Technology Flows, Outsourcing and Productivity: An Analysis of UK Trade and FDI

Nigel Driffield, Michael Henry and James H Love
Economics and Strategy Group
Aston Business School
Aston University
Birmingham B4 7ET
UK

Abstract

The literature on technology spillovers from trade and FDI is ambiguous in its findings. This may in part be because of the assumption in much of the work that trade and FDI flows are homogeneous in their determinants and thus in their effects. We develop a taxonomy of trade and FDI determinants based on R&D intensity and unit labour cost differentials, and test for the presence of spillovers from inward investment and imports on an extensive sample of UK manufacturing plants. We find that both trade and FDI have measurable spillover effects, but the sign and extent of these effects varies depending on the technological and factor cost differentials between the recipient and host economies. There is therefore an identifiable link between the determinants and effects of trade and FDI which the previous literature has not explored.

JEL Classification: F14, F21, F23

Acknowledgment:
The authors acknowledge the support of the ESRC under award RES-000-22-0468. This paper was written while Jim Love was an academic visitor at CIBAM, Judge Business School and Visiting Fellow of Wolfson College, Cambridge.

1. Introduction

The international transfer of technology is widely recognised as one of the major methods by which productivity, and ultimately living standards, can rise (see the survey by Keller, 2004 and the references contained therein). By engaging in economic activity with foreign partners, a country can access the R&D and related knowledge stocks of other countries (by accident or by design) and so benefit from those stocks of knowledge at a cost lower than that which would be incurred by developing the knowledge internally. This has given rise to both academic and policy interest in the mechanism by which such international transfers occur, and on the size of the growth effects which may arise from them.

Linked to this, however, is the recent interest in international outsourcing, as firms seek to relocate production to low cost locations (see for example Hijzen *et al*., 2005). This is consistent with Feenstra and Hanson (1999), who show that outsourcing of intermediate inputs is associated with labour cost differences between the home and foreign country. Further, Marin (2006) examines what factors influence the outsourcing decision of German and Austrian firms, in particular considering the impacts of outsourcing to Eastern Europe countries. The more labour intensive the production process, the higher the probability of outsourcing occurring to an independent input supplier from Eastern Europe, suggesting that labour costs matter.

Since technology can be either embodied in physical or human capital, goods or services or disembodied in knowledge, attention has naturally concentrated on the two main methods by which embodied or disembodied knowledge flows internationally: trade and foreign direct investment (FDI). There is now a substantial body of research which examines the importance of trade – specifically imports – as a method of enhancing productivity through accessing the knowledge stocks of trading partners. While much of this suggests that imports do promote knowledge flows and thus growth (Coe and Helpman 1995; Lichtenberg and van Pottelsberghe 1998; Falvey *et al* 2004), other work has cast doubt on imports as a source of technology spillovers (Keller 1998), or suggested that trade-related spillovers are mainly indirect in nature (Lumengo-Neso *et al* 2005).

The empirical work on FDI spillovers is even less consistent in its findings. While there is a body of evidence suggesting that there are (intra-industry) spillover effects running from

MNEs to host country firms, and that these effects can be substantial (see Blomström and Kokko (1998) for a survey), the conclusions of early cross-sectional industry-level studies have been questioned on econometric grounds (Görg and Strobl 2001). More recent micro-level panel data research has led to mixed results, with some showing evidence of positive horizontal spillovers (Haskel *et al.*, 2002; Keller and Yeaple, 2003), while others show evidence of a negative effect of FDI on domestic productivity (Aitken and Harrison, 1999). Issues such as outsourcing, either through trade or FDI, cloud this issue further. For example, if a foreign firm is attracted to a location through low wage costs and the availability of unskilled labour (or location incentives), then technology flows associated with this FDI may be limited. Equally, should a firm in a developed country seek to source certain inputs from low cost locations in the form of imports, then technology flows in either direction are likely to be minimal. Such activities would, however, be expected to generate productivity growth at home for the importing firm, resulting from the relocation of certain low value added activities and the simple ‘batting average’ effect.

The lack of consensus on the effects of trade and FDI, and on which has the greatest spillover impact, is rather disturbing, especially as enormous amounts of public money are spent on trade promotion activities and on subsidising the FDI activities of multinational corporations. One possible reason for the lack of consensus is the tendency among empirical studies to regard all trade or FDI respectively as homogeneous in nature and thus in effect. For example, the dominant theoretical perspective on the determinants of FDI suggests that firms will use FDI as a method of entering foreign markets where they possess some knowledge-based advantage which cannot easily be exploited by some other route such as licensing. While there is a large and growing literature that develops the theoretical treatment of why a firm should wish to undertake FDI (see for example Grünfeld and Sanna-Randaccio, 2006), this work generally ascribes the decision to undertake FDI as a feature of cost and technology differences across two countries, and subsequently ascribes certain spillover effects to this decision. However, theoretical work on the motivation for FDI in the absence of an observable technological advantage on the part of the firm, based on the initial contributions of Fosfuri and Motta (1999) and Siotis (1999), has stressed *technology sourcing* rather than technology exploitation as a motivation for FDI. This suggests that an important element in the internationalisation of production and R&D is not the desire to exploit existing technology within the firm, but to access the technology of leading edge firms within a given host economy. There is empirical support for technology sourcing as a determinant of FDI

(Kogut and Chang, 1991; Neven and Siotis, 1996), and crucially there is now evidence that technology sourcing FDI has a different pattern of spillover effects on domestic industry from FDI motivated by technology exploiting considerations. Specifically, technology exploiting FDI leads to positive domestic spillovers, while technology-sourcing FDI generally does not (Driffield and Love 2006; Driffield *et al* 2005).

This suggests that linking the motivation and effect of FDI may help to explain the contrasting results found in recent empirical studies of FDI spillovers. In principle the same argument applies to trade: although imports may not be consciously technology sourcing in nature, it is plausible to hypothesise that trade with technologically more advanced countries is more likely to lead to technology spillovers than trade with technological laggards. In addition, imports from sources which possess labour cost advantages may have quite different effects on domestic productivity from those where technology is the source of comparative advantage. The present paper therefore considers both trade and FDI as conduits for technology flows within the framework of different motivational patterns, using UK plant-level data. The UK is one of the most international economies in the world both in terms of trade and FDI, making this analysis particularly relevant. We find that both trade and FDI have measurable spillover effects, but the sign and extent of these effects varies depending on the technological and factor cost differentials between the recipient and host economies. There is therefore an identifiable link between the determinants and effects of trade and FDI which the previous literature has not explored. We also find that absorptive capacity matters for spillovers from FDI, but not from trade.

The remainder of the paper is divided as follows. Section 2 reviews the literature linking trade and FDI to productivity levels and growth. Section 3 first highlights some factors which help provide an explanation for the heterogeneity in the findings of previous research on technological spillover effects from trade and FDI on productivity, and then outlines a conceptual framework that incorporates these factors as the basis for empirical analysis. Section 4 describes the data that are used in the empirical analysis and discusses the estimation methodology employed. The results for both trade and FDI are discussed in Section 5, while Section 6 concludes the paper.

2. Evidence on productivity growth through trade and FDI

Transmission mechanisms

Both trade and FDI are potential channels by which spillovers may occur between countries. Rent (or pecuniary) spillovers arise when quality improvements by a supplier are not fully translated into higher prices for the buyer in some market transaction, while pure knowledge spillovers occur when the technology of one party has efficiency-enhancing effects on another without any market transaction occurring. In the case of imports, both forms of transmission have been hypothesised to give rise to productivity improvements in importing countries. For example, Coe *et al* (1997) discuss four mechanisms by which trade can enhance growth, and these are a mixture of rent and pure spillovers: the importation of inputs at market prices which do not reflect their quality; imitation by technologically-inferior countries of goods produced by technological leaders; the more efficient employment of resources through learning effects; and the ability of international trading contacts to stimulate the development of new indigenous technologies.

The theoretical base upon which the empirical international technology diffusion literature is built is provided by the open economy endogenous technological change models of Grossman and Helpman (1991) and Rivera-Batiz and Romer (1991). Drawing on the work of Romer (1990) and Aghion and Howitt (1992), they embed endogenous technological change theories into general equilibrium models to analyse the relationship between international trade, technological change and growth. For example, Grossman and Helpman (1991) identify a number of ways in which international flows of ideas and international trade in goods may affect long-run economic growth. One medium is through technological spillovers and the international transmission of knowledge which they demonstrated in a model with trade in both intermediate and final goods. Technology is diffused by being embodied in intermediate inputs: if research and development (R&D) expenditures create new intermediate goods that are different (horizontally differentiated inputs model) or better (the quality ladder model) and if these goods are exported to other economies, then the importing country's productivity will increase through the R&D efforts of its trade partner (see Keller, 2000). Therefore, to the extent that countries that are open to trade can either learn more quickly how to produce these new inputs or can import them; openness will be positively related to total factor productivity (TFP).

FDI may also bring benefits to host economies through productivity spillovers from multinational enterprises (MNEs). In many respects the transmission mechanisms are analogous to those described above for trade. First, productivity improvements may occur directly through backwards and forwards linkages with indigenous firms, through the licensing of a particular technology, through supplier networks or subcontracting arrangements. Secondly, rent spillovers may occur in several ways. For example, labour mobility may generate technology or knowledge spillovers, as employees moving from the foreign-owned to the domestic sector transfer firm-specific knowledge (Blomström and Kokko 1998; Fosfuri *et al* 2001). There is also the possibility of indirect productivity effects on local firms arising from foreign affiliates increasing the host country's knowledge of and access to specialised intermediate inputs at prices which do not reflect fully the costs and benefits entailed in the production of the inputs (Rodriguez-Clare, 1996). Finally, 'pure' knowledge spillovers may take place as knowledge generated by MNEs becomes public and is assimilated by the domestic sector.

Empirical evidence

The empirical evidence on spillover effects from trade begins with Coe and Helpman (1995) and their analysis of trade-related R&D spillovers. By accessing the R&D stocks of other countries through trade, a given country can raise its level of productivity and growth above the level determined by its own stock of R&D. Coe and Helpman find that for OECD countries over the period 1971-90 foreign R&D stocks do add to domestic productivity, and that this effect is both related to countries' trade patterns and is greater the more open the economy. Using a different weighting scheme to that of Coe and Helpman, Lichtenberg and van Pottelsberghe (1998) come to similar conclusions on the importance of imports for international technology spillovers, as do Falvey *et al* (2004).

However, not everyone accepts the Coe and Helpman argument uncritically. Keller (1998) finds that randomly-generated trade patterns lead to results which explain more of the international productivity variations than the actual trade weights employed by Coe and Helpman, and that international spillovers are found even where no particular pattern of trade is incorporated in the estimations. Keller concludes that the pattern of trade may well play a role in the international diffusion of technology, but that it is likely that trade-unrelated mechanisms (such as FDI) must play an important role. Subsequent work by Keller (1997b, 2000) based on industry level data for industrialised countries have given partial support to the import composition effect found by Coe and Helpman (1995). According to Keller, the composition of a country's imports is important only when it receives a disproportionately high share of its imports from one country.

Extensions of this approach can be found in Xu and Wang (1999), Coe et al (1997) and in Mayer (2001). These studies in various ways point to the likelihood of differences in technology effects across industries, based on the technological capacity of the industry and the degree of technology embedded in the trade flows. In a further development, it has been suggested that trade-related spillovers are mainly indirect in nature (Lumenga-Neso *et al* 2005). This research argues that imports into country A from country B give access not just to the R&D stocks of the trading partner, but also to all countries with which B trades, regardless of whether there is any direct trade between these countries and A. Lumenga-Neso *et al* find empirical support for this contention, casting further doubt on the importance of direct trade patterns as mechanisms for technology spillovers.

With respect to FDI, there is a large body of evidence suggesting that there are (intra-industry) spillover effects running from MNEs to domestic firms[1], and that these effects can be substantial (Blomström and Kokko 1998). While much of the early work was based on cross-sectional estimations often at a fairly aggregated level, more recent plant-level panel studies have failed to agree on the existence or extent of spillovers. Some studies show evidence of positive horizontal spillovers (Haskel *et* al 2002; Keller and Yeaple 2003), while others are more sceptical on both conceptual and econometric grounds (Görg and Strobl 2001; Görg and Greenaway 2004). The issue is further complicated by the existence of 'market stealing' effects arising from MNE entry. A technologically superior MNE may take market share from domestic enterprises, forcing them to produce at lower output levels with increased unit costs (Markusen and Venables 1999). Where the market stealing effect dominates the productivity spillover effect, the result may be a net reduction in domestic productivity (Aitken and Harrison 1999), at least in the short run[2].

---

[1] There is also a growing literature on vertical (supply-chain) spillovers from MNEs to domestic firms (Alfaro and Rodríguez-Clare, 2003; Javorcik, 2004), but our concern is with horizontal spillovers.

[2] In the long run the impact of competition from MNEs on domestic productivity is likely to be positive as less efficient firms either become more efficient or exit the market. The market stealing effect may, of course, also occur with imports.

There is a much more limited literature which considers both trade and FDI. Van Pottelsberghe and Lichtenberg (2001) extend their earlier analysis of international trade as a conduit for R&D spillovers[3] to consider FDI as a technology transfer mechanism. In an analysis of 13 industrialised countries from 1971 to 1990, they find that outward FDI makes a positive contribution to domestic total factor productivity through spillover effects from accessing the foreign R&D capital stock in target countries; by contrast, inward FDI has no such effect. Van Pottelsberghe and Lichtenberg therefore conclude that FDI flows are predominantly technology sourcing in nature, and that inward FDI is motivated principally by the desire to take advantage of the technological base of host countries. Hejazi and Safarian (1999) study both trade and FDI flows from six of the G7 countries to OECD countries, and find that both trade and FDI are important sources of positive productivity spillovers to the domestic sector, with FDI having the larger effect. Similar results are found in Keller and Yeaple (2003), who study the effect of imports and inward FDI into US manufacturing over the period 1987 to 1996. Again, FDI has the larger effect on domestic productivity, accounting for up to 11% of productivity growth in US manufacturing over this period. Finally, Chuang and Hsu (2004) examine trade and FDI spillovers in China’s manufacturing sector. They find that both imports and inward FDI results in productivity spillovers to the domestic sector, but that absorptive capacity acts in different ways for the two transmission mechanisms. FDI spillovers are higher where the technological gap between Chinese and investing firms is low, as is the case for the spillover effects of imports from the OECD. However, technology spillovers from imports from the Asian Tiger economies are higher where the technology gap with China is relatively high.

3. Linking FDI and trade determinants to spillover effects

The considerable variety in the findings of the empirical studies suggests that much remains to be understood about trade and FDI as technology transmission mechanisms. In the case of trade, much of the work on spillovers or international technology transfer is based on an apparent link between trade and observed productivity growth. Following Coe and Helpman (1995), this assumes that if a country imports goods, and then productivity rises in that sector, this is associated with technology transfer. However, this ignores the developing literature on outsourcing, which is generally associated with productivity growth. This may

---

[3] Lichtenberg and van Pottelsberghe de la Potterie (1998).

occur independently of technology transfer, and rather may be a feature of the offshoring of low value added (labour intensive) activities, such that average productivity at home increases. This is discussed in a vertically organised setting by Görg and Hanley (2005), though not in the context of differences in, for example, factor input prices. It is reasonable to assume that imports from a low wage economy may have different effects at the firm level from imports from a high wage, high R&D country, suggesting that there is merit in distinguishing potential trade spillovers arising from technological and factor-cost sources respectively.

Recent work on FDI spillovers also suggests that allowing for different motivational influences may help explain some of the variations in empirical findings. There are two elements to this: one is technology sourcing, and the other is ‘efficiency seeking’ (i.e. seeking low-cost production bases through offshoring).

There is increasing empirical and theoretical evidence that FDI may be motivated not by the desire to exploit some competitive advantage possessed by MNEs – the classic ‘ownership’ advantage (Dunning (1979) – but to access the technology of host economy firms (Fosfuri and Motta 1999; Siotis 1999; Kogut and Chang, 1991; Neven and Siotis, 1996). This is the technology sourcing hypothesis. Driffield and Love (2003) provide empirical evidence of the domestic-to-foreign ‘reverse spillovers’ on which the success of technology sourcing depends, and this in turn has led to studies examining the possibility of differential spillover effects arising from technology sourcing FDI. Driffield and Love (2006) draw on a panel of FDI flows across OECD countries and manufacturing sectors between 1984 and 1995, and distinguish between technology exploiting and technology sourcing FDI by using R&D intensity differentials between host and source sectors. The hypothesis that the motivation for FDI has an effect on total factor productivity spillovers is supported: technology exploiting FDI has a net positive effect, while technology sourcing FDI has a net negative effect.

The efficiency-seeking argument simply relates to the importance of factor costs as determinants of FDI flows. The literature consistently shows empirically that factor cost differentials, and in particular unit labour cost differentials, are an important determinant of FDI flows, even between advanced industrialised economies (Pain, 1993; Bajo-Rubio and Sosvilla-Rivero, 1994; Barrell and Pain 1996). This, too, can have implications for spillovers; as Keller (2004) points out, inward FDI which is simply seeking a low-cost production base is unlikely to form the basis for technological spillovers to the domestic sector.

The technology exploiting/sourcing and efficiency seeking issues are developed into a four-type taxonomy based on technology differences and factor cost differences in Driffield and Love (2005a) and Driffield *et al* (2005), and this is employed in the empirical analysis below (Table 1). This is at the industry level within countries, not merely at the national level. Technology is measured by R&D intensity (*RDI*) differentials[4], while costs are measured in terms of unit labour costs (*ULC*). Type 1 and 2 FDI both have some technology sourcing element. Type 1 is where the host economy is more R&D intensive and has lower unit labour costs than the source investor (at the industry level). This implies inward investment which may be motivated by technology sourcing and has the additional advantage of exploiting the host's locational advantage (lower unit labour costs). Type 2 is 'pure' technology sourcing investment, attracted by the host's higher R&D intensity despite its higher unit labour costs. Types 3 and 4 both have technology exploitation, which is the traditional ownership advantage, as the key determinant. Type 3 has the additional locational advantage of lower host unit labour costs, suggesting an 'efficiency seeking' motivation (Dunning, 1998). The final Type (4) is the 'pure' ownership advantage motivation, where source-country R&D intensity is greater than that of the corresponding host sector and FDI occurs despite the host sector having higher unit labour costs.

Table 1: Taxonomy of FDI/Trade Types

Type 1 FDI /Trade	$RDI_{HOST}>RDI_{SOURCE}$ and $ULC_{HOST}< ULC_{SOURCE}$
Type 2 FDI/Trade	$RDI_{HOST}>RDI_{SOURCE}$ and $ULC_{HOST}> ULC_{SOURCE}$
Type 3 FDI /Trade	$RDI_{HOST}<RDI_{SOURCE}$ and $ULC_{HOST}< ULC_{SOURCE}$
Type 4 FDI /Trade	$RDI_{HOST}<RDI_{SOURCE}$ and $ULC_{HOST}> ULC_{SOURCE}$

In terms of the taxonomy developed above, where the source industry is more technologically advanced than that in the UK (i.e. Types 3 and 4) we would expect to find positive net effects on domestic productivity, as long as any technological spilllover effects are not offset by market stealing effects. By contrast technology sourcing FDI (Types 1 and

---

[4] There are numerous measures of R&D intensity, such as the share of total national R&D, or the share of worldwide industry level R&D. However, as we wish to compare international R&D intensities at the sectoral level, we use R&D as a proportion of value added, in order to remove simple size effects.

2) is unlikely to result in productivity spillovers, and it is also less likely to generate competition effects, and for the same reason; technology laggards are in a relatively poor position to compete in international markets, unless (as in the case of Type 1 FDI) access to lower host country labour costs provides some basis on which to compete.

By analogy, these various effects may apply also to trade, although there is some difference with respect to the anticipated spillover effects. Seen from the perspective of the importing country, it is plausible to hypothesise that (as with FDI) trade with technologically more advanced countries is more likely to lead to technology spillovers than trade with (relative) technological laggards i.e. Types 3 and 4 are theoretically the most likely to generate positive technology transfer effects. However, the labour cost motivations must also be taken into account. Lower labour costs in the exporting country can be a source of motivation for trade, which may or may not lead in turn to productivity spillovers (in the importing country) depending on whether the exporting country is more (Type 4) or less (Type 2) technologically advanced than the importing economy. Such imports may also have an indirect effect on the domestic productivity of the importing economy through competition effects. In the short run, this may have a negative effect on domestic productivity as domestic producers lose market share and produce a lower volume of output at higher average cost.[5] In the longer run, the competition effect may have positive productivity effects as the least productive domestic producers either become more efficient or exit the market.

Imports of Type 1 are therefore intuitively likely to be the smallest group, as they suggest that the exporting country is both a technological laggard and has higher labour costs. As such, imports from such countries/sectors are likely to occur only in specialised sub-sectors.
Imports of Type 2 are stimulated by labour costs differences. In a UK context, this became more important over the period of analysis as trade with South East Asia and China increased. Imports of Type 3 are generated through some technological advantage that is sufficiently large to overcome cost disadvantages, while in the case of Type 4 imports the exporting country has both a technological and labour cost advantage over the importing economy. In principle, one would therefore expect Type 4 imports to dominate.

---

[5] Aitken and Harrison (1999) outline such a scenario of ‘market stealing’ in the context of FDI.

4. Data, Model Specification and Estimation Methodology

4.1 Data

All of the data for this study, with the exception of the data on trade and FDI, are taken from the Annual Respondents Database (ARD) which is housed at the Office for National Statistics (ONS). The ARD contains micro-level data on among other things gross output, employment, investment and intermediate goods expenditure, collected by the ONS from its mandatory annual survey of UK businesses known as the Annual Census of Production until 1998, and now the Annual Business Inquiry (ABI). Detailed descriptions of these data are provided by Oulton (1997), Barnes and Martin (2002) and Harris (2002) among others, and further discussion of the ARD data is provided in the data appendix.

The trade and FDI data employed in the estimation represent a panel of 13 countries, 11 manufacturing sectors and 9 years (1987-95). Details of the countries and sectors are shown in the Appendix. The countries include all of the major trading partners and direct investors in the UK and in the OECD generally. The manufacturing sectors are at the two digit level, the lowest level of aggregation compatible with combining Office for National Statistics (ONS) and OECD data for the relevant countries. Import data were taken from the UK Official Trade Statistics, and data for FDI inflows were provided by ONS. Data on R&D intensities and unit labour cost were derived from the OECD's ANBERD and STAN databases, for R&D expenditure and value added respectively[6]. The trade and FDI data (both as a homogenous block as well as the different types) were merged with the ARD plant level data at the 3-digit industry level for the manufacturing sector to undertake our analysis of the effects of imports and inward FDI on domestic productivity.

Table 2 illustrates the sectoral breakdown of both inward FDI and imports into the UK over the period 1987-95. The first point to note is that the distributions of imports and inward investment are remarkably similar across the four groups. This reflects that fact that, in terms of both trade and FDI, the main partners of the UK are those who have higher R&D intensities than the UK; over 70% of imports and 75% of inward investment falls into this category (Types 3 and 4). This would suggest that both trade and FDI may indeed be

---

[6] The breadth of the sectors is due to the need to find suitable deflators and PPP currency data at the sectoral level, in order to compare R&D intensity and unit labour costs consistently across countries.

vehicles for technology transfer into the UK, as such a high proportion originates from relatively R&D intensive countries. But it is also true that the UK attracts a significant amount of inward investment from countries with higher unit labour costs in the relevant sectors[7], and that almost 20% of imports are stimulated solely by cost differences (i.e. Type 2 imports, where the UK is more R&D intensive and has higher costs). This is indicative of outsourcing, especially in sectors such as paper and printing, and mechanical and electrical engineering, all of which have significant amounts of imports in Type 2. Such trade is unlikely to stimulate technology transfer, but may generate productivity growth in the UK through outsourcing.

(Table 2 here)

4.2 Model Specification and Estimation

There are essentially two possible approaches to estimating externalities in total factor productivity (TFP). The first possibility is to employ a 'two step' method in which one first obtains an estimate of total factor productivity as a residual as shown in the Equation (1) following the estimation of a production function.

$$TFP_{it} = \ln Q_{it} - \hat{\beta}_L \ln L_{it} - \hat{\beta}_K \ln K_{it} \qquad (1)$$

where Q, L and K represent output, labour and capital of the firm, and the estimates of the β terms are derived either through estimation or (more commonly) simply from the relative factor shares of the two inputs. The estimate of total factor productivity can then be regressed against the externality terms within a fixed effects model, including a time trend (or alternative measure of exogenous technical progress) and other explanatory variables. This approach can, however, generate biased results. This can arise firstly because, particularly where the β terms are derived through factor shares, the two-step approach does not test for the appropriate specification of the production function. Perhaps more importantly, such an approach does not allow for endogeneity of capital or labour, and this has been shown to perform poorly, especially where capital is proxied by some perpetual inventory method. For further discussion see Griliches and Mairesse (1995).

---

[7] One third of inward investment falls into this category (i.e. Types 1 and 3).

To determine whether there are technological externalities accruing to domestic plants from FDI and trade, we employ a production function for domestic plants augmented to include the externality terms along with other controls factors. In this augmented production function the non-input factors capture the impact on TFP. This approach has its genesis in the seminal paper by Griliches (1992), who postulates an augmented production function including both internal and external factors of production. The presence of such external influences on the firm is the consequence of externalities in production, due to formal or informal linkages between firms. The specification is thus:

$$\Delta \ln Q_{it} = \alpha + \beta_1 \Delta \ln K_{it} + \beta_2 \Delta \ln L^S{}_{it} + \beta_3 \Delta \ln L_{it}{}^U + \beta_4 \Delta \ln M_{it} + \sum_{p=1}^{r} \mu_p \Delta X_{it} + \gamma \Delta Z_{it} + \omega_{it} \quad (2)$$

where K, L^S, L^U and M are the factor inputs capital, skilled and unskilled labour and materials respectively. X is the vector of r externality terms, which is linked (usually positively) to total factor productivity and Z is a vector of other controls hypothesised to impact on TFP growth. i represents plant , t is time and Δ the difference operator. We also include a full set of industry, regional and time dummies which control for unobservables that may drive changes in our variables of interest. That is, $\omega_{it} = v_i + v_t + v_r + u_{it}$ where u_{it} are the random errors, assumed to be iid $\left(0, \sigma_u^2\right)$[8].

The gross output and material inputs data were deflated using 4 digit producer price and material indices respectively. Capital stock data also were constructed ‘in house’ by ONS officials, using data on investment (plant and machinery, buildings and vehicles) obtained from the ABI, based on the methodology employed in Martin (2002). With respect to the trade and FDI data, all monetary values were converted to real terms using sectoral level producer price index data, and purchasing power parity data where appropriate for international comparison. Crucially, this enables us to analyse trade and FDI flows in terms of unit labour costs and R&D intensity, not at the country level, but at the sectoral level between countries.

---

[8] This is the standard ‘fixed effects’ model, which is well understood, and is explained for example in Baltagi (2002). This allows for an industry specific component, and a time specific component. The econometric treatment of this is discussed in the text.

This framework has been used to test for spillovers from FDI in the conventional sense, that is, the extent to which capital investment by foreign owned firms is linked to total factor productivity in the domestic sector. For recent examples of this literature and methodology, see Haskel *et al*. (2002), Harris (2002), Harris and Robinson (2002), Driffield (2001) and the earlier literature summarized in Görg and Strobl (2001).

As Oulton (1997) and Driffield (2001) outline, many studies of externalities suffer from specification error. For example, Oulton (1996) and Basu and Fernald (1995) suggest that if the vector of externalities in a specification such as equation (2) contains output variables, then a change in aggregate demand, impacting simultaneously on internal and external output, may generate spurious 'evidence' of externalities or spillovers where none exist. This arises as a result of the error term in (1) being related to aggregate output growth. The problem of spurious externality effects can largely be alleviated by a more precise specification of the externality term.

On both theoretical and econometric grounds, the vector of spillovers used here is lagged inward FDI. The theoretical justification for this, derived from the theory of the firm, is that technological advance (or technology new to a particular location), or the international transfer of firm-specific assets, is embodied in new capital investment rather than in output, employment, or local R&D expenditure[9]. Our treatment of trade data is analogous to that for FDI: we employ lagged trade flows at the industry level, testing for the impact of international transfers of firm-specific assets embodied in trade flows on domestic growth rates. Econometrically, the use of lagged external investment or imports produces a tightly defined source of potential spillovers, so it is unlikely that the 'spillover' variable will be related to the error term in (1)[10]. One possible test for the appropriateness of our specification is to replace the investment term with the comparable value for contemporaneous output. If this produces no significant result, then one can be confident that any results generated using

---

[9] This argument is the basis for the importance of inward capital investment (rather than employment or output) on a host economy, see for example Dunning (1958), Hood and Young (1979). Blomström (1986) stresses that it is ownership of *assets* that counts in FDI, not employment, while Hejazi and Safarian (1999) point out that employment or output measures may understate the level of FDI, because of the greater capital intensity of MNEs compared to indigenous enterprises.

[10] See Oulton (1996) for a full discussion of this. Empirically this can be tested for using standard heteroskedasticity or specification tests.

lagged investment are not the result of a spurious correlation. This is discussed at length in Driffield (2001) and the appropriate test is carried out in the econometric analysis below[11].

Restricting the notation to FDI for convenience, the specification that we estimate is thus:

$$\Delta\ln Q_{it} = \alpha + \beta_1 \Delta\ln K_{it} + \beta_2 \Delta\ln L^{S}_{it} + \beta_3 \Delta\ln L^{U}_{it} + \beta_4 \Delta\ln M_{it} + \beta_5 \Delta\ln AGE_{it} + \beta_6 \Delta\ln HERF_{it} + \beta_7 \Delta\ln MKT\_SHARE_{it} + \sum\nolimits_{z=1}^{4} \phi_z \Delta\left(\ln IFDI_{it-1} \times D_z\right) + \omega_{it} \qquad (3)$$

where we envisage four possible types of inward FDI (see above and Table 1), and *z=1…4*. We therefore define the following four binary indicators:

$$\text{Type 1: } \begin{array}{l} D_1 = 1 \quad if \quad \left(RDI_{UK} > RDI_F\right) \quad \& \quad \left(ULC_{UK} < ULC_F\right) \\ D_1 = 0 \quad if \quad Otherwise \end{array}$$

$$\text{Type 2: } \begin{array}{l} D_2 = 1 \quad if \quad \left(RDI_{UK} > RDI_F\right) \quad \& \quad \left(ULC_{UK} > ULC_F\right) \\ D_2 = 0 \quad if \quad Otherwise \end{array}$$

$$\text{Type 3: } \begin{array}{l} D_3 = 1 \quad if \quad \left(RDI_{UK} < RDI_F\right) \quad \& \quad \left(ULC_{UK} < ULC_F\right) \\ D_3 = 0 \quad if \quad Otherwise \end{array}$$

$$\text{Type 4: } \begin{array}{l} D_4 = 1 \quad if \quad \left(RDI_{UK} < RDI_F\right) \quad \& \quad \left(ULC_{UK} > ULC_F\right) \\ D_4 = 0 \quad if \quad Otherwise \end{array}$$

D_z are four binary dummy variables defined in terms of Table 1 above, so if $D_z = 1$ then $D_{\tilde{z}} = 0$ where $z \neq \tilde{z}$. The dummy variables are defined using *RDI* and *ULC* at period *t-1*. This means that the motivation for FDI or trade is based at *t-1* and outcomes at time *t*, and so the classification of FDI/trade and its effects are non contemporaneous. Other regressors included in (2) are plant age (AGE), a proxy for industry concentration as measured by the Herfindahl-Hirschman Index (HERF) and another for market share (MKT_SHARE) (see Appendix for details on definition and construction of variables used in this paper). Our priors on the latter two measures, which captures the effect of product market competition on domestic TFP, is for greater competition to be associated positively with TFP growth.

---

[11] We formally test for this by substituting contemporaneous domestic output for lagged capital growth in estimating equation 3. This specification is rejected in all the results presented below, using standard specification tests.

With the exception of the externality variable (s), all the variables in (3) capture the activities of domestic plants. That is, like Haskel *et al*. (2002), we estimate a production function for domestic plants augmented by variables that capture foreign presence and other controls.[12]

Our preferred estimator for estimating Equation (3) is the feasible efficient two-step GMM-IV estimator.[13] Our choice of estimator was informed by the fact that both the factor inputs and the externality variables (FDI and IMPORTS) are possibly endogenous. In the case of the former, the discussion in Griliches and Mairesse (1995) is instructive, while for the latter (FDI) one can argue that foreign firms may be attracted to industries and/or regions with high productivity domestic plants (Haskel et al., 2002). Additionally, the GMM-IV estimator is more efficient than the conventional IV two-stage least squares estimator in the presence of heteroscedasticity of unknown form. If heteroscedasticity is present, then the conventional IV estimator although consistent, is inefficient.[14] Additionally, in our estimations we allow for unspecified correlation of error terms within groups (i.e. plants) but not between groups.

5. Results

5.1 FDI

The GMM-IV results for the effects on domestic productivity of inward investment are shown in Table 3. The results for age, Herfindahl index and market share indicate that younger plants and those exposed to less competitive conditions tend to have higher levels of productivity. Column 1 shows the estimation with FDI regarded as homogeneous in its determinants – the standard assumption in the empirical literature. Inward investment has a negative but insignificant coefficient. The picture changes when FDI is split into its component determinants (column 2); there is evidence of negative productivity effects from Type 2 and Type 3 FDI, indicating that competition effects outweigh positive spillover effects under some circumstances. Additionally, unlike the results in Column 1, the Hansen J test of overidentification shows the set of excluded instruments to be valid since we cannot reject the null hypothesis that the regression is overidentified.

---

[12] An analogous specification with imports replacing inward FDI as the externality variable was estimated separately due to apparent collinearity problems encountered when attempting to estimate all eight externality variables in a single regression.

[13] As a robustness check, we also employed alternative estimators on our specifications.

[14] It should also be noted that the problems posed by heteroscedasticity for the traditional IV estimator can only be partially resolved through the use of heteroscedasticity-consistent or "robust" standard errors and statistics (Baum, Schaffer and Stillman, 2003)

A more revealing insight into the productivity effects of FDI can be obtained by splitting the sample of plants into four standard technology groups based on EUROSTAT/OECD classification scheme[15] (Table 4). Clearly the impact of inward FDI depends not just on its determinants, but also on the technological profile of the sector into which the investment is made. The HIGHTEC and MEDLOW groups show precisely the pattern of results which would be expected *a priori*: inward FDI from technologically more advanced sources results in positive domestic productivity spillovers (i.e. Types 3 and 4), while technology sourcing FDI (Type 2) has no effect. Intriguingly, in both cases Type 1 FDI has a negative and significant coefficient, suggesting that inward investors which are less research intensive than their UK counterparts can compete successfully, presumably by exploiting the host economy's lower unit labour costs. By contrast, the pattern of effects for the remaining technology groups is quite different; the negative effects of Type 2 and 3 FDI noted in Table 3 derive exclusively from the MEDHIGH and LOW groups, with investment in these categories being dominated by FDI into just two industries, chemicals and paper, printing and publishing.

An area of increasing interest in the literature is the role of absorptive capacity in helping indigenous firms to capture the spillovers arising from FDI (see Girma, 2005). One simple way of examining this is to split the sample into those plants below minimum efficient scale (MES) and those at or above MES, thereby highlighting the difference between plants which have sufficient scale to be technically efficient and those which do not. This is done in Table 5: columns 1 and 2 performs this split for the sample as a whole, while the remaining columns show the absorptive capacity split for each of the technology groups in turn. The pattern of results in Table 5 indicates that the spillover effects of FDI – both positive and negative – occur overwhelmingly within plants at or above industry MES. The only exception to this is within the MEDLOW technology group which shows a more evenly spread pattern of results. However, in light of the failure of the instrument validity test by the specification shown for this technology group then one needs to be cautious in interpreting the results arising from it. The fact that both positive and negative effects show this pattern suggests not only that absorptive capacity is important in capturing the positive

---

[15] The industry composition of the technology groups is as follows: HIGHTEC – mechanical and instrument engineering; electrical engineering: MEDHIGH – chemicals; shipbuilding; vehicles: MEDLOW – metal manufacture; rubber: LOW – food, drink and tobacco: textiles etc: paper, printing and publishing; other manufacturing.

intra-industry spillovers from FDI, but also that where inward investors compete vigorously enough to have a market-stealing effect which offsets any positive spillovers, this competition takes place mainly with the larger domestic plants. By contrast, with the exception of the MEDLOW sector, there is virtually no positive or negative effect from inward FDI among plants below industry MES: overall, domestic sub-MES plants lack absorptive capacity and so gain little from inward FDI, but nor do they suffer greatly in terms of market-stealing effects. For these plants, incoming multinationals are largely a non-event.

5.2 Trade

The estimation results for trade (i.e. imports) are shown in Tables 6 to 8. Like FDI, when considered as a homogeneous block imports have an insignificant effect on domestic productivity (Table 6 column 1), but when split into the different types, there is evidence of positive technological spillover effects arising from imports from more R&D intensive sectors (Type 4 imports).

As with FDI, a much more revealing pattern of results becomes apparent when the sample is split into technology groups (Table 7). The results for the HIGHTEC and MEDLOW groups share similar characteristics with the corresponding FDI findings, with positive spillover effects arising from imports from more research-intensive sources (Type 3 and, for HIGHTEC only, Type 4). There is also evidence of a positive effect on domestic productivity in the two higher-technology groups arising from Type 2 imports i.e. imports from foreign sectors which are less technologically advanced but have lower unit labour costs than their UK counterparts. The mechanism for productivity increases here cannot be technology spillovers in the conventional sense since the foreign sectors are relative technological laggards; instead, this effect can arise from relatively hi-tech firms in the UK outsourcing or offshoring[16] production of relatively low value-added activities to locations with a (labour) cost advantage and importing the resulting output, with a corresponding rise in UK productivity as a result. This ‘batting average’ effect for increased domestic productivity is often ignored in the theoretical and empirical literature.

---

[16] International outsourcing involves the relocation of an activity to an external supplier in another country, while offshoring involves relocating an activity to a foreign (cheaper) location, but within the firm, typically through FDI (Marin, 2006).

Like FDI, the results for imports show evidence of competition effects outweighing technological spillovers, notably in the case of the MEDHIGH group, suggesting strong competition from both imports and inward investors in the UK chemicals, shipbuilding and vehicles industries. Surprisingly, Type 1 imports also show negative productivity effects in the MEDHIGH group. It is hard to rationalise this effect, as imports in this category come from relatively less technology intensive sources with higher unit labour costs than the UK, and so the source of potential competition is unclear. Unlike the FDI case, imports show identical spillover pattern across the sample when split by absorptive capacity (Table 8). For this reason we do not perform the absorptive capacity split by technology group.

6. Conclusions

The purpose of the paper is to determine the extent to which the UK gains productivity spillovers from imports and inward FDI. The empirical literature provides ambiguous findings on the existence and extent of such spillovers, and this research suggest one possible reason for this. Unlike the previous literature we neither impose an assumption of homogeneity of determinants in trade and FDI flows, nor do we infer motivation for trade or FDI from its spillover effects (c.f. van Pottelsbergh and Lichtenberg, 2001; Hejazi and Pauly; 2003). Our results indicate that there are positive spillover effects from both imports and inward FDI, but that these are neither automatic nor guaranteed. There is an identifiable link between the characteristics of the trade and FDI and the resulting pattern of spillovers, suggesting that the lack of consensus in the literature arises at least in part from failing to allow for the link between the determinants and effects of different types of trade and FDI flows.

These findings provide a link between the large theoretical literature on the FDI decision and the applied (and somewhat atheoretical) treatment of spillovers. We have shown that technology and labour costs differences (both of which are highlighted in the theoretical literature as important determinants of FDI) play an important role in the nature of spillover effects, not only from FDI but also from trade. The importance of capturing ‘technology’ effects of trade is well understood in the applied literature on trade and growth, but the FDI literature has rather lagged behind in this respect. The pattern of spillover effects is broadly similar for trade and FDI, but there are two key differences. First, nearly all the effects (positive and negative) from trade occur in the higher technology sectors, which is not the case with FDI. Second, absorptive capacity matters for FDI spillovers, but does not for trade spillovers. Taken together, these findings suggest that the productivity effects of FDI are largely restricted to plants with high absorptive capacity, while the productivity effects of imports occur largely among higher-technology plants regardless of their absorptive capacity.

In comparing our results with previous research it should be noted that our approach is rather different. Previous studies (Coe and Helpman,1995; Lichtenberg and van Pottelsberghe, 1998; van Pottelsbergh and Lichtenberg, 2001) deal with accessing the stock of R&D through imports or FDI by weighting domestic and foreign R&D stocks by trade or FDI patterns. We deal with trade and FDI flows, but split by relative R&D intensity differentials (and unit labour cost differentials). While it is thus not possible to compare our results directly with those discussed above, some comments can be made. Firstly, like previous authors we find evidence of both trade and FDI acting as vehicles for international technology transfer. However, much of what the literature has come to describe as technology sourcing may have been erroneously labelled, as the observed productivity gains may have occurred through offshoring and its associated batting average effect, rather than through technology transfer. For the same reason we do not directly compare the sizes of the coefficient estimates on trade and FDI spillovers, as has been done in some previous literature. This is because we are careful not to ascribe all effects on domestic productivity to technology flows: there is clear evidence in our results of outsourcing effects, notable through trade.

There are considerable policy implications of our findings, not least because of the large sums of public money spent on attracting inward investment in the hope of benefiting from spillover effects, in addition to the direct and indirect employment benefits. Our results suggest that further consideration should be given to the types of inward investment that are provided with subsidy. This paper has highlighted the importance of the nature of the source country sector in determining the effects of inward investment, yet this is largely ignored by policy makers when allocating inward investment incentives. Driffield and Love (2005b; 2007) discuss in some detail the patterns of FDI coming into the UK. Inward investment from notably the US, Germany and Switzerland, for example, is not only concentrated in the 4th category of our classification (where the source country is more R&D intensive but also with higher labour costs), but is also concentrated in the high-tech and medium-high technology sectors. This is the FDI that generates the greatest productivity effects of inward investment. Policy makers would therefore be wise to consider attracting investment from such countries, and to focus on sectors such as pharmaceuticals and electronics (see Table 2), if the social returns to investment are to be maximised.

Table 2: The distribution of UK imports and inward FDI by classification across industries, 1987-95 (£m)

	import1	**import2**	**import3**	**import4**	**inward1**	**inward2**	**inward3**	**inward4**
Food, drink, tobacco	721	7910	3422	36338	610	5027	2854	34507
Chemicals	4461	2781	42410	14374	3772	1943	35370	13650
Metal manufacturing	12	850	760	2855	10	594	634	2711
Mechanical and instrument manufacturing	226	9090	10341	27093	191	6351	8624	25728
Shipbuilding	0	0	1926	0	0	0	1606	0
Vehicles	32	149	12615	16564	27	104	10521	15729
Textiles, leather, clothes	56	40	1293	2555	47	28	1079	2426
Paper, printing and publishing	13309	34588	6939	12547	11256	24165	5787	11914
Rubber	0	2045	5114	529	0	1429	4265	503
Electrical engineering	13891	7031	9670	41803	11748	4912	8065	39697
Other manufacturing	382	8336	1280	19743	323	5824	1067	18748
Total	33090	72820	95769	174401	27985	50375	79872	165613
Percentage of total	8.8%	19.3%	25.5%	46.4%	8.6%	15.6%	24.7%	51.1%

Table 3: GMM-IV Panel Estimations - Inward FDI (1987-95)

DK	-0.090 (-0.37)	-0.115 (-0.48)
DL^S	0.149*** (9.12)	0.148*** (8.88)
DL^U	0.000 (0.01)	-0.006 (-0.37)
DMAT	-0.025 (-1.55)	-0.026 (-1.61)
DAGE	-0.152* (-1.69)	-0.180** (-1.69)
DHERF	-0.457*** (-15.25)	-0.450*** (-14.67)
DMKT_SHARE	0.853*** (50.43)	0.861*** (50.28)
DINWARD	-0.029 (-1.20)	
DINWARD1		0.034 (0.88)
DINWARD2		-0.006** (-2.06)
DINWARD3		-0.009* (-1.74)
DINWARD4		0..005 (0.56)
Hansen J χ^2 (p-value)	13.847 (0.003)	1.240 (0.538)
R^2	0.93	0.93
# of Observations	14,027	14,027
# of Establishments	6,385	6,385

Notes: The numbers in parentheses are robust t (z)- statistics.

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

All variables are growth rates (1st difference of logs). All regressions include a constant as well as region, year and 2 digit industry dummies. These are not reported due to space constraints. Lagged values of FDI (at least two periods) are used as instruments in the estimations.

Dependent variable: growth rate of real output of domestic plants

Table 4: GMM-IV Panel Estimates by Technology Group (1987-95)

	HIGHTEC	**MEDHIGH**	**MEDLOW**	**LOW**
DK	3.050*** (2.65)	-0.535 (-1.56)	-0.070 (-0.20)	0.068 (0.22)
DL^S	0.094** (2.43)	0.105*** (4.93)	0.12*** (6.22)	0.188*** (6.57)
DL^U	-0.012 (-0.24)	-0.024 (-1.04)	-0.047** (-2.20)	0.042 (1.55)
DMAT	-0090 (-1.48)	-0.015 (-0.64)	0.032 (1.17)	-0.011 (-0.43)
DAGE	0.224 (0.58)	-0.248 (-1.45)	-0.161 (-0.85)	-0.285** (-1.99)
DHERF	-0.231* (-1.91)	-0.344*** (-8.34)	-0.728*** (-10.18)	-0.537*** (-11.88)
DMKT_SHARE	0.962*** (16.96)	0.914*** (38.78)	0.888*** (27.17)	0.767*** (28.32)
DINWARD1	-0.825** (-2.36)	0.058* (1.87)	-0.039* (-1.97)	-0.051 (-0.55)
DINWARD2	0.014 (0.14)	-0.022*** (-3.80)	0.006 (1.45)	-0.011*** (-2.99)
DINWARD3	0.325*** (3.36)	-0.031** (-2.36)	0.019*** (4.68)	-0.016* (-1.95)
DINWARD4	0.336*** (3.06)	-0.038*** (-2.63)	0.058*** (5.48)	0.034 (0.33)
Hansen J χ^2 (p-value)	2.839 (0.829)	0.948 (0.622)	10.429 (0.108)	19.292 (0.000)
R^2	0.87	0.94	0.96	0.91
# of Observations	1,606	3,816	3,138	6,205
# of Establishments	868	1,669	1,528	2,799

Notes: The numbers in parentheses are robust z -statistics.

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

All variables are growth rates (1st difference of logs). All regressions include a constant as well as region and year dummies. These are not reported due to space constraints. Lagged values of FDI (at least two periods) are used as instruments in the estimations.

Dependent variable: growth rate of real output of domestic plants

Table 5: GMM-IV Panel Estimates by MES and Technology Group (1987-95)

	Plants >= MES	**Plants < MES**	**Plants >= MES HIGHTEC**	**Plants < MES HIGHTEC**	**Plants >= MES MEDHIGH**	**Plants < MES MEDHIGH**
DK	-0.115 (-0.31)	0.213 (0.50)	-1.056 (-1.15)	-1.929 (-1.54)	-0.970 (-1.17)	0.031 (0.07)
DL^S	0.182*** (8.77)	0.142*** (7.71)	0.107 (1.55)	0.133*** (2.90)	0.127*** (4.31)	0.108*** (4.23)
DL^U	0.004 (0.21)	0.030 (1.42)	-0.008 (-0.15)	0.086 (1.35)	-0.041 (-1.20)	0.019 (0.68)
DMAT	0.013 (0.58)	0.045** (1.98)	-0.134 (-1.41)	-0.073 (-0.90)	0.025 (0.70)	0.027 (0.80)
DAGE	-0.154 (-1.05)	-0.349*** (-2.85)	0.533 (0.94)	0.382 (0.74)	-0.068 (-0.24)	-0.435* (-1.76)
DHERF	-0.441*** (-10.91)	-0.373*** (-11.06)	-0.028 (-0.17)	-0.280** (-2.36)	-0.330*** (-6.36)	-0.308*** (-5.73)
DMKT_SHARE	0.775*** (29.39)	0.755*** (27.11)	0.962*** (10.74)	0.834*** (12.32)	0.864*** (24.01)	0.826*** (22.18)
DINWARD1	0.009 (0.14)	0.023 (1.17)	-1.545*** (-2.79)	-0.242 (-0.61)	0.067 (1.31)	0.036 (1.06)
DINWARD2	-0.006 (-1.59)	-0.005* (-1.69)	0.241 (1.58)	-0.134 (-1.11)	-0.022*** (-2.78)	-0.017** (-2.22)
DINWARD3	-0.006 (-0.86)	-0.010* (-1.79)	0.465*** (3.42)	0.177 (1.15)	-0.043*** (-2.76)	-0.012 (-0.66)
DINWARD4	0..006 (0.50)	-0..013 (-1.61)	0..539*** (3.32)	0.139 (0.89)	-0..052*** (-2.76)	-0.019 (-1.05)
Hansen J χ^2 (p-value)	0.295 (0.863)	10.308 (0.112)	3.799 (0.704)	6.341 (0.175)	0.961 (0.618)	0.370 (0.831)
R^2	0.90	0.90	0.88	0.88	0.91	0.92
# of Observations	7,197	6,830	426	442	1,940	1,876
# of Establishments	4,711	4,533	304	300	1,237	1,221

Notes: The numbers in parentheses are robust z- statistics.

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

All variables are growth rates (1st difference of logs). All regressions include a constant as well as region and year dummies. Additionally, regressions 1 & 2 include 2 digit industry dummies. These are not reported due to space constraints. Lagged values of FDI (at least two periods) are used as instruments in the estimations.

Dependent variable: growth rate of real output of domestic plants

Table 5 (Cont'd): GMM-IV Panel Estimates by MES and Technology Group (1987-95)

	Plants >= MES MEDLOW	**Plants < MES MEDLOW**	**Plants >= MES LOW**	**Plants < MES LOW**
DK	-0.125 (-0.20)	0.241 (0.66)	-0.273 (-0.73)	0.813 (1.36)
DL^S	0.151*** (5.06)	0.117*** (4.86)	0.232*** (7.13)	0.190*** (5.80)
DL^U	-0.042 (-1.30)	-0.062** (-2.33)	0.059* (1.82)	0.059 (1.50)
DMAT	0.088** (2.28)	0.073* (1.69)	0.057 (1.59)	0.056 (1.53)
DAGE	-0.373 (-1.25)	0.196 (0.86)	-0.106 (-0.43)	-0.491*** (-2.70)
DHERF	-0.765*** (-8.13)	-0.366*** (-5.74)	-0.484*** (-8.10)	-0.448*** (-7.56)
DMKT_SHARE	0.797*** (15.90)	0.856*** (15.57)	0.642*** (15.83)	0.667*** (14.68)
DINWARD1	-0.042 (-1.32)	-0.065*** (-2.66)	-0.023 (-0.29)	-0.077 (-0.75)
DINWARD2	0.006 (1.13)	0.010** (1.97)	-0.015*** (-3.48)	-0.002 (-0.44)
DINWARD3	0.021*** (3.40)	0.012** (2.37)	-0.022*** (-2.77)	-0.009 (-0.82)
DINWARD4	0..049*** (2.79)	0.031** (2.43)	-0..201** (-2.22)	0.141 (0.92)
Hansen J χ^2 (p-value)	3.667 (0.722)	20.688 (0.002)	13.880 (0.001)	5.728 (0.057)
R^2	0.93	0.95	0.88	0.87
# of Observations	1,624	1,514	3,207	2,998
# of Establishments	1,118	1,054	2,074	1,980

Notes: The numbers in parentheses are robust z- statistics.

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

All variables are growth rates (1st difference of logs). All regressions include a constant as well as region and year dummies. These are not reported due to space constraints. Lagged values of FDI (at least two periods) are used as instruments in the estimations.

Dependent variable: growth rate of real output of domestic plants

Table 6: GMM-IV Panel Estimations - Imports (1987-95)		
DK	-0.175 (-0.37)	-0.170 (-0.61)
DL^S	0.146*** (9.29)	0.146*** (9.29)
DL^U	-0.002 (-0.13)	0.002 (0.10)
DMAT	-0.021 (-1.37)	-0.022 (-1.43)
DAGE	-0.217** (-2.51)	-0.225*** (-2.60)
DHERF	-0.507*** (-18.12)	-0.507*** (-17.76)
DMKT_SHARE	0.854*** (55.92)	0.853*** (55.62)
DIMPORT	-0.011 (-0.14)	
DIMPORT1		-0.001 (-1.29)
DIMPORT2		0.031 (1.21)
DIMPORT3		-0.004 (-0.66)
DIMPORT4		0.043*** (2.87)
Hansen J χ^2 (p-value)	17.480 (0.001)	2.020 (0.568)
R^2	0.92	0.92
# of Observations	15,050	15,050
# of Establishments	6,496	6,496

Notes: The numbers in parentheses are robust t (z)- statistics.

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

All variables are growth rates (1st difference of logs). All regressions include a constant as well as region, year and 2 digit industry dummies. These are not reported due to space constraints. Lagged values of imports (at least one period) are used as instruments in the estimations.

Dependent variable: growth rate of real output of domestic plants

Table 7: GMM-IV Panel Estimates by Technology Group (1987-95)

	HIGHTEC	**MEDHIGH**	**MEDLOW**	**LOW**
DK	2.127 (1.27)	-0.389 (-0.94)	0.069 (0.12)	-0.147 (-0.55)
DL^S	0.097*** (2.66)	0.096*** (4.28)	0.118*** (5.80)	0.179*** (6.48)
DL^U	-0.037 (-0.80)	0.009 (0.36)	-0.025 (-1.13)	0.018 (0.67)
DMAT	-0.082 (-1.35)	-0.022 (-0.86)	0.014 (0.56)	-0.013 (-0.49)
DAGE	0.255 (0.77)	-0.215 (-1.19)	-0.080 (-0.38)	-0.334** (-2.46)
DHERF	-0.283** (-2.09)	-0.408*** (-7.96)	-0.698*** (-11.38)	-0.619*** (-14.93)
DMKT_SHARE	0.967*** (17.00)	0.908*** (37.11)	0.892*** (35.46)	0.795*** (31.14)
DIMPORT1		-0.068*** (-5.26)	0.004 (0.69)	0.004*** (3.13)
DIMPORT2	0.275*** (3.36)	0.522*** (4.40)	0.123 (1.16)	-0.073* (-1.73)
DIMPORT3	0.180*** (4.62)	-0.257*** (-4.87)	0.034** (2.40)	0.021 (0.92)
DIMPORT4	0.407*** (3.90)	-0.220*** (-4.77)	-0.013 (-0.23)	0.014 (0.49)
Hansen J χ^2 (p-value)	4.633 (0.327)	4.269 (0.234)	7.737 (0.052)	7.066 (0.070)
R^2	0.89	0.90	0.95	0.91
# of Observations	868	3,942	3,711	6,529
# of Establishments	439	1,692	1,602	2,825

Notes: The numbers in parentheses are robust z -statistics.

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

All variables are growth rates (1st difference of logs). All regressions include a constant as well as region and year dummies. These are not reported due to space constraints. Lagged values of imports (at least one period) are used as instruments in the estimations.

Dependent variable: growth rate of real output of domestic plants

Table 8: GMM-IV Panel Estimates by MES (1987-95)

	Plants >= MES	**Plants < MES**
DK	-0.190 (-0.34)	0.060 (0.14)
DL^S	0.178*** (8.98)	0.138*** (7.74)
DL^U	0.008 (0.40)	0.032 (1.55)
DMAT	0.016 (0.71)	0.041** (1.89)
DAGE	-0.177 (-1.26)	-0.400*** (-3.38)
DHERF	-0.498*** (-12.68)	-0.425*** (-13.15)
DMKT_SHARE	0.774*** (32.15)	0.762*** (31.06)
DIMPORT1	-0.001 (-0.51)	-0.001 (-0.95)
DIMPORT2	0.043 (1.40)	-0.034 (-1.02)
DIMPORT3	-0.008 (-0.84)	-0.007 (-0.78)
DIMPORT4	0.046** (2.22)	0.045** (2.19)
Hansen J χ^2 (p-value)	0.305 (0.959)	9.003 (0.029)
R^2	0.89	0.90
# of Observations	7,721	7,329
# of Establishments	4,874	4,700

Notes: The numbers in parentheses are robust z- statistics.

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

All variables are growth rates (1st difference of logs). All regressions include a constant as well as region and year dummies. Additionally, regressions 1 & 2 include 2 digit industry dummies. These are not reported due to space constraints. Lagged values of imports (at least one period) are used as instruments in the estimations.

Dependent variable: growth rate of real output of domestic plants

References

Aghion, P. and Howitt, P. (1992) ‘A Model of Growth Through Creative Destruction’, *Econometrica*, 323-51.

Aitken, B. J. and Harrison, A. E. (1999) ‘Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela’, *American Economic Review*, 89, 605-18.

Alfaro, L and Rodríguez-Clare, A (2003) ‘Multinationals and Linkages: An Empirical Investigation’, mimeo.

Bajo-Rubio, O and Sosvilla-Rivero, S (1994), ‘An econometric analysis of foreign direct investment in Spain, 1964-89’, *Southern Economic Journal*, 61, 104-120.

Baltagi, B. (2002) *Econometric Analysis of Panel Data* (Second Edition), John Wiley and Sons Ltd, England.

Barnes, M. and Martin, R. (2002) ‘Business Data Linking: An Introduction’ *Economic Trends*, No. 581, pp. 34-41.

Barrell, R.and Pain, N. (1996) ‘An econometric analysis of US foreign direct investment’ *Review of Economics and Statistics*, 78, 200-7.

Basu, S. and Fernald, J.G. (1995) ‘Are Apparent Productive Spillover Effects a Figment of Specification Error?’ *Journal of Monetary Economics*, 36, 165-168.

Baum, C., Schaffer, M. E. and Stillman, S. (2003) ‘Instrumental Variables and GMM: Estimation and Testing’, *Stata Journal*, 3 (1): 1-31.

Blomström, M. and Kokko, A. (1998) ‘Multinational Corporations and Spillovers’, *Journal of Economic Surveys*, 12, 247–77.

Chuang Y-C and Hsu P-F (2004) ‘FDI, trade, and spillover efficiency: evidence from China’s manufacturing sector’, *Applied Economics*, 36, 1103-1115.

Coe, D T and Helpman E (1995) ‘International R&D spillovers, *European Economic Review*, 39, 859-887.

Coe, D T, Helpman E and Hoffmaister E (1997) ‘North-South R&D spillovers’ *Economic Journal*, 107, 134-150.

Criscuolo C. and Martin R. (2004) ‘Multinationals, Foreign Ownership and Productivity in UK Businesses’, CERIBA Working Paper, QMW. Available at: http://www.qmw.ac.uk/~ugte153/CERIBA/publications/multinatsconf.pdf.

Driffield, N. L. (2001) ‘The Impact on Domestic Productivity of Inward Investment in the UK’, The Manchester School, Vol. 69, 103-119.

Driffield, N. L. and Love, J. H. (2003) ‘Foreign Direct Investment, Technology Sourcing and Reverse Spillovers’, *The Manchester* School, 71, 659-72.

Driffield, N. L. and Love, J. H. (2005a) ‘Intra-Industry FDI, Uneven Development and Globalisation: the Legacy of Stephen Hymer’, *Contributions to Political Economy*, 24, 55-78.

Driffield N and Love J H (2005b) ‘Who gains from whom? Spillovers, Competition and Technology Sourcing in the Foreign-owned sector of UK manufacturing’, *Scottish Journal of Political Economy*, 52, 663-686.

Driffield N and Love J H (2006) 'Does the Motivation for Foreign Direct Investment Affect Productivity Spillovers to the Domestic Sector?' *Applied Economics Quarterly*, 52, 3-28.

Driffield N and Love J H (2007) ‘Linking FDI Motivation and Host Economy Productivity Effects: Conceptual and Empirical Analysis’, *Journal of International Business Studies,* forthcoming.

Driffield N, Love J H and Taylor K (2005) ‘Productivity and Labour Demand Effects of Inward and Outward FDI on UK Industry’, Aston University Working Paper 0511.

Dunning, J.H. (1958), *American Investment in British Manufacturing Industry,* Allen & Unwin, London.

Dunning, J. H. (1979) ‘Explaining Patterns of International Production: in Defence of the Eclectic Theory’, *Oxford Bulletin of Economics and Statistics,* 41, 269–95.

Dunning, J.H. (1998) ‘Location and the multinational enterprise: a neglected factor?’, *Journal of International Business Studies,* 29, 45-66.

Falvey R, Foster N and Greenaway D (2004) ‘Imports, exports, knowledge spillovers and growth’ *Economics Letters*, 85, 209-213.

Feenstra, R.C. and Hanson, G.H. (1999) **‘**The Impact of Outsourcing and High-Technology Capital on Wages: Estimates for the United States, 1979-1990’, *Quarterly Journal of Economics*, 114, 907-40.

Fosfuri, A. and Motta, M. (1999) ‘Multinationals Without Advantages’, *Scandinavian Journal of Economics*, 101, 617–30.

Fosfuri, A. Motta M and Rønde, T (2001), ‘Foreign Direct Investment and Spillovers through Workers’ Mobility’, *Journal of International Economics,* 53, 205-222.

Girma, S.; Wakelin, K.(2001) ‘Regional Underdevelopment: Is FDI the Solution?’, GEP Research Paper 2001/11, University of Nottingham.

Girma, S. (2005) ‘Absorptive Capacity and Productivity Spillovers from FDI: A Threshold Regression Analysis’, *Oxford Bulletin of Economics*, Vol. 67(3), 281-306.

Görg, H. and Greenaway, D. (2004) ‘Much ado about nothing? Do domestic firms really benefit from foreign direct investment?’ *World Bank Research Observer,* 19 (2), 171-197.

Görg, H. and Strobl, E. (2001) ‘Multinational Companies and Productivity Spillovers: A Meta-analysis’, *Economic Journal*, 111, F723–F39.

Görg, Holger and Hanley, Aoife (2005), “International outsourcing and productivity: evidence from the Irish electronics industry” *The North American Journal of Economics and Finance,* vol. 16(2), pp 255-269.

Grossman, G. and Helpman, E. (1991). *Innovation and Growth and Growth in the Global Economy,* MIT Press, Cambridge, MA.

Grünfeld, L and Sanna-Randaccio, F. (2006) Who buys whom in international oligopolies with FDI and Technology transfer**?**. Presented at EARIE, Amsterdam.

Harris, R. (2002) ‘Foreign Ownership and Productivity in the United Kingdom – Some Issues When Using the ARD Establishment Level Data’, *Scottish Journal of Political Economy,* 49(3): 318–335.

Harris, R. and Robinson, C. (2002) ‘The impact of Foreign Acquisitions on Total Factor Productivity: Plant Level Evidence from UK Manufacturing, 1987-1992’, *Review of Economics and Statistics,* Vol. 84(3), 562-568.

Haskel, J., Pereira, S. and Slaughter, M. (2002) ‘Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms?’, NBER Working Paper 8724.

Hejazi W and Pauly P (2003)’Motivations for FDI and domestic capital formation’, *Journal of International Business Studies*, 34, 282-289.

Hejazi, W. and Safarian, A. E. (1999) ‘Trade, Foreign Direct Investment, and R&D Spillovers’, *Journal of International Business Studies,* 30, 491–511.

Hijzen, A., Görg, H. and Hine, R. C. (2005) ‘International Outsourcing and the Skill Structure of Labour Demand in the United Kingdom’, *Economic Journal,* 115, 860-78.

Hood, N. and Young, S. (1979), *The Economics of Multinational Enterprise,* Longman.

Javorcik, B. Smarzynska (2004). ‘Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages’, *American Economic Review,* 94(3): 605-27.

Keller, W (1998) ‘Are international R&D spillovers trade-related?’ *European Economic Review,* 42, 1469-1481.

Keller, W. (2000). ‘Do Trade Patterns and Technology Flows Affect Productivity Growth?’ *World Bank Economic Review,* 14 (1): 17-47.

Keller, W (2004) 'International technology diffusion', *Journal of Economic Literature*, 42, 752-782.

Keller, W. and Yeaple, S. (2003) 'Multinational Enterprises, International Trade and Productivity Growth: Firm-Level Evidence from the United States', CEPR Discussion Paper 3805.

Kogut, B. and Chang, S. J. (1991) 'Technological Capabilities and Japanese Foreign Direct Investment in the United States', *Review of Economics and Statistics*, 73, 401–13.

Lichtenberg, F. R. and van Pottelsberghe de la Potterie, B (1998) 'International R&D spillovers: a comment' *European Economic Review*, 42, 1483-1491.

Lumenga-Neso, O, Olarreaga M, and Schiff M (2005) 'On 'indirect' trade-related R&D spillovers', *European Economic Review*, 49, 1785-1798.

Marin, D. (2006) A New International Division of Labor in Europe: Outsourcing and Offshoring to Eastern Europe. *Journal of the European Economic Association*, forthcoming.

Mayer, Jörg. (2001) 'Technology Diffusion, Human Capital and Economic Growth in Developing Countries', UNCTAD Discussion Paper #154, UNCTAD Geneva.

Neven, D. and Siotis, G. (1996) 'Technology Sourcing and FDI in the EC: An Empirical Evaluation', *International Journal of Industrial Organization*, 14, 543–60.

Oulton, N. (1997) 'Total Factor Productivity Growth and the Role of Externalities', *National Institute Economic Review*, 162: 99–111.

Oulton, N. (1996) 'Increasing Returns and Externalities in UK Manufacturing: Myth or Reality?', *Journal of Industrial Economics*, 44(1): 99–113.

Oulton, N. (2001) 'Why do Foreign-Owned Firms in the UK Have Higher Labour Productivity?', in N. Pain (eds) *Inward Investment, Technological Change and Growth: The Impact of Multinational Corporations on the UK Economy*, Palgrave: Basingstoke, pp122-161.

Pain, N (1993), 'An econometric analysis of foreign direct investment in the United Kingdom', *Scottish Journal of Political Economy*, 40, 1-23.

van Pottelsberghe de la Potterie, B. and Lichtenberg, F. (2001) 'Does Foreign Direct Investment Transfer Technology across Borders?', *Review of Economics and Statistics*, 83, 490–97.

Rivera-Batiz, L. and Romer, P. (1991) 'Economic Integration and Endogenous Growth', *Quarterly Journal of Economics*, CVI, pp. 531-555.

Romer, P. (1990). 'Endogenous Technological Change', *Journal of Political Economy*, 98 (5), S71-S102.

Siotis, G. (1999) ‘Foreign Direct Investment Strategies and Firms’ Capabilities’, *Journal of Economics and Management Strategy*, 8, 251–70.

Xu, B. and Wang, J. (1999) ‘Capital Goods Trade and R&D Spillovers in the OECD’, *Canadian Journal of Economics*, 32 (5), pp. 1258-1274.

Appendix: Data and Sources

The Annual Respondents Database

The ARD contains two files: ‘selected’ and ‘non-selected ’. The former contains detailed information on a sample of plants that are sent inquiry forms and respond or have their responses imputed, while the latter file comprises non-sampled or non-response plants for which only basic information such as employment, location, industry grouping and foreign ownership status are recorded. In common with most users of these data, Haskel and Heden (1999), Girma and Wakelin (2001), Oulton (2001), we focus on “selected” establishments only, that is, those required by law to fill in a return for the ONS. Data on between 14,000-19,000 establishments across all manufacturing are provided in the selected file annually based on a stratified sampling methodology. These plants account for around 90% of total UK manufacturing. Though the sampling frame may vary from year to year, establishments with more than 100 employees are always sampled while smaller businesses are sampled randomly.

In the ARD, an establishment is defined as the smallest unit which can provide the full range of data required for the Census questionnaire. It is possible for an establishment to consist of several local units which is defined as a ‘plant’ or office operating at a single mailing address. Because some of these offices are spread across several sites, they are not plants in the strict sense of the word. In about 80% of all cases however, a business unit is located entirely at a single mailing address (Criscuolo and Martin, 2005). Therefore, most of the data from the ARD used in this study are in effect plant level data. Consequently, in this paper we use the terms establishments and plants interchangeably. A ‘parent’ establishment reports for more than one plant or local unit. Thus for multi-plant establishments the data are aggregate values for the constituent plants.

Table A1: Countries in Panel

Australia
Austria
Belgium
Brunei
Bulgaria
Canada*
China*
Cyprus
Czech Republic*
Denmark
Finland
France
Germany
Greece
Hong Kong
Hungary*
Iceland
Indonesia*
Irish Republic
Italy
Japan
Malaysia
Malta*
Netherlands
Norway
Philippines*
Poland*
Portugal
Romania
Russia
Serbia & Montenegro*
Singapore
South Korea
Spain
Sweden
Switzerland
Taiwan
Thailand*
Turkey
USA
Vietnam*

* trade partner country only, no FDI into UK

Table A2. Sectors in Panel

Sectors (ISIC 3 codes)
Food, Drink and Tobacco (15+16)
Chemicals (24)
Metal Manufacturing (27)
Mechanical & Instrument Manufacturing (29+33)
Transport Equipment exc. Vehicles (35)
Vehicles (34)
Textiles, Leather and Clothing (17+18+19)
Paper, Printing and Publishing (21+22)
Rubber & Plastics (25)
Electrical Engineering (30+31+32)
Other Manufacturing (20+26+28+36+37)

Table A3: Variable definitions and data sources

Variable	Definition	Source
Q_{it}	Total Manufacturing Real Gross Output. Deflated by 4-digit producer price index.	ONS-ARD; ONS
K_{it}	Real Capital stock	ONS-ARD
L^s_{it}	Employment of operatives	ONS-ARD
L^u_{it}	Employment of non-operatives	ONS-ARD
MAT_{it}	Materials. Real intermediate inputs deflated by 4-digit material price index	ONS-ARD
AGE_{it}	Age of plant	ONS-ARD
MKT_SHARE_{it}	Market Share. Measured as plant output as a share of 4-digit industry output.	ONS-ARD
$HERF_{it}$	Herfindahl-Hirschman Index..Sum of the squares of market shares.	ONS-ARD
RD_{it}	R&D expenditure	ANBERD
RDI_{it}	RD/Q	ANBERD/STAN
$INWARD\ (1)_{it}$	FDI where $RDI_{UK}>RDI_F$ and $ULC_{UK}< ULC_F$	ONS/ANBERD/STAN
$INWARD\ (2)_{it}$	FDI where $RDI_{UK}>RDI_F$ and $ULC_{UK}> ULC_F$	ONS/ANBERD/STAN
$INWARD\ (3)_{it}$	FDI where $RDI_{UK}<RDI_F$ and $ULC_{UK}< ULC_F$	ONS/ANBERD/STAN
$INWARD\ (4)_{it}$	FDI where $RDI_{UK}<RDI_F$ and $ULC_{UK}> ULC_F$	ONS/ANBERD/STAN
$IMPORT\ (1)_{it}$	Imports where $RDI_{UK}>RDI_F$ and $ULC_{UK}< ULC_F$	ONS/ANBERD/STAN
$IMPORT\ (2)_{it}$	Imports where $RDI_{UK}>RDI_F$ and $ULC_{UK}> ULC_F$	ONS/ANBERD/STAN
$IMPORT\ (3)_{it}$	Imports where $RDI_{UK}<RDI_F$ and $ULC_{UK}< ULC_F$	ONS/ANBERD/STAN
$IMPORT\ (4)_{it}$	Imports where $RDI_{UK}<RDI_F$ and $ULC_{UK}> ULC_F$	ONS/ANBERD/STAN
MES	Minimum Efficient Scale. Log of the median output of industry j.	ONS-ARD

Sectoral producer price deflators and OECD purchasing power parity deflators were employed in calculating relative R&D intensities across countries. All estimations carried out in log form.