity in each case.

Markusen (1984) builds on the theory of the firm rather than relying on imperfections in the traditional trade model. The basis for trade is formed by assuming the existence of multi-plant economies of scale in an activity assumed to be centralised in one country. This, combined with the other assumptions of that model, drives FDI (multinational activity) and trade to co-exist, resulting in a complementary relationship between the two.

Brainard (1993) is an example of a model that can generate results of both substitutability and complementarity. It assumes that a firm's choice between trade and FDI depends on a trade-off between proximity and concentration advantages, combined with non-zero transport costs.

This model draws on the new trade theory (imperfect competition with increasing returns to scale (IRS), and trade in differentiated products), and on the literature on strategies of multinationals (which mainly revolves around the framework provided by the OLI[2] theorem, or the Eclectic Theory, Dunning (1977)). It is a 2x2x2 model, with a CRS agricultural sector, and a differentiated products sector in which production can be broken down into different

[1] Namely: (i) identical technologies, (ii) identical homothetic demand, (iii) constant returns to scale technology, (iv) perfect competition, and (v) absence of domestic distortions.

stages, or activities, of production. It is assumed that there are IRS at the firm level associated with activities such as R&D (that can be used as an input in any number of production facilities without being reduced in value, like the sources of multi-plant economies of scale), scale economies at the plant level (hence the concentration of production will lower unit costs), and a variable transport cost that rises with distance (thus providing an incentive for proximity). Thus, firms in this sector can choose between exporting and establishing a production facility abroad as alternative ways of supplying the foreign market. This choice is based on a trade-off between proximity advantages from being located close to consumers, which lowers transport costs and could lead for example to better customer service, and scale advantages from concentrating production in one location. The model can be extended to multiple production stages.

Although this model can generate results of both substitutability and complementarity of trade and FDI, it does not provide a comprehensive integrated framework since it focuses only on horizontal FDI. Indeed, the papers discussed above have all viewed the multinational firm as horizontally integrated.

An alternative approach is to explicitly model multinational firms as vertically integrated firms that separate activities geographically in order to exploit differences in relative factor endowments. The production of headquarter services will be located in one country, and traditional production plants are established in different countries. An example is the model in Helpman (1984). By definition, the decision to establish foreign affiliates will raise trade in (headquarter) services in such a framework. Thus there could be a positive link between non-service FDI and trade in services.

Markusen, Venables, Konan and Zhang (1996), and Markusen (1998) formulate a model in which both horizontal and vertical MNEs, as well as national firms, can arise endogenously as a function of trade costs, absolute and relative factor endowment differences between countries, and investment barriers. This endogenises firms' locational decisions, allowing them, as well as decisions whether to horizontally or vertically integrate production across countries, to depend on national and technological characteristics. This model is used to make predictions about the volume and direction of trade, and about the effects of the various types of FDI on factor markets and on trade. Moreover, allowing a distinction to be made between

[2] According to Dunning, foreign investment will only take place in the presence of (i) ownership, (ii) locational, and/or (iii) internalisation advantages.

horizontal and vertical FDI permits a deeper analysis of the role of multinational firms, especially since these two types of foreign investment could, a priori, be expected to have a different relationship with trade. Indeed, it is traditionally thought that horizontal FDI is trade replacing. This is the case when (outward) FDI and trade (exports) are considered as two alternative ways of supplying foreign markets with the same good, or in other words, when trade and FDI are thought to be substitutes. On the other hand, it is generally believed that vertical FDI is trade creating, especially with trade in intermediates and/or intra-firm trade, so that FDI and trade would act as complements. Therefore, an analysis of the relationship between trade and FDI should include both types of foreign investment.

The model is set up as a 2x2x2 model, allowing both horizontal and vertical MNEs to arise endogenously in equilibrium. It is assumed that one good is unskilled labour intensive and uses CRS technology and the other good is skilled labour intensive with IRS technology, with the latter good traded in imperfectly competitive markets. The two factors of production can move between sectors, but are immobile internationally. Furthermore, it is assumed that a firm is composed of 'headquarters' and 'plant', which may be geographically separated, and firms can have plants in one or both countries. This results in six possible types of firm.

	Country 1, H, as the 'home' country	Country 2, F, as the 'home' country
Horizontal MNEs	Headquarters located in H, production plants located in H and F	Headquarters located in F, production plants located in H and F
National firms	Headquarters and a single production plant located in H; may or may not export to F	Headquarters and a single production plant located in F; may or may not export to H
Vertical MNEs	Headquarters located in H, production plant located in F; may or may not export to H	Headquarters located in F, production plant located in H; may or may not export to F

The introduction of MNEs implies that factors like country size, location, and the factor composition of fixed costs become important in determining what types of firms will arise in equilibrium. For example, country size will be important in the presence of non-zero trade costs (which give an incentive for proximity to the market), whereas plant-level economies of scale are conducive to having single production plants.

As it is impossible to solve the model analytically, the predictions in Markusen et al (1996, 1998) are obtained from simulations[3]. They depend on the interaction between trade costs, and absolute and relative factor endowments. For example, when trade costs are moderate to high, both absolute and relative endowments are the determinants of comparative advantage. When trade costs are low or zero, absolute endowments become irrelevant as each location can be supplied costlessly.

Thus, theory fails to provide a clear prediction as to what the nature of the relationship between trade and FDI may be. As a consequence, it is very important to examine this relationship empirically, as well taking on board practical considerations. However, the empirical implementation of these theoretical models is problematic, mainly due to data limitations. This problem is even more pronounced when looking at the services sector where the data remain less complete and detailed than for the manufacturing sector.

II.2 Practical considerations

In practice, there are many other considerations that influence both the amount and location of FDI. These can include strategic, market access and penetration, or 'tariff jumping' motivations. The existence of national and regional trade barriers (such as technical, legal, and social standards, local content requirements, as well as language) can be expected to play a role, and are generally expected to remain particularly important in the case of services. Indeed, services remained largely outside the scope of international trade policy arrangements prior to the start of the GATT Uruguay Round in 1986. The liberalisation of services sectors is now dealt with separately, a process initiated by the General Agreement on Trade in Services (GATS, 1995), and continued in the GATS 2000 negotiations that have been ongoing since February 2000.[4] Non-tariff barriers (NTBs) are important, first of all because they have not been dealt with by GATS,[5] but also because they may have a greater impact than in the case of goods. Indeed, they may be an important determinant of the locations in which particular services can be produced if, for example, there are language requirements or knowledge of local rules and regulations is needed.

[3] Data constraints will generally imply that the distinction cannot be made in any empirical studies.
[4] See Sauvé (2002) for a discussion of the ongoing services negotiations under the GATS.
[5] In fact Rose (2003) does not find any evidence that WTO membership encourages trade in services. This could either mean that nothing much has happened in terms of actually liberalising trade in services, or it could be suggestive of the importance of non-tariff barriers to trade in services.

Where barriers do remain in place, firms may have an incentive to establish operations within such 'closed' regions in order to gain barrier- and tariff-free access to the regional wide market. For example, Barrell and Pain (1999a) illustrate the extent to which the increasing use made of contingent protection within Europe and the United States has served to increase the level of FDI by Japanese companies in these regions.

Foreign investment undertaken in order to bypass merchandise trade barriers may improve market access, with reduced exports of finished goods being more than offset by greater exports of intermediate goods to assembly plants located abroad. This may not happen in the case of services where it is not necessarily the case that production abroad requires intermediate inputs from the home country, other than brand reputation or managerial skills, for example.

Some service sector firms may choose to locate abroad in order to follow expansion abroad by their manufacturing clients. For example, it is well established that cross-border investments in financial services have strong inter-linkages with cross-border investments by non-financial firms from the same home country (Moshirian, 2001; Esperanca and Gulamhussen, 2001). So it may be important to look at the relationship of services exports with the total FDI stock, as well as with services FDI.

In some industries direct investment may be the sole means of entering foreign markets given institutional barriers in areas such as public procurement, differing technical standards and the extent to which products are directly tradable. In such cases changes in the level of direct investment are unlikely to have any direct effect on trade performance. This is likely to be the situation in certain service industries, such as the telecommunications sector which remains highly regulated.

Some direct investments may be motivated by strategic considerations as much as by a desire to seek out low-cost locations. In imperfectly competitive product markets, the sunk-costs occurred in undertaking foreign direct investment act as a barrier to entry by other firms, allowing the investing form to gain market power and exploit intangible firm-specific assets such as brand names. Of course, even if direct investment improves market access for the parent firm, this may be at the expense of other firms exporting from the home economy. This is one reason why studying the aggregate effects of foreign investment on trade performance should, ideally, be combined with an examination of firm level data.

II.3 Empirical studies

Merchandise Trade

Overall it is possible that international production may either create or displace trade, with the particular effect likely to differ between economies and industries, and between inward and outward investment. Many studies using aggregate data find evidence of a complementary relationship. However, it is very likely that this is because the level of aggregation will mask different underlying forces, and because a lot of these studies just examine the bivariate relationship between trade and FDI. As both trade and FDI will grow over time with the general level of economic activity, this may suggest spurious complementarity. A high level of aggregation may be a problem as that means only the net effect of foreign investment on trade can be picked up. Even if a foreign production plant producing final goods or services that were previously exported from the home country displaces exports of final goods or services, it may increase trade if it relies on intermediate inputs from the home country. Moreover, such relationships may change over time. For example, a foreign subsidiary may eventually switch to local suppliers of intermediate inputs.

Where a distinction is made between inward and outward investment, the available evidence tends to suggest that inward investment is perhaps more likely to raise exports from the host economy than outward investment. In small open economies such as Ireland, inward investment is often intended to establish an export platform to serve a wider regional market (O'Sullivan, 1993)[6].

In accounting terms a high level of inward or outward investment by export-orientated firms may change the range of products produced within the host economy and hence the proportion of the (given) world market accounted for by exports from that country (Pain and Wakelin, 1998). Failure to allow for the impact of production relocation on product variety in conventional trade relationships would then give rise to apparent shifts in the income elasticity of demand for exports (Krugman, 1989).

Moreover, theory seems to suggest that the nature of the relationship will vary according to the type of investment, horizontal or vertical, and the nature of the goods traded (intermediate

[6] There is little evidence of a negative relationship between inward investment and export performance in developed economies, although in theory such a relationship is possible. For example, exports of intermediate products may decline if an importing country relocates assembly activities to the exporting country.

or final goods). One would expect vertical FDI, which involves trade in intermediate goods, to imply a complementary relationship. Horizontal FDI, on the other hand, is usually expected to involve the production of final goods and is, therefore, more likely to act as a substitute for trade. However, as noted above, it may increase trade if it continues to rely on the home country for its supply of intermediate goods.

Empirical studies are complicated by the fact that there is no clear-cut prediction emerging from the theoretical literature. The specification of testable equations tends to include similar variables, even when they are meant to be drawn from different theories. Thus most studies test some fairly standard trade model, where trade is a function of factors such as market size, relative prices, and distance, and augment that with a variable representing FDI. Various methodologies are employed, e.g. cross-section, panel data, time series, generally dictated by data availability. Many of these have used US data, reflecting the availability of detailed data on activities by multinational companies.

Many cross-sectional studies find a complementary relationship between exports and outward FDI after controlling for other determinants of exports. Lipsey and Weiss (1981, 1984), using industry-level and firm-level data for 1970 respectively, report a generally positive relationship between the level of output of US foreign affiliates in a country and US exports to that country, owing to an increased demand for intermediate goods. Blomström et al. (1988) use industry level data for the level of exports from Sweden and the US in 1978 and 1982 respectively and the change in exports from Sweden between 1970 and 1978. The balance of the evidence again points to a positive relationship for both Sweden and the US between affiliate sales and exports, although a negative relationship was obtained for a minority of US industries. Veugelers (1991) finds evidence of a positive association between FDI and exports from the home country using a cross-sectional panel for all countries that are members of the OECD.

Some papers, for example Eaton and Tamura (1996) and Graham (2000), adopt an approach based on gravity models. Eaton and Tamura (1996) explore the choice between exports and foreign investment, using annual data on Japanese and US exports and FDI to 72 other countries between 1985 and 1990. The model points to the destination country's size, available labour force, ability to absorb foreign capital and distance from the source country as the primary factors influencing the choice between trade and direct investment. In particular, distance tends to inhibit FDI much less than exports. The empirical results

highlight some interesting distinctions between the US and Japan. For both countries direct investment is favoured over trade with more distant countries. However whilst there is some evidence that US FDI increases relative to exports as destination countries become more advanced, Japanese exports and FDI show the opposite pattern.

Another difference between Japan and the US is found in Graham (2000). Using a gravity-type model on US and Japanese exports and FDI to 40 and 36 destination countries in 1991 and 1993 respectively, he finds that the nature of the relationship may vary according to the geographical area being considered. The results suggest that US exports and outward FDI are complements globally and in East Asia and Europe, but that they are substitutes in the Western Hemisphere. In contrast, the results for Japan point to overall complementarity.

There is some evidence that suggests that the nature of the relationship between trade and FDI may change over time, emphasising the need for further research within a dynamic context. For example, in contrast to earlier studies by Lipsey and Weiss based on 1970 data, Ramstetter (1991) finds evidence for a significant negative relationship between parent company exports and the activity of their foreign affiliates, using US industry-level data for export growth between 1977 and 1982. Indeed, it has been suggested (McGuire, 1995) that many US foreign affiliates now have a relatively high local content in their output, possibly reflecting the relative age of many investments and the extent to which affiliates now resemble their locally-owned competitors. Similarly, Svensson (1996), using Swedish data for 1990, obtains evidence of a substitution effect, while previous research using Swedish data covering the 1970s and early 1980s had typically concluded that FDI had a complementary net effect on domestic exports, with greater market proximity serving to raise overall market share. During the earlier period, increases in exports of intermediate goods more than made up for the decline in exports of finished goods, whereas in Svensson's study exports to third parties from the foreign affiliates of Swedish companies were found to take place at the expense of exports from the parent firm.

There is also some evidence to suggest that findings of complementarity in many empirical studies may be explained by the high level of aggregation of the data employed. Swenson (1999) finds evidence for complementarity in the absence of disaggregation. However, she finds that at the industry and product levels FDI substitutes for trade. Blonigen (2001) uses product level data on Japanese production in the US and exports to the US for two types of products, automobile parts (because of strong vertical linkages), and eleven final consumer

products (to avoid the effects of vertical linkages) not subjected to any kind of protectionist measures. He finds strong evidence for substitution effects between Japanese exports and Japanese production of automobile parts in the US, as well as a complementarity effect between Japanese exports of automobile parts to the US and Japanese production of automobiles in the US. In the case of the final consumption goods, the results point to substantial substitution effects which tend to occur in large one-off changes rather than gradually over time.

Endogeneity and simultaneity are two potentially important empirical problems that are likely to occur when examining the relationship between international trade and FDI as these two variables are expected to be largely determined by the same factors, and also because of the direct interlinkages that can exist between the two. Indeed, a number of studies suggest that the level of foreign direct investment can be partially explained by past trade linkages (e.g. Barrell and Pain, 1999a). The possibility of simultaneity has led to the use of a 2SLS approach in some cross-sectional studies.

The endogeneity issue has also been considered in a time-series context by Pfaffermayr (1994) using data on outward direct investment and exports from Austria. His results reject unidirectional causality between the two, implying the possible need for a simultaneous estimation framework. In subsequent work, Pfaffermayr (1996), both FDI and exports are analysed simultaneously in a dynamic, pooled time-series cross-section model. The author applied a trade model based on factor intensities to explain trade and FDI using industry level data for the Austrian economy. The results show a significant complementary relationship between exports and FDI with causation in both directions. In addition, relative technology (proxied by R&D intensity) was found to be a significant determinant of both FDI and exports.

In contrast, the time series study on UK data by Blake and Pain (1994) uses cointegration techniques to establish that there is a unique long-run relationship between UK exports, market size, relative prices, net FDI and proxies for relative product quality, with net inward foreign direct investment shown to have improved export performance over time. However the resulting elasticity is small, with a 1 per cent rise in the net stock of inward investment raising the volume of exports by around 0.15 per cent.

Pain and Wakelin (1998) argue that the relationship between trade and FDI should not be examined by estimating equations including only the levels of these two variables, as both of them increase over time and are affected by total demand. Instead they suggest examining the relationship between FDI and export performance – exports relative to market size. Thus, they examine the relationship between the location of production and the trade performance of 12 OECD countries over time using an augmented export demand model. They include standard variables, such as market size and relative prices, as well as measures of relative innovation and indicators of inward and outward levels of investment. They find that outward investment tends to have a negative effect on export performance, whereas inward investment is found to generally have a positive effect. Related results for exports are reported by Barrell and Pain (1997), and for imports by Barrell and te Velde (2002).

Overall, there does not appear to be any single conclusion regarding outward FDI and exports that can be drawn with confidence from the range of studies we survey. On balance the evidence from cross-section studies and panel studies with a limited time dimension suggests that the two are complements, whereas studies with a greater time dimension obtain stronger evidence that the two are substitutes with the exception of the studies on Austria.

Trade In Services

The papers discussed above largely focused on manufacturing industries, or at least, did not consider service sectors separately. We will now review some papers that have sought to model services explicitly. There are a much smaller number of these, but they do suggest that many of the conventional determinants of merchandise trade also appear to be important for services trade.

Hung and Viana (1995) model US services trade flows, using data covering the period since the start of the present floating exchange rate era (1973) to the early 1990s to estimate an econometric model of real non-military and non-transportation services trade between the US and the rest of the world. Specifically, their aim was to examine the factors accounting for the surge of $60 billion in the US services surplus between 1985 and 1992. They found evidence refuting the hypothesis that this development could be explained by data improvements. Indeed, the latter were found to have had a negative effect on the surplus as imports were more affected than exports. Furthermore, there were frequent revisions, discontinuities and breaks in the data for the early part of the sample. They also found evidence suggesting that

strong foreign growth, and, to a lesser extent, the depreciation of the dollar explained the bulk of the increase in the services surplus. Finally, they found that an increase in either outward or inward FDI assets had a significant and positive effect on both exports and imports of other private services, but had only a modest net effect on the US services balance.

Ansari and Ojemakinde (2003) examine the difference in the performance of the goods and services components of the US trade account. The merchandise account has shown a continuing decline (from a deficit of around 2 billion US$ in 1971 to one of around 245 billion US$ in 1998) whereas the services account has shown a rising surplus (from a deficit of less than 3 billion US$ to a surplus of around 81 billion US$ over the same period). At the same time, the GDP share of services has also grown faster than that of the goods sector. Using time series estimation techniques, the authors find evidence suggesting that the difference in the performance of the merchandise and service accounts can be explained by differences in both income and price elasticities, as well as by the rapid growth of the service sector itself. Indeed, while the income elasticities in the import demand equations were very similar for both merchandise and services (1.85% and 1.83%, respectively), they were very different for the export demand equations, with a merchandise demand elasticity of 0.95% and a service demand elasticity of 1.37%. Moreover, while for both merchandise and services the absolute price elasticities on imports were much larger than on exports (-0.40% and –0.09%, not significant, for merchandise, compared to –1.19% and -0.42% for services, respectively), the absolute difference and the absolute elasticities were far greater for services.

Freund and Weinhold (2002) examine two different ways of modelling the impact of the Internet, as measured by the number of web hosts in a country, on US trade in business services. In the first approach they regress growth in 14 US services industries over the period 1995-1999, using separate equations for imports and exports, on industry fixed effects, the Internet variable, GDP growth, the real-exchange rate and the initial level of trade. The results indicate that there is a positive and significant effect from Internet adoption on services trade growth. Freund and Weinhold then re-estimate their equation controlling for factors that were omitted from the first specification but that may be correlated with Internet adoption while also constituting important determinants of services trade. They include variables that control for relative per capita income and for the existence of a certain comparative advantage in the production of services and find that the Internet variable

remains unchanged, positive and very significant in the import-growth equation while it halves in size in the export equation. The second modelling approach consists of estimating a gravity-type equation for services trade. The results confirm the positive impact of the Internet on US services imports but there is no evidence of any stimulus to US exports (although trade policy is not controlled for).

Having reviewed the existing literature on the relationship between trade and FDI in this section, we now turn to a discussion on services in the next section.

III Services

We start this section by discussing the definition, classification, and measurement of services and of trade in services, followed by a brief discussion of how services have been perceived in the economic literature. A more detailed discussion of these issues can be found in van Welsum (2003). Subsequently we describe the services data that we employ in this paper.

III.1 The definition of services and of trade in services

One longstanding common definition of a service is 'a change in the condition of a person, or of a good belonging to some economic unit, which is brought about as the result of the activity of some other economic unit, with the prior agreement of the former person or economic unit' (Hill, 1977, p. 318). This definition was inspired by the intangible nature of services and their apparent non-storability, which implied simultaneity of production and consumption and, therefore, that the producer and the consumer had to be in the same location. However, the nature of services has evolved over time, mainly as a result of technical progress which has increased the tradability of many services (by making them storable and/or transportable), and also created new services.

Stern and Hoekman (1987) propose a useful classification of services that allows for the various characteristics of services to be taken into account. They distinguish between four different types of services:

1) separated services (where neither the consumer nor the producer need to move, for example services embodied in goods[7] (books, floppy discs etc.) or services that are traded electronically),

2) demander-located services (where the producer moves to the consumer, e.g. certain types of consultancy),

3) provider-located services (where the consumer moves to the producer, e.g. tourism), and

4) footloose or non-separated services (where both the consumer and the producer move, e.g. entertainment services such as the World Cup organised in Japan and Korea).

This is a very useful classification, but it is not a definition as such. The Manual on Statistics of International Trade in Services (MSITS) (2001) argues that the term 'services' refers to a wide range of intangible products and activities that cannot easily be captured by a single definition. Moreover, it recognises that many services are bundled to goods, which may make it difficult to identify them. Therefore, the MSITS tends to adopt the System of National Accounts 1993 approach which defines services as follows: 'Services are not separate entities over which ownership can be established. They cannot be traded separately from their production. Services are heterogeneous outputs produced to order and typically consist of changes in the condition of the consuming units realised by the activities of the producers at the demand of the customers. By the time their production has been completed they must have been provided to the consumers.' (Manual on Statistics of International Trade in Services, 2001, p. 21).

Clearly, the definition of services, and therefore the definition and measurement of trade in services, is problematic due to their intangible nature.

Trade in services.

Under the General Agreement on Trade in Services (GATS, 1995), trade in services is defined as 'the supply of a service:

1) from the territory of one Member into the territory of any other Member (mode 1: cross-border supply), for example services that are embodied in goods or services that can be traded electronically;

[7] As Sampson and Snape (1985), for example, note: the problem with these separated ('separated' because they can be separated from both producer and consumer) services is that they may be identified as goods rather than

2) in the territory of one Member to the service consumer of any other Member (mode 2: consumption abroad), for example expenditure by tourists abroad, or by students on education abroad;

3) by a service supplier of one Member, through commercial presence in the territory of any other Member (mode 3: commercial presence), for example services delivered through subsidiaries, e.g. of banks; note that such commercial presence abroad takes place as result of foreign direct investment;

4) by a service supplier of one Member, through presence of natural persons of a Member in the territory of any other Member (mode 4: presence of natural persons), for example on-site consultancy abroad;'

(Manual on Statistics of International Trade in Services, 2001, p. 26).

This definition can be, more or less, matched up with the classification of various services proposed by Stern and Hoekman (1987). Trade in separated services can be considered under GATS mode 1, demander-located services as GATS modes 3 and 4, provider-located services as GATS mode 2, and footloose services, possibly, as GATS modes 3 and 4.

One important implication of the GATS definition is that it allows almost all services to be classified as tradable. However, it does not always necessarily match with the definition adopted in balance of payments (BOP) statistics where trade in services is only recorded when transactions between residents and non-residents take place. This is an important difference, since it is BOP statistics that are generally used in empirical analyses. So any results may not carry over to those types of services not included in the BOP data. Cave (2002) notes that the IMF's Balance of Payments Manual 5 (BPM5) will account for most trade under GATS modes 1 and 2, for a significant amount of that under mode 4, but only some of that under mode 3. However, since mode 3 is believed to be, by far, the largest mode of supply (Karsenty, 2002), failure to take this mode of transactions into account adequately implies a significant under-recording of trade in services in current BOP statistics.

III.2 The implications of the nature of services

The approach to services taken in the economic literature has pointed to many aspects of services and of trade in services, but has failed to come up with a single, clear economic

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as services.

definition, as opposed to the statistical definitions of the BPM5 and GATS, for example (see van Welsum (2003) for a detailed discussion). Moreover, it seems to have largely ignored the obvious characteristic that distinguishes a service from a good, namely its intangibility: we cannot hold a service in our hand, or break it in two. Thus, it appears that, economically, the fundamental difference between a good and a service comes down to the issue of the measurement of price and quantity, possible in the case of a good, but harder for a service[8]. Nevertheless, it is not obvious that the intangible nature of a service should make a difference to its economic analysis. However, one distinction that could be important is whether the service considered is for 'final' or 'intermediate' use, as that is where the relationship between trade and FDI can be expected to differ. Finally, as van Welsum (2003) discusses, it appears that, on the whole, the literature has not established any objections against using theories that relate to goods when analysing services, formally or empirically. As shown above, empirical models of services trade often successfully utilise the same types of variables as empirical models of merchandise trade.

III.3 Description of the data

We use annual data from the US Bureau of Economic Analysis on exports of services and outward foreign direct investment for the US (in millions of US$). The data on private services trade, measured on a BOP basis, are broken down into the following six categories:

1. Travel
2. Passenger fares
3. Other transportation
4. Royalties and licence fees
5. Other private services, affiliated
6. Other private services, unaffiliated.

The publicly available data for the US investment position abroad in the total private services sector (on a historical-cost basis) are broken down into the following categories:

1. Banking[9]
2. Non-banking finance (including insurance and real-estate)
3. Total finance (which is the sum of the banking and non-banking finance categories)

[8] Similarly, it is also more difficult to measure output and productivity, for example, for services than for manufacturing.

[9] U.S. parents and foreign affiliates in banking are parents and affiliates that had over 50 percent of their total revenues generated by activities characteristic of depository institutions (banks, savings and loans, and credit unions). From 1994 onwards, 'banking' is called 'depository institutions'.

4. Other private services.

Unfortunately, it is not possible to match the two data sets precisely. However, based on our discussion above, it is reasonable to expect a relationship between total trade and FDI. Therefore, for each of the 6 services exports categories, we discuss the interpretation of the data and the relationship between export performance and the total and/or total services FDI stock. The basis for recording trade and investment is provided by the BPM5 criterion of whether or not a transaction between a resident and a non-resident has taken place.

We discuss each category in turn. A common problem is posed by services that can be traded without the producer or the consumer having to move (separated services in the Stern and Hoekman (1987) classification), especially when they can be traded electronically. This can make it difficult to establish exactly where, when, and between whom transactions have taken place. We include affiliate sales, often used as a proxy for the foreign activities of domestic companies, in our discussion to illustrate the recording and interpretation problems. Affiliate sales can be considered as trade in the GATS classification under 'Mode 3: commercial presence', which can take place only if FDI has occurred. However, this type of data is not recorded in the Balance of Payments statistics at present, although it is included in FATS (Foreign Affiliates Trade in Services) Statistics.

The following table summarises the categories of exports and the type of transaction they represent:

Table 1: Summary of the nature of the trade data

Services category	Classification of exports
Travel	Provider-located services *(Mode 2: consumption abroad)*
Passenger fares	Separated services *(Mode 1: cross-border supply)*
Transportation	Separated services *(Mode 1: cross-border supply)*
Royalties And licence fees	Separated services *(Mode 1: cross-border supply)*
Affiliated other private services	Separated services *(Mode 1: cross-border supply)*; and in some cases demander-located services *(Mode 4: presence of natural persons)*
Unaffiliated other private services	Separated services *(Mode 1: cross-border supply)* and in some cases provider-located services *(Mode 2: consumption abroad)* or demander-located services *(Mode 4: presence of natural persons)*

Note: Mode 3: commercial presence is not included in this table as it requires FDI to have taken place and will record sales by foreign affiliates (i.e. FATS, not Balance of Payments statistics).

Travel

Travel exports include all travel-related expenditures and purchases made by visitors (for business or leisurely purposes) to the US, such as expenditure on hotels, restaurants, and entrance fees. In terms of the classifications of services, these travel exports are an example of the GATS 'Mode 2: consumption abroad', or 'provider-located services' in the Stern and Hoekman (1987) classification. FDI would consist of establishing foreign subsidiaries. Affiliate sales consist of expenditure by foreign nationals in American subsidiaries outside the US established through travel FDI, for example in hotels that are American-owned (e.g. American hotel chains).

As discussed in section III, the actual measurement and recording of this type of trade, affiliate sales and FDI is difficult. Take consumer expenditure on hotels, for example. It may be hard to establish exactly where and between whom the transaction has taken place, especially since hotel bookings can be done over the Internet from anywhere in the world. Moreover, it may not be obvious whether the sale of a hotel night should be recorded as an

export or as an affiliate sale, as this should depend on the nationality of the customer. As an example, consider a hotel in New York that is American-owned. The stay of a British guest should be recorded as an export of a travel service for the US (and an import for the UK). However, if the guest was American it should not be recorded as an export as the transaction is between residents of the same country. Foreign ownership of the same hotel could complicate matters further.

We would expect some types of travel services exports to be negatively related to FDI in the travel sector. For example, take FDI by the Disney Corporation. One consequence of Disney having invested abroad (FDI) in Disneyland Paris and Tokyo is that fewer people may travel to the US to go to Disneyworld in Florida. In this example travel FDI has a negative impact as it brings about a fall in travel exports, as well as a fall in the leisure component of passenger fares exports.

But, more generally, the development of stronger business ties across countries through foreign direct investment might be expected to stimulate business travel. Services such as advertising by US travel FDI subsidiaries abroad might also help encourage travel to the US. We would also expect some negative effects on the relationship with total FDI, even if these effects may not outweigh the complementary type effects. With increased outward FDI, it could be argued that there is less need for travel to the US in order to deal with US companies, implying less expenditure by business travellers. This also affects the passenger fares category as with less need to travel, there will also be a negative effect on the business component of passenger fares. Globalisation could also have a negative as well as a positive effect, as it increases information and access to alternative destinations that had previously been more difficult to travel to than the US.

Passenger fares

Exports in this category include expenditures on transportation related to persons, thus including both a business and a leisure component. FDI would consist of establishing sales offices abroad, and affiliates sales would include sales through such local offices abroad for example. Under the Stern and Hoekman (1987) classification, this type of service export can be classified as ‘separated services’ where neither the consumer nor the producer need to move, or GATS ‘Mode 1: cross-border supply’. This category may also be difficult to interpret, with the method of transaction affecting whether it enters the Balance of Payments

statistics or not. For example, if a foreign national (i.e. non-US resident) buys a plane ticket from a sales office of an American airline in the US, e.g. online, or by phone or fax or on location, then this is recorded as exports. However, if this plane ticket was bought in the airline's sales office abroad then it would be recorded as affiliate sales and not included in the Balance of Payments statistics.

Again, we would expect some negative effects on the overall relationship between this type of export and outward FDI but these effects may not be large enough to offset the general complementary effect from stronger business linkages through FDI. However that component of total FDI which consists of investment to set up sales offices and call centres abroad may reduce direct sales (exports) from the US and raise foreign affiliate sales. A negative effect on US exports might also arise from increased information about alternative destinations.

Transportation[10]

Exports of transportation services consist of expenditure on freight and port services. These include the movement of freight and other related transport services, such as the chartering of ships or aircraft with crew, cargo handling, storage and warehousing, towing, pilotage and navigation, maintenance and cleaning, port charges, and commission and agents' fees associated with freight transportation. The MSITS (1999, p. 35) recommends that all transport is allocated to GATS 'Mode 1: cross-border supply'. FDI in this sector could consist of setting up sales offices abroad.

We would expect a positive relationship between this type of export and outward FDI in general. Indeed, if the relationship between total trade and total FDI is positive, as is suggested by the empirical evidence reviewed above, and transportation is a complement to trade, then the relationship with between total FDI and exports of transportation services will also be positive. However, a specific increase in transportation FDI may have a negative impact on transport exports for any given level of demand, as foreign companies can use the services of foreign subsidiaries (affiliate sales) rather than the US sales offices. Nevertheless, if US subsidiaries abroad use US-owned transportation services to ship goods back to the US this would contribute to a positive relationship with total FDI.

[10] Transportation includes air, sea, rail, and pipeline transport.

It is interesting to note that there are some potential overlaps between the travel category and the leisure component of the passenger fares category, as well as between the business component of the travel category, the business component of the passenger fares category and other transportation.

Royalties and licence fees

This category records payments between residents and non-residents arising from, for example, the authorised use of intangible, non-produced, non-financial assets and proprietary rights (such as patents, copyrights, trade marks, design, industrial processes, franchises), manufacturing rights, the use of technical 'know-how', receipts for the rights to distribute, use and reproduce computer software, the use through licensing agreements of produced originals or prototypes (such as manuscripts and films), mineral royalties, and royalties on printed matter, sound recording, and performing rights. It includes affiliated transactions (receipts by US parents from their foreign affiliates), and by US affiliates from their foreign parents) and unaffiliated transactions. These services can be thought of as 'separated' in Stern and Hoekman's classification, and GATS 'Mode 1: cross-border supply'. Many will reflect payment for the use of firm-specific assets owned by companies located in the US. The level of such assets should be positively correlated with the level of expenditure on innovation (such as R&D) undertaken in the US.

The relationship between this type of export and FDI is ambiguous. We would expect a positive relationship for affiliated transactions. If FDI increases through an increase in the number and/or size of affiliates it can be expected that there will be more transactions between parents and affiliates, with firm-specific assets being utilised jointly across multiple locations. Thus, affiliated trade in royalties and licence fees will increase as total FDI increases.

In contrast, there may at times be a negative relationship for unaffiliated transactions. If royalties and licence fees are a complement to total trade, and an increase in FDI reduces this trade, then exports of royalties and licence fees will also fall. For example, if a new MacDonald's opens outside the US as a franchise, it will pay a franchise fee to the US parent company, which is an export of royalties and licence fees. However, if the US parent company were to set up restaurants abroad itself (i.e. undertake FDI in a services sector),

there would be outward FDI but no exports of royalties and licence fees. Thus, trade in this category would be negatively related to total FDI.

Other private services

This category includes expenditure by foreign nationals in the US on a wide range of different types of services activity, including education, financial services, insurance, telecommunications, and business, professional and technical services.[11] These services exports could be classified under Stern and Hoekman (1987) as 'separated' (GATS 'Mode 1: cross border supply') if the service can be embodied in a good or traded electronically, as many financial, insurance, consultancy services can be. Some of them could be classified as 'provider-located' (GATS 'Mode 2: consumption abroad'). One example would be when foreign nationals come to the US for education. Other types of services which are sold through on-site consultancy would be classified as 'demander-located' (and GATS 'Mode 4: presence of natural persons'). These transactions can take place between US parents and US affiliates ('affiliated services') and with unaffiliated third parties.

Other private services, affiliated

We would expect negative effects on exports if an increase in FDI implies an increase in the range of activities undertaken by affiliates. This would mean that there was less need for parent-affiliate transactions, reducing trade relative to the level it might otherwise have been at. For example, branch offices may be expanded to become fully independent subsidiaries. On the other hand, if the affiliates continue to rely on headquarter services or intermediate inputs (for example intermediate labour inputs from consultants, designers, engineers etc.) from the parent company, then there will be a positive effects on the relationship between FDI and exports.

[11] A more comprehensive list includes: education, financial services, insurance, telecommunications, [business, professional and technical services], and other, where [business, professional and technical services] include: [accounting, auditing, and bookkeeping services], [advertising], [agricultural services], [computer and data processing services], [construction, engineering, architectural, and mining services], [data base and other information services], [industrial engineering], [installation, maintenance, and repair of equipment], [legal services], [mailing, reproduction, and commercial art], [management of health care facilities], [management, consulting, and public relations services], [medical services], [miscellaneous disbursements], [operational leasing], [personnel supply services], [research, development, and testing services], [sports and performing arts], [training services], and [other business, professional and technical services].

Other private services, unaffiliated

We would expect negative effects on the relationship for this category if the services can be obtained from local subsidiaries or branches established through FDI (affiliate sales), rather than purchased from the US (exports). For example, a consultancy firm that sells its services directly from its US offices to foreign nationals may switch to selling the services through locally established branches. Then FDI, through affiliate sales, would replace the exports of the services. However, these negative effects may not outweigh the overall positive effects.

Summary

It is clear from the discussion above that there are many different modes through which international services might be supplied. The potential relationship between different types of exports and foreign direct investment in different sectors is likely to ambiguous in some cases, and is certainly likely to differ across different types of exports. However, in most cases the grounds for believing that the relationship with service sector FDI is negative appear somewhat stronger than the grounds for concluding that it is likely to be positive. The relationships between services trade and non-services FDI are theoretically ambiguous. Of course even if the relationship between exports and FDI were negative, it should be remembered that the relationship between FDI and the total sales made by the parent company and its affiliates is likely to be positive, because affiliate sales will rise. However, these are not recorded in the Balance of Payments statistics.

III.4-2 Descriptive statistics

The basic trade data are summarised in Chart 1 and 2 below (and Tables 1 and 2 in the appendix). It is clear that the value of private services exports has risen rapidly over time, with an average annual growth rate of 9¾ per cent per annum between 1986 and 2000. The annual growth rate was faster over the first half of the sample, possibly reflecting the higher annual rate of price inflation experienced over this period. Travel and other non-affiliated services are the largest two categories of private services exports, each accounting for just over a quarter of the total. Transportation services stand from the rest, because they have grown much more slowly over time, with their share in total service exports almost halving from almost 20 per cent in 1986 to 10.8 per cent in 2000.

Chart 1. **US Exports of services**

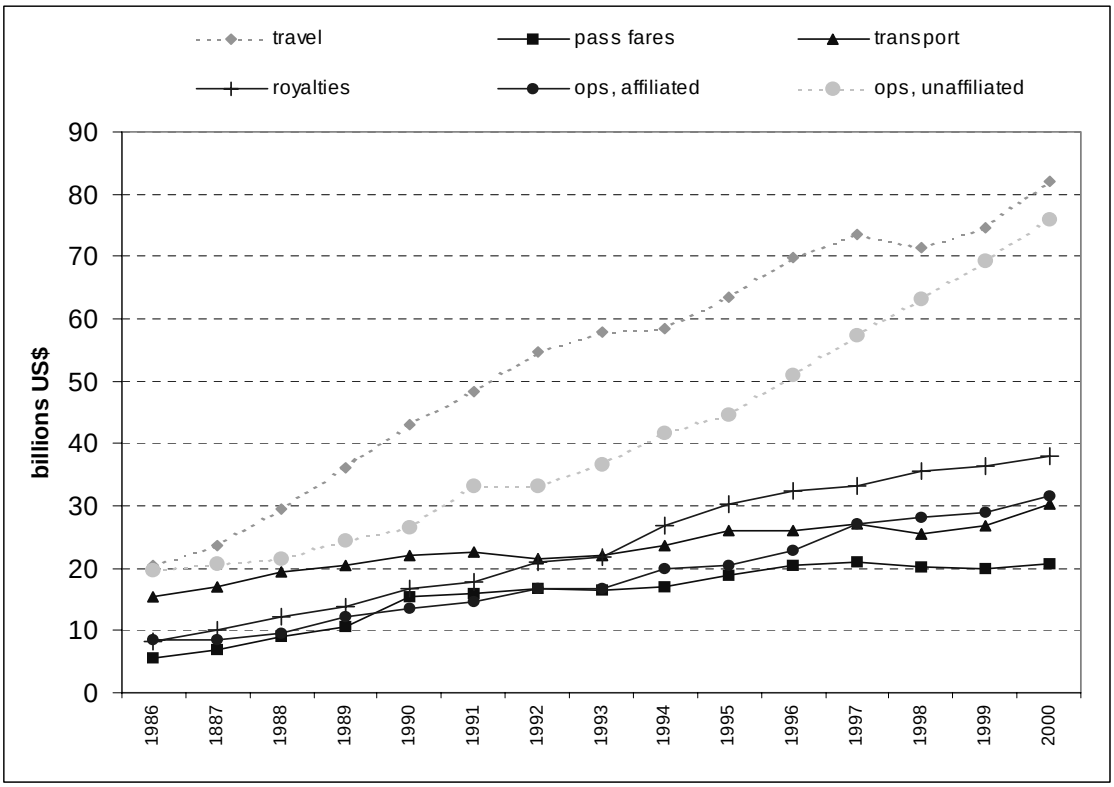
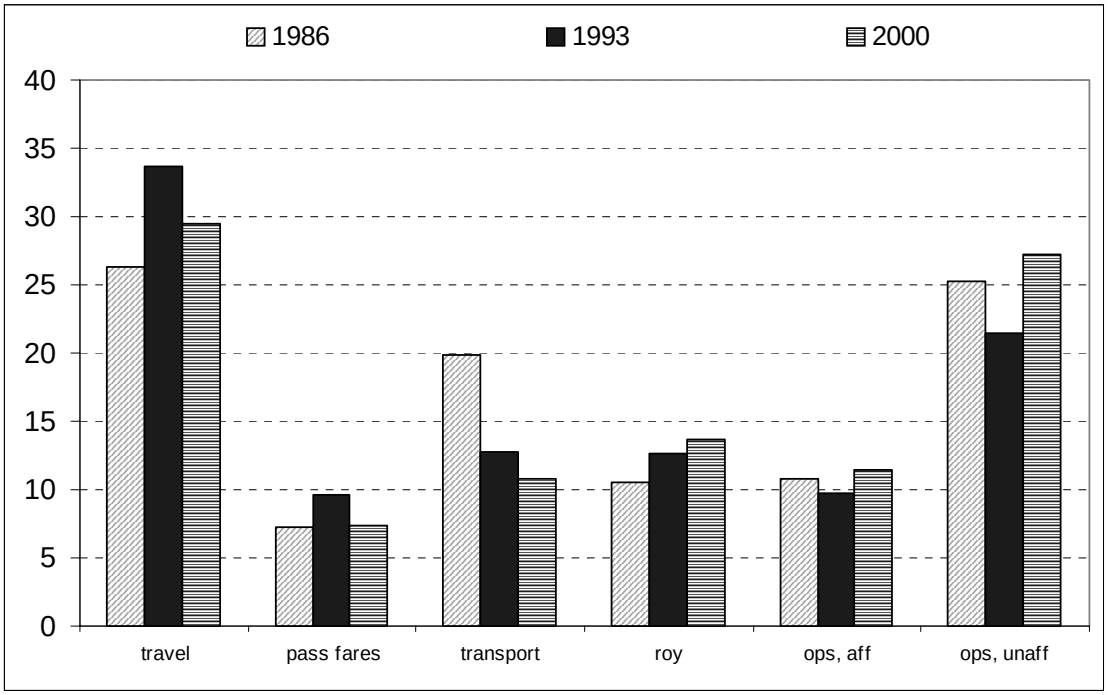


Chart 2. **Share in total private services**



In Charts 3 and 4 below we show the US share of global services trade. The data for total global services trade are taken from the IMF *Balance of Payments Statistics* and are measured as total imports of services in all countries apart from the US. This provides one measure of the potential market size facing US-based producers of tradable services. The IMF data allow the construction of separate data for private and government services. Private services can be split into travel, passenger services, freight and other transportation, and a fourth, residual category which includes royalties and other affiliated and unaffiliated services, which we term 'rest'.

From Chart 3 it is apparent that time series profile of the US share of global trade differs significantly across categories of services. The US accounts for around one-third of imports of passenger services in non-US countries, but after this proportion rose sharply at the start of the 1990s it has since stagnated. The first half of the sample period also saw an improvement in the US share of travel services, whilst the latter half of the sample has been notable for the improvement in the US share of the residual, non-transport, non-travel category. In contrast, the US share of other transportation services has fallen over the sample period, particularly in the late 1980s and early 1990s.

Chart 4 shows the shares of royalties, affiliated and unaffiliated services in global non-travel, non-transportation trade. Again different trends are apparent in the three series, with gradual upward trends in the shares due to royalties and affiliated services, and a much more marked jump in the share due to unaffiliated services in the latter half of the 1990s following a period of relative poor performance in the late 1980s.

Chart 3. **US Share of Global Services Trade**
(percentages)

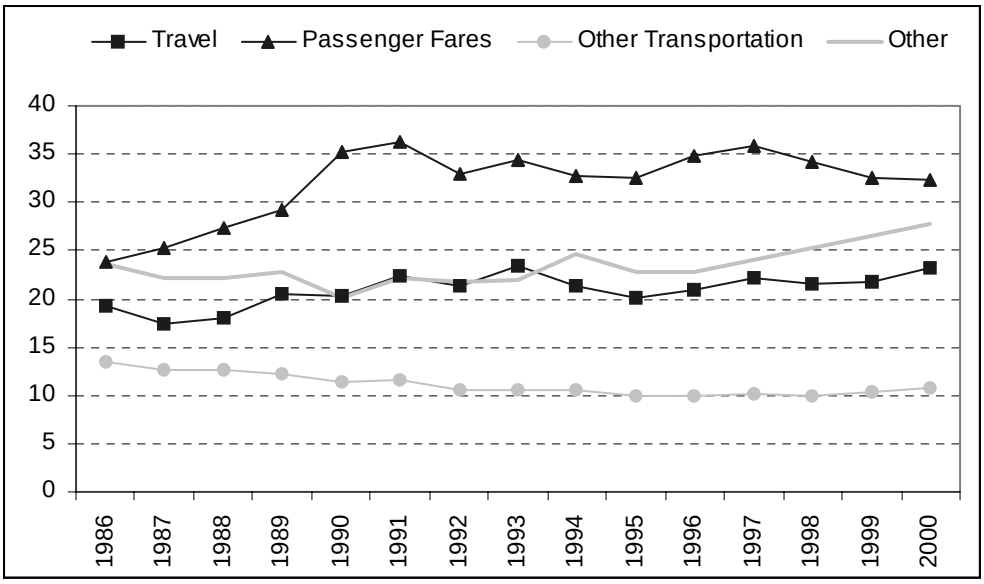
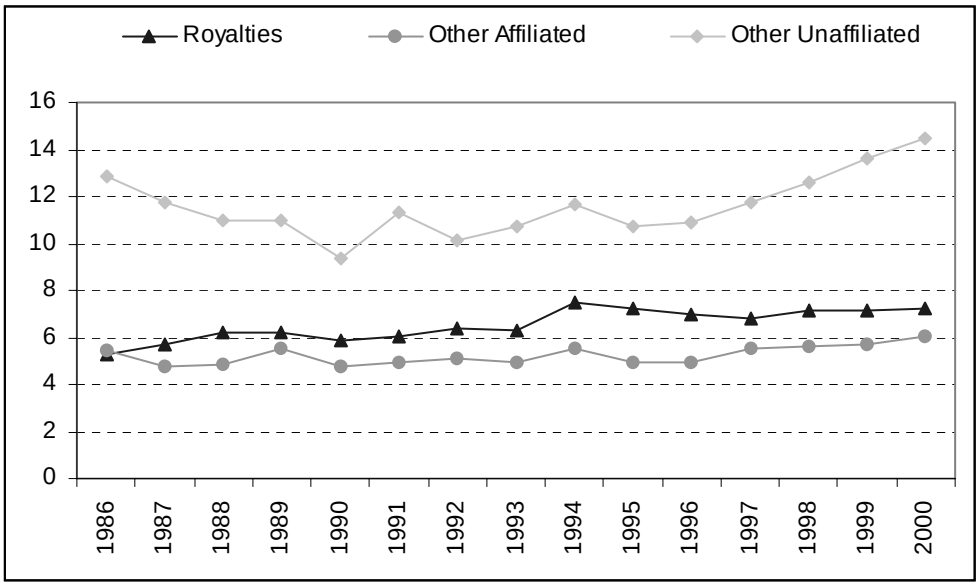


Chart 4. **US Share of Global Non-Travel, Non-Transportation Services Trade**
(percentages)



Data for the US investment position abroad in the total private services sector (on a historical-cost basis) are broken down into the following categories: banking, non-banking finance (including insurance and real-estate), total finance (which is the sum of the banking and non-banking finance categories), and other private services. The basic data are summarised in Charts 5, 6 and 7 (and Tables 3 and 4 in the appendix). Chart 5 shows the evolution of the FDI stock in manufacturing, total services, and non-banking finance (the largest services category). It is obvious that total services FDI has increased in importance relative to manufacturing FDI, and also that the pattern of total services FDI closely follows that of non-banking finance.

Chart 5. **Evolution of FDI stocks**

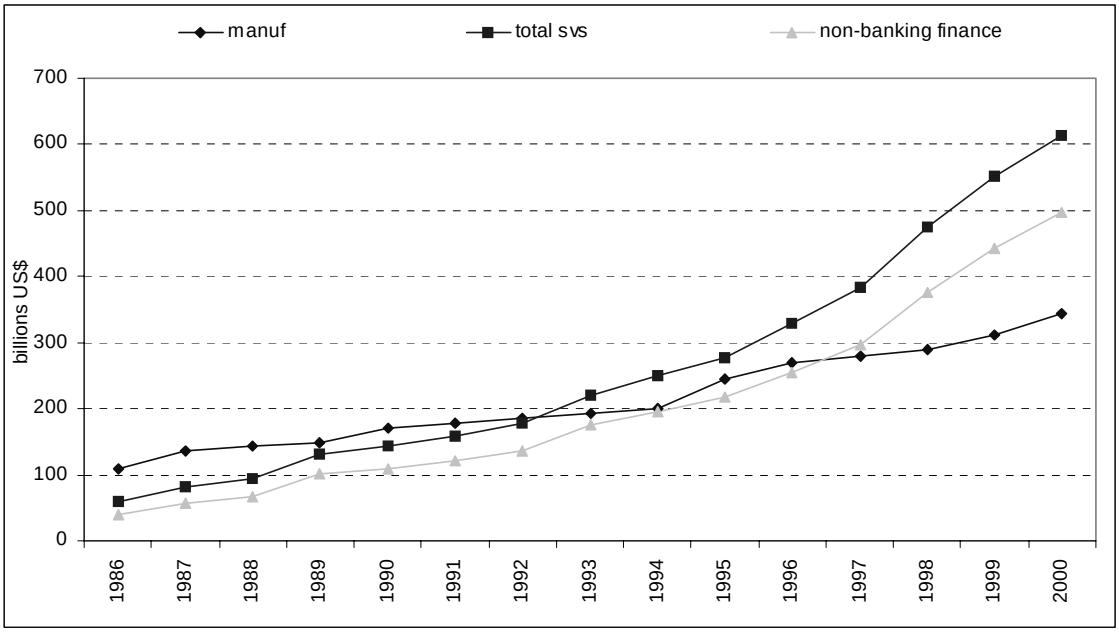
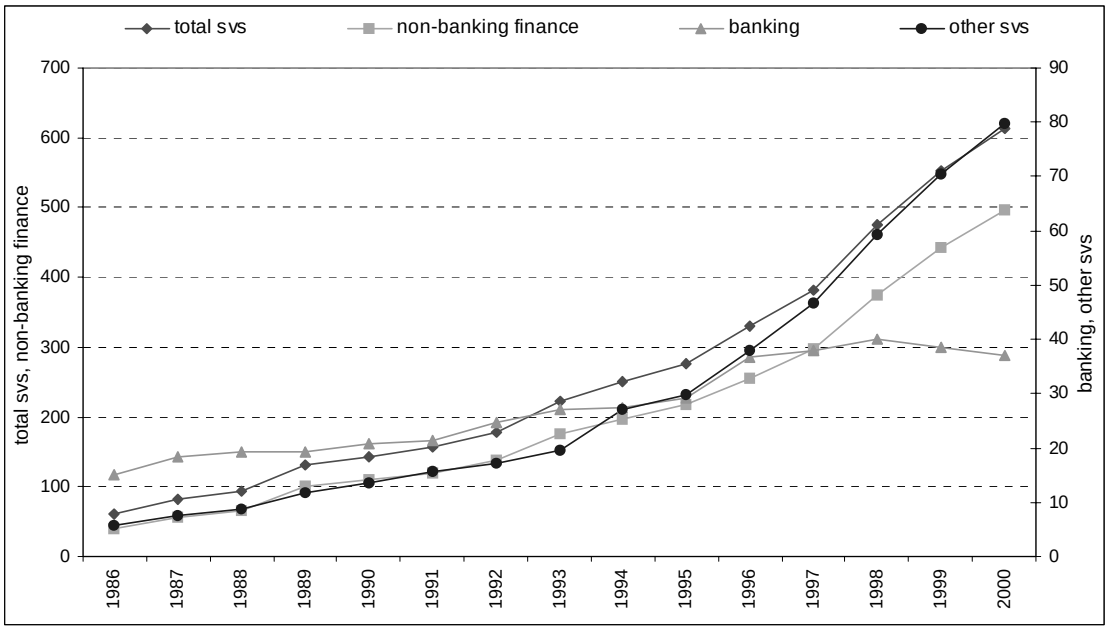


Chart 6 illustrates the evolution of FDI stocks by services sector. It clearly shows the importance of the non-banking finance sector in the total services FDI stock. Moreover, towards the end of the sample period, banking FDI seems to be in decline, whereas other services are starting to increase.

Chart 6. **Evolution of services FDI**

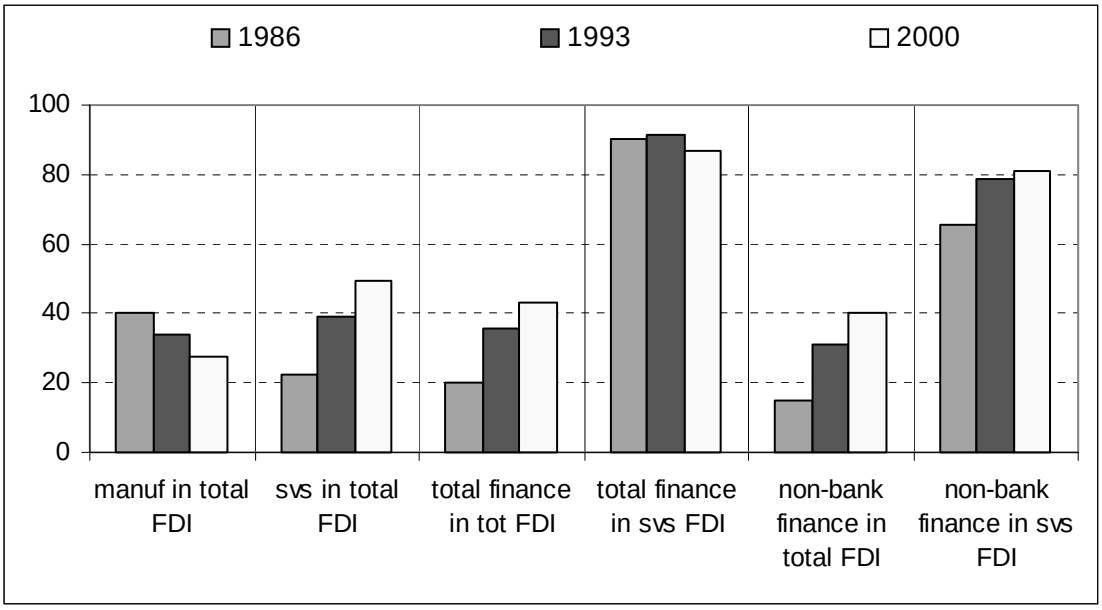
(billions US$)



The growing importance of the services sector is illustrated in Chart 7 (Table 4) which shows that the share of the stock of services FDI has increased from 22.3 per cent in 1986 to just over 49.3 per cent in 2000, whereas the share of the stock of manufacturing FDI has decreased from around 40 per cent in 1986 to 27.7 per cent in 2000. The non-banking finance category is the most important services sector, its stock accounting for 14.7 per cent of the total FDI stock and 65.8 per cent of the total services FDI stock in 1986, increasing to 40 per cent and 81 per cent in 2000 respectively. The overwhelming importance of FDI in the non-banking finance sector may have some implication for our analysis, especially since the sectors in the investment data cannot be directly matched up with those in the trade data. The most important trade sectors are travel and other unaffiliated private services. FDI in these categories would all be lumped under the category 'other services', the category with the smallest investment share.

	1986	1993	2000
FDI in other private services as a percentage of total FDI	2.1	3.5	6.4
FDI in other private services as a percentage of total services FDI	9.5	8.8	13

Chart 7. **Relative shares of FDI stocks**



IV. Econometric Approach and the Empirical Model

Analysis of panel data has become increasingly popular as it provides a means of examining the behaviour of different groups or individuals over time. Thus, estimating a panel data set allows for both cross-sectional and time-series information to be taken into account, thereby increasing the number of observations compared to a one-dimensional data set. As a result the degrees of freedom available increase and collinearity among explanatory variables is reduced, improving the efficiency of the estimates. We use three different estimators in our analysis: the mean-group estimator, the least-squares dummy variable estimator, and a pseudo pooled mean-group estimator.

IV.1 Panel data estimation

The basic model can be written as:

$$y_{it} = \alpha_i + \beta_i' x_{it} + u_{it} \ , \qquad \text{and} \qquad u_{it} \sim N\left(0, \sigma_i^2\right), \qquad [1]$$

where x_{it} is a kx1 vector, $i=1, \ldots, N$ (the number of panel groups), and $t=1, \ldots, T$ (the number of time periods).

One approach is to use the mean-group estimator, which estimates the model separately for each panel member (i.e. *N* separate regressions). 'Panel' coefficients are then obtained by averaging the individual group estimates. Pesaran and Smith (1995) showed that the mean group estimator produces consistent estimates of the averages of the parameters. As a result, this estimator provides consistent slope estimates even if significant heterogeneity is present. However, the large number of degrees of freedom taken up by estimating individual equations for each of the panel groups can be a problem when the number of regressors is large and/or the number of observations is small. The mean group estimator is obtained as follows:

$$\bar{\beta} = \frac{\sum \hat{\beta}_i}{N} \qquad [2]$$

A much simpler approach is to estimate a one-way fixed-effects model, in which the OLS estimator is the least-squares dummy-variable estimator (or the within-group estimator). This model can be written as:

$$y_{it} = \alpha_i + \beta' x_{it} + u_{it} \qquad \text{and} \qquad u_{it} \sim N(0, \sigma^2) \qquad [3]$$

where x_{it} is a kx1 vector, $i=1, \ldots, N$ (the number of panel groups), and $t=1, \ldots, T$ (the number of time periods). This model allows for effects that are specific to each panel group, α_i, to be taken into account, but imposes common slope parameters ($\beta_i = \beta$) and a common variance ($\sigma_i^2 = \sigma^2$).

Similarly, a two-way fixed effects model, includes not only effects that are specific to each panel group, α_i, but also fixed time effects, α_t:

$$y_{it} = \alpha_t + \alpha_i + \beta' x_{it} + v_{it} \qquad \text{and} \qquad v_{it} \sim N(0, \sigma^2) \qquad [4]$$

None of the three models set out above include any lagged dynamic terms. If a lagged dependent variable is introduced model [1] becomes:

$$y_{it} = \alpha_i + \beta_i' x_{it} + \lambda_i y_{i,t-1} + u_{it} \qquad [5]$$

where the long-run coefficients are obtained as:

$$\theta_i = \frac{\beta_i}{1-\lambda_i} \qquad [6]$$

In this case we can use the pooled mean group estimator, as described by Pesaran, Shin and Smith (1999), which combines elements from the mean-group estimator approach as well as from fixed effects models. The mean-group estimator ignores the possibility that parameters may be identical across certain panel groups, whereas fixed-effects estimators allow the intercepts to vary for different panel groups but impose common coefficients and error variances. The pooled mean group estimator, deriving its name from the fact that it involves both averaging and pooling, allows the intercepts, the short-run coefficients and the error variances to vary across panel groups, but imposes common long-run coefficients. Pesaran, Shin and Smith justify this approach by arguing that while the short-run effects are likely to be heterogeneous, it is more likely that the long-run effects are homogenous as a result of budget or solvency constraints, arbitrage conditions, or common technologies.

Expression [5] can be re-written as:

$$\Delta y_i = -(1-\lambda_i)[y_{i\,t-1} - \theta_i x_{it}] + \varepsilon_{it}\,, \qquad [7]$$

where

$$\theta_i = \frac{\beta_i}{1-\lambda_i}\,. \qquad [8]$$

Long-run homogeneity is given by:

$$\theta_i = \theta \qquad \forall i = 1,...,N \qquad [9]$$

and the error-correction component can be written as:

$$\xi_i(\theta) = y_{it-1} - \theta x_{it}\,. \qquad [10]$$

The model that we estimate differs only in that we impose a common variance, re-writing equation [5] as:

$$y_{it} = \alpha_i + \beta_i' x_{it} + \lambda_i y_{i,t-1} + e_t\,. \qquad [11]$$

As a result, the estimator obtained in this way is not strictly equivalent to the pooled mean-group estimator. We refer to it as the pseudo pooled mean-group estimator. It is possible to test directly the restrictions required to impose a common variance by using the log-likelihoods from [5] and [11].

In passing it is worth noting that it is sometimes convenient to estimate equation [5] in the non-linear form of [7] because the latter gives direct estimates of the long-run parameters and their associated standard errors, as well as estimates of the dynamic adjustment parameters. In contrast, [5] only gives a direct estimate of the impact effect of the explanatory variables in the vector x_{it}.

Similar considerations apply to the dynamic version of the one-way fixed effect model. This can be written either as:

$$y_{it} = \alpha_i + \beta' x_{it} + \lambda\ y_{i,t-1} + u_{it} \qquad \text{and} \qquad u_{it} \sim N\left(0, \sigma^2\right) \qquad [12]$$

or as:

$$\Delta y_i = -(1-\lambda)\left[y_{i\,t-1} - \theta\ x_i\right] + u_{it} \qquad [13]$$

IV.2 Model selection

We report the log-likelihood for each of the estimated models. In the case of an unrestricted variance this is calculated as:

$$MLL = \frac{-NT}{2}\left(\ln 2\pi + 1\right) - \frac{T}{2}\sum_{i=1}^{N} \ln \hat{\sigma}_i^2 \qquad \text{where} \quad \hat{\sigma}_i^2 = \frac{\sum_{t=1}^{T} \hat{u}_{it}}{T}. \qquad [14]$$

When we impose a common variance, the formula becomes:

$$MLL = \frac{-NT}{2}\left(\ln 2\pi + 1\right) - \frac{NT}{2} \ln \hat{\sigma}^2 \qquad \text{where} \quad \hat{\sigma}^2 = \frac{\sum_{i=1}^{N}\sum_{t=1}^{T} \hat{u}_{it}^2}{NT}. \qquad [15]$$

While the log-likelihood is useful for comparing nested models and undertaking formal hypothesis testing, different information criteria can be used in order to compare the various

non-nested models. We use the Schwarz Bayesian Criterion (SBC), which for any model *m* is given by:

$$SBC_m = MLL_m - \left[0.5 * k_m * \ln(NT)\right] \qquad [16]$$

where MLL_m is the maximised value of the log-likelihood function for model *m*, k_m is the number of freely estimated parameters[12], and *NT* is the sample size. Using this formula for the SBC, we choose the model that maximises the value of the SBC.

Information criteria such as the SBC trade off goodness of fit and the parsimony of the model specification by using penalty functions that penalise the estimation of additional parameters (i.e. the number of regressors and freely estimated variances). An alternative information criterion that we could have used is Akaike's Information Criterion (AIC), which for any model *m* is given by:

$$AIC_m = MLL_m - k_m \qquad [17]$$

where MLL_m is the maximised value of the log-likelihood function for model *m*, and k_m is the number of freely estimated parameters. Comparing these two criteria, the SBC has a stronger preference for parsimonious models.

IV.3 The empirical model

1. *Specification of the variables used in estimation.*

The underlying export demand relationship which lies at the heart of our empirical analysis can be expressed as:

$$X_{it} = f\left(Y_{it}, RP_{it}, Z, FDI_t\right) \qquad [18]$$

for *i=1, …, N,* and for *t=1, …, T.* Six different categories of service exports are considered in our panel (i.e. *N=6*) – travel and tourism, passenger fares, transportation, royalties, other affiliated exports and other non-affiliated exports. We use annual data from 1987-2000, so *T=14*. We pool the data to obtain a panel containing 84 observations in total. The panel size

[12]The number of free parameters in our calculations of the SBC includes the number of variances. This is of particular importance for panel models where either 1 or N variances may be estimated.

is partially determined by the availability of consistent disaggregate information on services exports and the stock of direct investment. All the variables used are in logarithms.

The total volume of US exports in service category *i* at time *t* (X_{it}) is the dependent variable, which is regressed on a measure of world demand[13] (Y_{it}), a measure of the relative price of US exports[13] (RP_{it}), and Z which is a vector of other variables, such as the relative R&D stock, the stock of ICT investment, or the ratio of world trade to world GDP. In order to examine the relationship between relative export performance and outward FDI we add the aggregate total and aggregate total service stock of outward foreign direct investment from the US (denoted FDIT and FDIS respectively below). These are converted into constant 1996 prices by deflating using the US GDP deflator.

The FDI terms allow for the possibility that the level of exports may change as a consequence of production relocation even if the level of foreign demand and the other characteristics of domestically produced goods remain unchanged. A related approach is adopted by Barrell and Pain (1997) and Pain and Wakelin (1998) in their models of manufacturing exports and Barrell and te Velde (2002) in their model of import demand. We use the FDI stock in this paper to ensure consistency with the existing literature on FDI and manufacturing trade. An alternative would have been to try and utilise the data on the overseas operations of US-owned multinational companies, although obtaining a consistent time series measure would be much harder, because of gaps in the available data.

We subsequently extend the model to test whether there are different effects from different forms of foreign investment. To illustrate how this can be done, suppose we wish to test for differential effects from services and non-services *FDI*, denoted *FDIS* and *FDIN* respectively (where *FDIS+FDIN = FDIT*). We can write:

$$\alpha \ln(FDIT) = \alpha_1 \ln(FDIS) + \alpha_2 \ln(1 + FDIN/FDIS) \qquad [19]$$

The hypothesis of similar effects from both forms of FDI implies that $\alpha_1 = \alpha_2$. Alternatively, 4.3.2 can be written as:

$$\begin{aligned} \alpha \ln(FDIT) &= (\alpha_1 - \alpha_2) \ln(FDIS) + \alpha_2 \ln(FDIT) \\ &= \beta \ln(FDIS) + \alpha_2 \ln(FDIT) \end{aligned} \qquad [20]$$

[13] We experiment with demand and relative price measures that are common to all panel members as well as industry-specific demand and relative price measures.

In this case the hypothesis of equal effects from both types of FDI implies that $\beta=0$. We adopt this approach in the empirical work below.

The relative price measure uses US consumer prices relative to a weighted average of the consumer prices of other OECD economies, who will be the major competitors to US exporters in world markets.[14] We experiment with three different measures of world demand – an industry specific measure derived by deflating world dollar values into constant prices, an aggregate world total derived by summing the volume of imported services in the major industrialised countries and world GDP at constant prices. Growth in global GDP over time is likely to understate the growth of market opportunities available to US exporters, as it is well-known that the growth of global trade has exceeded the growth of GDP for many years, and thus, other things being equal, the elasticities on this measure could be expected, *a priori*, to be larger than those on the imports measures.

We extend [18] to allow for adjustment costs, resulting in a dynamic panel model that includes dynamic terms in exports (lagged dependent variable) and world demand. The dynamic model can be expressed as:

$$X_{it} = f\left(Y_{it}, RP_t, Z, FDI_t, X_{i,t-1}, Y_{i,t-1}\right). \qquad [21]$$

2. Specification of the dummy variables included in estimation.

- <u>industry-specific effects</u>

Industry-specific fixed effects are included in order to allow for unobserved influences that remain constant over time.[15] This could include characteristics that are specific to particular types of exports but that have not explicitly been included in the model. The one-way fixed-effects model [3] is also called the least-squares dummy variable model because including such industry-specific effects, α_i, takes the form of dummy variables.

[14] In 1999 for instance industrialised economies accounted for 73.3% of global service exports, with the US accounting for just over one quarter of all exports by industrialised countries (*IMF Balance of Payments Statistics Yearbook* 2000).

[15] Although we place relatively little weight on conventional panel estimators that impose homogeneous parameters across all panel members, for reasons we explain below, it is worth noting that when they were employed Hausman tests decisively rejected the use of a random effects model in favour of a fixed effects model.

- dummies for outliers

We experiment with including dummies for outliers in some of the specifications for which the results are reported below. We included a switch dummy, (+1,-1), for royalties and license fees in 1993-1994, and a dummy for affiliated services in 1989.

- time dummies

The two-way fixed-effects model [4] includes time dummies, or fixed time effects, α_t, as well as fixed industry effects. This model can also be parameterised as:

$$y_{it} = \alpha + \eta_i + \eta_t + \beta' x_{it} + e_{it} \qquad \text{and} \qquad e_{it} \sim N\left(0, \sigma^2\right) \qquad [22]$$

with the following restrictions:

$$\sum_{i=1}^{N} \eta_i = \sum_{t=1}^{T} \eta_t = 0 \,. \qquad [23]$$

This way of including time dummies corresponds to adding a flexible trend, as opposed to a linear time trend. It allows for factors that vary over time but which are common to all panel members to be taken into account. Not doing so could imply that some cross-sectional serial correlation remains in the errors.

The parameterisation set out above avoids the dummy variable trap. An alternative would be to add time dummies to the one-way fixed effects model but then discard some to avoid perfect collinearity with the number of variables included in the model that do not have any cross-sectional variance. Failing to do so would result in a situation of perfect collinearity, where a linear combination of the variables would generate the time dummies. In this case the number of time dummies included is equal to *T* minus the number of variables that are common to all panel members minus one (because of the fixed effects). This approach generates an equation with an identical standard error and slope coefficients on the remaining explanatory factors to the parameterisation set out above, but the standard errors on those coefficients will vary according to which individual time dummies are dropped.

As our model includes some variables which vary over time, but not over panel members, we are left with the task of trying to establish how much of the common time effects from the

two-way fixed effects model these variables explain. This can be done using a second stage regression of the estimated time effects on the set of behavioural variables:

$$\eta_t = \delta_0 + \delta_i' w_t + v_t \qquad \text{and} \qquad v_t \sim N(0, \sigma^2) \qquad [24]$$

where w_t is the vector of variables that do not vary over time.

V. Empirical Results

Overview and Structure of Results

We have experimented with various measures of demand and prices and three different variables (Z) to try and capture non-price effects arising either from product quality and innovation or from the globalisation of economic activities[16]:

- The stock of service sector R&D undertaken in the US relative to a total non-US service sector R&D stock constructed using data for 12 other OECD economies. All the data for the annual flow of R&D expenditure were taken from the OECD ANBERD database. Classification changes mean that it may be difficult to break the aggregate figures down consistently into different types of service sector R&D. R&D is generally thought to capture relative quality effects, in which case we would expect a positive coefficient on this variable. However, it is conceivable that for certain services prices or reputation may be used to signal quality instead.
- The share of business sector GDP in the US accounted for by investment in information processing equipment and software (IPES). This is an imperfect proxy for the growth in the availability of information resulting from the development of the Internet. The effect from this variable may be ambiguous. Increased information could enlarge the market for US services exports as more people, and in more destinations find out about US products. However, the effect could also be negative since the amount of information about other producers of services (and other destinations in the case of travel, for example) may also become available, thus increasing the competition for US services exports.
- The ratio of world merchandise trade to world GDP, constructed using data from the World Trade Organisation Annual Report. Trade has risen faster than income over time, providing one measure of the potential globalisation of economic activities. Given that

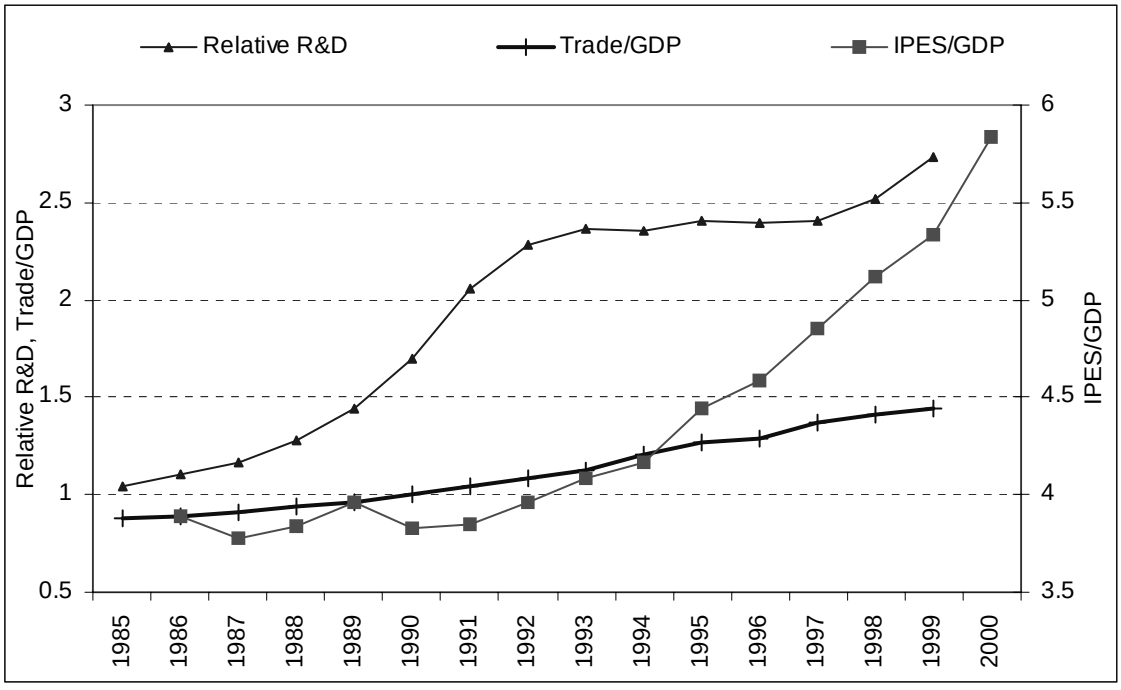
[16] These variables are common to all panel members as, unfortunately, data were not available to disaggregate them to correspond to the six service industries.

this variable is also an indicator of globalisation, the previous point applies here too. Increased globalisation can have a positive effect through increasing the potential market size for US exports, but at the same time it may increase competition as information about services produced in other countries become more widely available and can lead to a reduction in the consumption of US services.

To avoid potential problems with the degrees of freedom, we have not used the relative R&D variable at the same time as a globalisation variable.

It can be seen from Chart 8 below that the three series behave differently over time. R&D rose especially rapidly in the US relative to other countries in the early 1990s, and again at the end of the decade. The expenditure on ICT-type equipment started of with some minor fluctuations around a stable and upward trend before beginning to rise more rapidly from the second half of the 1990s. The trade-GDP measure has risen steadily across the sample period.

Chart 8. Relative R&D, ICT Investment/GDP and Trade/GDP



(ratios)

The econometric results from estimating the different models discussed above are reported in Tables 5-21 below. In most cases data for the volume of service exports are constructed by deflating the value of service exports by the US private consumption deflator, although we also experiment with some expenditure-specific deflators taken from the US National Income and Product Account (NIPA). In all models the relative price of US exports is measured using US consumer prices relative to a weighted average of consumer prices in other OECD economies in dollar terms.

- Tables 5-8 use world GDP at constant prices as a measure of world demand, Tables 9-12 use total world imports and Tables 13-21 use the industry-specific world imports.
- Tables 5, 9, 13 and 17-21 use the basic model with the relative R&D stock included. Tables 6, 10, and 14 re-estimate this model using the alternative industry-specific export price deflators.
- Tables 7, 11, and 15 use the basic model, but replacing the relative R&D variable with the ICT variable.
- Tables 8, 12, and 16 use the ratio of world trade to world GDP as a proxy for globalisation (and instead of the R&D variable).

The discussion of the empirical results is broken into three main sections. In the first sub-section, V.1, we discuss the results obtained using the mean group, pseudo pooled mean group and one-way fixed effects panel estimators. These estimates are reported in Tables 5-16. In the next sub-section, V.2, the results of extending these estimators to include outlier dummies are discussed and reported in Tables 17-18. The final subsection, V.3, and Tables 19-21 report the results from estimating various two-way fixed effects models.

V.1 Mean Group and One-Way Fixed Effects Models

The table below summarises the results tables by the variables that were included in estimation.

Table number	5	6	7	8	9	10	11	12	13	14	15	16
Measure of world demand	world GDP	world GDP	world GDP	world GDP	world im-ports	world im-ports	world im-ports	world im-ports	ind. spec. world im-ports	ind. spec. world im-ports	ind. spec. world im-ports	ind. spec. world im-ports
Z	R&D	R&D[1]	ICT	WDTY	R&D	R&D[1]	ICT	WDTY	R&D	R&D[1]	ICT	WDTY

[1]These models were estimated using the industry-specific export price deflator.

All of these tables have been set up in the same way, with columns 1-3 reporting the results for the mean group estimates, columns 4-6 the pooled long-run results, and columns 7-9 the results from the one-way fixed-effects model. Furthermore, results in columns 1, 4, and 7 refer to a model including only total FDI; columns 2, 5, and 8 to a model including only services FDI; and columns 3, 6, and 9 to a model that includes both total and services FDI.

We will first examine the models globally in terms of the demand and price measures used, and then we will examine them by variable *Z* included. Estimates of the long-run and dynamic parameters for the pooled long-run and one-way fixed effects panel models were obtained by estimating the models in a non-linear form, as shown in equations [7] and [13].

Looking at the log-likelihood and the SBC across models and specifications, it seems that, on the whole, the industry specific world imports measure tends to perform best. The models including the industry specific export price deflator (this was tested only on the specification including the R&D variable) perform, in general, worse than those using the private consumption deflator, for each of the demand measures.

In terms of the type of panel estimation, the log-likelihood measure indicates a preference for the mean-group estimator, which could be expected given the likely presence of heterogeneity. However, judging by the SBC, the overall preference seems to be for the fixed-effects model, especially since the mean-group estimator will be substantially penalised as it includes far more parameters in estimation, some of which are likely to be insignificant. The small number of panel groups and time periods that we are able to include in our sample may also be a problem when using the mean-group estimator and the reported results from it may therefore have low power.

We will now look at the results in more detail, examining them by the variable Z included.

Models with R&D

We start by looking at models including relative R&D, starting with Table 5, using world GDP as the measure of demand. The results in this Table are broadly representative of those in the other Tables, in that the restrictions imposed on the mean group estimates to pool the long-run parameters and the variances appear to be rejected by the data, as are the restrictions required to go from the pooled–long-run model to the standard fixed effects panel.

The mean group estimates are reported in columns [1]-[3]. Results for a simple model including only total FDI are reported in column [1]. The model reported in column [2] uses services FDI, and column [3] reports the results from including both total FDI and services FDI. In general, the equilibrium-correction parameter is well determined, suggesting the presence of a valid (cointegrating) long-run solution, and there are significant long-run effects on exports from world demand, the real exchange rate and the FDI stock. The world demand elasticity tends to be significantly greater than unity, except in column [2], reflecting the extent to which exports of services have risen relative to world income. The model with both total and services FDI has a higher log-likelihood than the other two, suggesting that there are differential FDI effects across categories of services, and suggesting that while the individual effects may not be significant, the variables are jointly important. Nevertheless, the SBC is slightly lower than for the specifications including only one FDI variable as it is penalising the additional parameter.

This result may reflect the gradual relaxation of barriers to trade in services following the Uruguay Round of trade negotiations which led to the General Agreement on Trade in Services (GATS), or it might reflect other factors such as the extent to which improvements in transportation and communications technologies have helped to integrate world markets, or the extent to which foreign investments have improved market access for US exporters. The latter does not appear to be the principal explanation as we generally obtain a significant negative effect from the total FDI stock, implying that, on average, US outward investment has adversely affected services export performance, as found by Pain and Wakelin (1998) for manufactures trade. This does not necessarily mean that outward investment and exports are substitutes, but simply that exports have risen less rapidly than might otherwise have been expected given world demand and relative prices. The coefficient on services FDI, on the other hand, tends to be positive but insignificant, implying that, on average, US outward investment in the services sector would improve US services export performance.

Columns [4]-[6] report the results of estimating the 3 models with pooled long run parameters and a common error variance. The basic pattern of the results is similar to that from the mean-group estimates, with a significant negative effect from the total FDI stock, a positive but insignificant effect from services FDI, and a generally positive, but insignificant, effect from the relative R&D stock. However the marked difference in the size of the coefficients on both the long-run parameters and the equilibrium-correction term may be suggestive of

heterogeneity. The demand elasticities, while significant, are very high for the models including either total FDI or both types of FDI, but negative and insignificant for the specification including only services FDI. This pattern appears even stronger in columns [7]-[9], containing the results from the standard panel estimation. Again, this is indicative of a heterogeneity bias. The restrictions required to move from the Pooled Mean estimates to the basic panel estimates are rejected by the data. However it is worth noting that when estimating the standard panel model, a Hausman test rejects the use of a random effects model in favour of the alternative of a fixed effects model.

The regressions in Table 5 are repeated in Table 9 using the total volume of world imports as a measure of demand, and in Table 13 using the industry specific measure of world import demand. There is a marginal improvement in the log-likelihoods and SBCs in both tables. In both Tables the demand elasticity is much lower than in Table 5, and is even at times negative in the one way fixed-effects model in Table 9. The coefficients in Table 13 seem to be better determined than in Table 9 overall.

Moving to the industry-specific measure of demand (Table 13) generates a number of other changes. Most notably, the R&D variable now has a negative coefficient, although it is not significant, whilst the total FDI measure no longer has a significant negative coefficient, but a generally positive, insignificant one. The equilibrium-correction term also appears to be better determined in the Table 13 equations than in the Table 9 ones. It is also notable that the restrictions required to move to the conventional panel results in Table 13 cannot be rejected against the pooled long-run model.

Tables 6, 10, 14 repeat the models in Tables 5, 9 and 13, but use the industry-specific deflator in place of the private consumption deflator to generate a measure of export volumes. The gains from doing this appear to be negligible, and in most cases the fit of the equation deteriorates and the equilibrium correction term is less well determined. Therefore, we do not report results for other the other models using this price measure.

Models with ICT investment

Tables 7, 11, and 15 repeat the models in Tables 5, 9 and 13, but with the proxy for ICT investment rather than the relative R&D variable. This variable could in principle capture both globalisation effects, leading to a simultaneous increase in both trade and foreign investment, and the improvements in information availability as a result of new technological

developments. In general the fit of the equations using the ICT measure is poorer than those using the R&D measure. The coefficients on ICT vary according to the measure of demand used, with positive effects obtained when using industry specific world exports, while both positive and negative effects are obtained when using world GDP or world imports.

Models with the trade to GDP ratio

Tables 8, 12 and 16 repeat, again, the models in Tables 5, 9 and 13, but with the ratio of world trade to world GDP being used to account for globalisation effects in place of the relative R&D variable. In general the fit of the models with this variable are better than those using either the R&D or the ICT measures. But again, the coefficient on the trade-GDP ratio varies according to the demand term used. With world GDP, or total world imports several significant positive coefficients are obtained, but when the industry-specific demand measure is used the coefficients become negative and, in the pooled long-run model and the fixed-effects model, negative and significant. The coefficients on the total FDI variable change in the same way they did when relative R&D was used, being negative in Tables 8 (world GDP) and 12 (world imports), but positive in Table 16 (industry-specific world imports).

V.2 Adding Outlier Dummy Variables

In this section we discuss the results from adding outlier dummies to the models estimated so far. We use the model with industry-specific demand and relative R&D as shown in Table 13. In that model, as in most of the models presented above, the restrictions required to move from the mean group estimates to the pooled long-run, pooled variance estimates are rejected by the data. It is possible to test these restrictions separately by estimating another model with pooled variances but without pooled parameters.

The results from doing this for the model with both total and services FDI from Table 13 are reported in the bottom panel of Table 17. There is a much smaller decline in the log-likelihood, but the five restrictions on the mean-group model (with 6 categories of exports) are still rejected by the data. The fit of the individual equations for the mean group estimator is reported in the upper panel of Table 17. Two categories of services, royalties and affiliated services, have much higher error variances than the other four. Inspection of the residuals from these equations showed that both had a large outlier (a [+1,-1] for royalties, a [1,0] for affiliated services) with an error over 7 per cent in the relevant year. Including dummy variables to remove these outliers reduced the standard error of the equations considerably, as

can be seen from the upper panel of Table 17. Using this model, the restrictions of a common error variance could not be rejected, although the joint imposition of a common variance and common long-run parameters still was.

Table 18 reports the mean group and pooled long-run parameters from the model with and without the dummy variables for outliers. Including the dummies appears to make little difference to the parameter estimates, but does change the test statistics, with an increase in both the log-likelihood and the SBC.

V.3 Adding time dummies

In this section we examine the effect of adding time dummies. We start by using the one-way fixed effects panel estimator to run the standard model (the R&D specification) without the time dummies but including the variables that vary over time but not across panel groups. The two additional outlier dummies described above are also included. In contrast to the earlier regressions we do not use the non-linear version of the one-way fixed effects model (equation [13]) so the coefficients on the main behavioural variables now show impact elasticities rather than long-run elasticities. The latter can be found by dividing the impact elasticity by (minus) the coefficient on the lagged dependent variable.

In order to test how much of the variation over time the main behavioural variables can explain, the resulting estimates are compared to those from a two-way fixed effects model with the restrictions described in section IV.3.2 [23] to avoid the dummy variable trap. In this second model we start with an equation that includes the time dummies but excludes the variables that do not vary across panel groups (relative prices, R&D, and FDI). We then regress the annual time effects obtained in the first stage on the variables that do not vary over the panel groups. We then calculate a likelihood ratio test to compare the two specifications. This is done initially for a panel model including all six separate categories of exports. If heterogeneity is important, as the earlier findings suggested, then this could result in biased parameter estimates. We therefore repeat the exercise using two sub-groups of export categories and test whether common coefficients and variances can be imposed.

The likelihood ratio tests, [LR(10)=22.40] for both the first two versions of the standard model including all six types of services and [LR(9)=22.38] for the third model, indicate that we have to reject the null of no significant difference between the specifications for each of the three models (total FDI only, services FDI only, and both types of FDI, respectively).

This means that the behavioural variables used do not explain all of the time variation, and that the use of time dummies is to be (marginally) preferred.

Table 19 reports the coefficients obtained from the one-way and two-way fixed effects models, using the specification that includes R&D and industry-specific world imports as a demand measure, as well as the two outlier dummies. Including the time dummies improves the model and gives stronger effects on the all of the variables, except on market growth. The coefficient on the R&D variable is consistently negative and significant. It is difficult to interpret this result. Indeed, a priori, the coefficient on the R&D variable might be expected to vary across services categories. R&D, traditionally, is thought to capture relative quality effects. However, for services, quality may be a more complicated concept, especially since for certain services the quality cannot be known until consumption. It has been suggested, therefore, that prices may be more important as a signal of quality.

The estimates in Table 19 suggest that higher outward FDI has a negative impact on service exports. This can be captured either using total FDI or total FDI in the services sectors. The coefficient on the FDI variable is significant in two of the two-way fixed effects models, but not in any of the one-way fixed effects models. When both types of FDI are included jointly, both become insignificant (they are however jointly significant at the 10 per cent level, but not at the 5 per cent level). The negative coefficient across groups may again hide differential effects between the groups. We examine this further below in the section where we analyse the issue of heterogeneity in the sample.

Illustrating the Heterogeneity Issue

The results reported in subsection V.1 and the points raised in section 3 on the specificities of services both suggest that there may be considerable parameter heterogeneity across service sectors. In order to investigate this further we repeat the estimation of the one-way and two-way fixed effects models, but this time splitting the sample up in two groups. Initially the first three categories of services (travel, passenger fares, and transportation) were grouped together, with the other three (royalties, other affiliated and other unaffiliated) being put in a second group. This exercise was then repeated, moving other unaffiliated services from the second group to the first. This choice of groups was based on a priori expectations about the behaviour of the individual categories of services. In particular, we expect a differential effect

for categories of services according to the degree of relation to intra-firm transactions (royalties and other affiliated services).

The initial step involved the estimation of the two-way fixed effects model for each of the two groups with three categories of services. The restrictions required to move back to the single model for all categories of services (common time effects and a common variance) could not be rejected by the data at the 5% level [LR(15)=21.18], suggesting that there are no significant differences in the time variation across the two groups. Thus we do not report these results here.

However, when this exercise was repeated for the other two sub-groups, one with 4 categories of services and one with two categories of services, the restrictions required to move back to the full panel model were found to be significant [LR(15)=33.90]. This provides evidence of heterogeneity across categories of service exports. For each of the two sub-groups we again found that the restrictions required to move to a model in which all of the time variation was explained by the set of behavioural variables that do not vary across export categories (the one-way fixed effects model) were almost always rejected by the data. So it is more efficient to adopt the two-step procedure, estimating the two-way fixed effects model and then regressing the estimated time effects on the other behavioural variables (as shown in equations [22] and [24]).

The results from doing this are reported in Tables 20 (4 categories) and 21 (2 categories), along with the results from the equivalent one-way fixed effects models. We again use the model specification that includes R&D, the industry specific measure of world demand and the two outlier dummies.

Several points emerge from comparing the results in Tables 20 and 21. Most notably, the FDI effects differ significantly across the two groups. Royalties and affiliated services have a significant positive relationship with outward FDI, as our discussion of the theoretical effects suggested, whereas the other four categories have a negative relationship that is not significant. This is the case whether total or services FDI is used. A similar pattern emerges for R&D – it has a significant negative relationship with exports in the group with four types of exports, but a positive, albeit insignificant, effect on royalties and affiliated services.

Demand and relative prices have roughly equal but opposite effects in both groups. However the impact and long-run elasticities for Group 1 – the group with four categories of exports –

are much larger than they are for royalties and affiliated services. Taken with the findings for R&D this suggests that price competition is more important for the first type of services, while non-price competition and the location strategies of multinationals matter more for the second category.

VI Conclusions

In this paper the approach of Pain and Wakelin (1998) has been used to investigate the relationship between foreign direct investment and exports of services from the United States. In a time series context, it is not sensible to ask whether FDI and exports of services are complements or substitutes as both will increase over time as a result of changes in demand and technological innovations. What matters is whether the growing level of FDI affects the level of exports given global demand for services and the price of exported services relative to those produced by competitors.

Our results suggest that the relationship between exports and FDI is sensitive to the empirical specification, and to the measure of demand employed. Likelihood ratio tests suggest that the imposition of common coefficients and common error variances across all categories of exports is frequently rejected, providing clear evidence of the existence of heterogeneity.

When time dummies are included, the effect of total FDI and services FDI, included separately, on services exports is negative. However, when we allow for different effects for groups of categories of services we find that while both types of FDI included separately have a negative effect on 'arms-length' exports in the categories travel, passenger fares, transportation and other unaffiliated services, the effect on exports of royalties and other affiliated services is positive. This implies that for given levels of demand, a higher level of outward investment will raise these types of exports, both of which are largely intra-firm, but reduce other types of exports. We also find evidence of differential effects across categories of trade from the various proxy measures we examine for non-price effects, but find consistently signed positive effects from world demand and negative effects from the real exchange rate.

Judging the various panel models by their log-likelihoods, it appears that, on average, the mean-group estimator gives the best fit. This is not surprising as this model is supposed to provide consistent estimators even in the presence of significant heterogeneity. However, this estimator has low power in our case as the number of time periods is small and the number of

estimated coefficients is relatively large. As a result, it does not perform well in terms of the SBC which appears to prefer more parsimonious fixed-effects models.

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Table 1. US Private Services Exports (millions of US$)

	1986	1993	2000
Travel/Tourism	20385	57875	82042
Passenger Fares	5582	16528	20745
Transportation	15438	21958	30185
Royalties	8113	21695	38030
Other Affiliated Services	8385	16813	31628
Other Non-Affiliated Services	19641	36718	75940
Total Private Services Exports	77545	171588	278570

Table 2. Share in total private services exports (percentages)

	1986	1993	2000
Travel/Tourism	26.3	33.7	29.5
Passenger Fares	7.2	9.6	7.4
Transportation	19.9	12.8	10.8
Royalties	10.5	12.6	13.7
Other Affiliated Services	10.8	9.8	11.4
Other Non-Affiliated Services	25.3	21.4	27.3

Table 3. US outward FDI stock on a historical-cost basis (millions of US$)

	1986	1993	2000
total FDI	270472	564283	1244654
total manufacturing FDI	108107	192244	343992
total services FDI	60422	221247	614279
total finance	54652	201758	534422
of which:			
banking	14910	27074	37155
non-banking finance	39742	174684	497267
other private services	5770	19489	79857

Table 4. Evolution of relative importance of FDI stocks

	1986	1993	2000
% of manufacturing FDI stock in total FDI stock	40.0	34.0	27.6
% of total services FDI stock in total FDI stock	22.3	39.2	49.4
% of total finance FDI stock in total FDI stock	20.2	35.8	43.0
% of total finance FDI stock in total services FDI stock	90.5	91.2	87.0
% of non-banking finance FDI stock in total FDI stock	14.7	31.0	40.0
% of non-banking finance FDI stock in total services FDI stock	65.8	79.0	81.0

Table 5 (world GDP, R&D)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Mean Group			Pooled Long-run			Standard Panel		
Long-run parameters									
Demand	3.70 (2.4)	0.22 (0.1)	1.84 (0.8)	7.79 (3.7)	-1.09 (0.3)	6.07 (2.5)	8.65 (1.5)	0.61 (0.1)	5.29 (1.0)
Relative Prices	-0.49 (1.1)	-1.02 (1.4)	-0.26 (0.5)	-1.70 (5.0)	-2.91 (5.1)	-1.53 (3.7)	-1.95 (1.3)	-2.83 (2.1)	-1.51 (1.0)
Relative R&D	0.31 (1.6)	-0.03 (0.1)	0.20 (1.0)	0.15 (1.2)	-0.57 (1.3)	0.04 (0.3)	0.24 (0.5)	-0.31 (0.5)	0.10 (0.2)
Total FDI	-0.69 (1.6)		-1.00 (1.3)	-1.76 (2.7)		-2.17 (2.8)	-2.25 (1.2)		-2.64 (1.2)
Services FDI		0.35 (0.8)	0.49 (1.0)		0.73 (1.0)	0.55 (1.1)		0.38 (0.4)	0.86 (0.7)
Dynamic parameters									
Market Growth	3.66 (2.5)	1.95 (1.9)	2.75 (1.8)	3.52 (3.3)	1.25 (1.9)	3.18 (3.3)	4.29 (2.9)	2.23 (1.9)	3.81 (2.7)
Equilibrium Correction	-0.74 (5.1)	-0.55 (5.5)	-0.57 (3.6)	-0.24 (2.3)	-0.16 (2.9)	-0.22 (2.4)	-0.16 (3.8)	-0.16 (3.9)	-0.16 (3.8)
Log-Likelihood	178.84	179.92	192.00	144.08	140.34	144.69	124.61	123.61	124.97
$\bar{R}^2$				0.50	0.45	0.50	0.31	0.30	0.31
Standard Error				5.07%	5.30%	5.07%	5.93%	6.00%	5.94%
Hausman [p-val]							0.018	0.021	0.047
SBC	72.50	73.58	72.37	93.12	89.39	91.52	95.81	94.81	93.95

Notes: heteroscedastic t-statistics in parentheses. Hausman test of random vs fixed effects models.

Table 6 (world GDP, R&D, export price measure)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Mean Group			Pooled Long-run			Standard Panel		
Long-run parameters									
Demand	5.14 (1.6)	0.46 (0.2)	2.49 (0.7)	11.20 (1.2)	-2.07 (0.6)	7.94 (1.8)	10.32 (1.3)	0.30 (0.0)	6.53 (0.7)
Relative Prices	-0.35 (0.8)	-1.02 (1.1)	-0.06 (0.1)	-1.20 (2.3)	-1.51 (2.4)	-0.93 (1.0)	-1.96 (0.8)	-3.22 (1.4)	-1.45 (0.6)
Relative R&D	0.37 (2.1)	-0.02 (0.1)	0.30 (2.0)	0.26 (1.1)	-0.24 (0.6)	0.24 (0.6)	0.49 (0.6)	0.21 (0.2)	0.33 (0.4)
Total FDI	-1.20 (1.1)		-1.42 (1.0)	-3.00 (2.6)		-4.03 (2.0)	-3.11 (0.9)		-3.52 (1.0)
Services FDI		0.30 (0.7)	0.58 (1.1)		0.64 (0.9)	1.00 (1.0)		0.31 (0.2)	0.96 (0.5)
Dynamic parameters									
Market Growth	3.75 (1.9)	1.71 (2.1)	2.32 (1.2)	3.38 (2.1)	1.09 (1.8)	3.43 (2.6)	4.22 (2.6)	2.39 (1.9)	3.84 (2.4)
Equilibrium Correction	-0.71 (3.8)	-0.59 (3.4)	-0.57 (2.7)	-0.15 (1.6)	-0.17 (2.4)	-0.12 (2.3)	-0.11 (2.1)	-0.11 (2.2)	-0.11 (2.1)
Log-Likelihood	180.57	179.54	192.56	138.88	135.90	139.12	119.91	119.07	120.10
$\bar{R}^2$				0.42	0.38	0.42	0.22	0.20	0.21
Standard Error				5.39%	5.59%	5.42%	6.27%	6.33%	6.30%
Hausman [p-val]							0.179	0.186	0.063
SBC	74.23	73.20	72.93	87.93	84.95	85.95	91.10	90.27	89.07

Notes: heteroscedastic t-statistics in parentheses. Hausman test of random vs fixed effects models.

Table 7 (world GDP, ICT)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Mean Group			Pooled Long-run			Standard Panel		
Long-run parameters									
Demand	3.26 (0.9)	0.78 (0.2)	1.67 (0.4)	7.84 (3.3)	3.30 (2.1)	5.92 (2.3)	7.87 (1.5)	1.34 (0.3)	4.85 (0.9)
Relative Prices	-2.48 (1.5)	-0.24 (0.2)	-0.49 (0.4)	-2.61 (2.1)	-1.37 (1.4)	-1.68 (1.3)	-3.13 (1.3)	-1.62 (0.5)	-1.51 (0.6)
ICT	1.83 (0.9)	-1.15 (1.3)	-0.04 (0.0)	0.91 (0.6))	-1.16 (1.1)	0.15 (0.1)	1.21 (0.3)	-1.21 (0.4)	-0.15 (0.0)
Total FDI	-1.02 (0.8)		-1.17 (0.9)	-1.95 (2.0)		-2.25 (2.3)	-2.15 (1.0)		-2.52 (1.1)
Services FDI		0.45 (0.7)	0.69 (0.9)		0.04 (0.1)	0.61 (1.2)		0.29 (0.4)	0.95 (0.8)
Dynamic parameters									
Market Growth	3.05 (1.6)	2.17 (1.7)	2.43 (1.2)	3.19 (3.2)	2.0 (2.4)	3.10 (3.2)	3.78 (3.0)	2.73 (2.3)	3.65 (3.0)
Equilibrium Correction	-0.49 (3.8)	-0.45 (7.7)	-0.42 (3.3)	-0.21 (2.4)	-0.26 (2.4)	-0.21 (2.5)	-0.16 (3.6)	-0.17 (3.2)	-0.16 (3.7)
Log-Likelihood	176.00	176.89	189.50	143.98	139.56	144.68	124.58	123.49	124.95
$\bar{R}^2$				0.48	0.44	0.50	0.31	0.30	0.31
Standard Error				5.07%	5.35%	5.07%	5.93%	6.01%	5.95%
Hausman [p-val]							0.022	0.004	0.005
SBC	69.66	70.55	69.87	93.03	88.61	91.51	95.78	94.69	93.93

Notes: heteroscedastic t-statistics in parentheses. Hausman test of random vs fixed effects models.

Table 8 (world GDP, trade to GDP ratio)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Mean Group			Pooled Long-run			Standard Panel		
Long-run parameters									
Demand	3.73 (2.6)	0.70 (0.4)	2.77 (1.7)	7.71 (4.3)	-1.39 (0.3)	7.31 (3.5)	8.64 (1.5)	0.39 (0.1)	5.40 (0.9)
Relative Prices	-0.88 (2.4)	-1.01 (2.3)	-0.66 (1.6)	-1.86 (7.6)	-1.80 (2.3)	-1.78 (5.0)	-2.30 (2.0)	-2.16 (1.6)	-1.67 (1.2)
WDTY	1.13 (2.7)	0.09 (0.1)	1.05 (2.5)	1.12 (3.2)	-1.71 (1.1)	1.04 (2.4)	0.91 (0.7)	-1.28 (0.7)	0.36 (0.2)
Total FDI	-0.92 (1.9)		-0.91 (1.4)	-2.12 (3.4)		-2.20 (3.3)	-2.47 (1.2)		-2.70 (1.2)
Services FDI		0.25 (0.7)	0.15 (0.6)		0.94 (0.9)	0.13 (0.3)		0.61 (0.5)	0.83 (0.6)
Dynamic parameters									
Market Growth	3.4 (2.0)	1.61 (1.7)	2.32 (1.5)	3.60 (3.4)	1.66 (2.2)	3.52 (3.4)	4.20 (3.0)	2.42 (2.4)	3.78 (3.0)
Equilibrium Correction	-0.98 (6.2)	-0.62 (5.4)	-0.81 (3.7)	-0.28 (2.3)	-0.16 (3.0)	-0.27 (2.3)	-0.17 (3.7)	-0.16 (3.8)	-0.16 (3.7)
Log-Likelihood	187.46	181.29	198.95	145.67	140.28	145.72	124.66	123.76	124.97
$\bar{R}^2$				0.52	0.45	0.51	0.31	0.30	0.31
Standard Error				4.97%	5.30%	5.01%	5.93%	5.99%	5.95%
Hausman [p-val]							0.005	0.026	0.020
SBC	81.12	74.95	79.32	94.72	89.33	92.55	95.86	94.96	93.92

Notes: heteroscedastic t-statistics in parentheses. Hausman test of random vs fixed effects models.

Table 9 (world imports, R&D)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Mean Group			Pooled Long-run			Standard Panel		
Long-run parameters									
Demand	0.65 (1.3)	0.15 (0.3)	-0.01 (0.02)	2.01 (4.0)	1.29 (2.0)	1.14 (2.1)	-0.05 (0.03)	-1.66 (0.9)	-1.83 (1.0)
Relative Prices	-0.54 (1.2)	-0.62 (1.0)	-0.12 (0.2)	-1.87 (7.8)	-2.44 (5.1)	-1.40 (4.3)	-2.04 (1.5)	-1.74 (1.5)	-0.75 (0.5)
Relative R&D	0.28 (1.8)	0.13 (0.8)	0.16 (1.0)	0.11 (1.2)	-0.10 (0.4)	-0.003 (0.0)	-0.18 (0.4)	-0.41 (0.8)	-0.33 (0.7)
Total FDI	0.09 (0.5)		-0.50 (1.0)	-0.51 (2.1)		-1.30 (2.5)	0.65 (0.7)		-1.23 (0.7)
Services FDI		0.29 (2.1)	0.54 (1.4)		0.03 (0.2)	0.75 (2.0)		1.00 (1.6)	1.69 (1.4)
Dynamic parameters									
Market Growth	0.87 (2.5)	0.64 (2.2)	0.55 (1.7)	0.85 (2.7)	0.67 (2.7)	0.74 (2.8)	0.59 (2.1)	0.41 (1.6)	0.45 (1.7)
Equilibrium Correction	-0.79 (5.8)	-0.67 (7.8)	-0.62 (4.4)	-0.25 (1.9)	-0.21 (2.1)	-0.22 (2.0)	-0.17 (3.9)	-0.17 (3.9)	-0.17 (3.8)
Log-Likelihood	182.34	183.91	196.26	143.74	142.46	145.45	123.19	124.45	124.92
$\bar{R}^2$				0.49	0.48	0.51	0.29	0.31	0.31
Standard Error				5.09%	5.17%	5.03%	6.03%	5.94%	5.95%
Hausman [p-val]							0.004	0.004	0.004
SBC	76.00	77.57	76.63	92.79	91.51	92.28	94.39	95.65	93.90

Notes: heteroscedastic t-statistics in parentheses. Hausman test of random vs fixed effects models.

Table 10 (world imports, R&D, export price measure)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Mean Group			Pooled Long-run			Standard Panel		
Long-run parameters									
Demand	0.49 (0.9)	-0.21 (0.3)	-0.28 (0.4)	2.56 (4.5)	2.43 (3.5)	2.04 (3.8)	-0.75 (0.3)	-2.69 (1.0)	-2.89 (1.0)
Relative Prices	-0.47 (1.0)	-0.45 (0.7)	0.06 (0.1)	-1.23 (3.5)	-2.03 (3.9)	-0.94 (2.2)	-1.92 (0.9)	-1.51 (0.8)	-0.31 (0.1)
Relative R&D	0.25 (0.7)	0.09 (0.5)	0.15 (1.0)	0.12 (1.0)	0.002 (0.0)	0.09 (0.7)	-0.10 (0.1)	-0.38 (-0.4)	-0.28 (0.3)
Total FDI	0.21 (0.7)		-0.53 (0.8)	-0.98 (3.6)		-1.46 (2.9)	0.80 (0.6)		-1.50 (0.6)
Services FDI		0.41 (2.5)	0.64 (1.6)		0.45 (2.2)	0.46 (1.3)		1.22 (1.2)	2.07 (1.1)
Dynamic parameters									
Market Growth	0.70 (1.6)	0.49 (1.3)	0.42 (1.0)	0.60 (1.1)	0.52 (1.1)	0.63 (1.3)	0.57 (1.8)	0.42 (1.5)	0.46 (1.5)
Equilibrium Correction	-0.71 (4.6)	-0.62 (4.3)	-0.60 (3.1)	-0.12 (0.8)	-0.10 (0.7)	-0.14 (1.0)	-0.12 (1.9)	-0.12 (2.2)	-0.12 (2.2)
Log-Likelihood	184.55	186.13	199.60	143.31	140.46	143.94	118.96	119.81	120.12
$\bar{R}^2$				0.48	0.44	0.48	0.20	0.22	0.21
Standard Error				5.11%	5.29%	5.12%	6.34%	6.28%	6.30%
Hausman [p-val]							0.161	0.051	0.284
SBC	78.21	79.79	79.97	92.36	89.51	90.77	90.16	91.01	89.10

Notes: heteroscedastic t-statistics in parentheses. Hausman test of random vs fixed effects models.

Table 11 (world imports, ICT)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Mean Group			Pooled Long-run			Standard Panel		
Long-run parameters									
Demand	0.10 (0.1)	-0.05 (0.1)	-0.28 (0.3)	1.94 (3.6)	1.37 (2.2)	1.14 (2.0)	-0.17 (0.1)	-1.40 (0.8)	-1.54 (0.9)
Relative prices	-2.12 (1.8)	-0.002 (0.0)	0.0004 (0.0)	-2.98 (3.5)	-1.60 (2.0)	-1.54 (1.8)	-3.82 (1.6)	-1.40 (0.6)	-1.10 (0.4)
ICT	1.34 (0.8)	-1.00 (1.3)	-0.46 (0.5)	1.35 (1.1)	-0.83 (0.9)	0.20 (0.2)	3.23 (0.9)	0.24 (0.1)	1.08 (0.3)
Total FDI	0.08 (0.2)		-0.43 (0.7)	-0.81 (1.5)		-1.35 (2.2)	-0.39 (0.3)		-1.45 (0.8)
Services FDI		0.58 (1.6)	0.73 (1.3)		0.11 (0.5)	0.74 (2.2)		0.66 (0.9)	1.37 (1.3)
Dynamic parameters									
Market Growth	0.68 (1.9)	0.58 (1.6)	0.47 (1.3)	0.77 (2.6)	0.73 (0.5)	0.74 (2.7)	0.60 (2.2)	0.50 (2.0)	0.53 (2.0)
Equilibrium Correction	-0.50 (4.5)	0.56 (1.7)	-0.45 (0.7)	-0.20 (2.0)	-0.24 (2.1)	-0.21 (2.0)	-0.17 (3.9)	-0.18 (4.0)	-0.17 (3.9)
Log-Likelihood	177.27	177.09	189.32	143.98	142.57	145.46	123.76	124.07	124.74
$\bar{R}^2$				0.50	0.48	0.51	0.30	0.30	0.31
Standard Error				5.07%	5.16%	5.03%	5.99%	5.97%	5.96%
Hausman [p-val]							0.040	0.010	0.012
SBC	70.93	70.75	69.69	93.03	91.62	92.29	94.96	95.27	93.72

Notes: heteroscedastic t-statistics in parentheses. Hausman test of random vs fixed effects models.

Table 12 (world imports, trade to GDP ratio)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Mean Group			Pooled Long-run			Standard Panel		
Long-run parameters									
Demand	0.95 (2.4)	0.19 (0.3)	0.23 (0.3)	2.22 (6.7)	1.46 (2.5)	0.99 (7.4)	-0.09 (0.1)	-2.31 (1.0)	-2.23 (1.0)
Relative Prices	-0.95 (2.5)	-0.89 (1.8)	-0.52 (1.1)	-2.03 (15.1)	-2.35 (8.4)	0.05 (0.3)	-1.69 (1.9)	-0.58 (0.6)	-0.04 (0.0)
WDTY	1.15 (2.7)	0.47 (0.82)	0.80 (1.3)	1.20 (5.5)	0.10 (0.1)	1.48 (9.1)	-0.14 (0.1)	-1.78 (0.9)	-1.26 (0.7)
Total FDI	-0.32 (1.2)		-0.39 (1.1)	-1.07 (4.9)		-0.71 (7.9)	0.57 (0.4)		-1.00 (0.6)
Services FDI		0.23 (0.9)	0.32 (1.2)		-0.09 (0.3)	0.21 (2.2)		1.48 (1.4)	1.86 (1.4)
Dynamic parameters									
Market Growth	0.97 (2.7)	0.57 (1.9)	0.55 (1.5)	0.96 (2.7)	0.72 (2.7)	0.63 (3.6)	0.62 (2.1)	0.40 (1.7)	0.45 (1.7)
Equilibrium Correction	-1.10 (6.5)	-0.72 (6.8)	-0.94 (2.8)	-0.30 (1.9)	-0.23 (2.1)	-0.57 (1.5)	-0.17 (3.8)	-0.16 (3.7)	-0.16 (3.7)
Log-Likelihood	192.79	189.13	207.23	146.25	142.39	121.92	123.12	124.69	124.96
$\bar{R}^2$				0.52	0.48	0.14	0.29	0.32	0.31
Standard Error				4.94%	5.17%	6.65%	6.04%	5.92%	5.95%
Hausman [p-val]							0.004	0.006	0.005
SBC	86.45	82.79	87.60	95.30	91.44	68.75	94.32	95.89	93.94

Notes: heteroscedastic t-statistics in parentheses. Hausman test of random vs fixed effects models.

Table 13 (industry-specific world imports, R&D)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Mean Group			Pooled Long-run			Standard Panel		
Long-run parameters									
Demand	0.92 (1.9)	0.89 (2.1)	0.68 (1.8)	1.30 (5.2)	1.24 (5.1)	1.22 (5.3)	1.55 (7.9)	1.55 (8.0)	1.55 (8.0)
Relative Prices	-1.07 (2.0)	-0.79 (1.5)	-1.03 (1.2)	-1.76 (4.4)	-1.74 (4.6)	-1.51 (3.5)	-1.70 (4.3)	-1.67 (4.7)	-1.72 (3.6)
Relative R&D	-0.11 (0.6)	-0.07 (0.4)	-0.21 (0.9)	-0.21 (1.1)	-0.23 (1.2)	-0.21 (1.1)	-0.38 (2.4)	-0.38 (2.2)	-0.38 (2.3)
Total FDI	0.29 (1.5)		0.25 (0.5)	0.11 (0.7)		-0.30 (0.6)	0.04 (0.2)		0.06 (0.1)
Services FDI		0.15 (2.6)	0.06 (0.4)		0.10 (1.0)	0.27 (0.9)		0.02 (0.2)	-0.02 (0.1)
Dynamic parameters									
Market Growth	0.60 (2.9)	0.53 (2.8)	0.46 (2.8)	0.46 (4.0)	0.44 (3.8)	0.41 (3.6)	0.50 (4.6)	0.50 (4.8)	0.50 (5.2)
Equilibrium Correction	-0.86 (5.5)	-0.88 (5.0)	-0.80 (3.3)	-0.39 (5.0)	-0.39 (4.8)	-0.39 (4.4)	-0.41 (7.8)	-0.41 (8.2)	-0.41 (7.5)
Log-Likelihood	188.46	182.94	193.40	142.06	142.33	142.57	136.42	136.42	136.43
$\bar{R}^2$				0.49	0.48	0.51	0.48	0.48	0.47
Standard Error				5.09%	5.17%	5.03%	5.15%	5.15%	5.19%
Hausman [p-val]							0.000	0.000	0.000
SBC	82.12	76.60	73.77	91.11	91.38	89.40	107.62	107.72	105.41

Notes: heteroscedastic t-statistics in parentheses. Hausman test of random vs fixed effects models.

Table 14 (industry-specific world imports, R&D, export price measure)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Mean Group			Pooled Long-run			Standard Panel		
Long-run parameters									
Demand	1.04 (1.9)	1.03 (1.9)	0.80 (1.8)	0.67 (3.7)	0.65 (4.0)	0.64 (3.9)	1.62 (8.4)	1.63 (8.6)	1.63 (8.6)
Relative Prices	-0.79 (1.9)	-0.61 (1.2)	-0.64 (1.1)	-1.16 (6.8)	-0.93 (4.3)	-1.10 (5.7)	-1.40 (3.5)	-1.41 (3.9)	-1.49 (3.1)
Relative R&D	-0.05 (0.4)	-0.05 (0.3)	-0.09 (0.5)	-0.28 (4.8)	-0.28 (2.8)	-0.29 (3.9)	-0.33 (1.9)	-0.32 (1.7)	-0.32 (1.8)
Total FDI	0.23 (1.1)		0.08 (0.2)	0.31 (4.1)		0.24 (0.8)	-0.02 (0.1)		0.09 (0.2)
Services FDI		0.13 (1.3)	0.10 (0.8)		0.18 (2.7)	0.05 (0.3)		-0.02 (0.2)	-0.07 (0.2)
Dynamic parameters									
Market Growth	0.60 (2.7)	0.53 (1.3)	0.46 (2.2)	0.35 (2.3)	0.33 (2.2)	0.34 (2.2)	0.51 (4.4)	0.52 (4.6)	0.52 (4.9)
Equilibrium Correction	-0.85 (6.3)	-0.88 (5.0)	-0.79 (3.8)	-0.35 (2.0)	-0.34 (2.0)	0.35 (1.9)	-0.43 (6.6)	-0.43 (6.7)	-0.43 (6.2)
Log-Likelihood	185.52	180.91	188.84	138.59	138.39	138.62	130.92	130.93	130.95
$\bar{R}^2$				0.42	0.42	0.41	0.40	0.40	0.39
Standard Error				5.41%	5.42%	5.45%	5.50%	5.50%	5.54%
Hausman [p-val]							0.000	0.000	0.000
SBC	79.18	74.57	69.21	87.64	87.44	85.45	102.12	102.13	99.93

Notes: heteroscedastic t-statistics in parentheses. Hausman test of random vs fixed effects models.

Table 15 (industry-specific world imports, ICT)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Mean Group			Pooled Long-run			Standard Panel		
Long-run parameters									
Demand	0.88 (2.3)	0.86 (2.8)	0.71 (2.4)	3.26 (7.3)	1.12 (5.9)	1.13 (5.7)	1.44 (7.9)	1.47 (8.1)	1.48 (7.9)
Relative Prices	-0.95 (2.3)	-0.69 (1.4)	-0.63 (1.3)	-0.98 (1.3)	-1.04 (1.8)	-0.99 (1.9)	-1.32 (1.8)	-1.90 (2.3)	-1.85 (2.2)
ICT	0.14 (0.3)	-0.07 (0.1)	0.04 (0.1)	-0.40 (0.3)	-0.37 (0.6)	-0.19 (0.2)	0.74 (0.7)	0.99 (1.0)	1.10 (1.1)
Total FDI	0.14 (0.5)		-0.02 (0.1)	-0.79 (1.4)		-0.35 (0.7)	-0.49 (1.3)		-0.19 (0.3)
Services FDI		0.12 (1.0)	0.11 (0.9)		0.09 (0.5)	0.26 (1.0)		-0.33 (1.7)	-0.25 (0.7)
Dynamic parameters									
Market Growth	0.56 (3.1)	0.54 (2.8)	0.45 (2.8)	0.34 (1.2)	0.43 (3.7)	0.40 (3.5)	0.45 (4.7)	0.49 (4.7)	0.48 (5.2)
Equilibrium Correction	-0.72 (9.6)	-0.81 (5.1)	-0.69 (4.5)	-0.09 (0.6)	-0.43 (4.0)	-0.42 (3.9)	-0.43 (7.4)	-0.42 (7.1)	-0.42 (6.8)
Log-Likelihood	170.28	170.24	174.62	132.72	141.29	141.67	133.48	133.77	133.84
$\bar{R}^2$				0.34	0.46	0.46	0.44	0.45	0.44
Standard Error				5.80%	5.23%	5.26%	5.33%	5.32%	5.35%
Hausman [p-val]							0.000	0.000	0.000
SBC	63.94	63.90	54.99	81.77	90.34	88.50	104.68	104.97	102.82

Notes: heteroscedastic t-statistics in parentheses. Hausman test of random vs fixed effects models.

Table 16 (industry-specific world imports, trade to GDP ratio)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Mean Group			Pooled Long-run			Standard Panel		
Long-run parameters									
Demand	1.23 (2.4)	1.17 (2.2)	1.00 (2.0)	1.69 (11.8)	1.37 (6.1)	1.70 (12.8)	1.68 (9.2)	1.66 (9.1)	1.69 (9.4)
Relative Prices	-0.84 (3.8)	-0.67 (2.6)	-0.63 (2.5)	-0.86 (4.0)	-0.97 (3.8)	-1.01 (3.6)	-0.96 (4.0)	-0.66 (2.6)	-1.06 (2.6)
WDTY	-0.44 (0.7)	-0.23 (0.4)	-0.37 (0.5)	-1.92 (5.4)	-1.09 (2.1)	-1.86 (5.6)	-1.88 (3.6)	-1.52 (2.8)	-1.88 (3.6)
Total FDI	0.28 (1.6)		0.12 (0.4)	0.52 (2.7)		0.73 (2.1)	0.54 (2.2)		0.68 (1.2)
Services FDI		0.12 (2.1)	0.07 (0.9)		0.23 (1.8)	-0.14 (0.7)		0.20 (1.4)	-0.09 (0.3)
Dynamic parameters									
Market Growth	0.77 (2.8)	0.71 (2.6)	0.60 (2.2)	0.69 (4.3)	0.50 (4.3)	0.73 (4.2)	0.61 (5.0)	0.56 (5.0)	0.62 (5.7)
Equilibrium Correction	-0.98 (7.9)	-1.03 (8.7)	-0.86 (5.6)	-0.49 (6.0)	-0.43 (5.0)	-0.51 (5.3)	-0.43 (8.5)	-0.44 (8.5)	-0.43 (7.9)
Log-Likelihood	198.16	189.27	202.34	144.96	143.74	145.25	139.16	138.20	139.22
$\bar{R}^2$				0.51	0.49	0.50	0.51	0.50	0.51
Standard Error				5.01%	5.09%	5.04%	4.99%	5.04%	5.02%
Hausman [p-val]							0.000	0.000	0.000
SBC	91.82	82.93	82.71	94.01	92.79	92.08	110.36	109.40	108.20

Notes: heteroscedastic t-statistics in parentheses. Hausman test of random vs fixed effects models.

Table 17 Regression summary statistics

	Without Outlier Dummies			With Outlier Dummies		
	$\bar{R}^2$	Standard Error	Log – Likelihood	$\bar{R}^2$	Standard Error	Log - Likelihood
Travel	0.71	3.38%	33.47			
Passenger Fares	0.90	3.35%	33.62			
Other Transportation	0.77	2.50%	37.72			
Royalties	0.27	5.62%	26.37	0.74	3.33%	34.97
Other Affiliated Services	0.43	5.23%	27.38	0.74	3.51%	34.22
Other Unaffiliated Services	0.67	3.07%	34.84			
Σ LogL			193.40			208.84

WITHOUT DUMMIES	Log-Likelihood	Test of Restrictions
Mean Group	193.40	
Pooled Variances	186.23	LR(5) = 14.34*
Pooled Variances and Long-Run	142.57	LR(30) = 101.65*
WITH OUTLIER DUMMIES		
Mean Group	208.84	
Pooled Variances	208.05	LR(5) = 1.58
Pooled Variances and Long-Run	152.34	LR(30) = 113.0*

Table 18 Regression comparisons

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]
	Mean Group		Pooled Long-run	
DUMMIES	No	Yes	No	Yes
Long-run parameters				
Demand	0.68 (1.8)	0.71 (1.9)	1.22 (5.3)	1.35 (8.2)
Relative Prices	-1.03 (1.2)	-0.99 (1.2)	-1.51 (3.5)	-1.34 (3.6)
Relative R&D	-0.21 (0.9)	-0.18 (0.7)	-0.21 (1.1)	-0.13 (0.9)
Total FDI	0.25 (0.5)	0.21 (0.4)	-0.30 (0.6)	-0.41 (1.0)
Services FDI	0.06 (0.4)	0.05 (0.3)	0.27 (0.9)	0.25 (1.0)
Dynamic parameters				
Market Growth	0.46 (2.8)	0.44 (2.7)	0.41 (3.6)	0.43 (3.7)
Equilibrium Correction	-0.80 (3.3)	-0.76 (3.1)	-0.39 (4.4)	-0.42 (4.3)
Log-Likelihood	193.40	208.84	142.57	152.34
$\bar{R}^2$			0.51	0.57
Standard Error			5.03%	4.71%
SBC	73.77	82.26	89.40	92.52

Notes: dummies for 3 outliers: royalties 1993-94 (+1, -1), affiliated services, 1989

Table 19 (industry-specific world imports, R&D, outlier dummies)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]
	One way fixed effects			Two way fixed effects		
Impact parameters						
Demand	0.70 (6.5)	0.70 (7.3)	0.70 (6.8)	0.91 (7.6)	0.91 (7.6)	0.91 (7.6)
Relative Prices	-0.68 (4.1)	-0.70 (4.2)	-0.70 (4.2)	-0.74 (5.0)	-0.84 (6.6)	-0.73 (4.1)
Relative R&D	-0.14 (2.5)	-0.14 (2.1)	-0.14 (2.1)	-0.15 (2.7)	-0.16 (2.9)	-0.15 (3.0)
Total FDI	-0.03 (0.5)		-0.01 (0.0)	-0.13 (2.0)		-0.13 (0.9)
Services FDI		-0.02 (0.4)	-001 (0.1)		-0.07 (2.0)	0.003 (0.1)
Market Growth	0.50 (5.0)	0.50 (5.3)	0.50 (5.9)	0.46 (3.4)	0.46 (3.4)	0.46 (3.4)
Equilibrium correction	-0.42 (8.3)	-0.42 (8.7)	-0.42 (8.0)	-0.47 (8.1)	-0.47 (8.1)	-0.47 (8.1)
Log-likelihood	144.11	144.11	144.12	155.31	155.31	155.31
Log-likelihood (second stage)				31.78	31.62	31.78

Notes: heteroscedastic t-statistics in parentheses. Shaded grey in the two way fixed effects models indicates it was estimated in the first stage (which includes the time dummies, but excludes the variables that do not vary across the panel groups).

Illustration of heterogeneity, group 1: travel, passenger fares, transportation, other non-affiliated private services

Table 20 (industry-specific world imports, R&D, outlier dummies)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[4]	[5]	[6]
	One way fixed effects			Two way fixed effects		
Impact parameters						
Demand	0.76 (6.1)	0.75 (7.1)	0.75 (6.7)	0.93 (7.0)	0.93 (7.0)	0.93 (7.0)
Relative Prices	-0.73 (3.9)	-0.75 (4.0)	-0.70 (3.6)	-0.76 (4.4)	-0.82 (6.1)	-0.78 (3.4)
Relative R&D	-0.21 (3.3)	-0.22 (2.7)	-0.22 (2.9)	-0.23 (4.1)	-0.23 (4.5)	-0.23 (4.4)
Total FDI	-0.02 (0.2)		-0.07 (0.2)	-0.09 (1.3)		-0.06 (0.3)
Services FDI		-0.003 (0.1)	0.03 (0.2)		-0.05 (1.6)	-0.02 (0.2)
Market Growth	0.52 (4.0)	0.52 (4.3)	0.51 (5.1)	0.65 (3.9)	0.65 (3.9)	0.65 (3.9)
Equilibrium correction	-0.40 (7.8)	-0.40 (8.4)	-0.40 (7.7)	-0.41 (6.9)	-0.41 (6.9)	-0.41 (6.9)
Log-likelihood	97.21	97.19	97.25	107.37	107.37	107.37
Log-likelihood (second stage)				31.43	31.41	31.44

Notes: heteroscedastic t-statistics in parentheses. Shaded grey in the two way fixed effects models indicates it was estimated in the first stage (which includes the time dummies, but excludes the variables that do not vary across the panel groups).

Illustration of heterogeneity, group 2: royalties and licence fees, other affiliated private services

Table 21 (industry-specific world imports, R&D, outlier dummies)

Dependent Variable: $\Delta \ln(X_{it})$ Sample Period: 1987-2000

	[1]	[2]	[3]	[1]	[2]	[3]
	One way fixed effects			Two way fixed effects		
Impact parameters						
Demand	0.42 (2.1)	0.44 (2.1)	0.42 (2.0)	0.32 (1.9)	0.33 (1.7)	0.32 (1.6)
Relative Prices	-0.43 (2.3)	-0.29 (1.4)	-0.45 (1.7)	-0.41 (1.9)	-0.25 (1.1)	-0.38 (1.2)
Relative R&D	0.17 (2.2)	0.17 (2.2)	0.17 (2.2)	0.15 (1.1)	0.15 (1.1)	0.15 (1.1)
Total FDI	0.22 (2.2)		0.24 (1.3)	0.24 (2.5)		0.19 (0.8)
Services FDI		0.11 (1.9)	-0.02 (0.1)		0.13 (2.3)	0.03 (0.2)
Market Growth	0.54 (4.1)	0.50 (3.5)	0.55 (3.3)	0.47 (3.5)	0.41 (2.7)	0.45 (2.3)
Equilibrium correction	-0.72 (6.6)	-0.72 (6.6)	-0.72 (6.7)	-0.64 (6.6)	-0.64 (6.6)	-0.64 (6.6)
Log-likelihood	57.22	56.71	57.23	64.89	64.89	64.89
Log-likelihood (second stage)				30.91	30.68	30.92

Notes: heteroscedastic t-statistics in parentheses. Shaded grey in the two way fixed effects models indicates it was estimated in the first stage (which includes the time dummies, but excludes the variables that do not vary across the panel groups which for these groups also includes demand