Is FDI the most important source of international technology transfer? Panel Data evidence from the UK

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Abstract

This study examines the different sources of international technology transfer to 205 UK industries in a panel running from 1979-1991. FDI is found to be more important than trade in the transfer of knowledge to UK industries. The estimated elasticities have a range; in the static model that looks at the long run relationship between FDI and value added the estimated elasticity is 0.24.

Keywords: Panel Data, FDI, technology transfer, spillovers

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1. INTRODUCTION

Endogenous and classical growth theories have a role for technology in promoting economic growth. It then becomes necessary for economies to have policies that promote technology transfer. Technology is key to economic development (United nations Conference on Trade and Development (UNCTAD) 1992, pp.53). Innovation and technology diffusion is important for growth (Organisation for Economic Co-operation and Development (OECD) 1991). Much as domestic efforts can enhance technology advancement, foreign sources can also contribute through FDI and trade.

There is some degree of non-excludability in knowledge, so benefits can accrue to entities that are external to the advancement or development of new techniques of production and management. Spillovers occur if knowledge transfer is not fully compensated. Knowledge can diffuse through different avenues as will be discussed in section 2. [1]

In the face of ageing populations in developed countries, putting considerable strain on public funds and the reductions of active labour force. Technology advancement not only increases output pa capita but also maintains tax revenues.

The research problem is centered on two questions. Is their evidence in the data to suggest FDI has exceeded trade in promoting technology transfer? Is the transmission of such knowledge instantaneous; or does it appear in a distributed lag structure?

This study can be seen as an addition to the literature investigating Spillovers from FDI, learning by exporting and imports penetration. The contrasting aspect; from the closest of the studies using industrial level data for the UK- Liu *et al* (2000) was more concerned about bi-directional spillovers first considered by Kokko (1996) and did not consider international trade. In addition, the different time period; 1979-91; is believed to have signified increased openness and the restructuring of British industry after the slump of

[1] See Keller (2001); Gorg and Greenaway (2001); Blomström and Kokko (1998)

the 1970s; it can offer fruitful evidence on the existence of transfers as well as the relative importance of different sources. [2]

Greenaway *et al* (1999); while investigating the impact of trade on employment; assumed technical efficiency to be correlated with trade changes. FDI is considered as one of the determinants of technical efficiency. Although these studies investigate different issues not considered here, they are related to this research because they use industry level data for the UK, and together motivate the economic model on which this study is based. The specification that productivity can be estimated by a time trend, import penetration and export propensity is augmented by incorporating FDI as one of the sources of productivity growth.

The purpose of this study is to verify whether FDI is the most important avenue for accessing foreign technology, using industry level panel data from the Census of Production for 205 four-digit industries in the UK. UK is one of the leading participants in trade, as well as a major host of FDI. Another advantage is that transfers are not limited by policy restrictions, as well as the absorptive capacity in Britain that is one of the industrialised countries in the world. In the analysis of transfers in developing countries such limitations are critical; OECD (1998). Policy relevance: Should the UK focus on FDI promotion or trade promotion in attempting to enhance productivity growth?

In the next section a rather extensive literature is surveyed, section 3 discusses the data, economic model as well as the panel data modeling framework. The results are presented in section 4 and

2. LITERATURE REVIEW

2.1 Import spillovers and R&D regressions

International trade and Foreign Direct Investment (FDI) can cause passive spillovers by enhancing trade in intermediates. Active spillovers occur through personal contacts and

[2] See Griffith (1999a) for the advantages of investigating spillovers in this period and Davies and Caves (1987) for an analysis of the relative gap in technology in British industry relative to the US.

reverse engineering. The contemporary view of technology in endogenous growth theories renders it an important determinant of cross-country incomes[3]. Passive spillovers may be localised because of the spatial structure of international trade. "At the broader level, international activity such as; importing, exporting or FDI might also help to establish and sustain channels of communication that stimulate cross-broader learning of production methods, product designs, organizational methods, consumer preferences and market conditions" Keller (2001). He also presents evidence on R & D regressions that suggest existence of substantial contributions of foreign technological activity to domestic productivity.[4]

Coe and Helpman (CH) (1995); analysed the Total Factor Productivity (TFP) elasticity of domestic and foreign R&D. For small-industrialised countries foreign R&D had large positive effects, and was also more pronounced for G7 countries that are closer to the world's technology frontier. Foreign R&D; was augmented by large shares of imports; rendering international trade a catalyst for technology transfers. In the CH specification imports are horizontally or vertically differentiated embodying foreign technology. This is contrary to the competitive channel, where they are regarded as a source of competition for local firms that may improve x-efficiency. However, when imports were included as explanatory variables the elasticity was negative, which does not rule out the possibility of adverse competition, or in case of developing countries; inappropriate technology that cannot be absorbed fully; this leaves the sign of the coefficient on imports ambiguous. Coe *et al* (1997) found similar results for imports from industrialised to less developed countries. [5] .

However, once distance is controlled for; bilateral imports fail to predict patenting activity; Eaton and Kortum (1996). In addition, Keller (1998) repeats the CH analysis with counterfactual import shares that cast doubt on the evidence of spillovers, although

[3] Romer (1980); Grossman and Helpman (1995)
[4] See Grilliches (1992) for a survey.
[5] More recent work and the debate on which weights to use as well as contradictory evidence are discussed in Keller (2001)

this approach is not without flaws[6]. Xu and Wang (1999), find a robust effect by considering capital goods trade, so does Sjoholm (1991) who found a positive correlation between Swedish patent citations and bilateral imports; Keller (2001).

The above studies are limited by the analysis that considers only one channel of technology diffusion. Hejazi and Safarian (1999) find evidence that FDI is more important than trade in spilling know how, proxied by their R&D; of the G6 countries amongst OECD countries. The spillovers increase significantly when FDI is included in the analysis. It is therefore necessary to investigate this evidence at a more disaggregated level and it is this gap that this study hopes to fill. They add that; studies that concentrate on trade underestimate the extent of spillovers. How far true this is; is a question to be resolved by further empirical evidence. They argue that a country can improve its productivity through imports of intermediates and capital goods. In other studies that assess intra-industry spillovers; imports are a source of competition that may lead to productivity leaps to protect markets. Whichever way we look at it we expect the imports impact on productivity, regardless of whether they are vertical or horizontal to be positive due to either competition or embodiment of foreign technical know how. However, there might be exceptions to the rule; Aitken and Harrison (1991).

Xu and Wang (2000); also consider multiple channels including outward FDI, on the contrary; they find no evidence for inward FDI having any lasting effects on productivity among industrialized countries. However, they find strong empirical support for capital goods trade as a conduit for spillovers; an allowance is made for a technology gap effect.

2.2 Export spillovers

It has been argued that firms' productivity can improve when they become exporters due to foreign competition, economies of scale and buyers' instructions. Although the literature consistently finds exporters to be more productive; the evidence on learning by exporting is still slim as reported by Girma *et al* (2002); Keller (2001).

Clerides *et al* (1998) argue that exporters' efficiency over non-exporters is a result of self-selection as opposed to learning through exporting. However, Girma *et al* (2002) find

[6] Keller (2001) citing Coe and Hoffmaister (1999)

evidence in support of the learning hypothesis using matching techniques for UK firms; they also provide a comprehensive review of the evidence in the literature. They conclude that evidence on the learning hypothesis is scant citing Kraay (1999), Catellini (2001) as supporters of the learning hypothesis, while Bernard and Jensen (1995) (1999), Bernard and Wagner (1997), Aw and Hwang (1998) fail to find any evidence. This study incorporates export propensity as a conditioner of productivity; alongside imports and FDI. It may also provide some evidence on the existence of learning by exporting transfers of technology at the industry level, although such evidence is suspect when issues like self-selection are considered.

2.3 FDI spillovers

Another potential avenue for international technology diffusion is FDI through several channels like: demonstration and imitation, competition, linkages, training and market access. Caves (1974) pioneered work that examines this channel. Absorptive capacity, policy and technology gap might be important in determining the rate of diffusion.[7] Negative effects are also possible due to competition Aitken and Harrison (1991).

Earlier studies for the UK analyse channels for FDI spillovers, and its spatial nature relative to absorptive capacity and technology gap; Gorg and Greenaway (2001). Other studies look at the labour market impact and deal with issues such as wage differentials. The focus here shall be on the relative importance of transfer channels. Are the large incentives offered to companies to locate in the UK justified? Is FDI more important than traditional trade in the transfer of technology across borders? These questions have been addressed in the literature at the macro level and but not at the micro level.

[7] See Findlay (1978); Glass and Saggi (1998); Wang and Blomström (1992) and a review by Gorg and Greenaway (2001) for intra industry spillovers.

Table 2.1 spillover channels

Driver	Source of productivity Gain
Imitation	• Adoption of new production methods • Adoption of new management practices
Competition	• Reduction in x-inefficiency. • Faster adoption of new technology
Human Capital	• Increased productivity of complementary labour • Tacit knowledge
Export	• Scale economies • Exposure to technology frontier

Source: Gorg and Greenaway (2001)

Caves (1974) examined the benefit of FDI in the manufacturing sectors of two leading host countries at the time; Canada and Australia. He reasoned that the rate of technology advancement is faster in domestic firms linked horizontally or vertically to foreign firms. Industries must be fully efficient and must still be enjoying abnormal profits in order for the spillovers to occur. Foreign firms possess firm specific knowledge that enables them to compete in the local market: Brands, organizational skills and higher productivity. Firms may tolerate dynamic or static inefficiency where the former is associated with a lag in the adoption of process innovations established elsewhere. FDI may be influential in making laggards realize how far or slow they are in adoption of new technologies directly or indirectly. The Canada results were inconclusive due to data limitations, signaling insignificant diminishing gains from FDI in a quadratic functional form. However, he found evidence for spillovers in the Australian manufacturing sector.

Spillovers occur if local firms do not fully pay for the knowledge they acquire from MNCs. "The host nation's private sector does not benefit directly because the foreign subsidiary is efficient or brings to its shores skilled entrepreneurship or productive knowledge. Rather its gains depend on spillovers of productivity that occur when the multinational corporation cannot capture all quasi-rents due its productive activities, or the removal of distortions by the subsidiary's competition pressure" Caves (1974); other possible benefits include technical efficiency and technology transfer.

Globerman (1979); found labour productivity in Canadian manufacturing plants positively correlated with foreign ownership[8]. In addition to efficiency improvements other benefits may accrue from the migration of workers trained by foreign firms. On the downside; the centralization of substantive managerial decision making in the parent firm, may lead to a net outflow of skilled manpower to the home countries of MNCs.
Many studies have sought to verify or refute these findings using different methodology and are reviewed in Gorg and Greenaway (2001). The question of whether FDI is the most important source of international technology transfer, presupposes the knowledge that international to trade is a competing avenue in the literature for this purpose. In, addition FDI flows have exceeded trade in many countries. In the past, foreign technology was mainly accessed using export oriented or import substitution strategies, East Asia for the former and Latin America for the latter. So the competing avenues are promotion of imports as uncomfortable as this sounds, exports or attracting FDI. Which of these is the most important? Is what we don't know? Theoretically host companies can eliminate x-inefficiency due to import penetration and competition from foreign firms.

The justification for expecting spillovers is that foreign firms locate in industries with high barriers to entry. They destabilise collusions and boost competition that may improve x-efficiency; hence innovations and improvements in productive activities of local firms. Caves (1974); Blomström and Kokko (1998).

[8] Blomström and Persson (1983); using similar methodology found similar results for Mexico. It can also be noted that these studies though path breaking are limited by measuring technology using labour productivity and therefore do not control for differing capital intensities.

The rationale of FDI is usually to maximise gains from intangible proprietary knowledge, which may include the latest technology. Mansfield and Romeo (1980); found that affiliates received technology of a lesser vintage than that sold, an average of 5.8 (9.8 years for developing countries) whereas that through licensing and joint ventures averaged 13.1 years. It is difficult to establish whether spillovers exist using industry level data due to composition, other avenues for transfer of knowledge not considered include; free international transactions in consulting services, international licensing of technology.

In a review of the literature on MNCs and spillovers Blomström and Kokko (1998) conclude that the evidence on the extent and magnitude of spillovers is inconclusive. The extent of spillovers is likely to depend on local capability and competition. In addition, market access spillovers may exist because MNCs often posses competitive advantages in entering world markets. MNCs remove doubt on new technologies untested by local firms and therefore speed up the adoption of new technologies.

Blomström and Kokko (1998) provide an extensive review of the channels of spillovers. On the downside, MNCs might out-compete dynamically inefficient firms and create more concentrated structures associated with x-inefficiency alongside profit repatriation and transfer pricing. MNCs may transfer technology intensive plants to more technology able countries hence leading to negative externalities of technological erosion. This could explain the exodus of UK firms to east Asia which not only offers cheap labour but it is also a technically competent continent owing to its participation in export markets, the evidence on productive superiority of export oriented industries is well documented in Girma *e t al* (2002).

Blomström and Kokko (1998); argue that foreign presence may increase technology transfer and diffusion, by breaking supply bottlenecks, demonstrating new technologies, training new workers, breakdown monopolies and stimulate competition. In addition, force local firms to improve managerial and organizational skills. Inter-industry spillovers may occur through backward and a forward linkages, that is, foreign firms may help prospective suppliers to set up production facilities, may provide information on recent product designs alongside technical assistance. MNCs may affect the industry

structure; On the one hand, concentrated industries may carry out more Rand D for survival in the rough competitive environment and hence speed up the process of technology transfer. While on the other hand less productive firms may be kicked out if the cannot handle the competition, which may aggravate the composition problem.

Gorg and Greenaway (2001) review the literature on intra-industry spillovers and conclude that the evidence is weak. They identify four channels of productivity spillovers presented in table 2.1 adopted from their review. Imitation; skills acquisition; competition; enhanced export propensity. They cite Liu *et al* (2000) and Damijan *et al* (2001) as the only studies with positive results using panel data. The former could have simply picked up composition effects rather than spillovers. That leaves only one study using panel data at an appropriate level of aggregation to find evidence for spillovers.

Keller and Yeaple (2003) find FDI to be stronger than imports in improving productivity of 1100 US manufacturing firms for the years 1987-96. FDI accounts for 14% of productivity growth. This is only the second paper using firm level panel data with significant spillovers. The authors attribute this to improved measurement of foreign multinational activity.

Reasons for lack of evidence could be adverse competition in both products and labour markets. The wage gap between MNCs and local firms may attract the best workers hence mitigating any gains from FDI. MNCs may be very effective in locking in their knowledge. Domestic firms may fail to improve if due to low absorptive capacity or low skilled workers, Gorg and Greenaway (2001). In a nutshell, it is clear that evidence on panel data for firms is scarce. It can be argued that developed countries like the UK could have already exhausted diminishing spillovers from FDI.

Industry studies could simply pick up a composition effect of the truncated distribution of foreign firms that locate in the UK, only the more productive firms location in the UK; Griffith (1999b). This is sad news for spillover searches using aggregated data but not very sad news for those investigating technology transfer.

Regardless of whether it is composition effect if TFP or labour productivity of industries is positively related to foreign presences then the distributions of technology of different

countries are indeed getting closer. The benefits associated with high productivity still accrue to a country among which is maintaining exports that are a fount of foreign exchange, increased employment in case of Greenfield FDI and efficient allocation of resources. It may indirectly mean that a country is already technically able and thus has nothing to learn from foreign firms that may have located there to tap into the technology of the host rather than spill theirs.

2.3.1 Evidence from developing countries

Haddad and Harrison (1993) examined data for Moroccan manufacturing industries but find no positive spillovers. This casts doubt on the hypothesis that backward countries may benefit more from FDI. On the contrary, the more advanced a country is or the firm in terms of skilled labour which is assumed proportional to absorptive capacity the higher the technology transferred.

Byun and Wang (1995); Skilled people usually become entrepreneurs after being trained by multinational corporations. Presenting Korea's case they argue that the competing avenues should be treated as compliments rather than substitutes, they conclude that certain advanced technologies are simply not available through means other than FDI. They single out the semi conductor industry as a case in point and assert that FDI will remain an important vehicle in the international transfer of technology.
Theoretical contributions have asserted the importance of a gap for spillovers to occur; Wang and Blomström (1992), contradictory findings may be due to differing characteristics of the hosts. Analyzing data for Mexican manufacturing industries in 1970; Kokko (1994) argue that gaps alone don't constitute obstacles to spillovers but enclave industries where gaps and large foreign shares coincide may explain. He concludes that local countries should encourage FDI in industries where local capability is already strong.

Liu and Wang (2002) analyse the impact of FDI on TFP for a cross-sectional sample of the Chinese industrial sectors with positive results. They conclude that attracting FDI is significant way of capturing advanced technologies. They give a creditable and interesting exposition on the theoretical explanations of FDI industrial organization**,**

international trade and endogenous growth theories. All of which are potential justifications for expecting spillovers.

Most Micro studies consider only one channel of spillovers that may be a source of omitted variable bias. One of the exceptions is, Co (1999) who analysed the impact of FDI and imports from a panel of 448 US manufacturing industries for the period 1982-1990. The paper considers the endogeneity of concentration levels, non-Greenfield FDI affects margins positively and the effects depend on the level of industry concentration. This study identifies the potential for imports' competitive displine. Imports have a large competitive effect in high concentration industries that need displining.

2.3.2 Evidence from the UK

Liu *et al* (2000) examine intra-industry spillovers in 48 industries in the period 1991-1995. They find positive spillovers whose benefits depend on the technology gap measured as the ratio of labour productivity in foreign owned firms to that in locally owned firms. Spillovers are higher the smaller the gap, which is a testimony in favour of absorptive capacity as a key determinant of the extent of spillovers.

Girma, Greenaway and Wakelin (2001) find no evidence of intra-industry spillovers in 4000 UK firms for the period 1991-1996. Firms with low skill and competition gain less from foreign firms. However, they find that a productivity gap exists between foreign and local firms. This could be due to a truncated distribution of high productive foreign firms but not necessarily drawn from a superior technology distribution to that of UK firms. The productivity gap is largely explained by inputs choices and intermediates in the UK car industry; Griffiths (1999). However, this may not necessarily generalize to all industries.

Driffield (2001) find no evidence for spillovers while Harrison and Robinson (2001) suggest that inter- industry spillovers are more prevalent than agglomeration and intra-industry spillovers. In addition, the benefits of FDI may be localized

3. METHODOLOGY

3.1 Data

The data was collected from the UK Census of production.[9] The level of aggregation is the four-digit level with 1980 as the year of classification the dataset contains 205 industries for the years 1979-1991. It is an unbalanced short panel; each industry has varying numbers of observations minimum period one year and the average is 12 years but 75% of the industries have a full balanced panel.

The dependent variable is Value added, as defined in the special report of the census of production 1986 explanatory notes and glossary, Value added or net output is the gross output minus cost of purchases of materials for use in production, packaging and fuel. Purchase of goods for merchanting or factory cost of industrial services received. The result of this deduction is adjusted for net duties and levies; purchases are adjusted for changes of stocks, materials, stores and fuel during the year. This dependent variable has the advantage of mitigating bias caused by different use of inputs.

The other variables are export propensity, import penetration, capital expenditure and number of employees in the industry. To investigate intra-industry technological gains the share of employment in foreign firms to total industry employment used as a measure of FDI or foreign presence Caves 1974; Aitken and Harrison 1991. Export penetration is the share of exports in production and import penetration is the imports share of apparent consumption.

3.2 Economic model

Assuming a Cobb-Douglas production function with stable long run elasticities; Haddad and Harrison (1991); Griffith (1999b).

$$Y = AK^{\phi} L^{\varphi} \qquad (1)$$

[9] I thank Sourafel Girma for providing this dataset.

Where *K* is capital expenditure, *L* total industry employment, A is a productivity shift or efficiency parameter; productivity growth in a dynamic model; Solow (1957). In this framework FDI, export penetration (x) and import penetration *(m)* are the competing sources of international knowledge that is performance enhancing, but which of them is more pronounced is what the data can tell us, for purposes of aiming policy in the right direction.

$$\therefore A = f(FDI, X, M)$$

More precisely the following functional form is assumed because foreign knowledge has a limit to what amount of knowledge it can bring, and the competing channels can be modelled as factors of production in the context of the endogenous growth theories Romer (1980); Grossman and Helpman (1995).

$$A = FDI^{\delta_1} X^{\delta_2} M^{\delta_3} \qquad (3)$$

An alternative modeling framework would have been to estimate industry productivity using the Olley –Pakes framework; Keller and Yeaple (2002); and estimate the elasticities of *fdi*, *x* and *m*. However, productivity measured as a residual fails to separate the components of the one-way error term; idiosyncratic industry effects as well as the IID error in the regression. It is also difficult to consider the composition effects and the self-selection problem at the industrial level of aggregation that is why investigating spillovers at the industrial level is futile. However this does not affect the comparison of competing avenues of technology transfer. Whether its a composition effect; if the elasticities of the covariates are significant; it is evidence of technology being a function of these factors although it may not mean that spillovers have actually occurred.

3.3 Econometric model

Using 3 in 1 and applying the natural log transformation yields the basic estimating equation lower case letters represent the natural log of the variables defined above

$$y_{it} = \delta_1 fdi_{it} + \delta_2 x_{it} + \delta_3 m_{it} + \phi k_{it} + \varphi l_{it} + e_{it} + \lambda_t \quad (4)$$

$$e_{it} = \alpha_i + u_{it} \quad (5)$$

i Denoting SIC (80) industries and *t*; time. α_i Captures industry heterogeneity such as concentration levels, technology gap and autonomous productivity, u_{it} is the usual IID error term in a regression. λ_t capture shocks that affect all industries at a point in discrete time such as macroeconomic shocks captured by time dummies in a two way error component model, if not included in (4) then it is one way error component model; Baltagi (1995).

The main issue is whether to pool or not to pool, depending on whether industrial specific effects exist; if so then OLS is biased due to omitted variables and the Random Effects (VC) model that treats α_i ~IID $(0, \sigma_\alpha^2)$ is estimated by feasible GLS. However if α_i is endogenous then Fixed Effects (LSDV) that wades it out by the within transformation is more appropriate, although it results in a severe loss of degrees of freedom alongside elimination of some variation within the data. The VC model assumes that α_i are random variables independent of u_{it} and among themselves; at the cost of correlation in the errors of the same cross-section unit and therefore warrants the use of GLS to obtain efficient estimates.

However if some covariates are correlated with the industry specific effect such may be the case for FDI whose effects are dependant on the levels of concentration and technology gap; Liu *et al* (2000); moreover some industries may attract FDI because they are inherently more productive or are concentrated and can only be challenged by multinationals. Exporters are usually more productive before they start exporting and may differ from other firms in the use of capital and benefit from economies of scale that are associated with large foreign markets in this study most of these effects are lumped into α_i which clearly may violate one of the key assumptions of GLS and warrant the use of the fixed effects estimator that removes α_i assumed to be fixed over time.

Fortunately, there are two tests often cited that can aid these distinctions

3.3.1 Breusch Pagan test

It tests whether $\sigma_{\alpha}^{2} = 0$. If rejected then OLS is no longer feasible. The test statistic follows a $\chi_{(1)}^{2}$ distribution.

3.3.2 The Hausman test

$$H_0 : Cov(\alpha_i, X_{it}) = 0$$
$$H_A : Cov(\alpha_i, X_{it}) \neq 0$$

Under the null GLS is consistent and efficient but inconsistent under the alternative. The LSDV estimator is consistent even under the alternative. The test statistic has a χ_{k}^{2} where *k* is the number of covariates.[10]

The model in equation (4) assumes instantaneous gains from FDI, imports and exports. It may take time to observe and copy or feel the competition from FDI and imports; it may also take time to implement foreign buyers' ideas. In case of Greenfield FDI plants may take time to reach their full potential, for non-Greenfield FDI acquirers may take time to implement their plans or invoke efficiency in the laggard firms they acquire. It has been argued that the productivity distributions of local firms may be similar to those of foreign firms only that that the top firms in other countries enter the UK market; the distribution of foreign firm's productivity is truncated and are therefore inherently more productive Griffith (1999), this may be a reason to expect productivity leaps from mere foreign presence of MNCs in the UK, productivity gains may be augmented by spillovers to local manufacturers.

On that note, the analysis in Liu *et al* (2000) can be augmented by considering the lag in transmission of knowledge, as well as more channels of spillovers in the static model. It may be more elaborate to capture the persistence in value added which may be I (1), it can be assumed that the capacity to innovate is enhanced by the existing pool of

[10] These tests are well documented in Liu *etal* (2000); Baltagi (1995)

knowledge. The cave man discovered fire simply out of need, long before FDI or international trade came into existence; this may justify the time trend in Greenaway et al (1999)'s specification whose model is augmented by incorporating FDI alongside trade in a dynamic panel framework.

From (3) becomes

$$A = e^{\delta_0 T} FDI^{\delta_1} X^{\delta_2} M^{\delta_3} \qquad (6)$$

Using (6) in (1); transforming the model by taking logs and differencing the model to remove industry specific effects yields

$$\Delta y_{i,t} = \delta_0 + \sum_j \delta_{1j} \Delta fdi_{i,t-j} + \sum_j \delta_{2j} \Delta x_{i,t-j} + \sum_j \delta_{3j,t-j} \Delta m + \phi \Delta k_{i,t-j} + \varphi \Delta l_{i,t-j} + \sum_j \psi_j \Delta y_{i,t-j}$$

Also controlled for is the persistence in value added, current performance is most likely to be a function of past performance, the relevance of earlier performance with respect to current performance is assumed to lessen with time.

This model is not without flaws; it does not control for wage differentials as well as the technology gap that may me interacted with FDI. In the analysis of firm level data Girma (2001) take the productivity of the 90th percentile firm as the technology frontier and find that Spillovers depend on absorptive capacity. However, this model is based on value added that is not a measure of technology and thus such analysis would require the estimation of industry productivity that would be flawed by composition effects and the inability t o decompose the error components. Concentration levels that proxy the level of competition may also be correlated with the covariates but in this case they are treated as industry specific effects. Possible bidirectional Spillovers or technology sourcing FDI is also not considered.

The random effect model (GLS) is ruled out because the lagged dependent variable is correlated with the industry specific effect. The within transformation takes the individual

specific effects out but still doesn't eliminate the correlation unless the panel is long. In addition the transformed error term is no longer IID.

Differencing introduces correlation between the lagged dependent variable and the unobserved fixed effects in the residual; therefore an IV approach is used. It uses the lags of the endogenous variable dated *t*-2 and earlier as instruments. This method is suggested in the literature by Anderson and Hsiao (1981). However, its execution depends on the relevance of the instruments that can be tested by the Sargan test of over-identifying restrictions. It gives consistent and unbiased estimates as long as the error term is not serially correlated. The chosen instruments are correlated with the differenced lagged dependent variable but uncorrelated with the error term.

4. EMPIRICAL RESULTS

The results presented in table 4.1 are for the static model where the potential benefits from FDI, export propensity and import penetration are assumed to have a long run effect on technology advancement, and hence are implicitly positively correlated with Value Added. In all the estimated equations the top and bottom percentiles in terms of Value Added were eliminated to avoid outliers, which left a total of 190 SIC (80) industries from an original total of 205. The estimated coefficients are all elasticities because all the variables were transformed to their natural log, a part from time dummies. The preferred estimates are those of the LSDV model after looking at the test statistics of the Breush-Pagan LM test and the Hausman (HS) specification test presented in table 4.1.

In table 4.1 the results from the basic model are presented for the different estimation techniques. Column (1); OLS that ignores the panel nature of the data suggests substantial transfers from all channels. The elasticity of value added with respect to FDI is 0.33. It is significant at the 1% level and greater than that of export propensity 0.23 which is also significant at the 1% level. There seems to be evidence for adverse competition from imports.

Column (2) of table 4.1: VC estimates are presented and estimate a 23.9% increase in value added whenever FDI increases by 100% that is quite substantial. The Breush-Pagan Lagrange Multiplier test rejects the OLS model, which implies that there are industry specific effects that cannot be ignored. However it is assumed that the covariates are independent of the fixed effects. This may not be the case since more efficient industries are likely to use more inputs. In addition, the literature suggests correlations between FDI and industry concentration.

Table 4.1

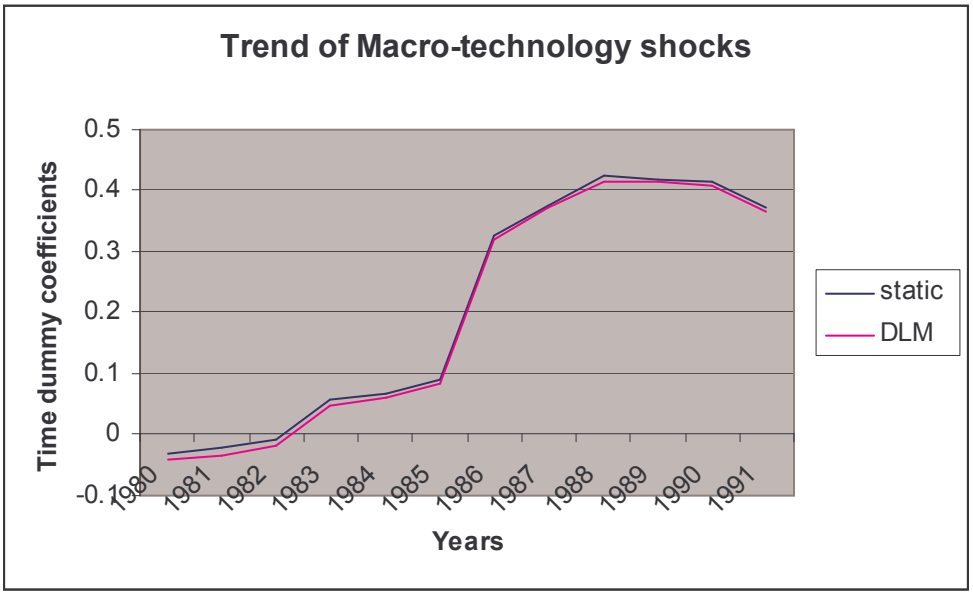
Static model results for a sample of 190 industries, 1979-1991

Dependent variable: Value added

Variables	(1) OLS	(2)VC	(3) LSDV	(4)LSDV with time dummies
Constant	2.860(107.30)**	3.295(67.15)**	4.215(60)**	3.143(51.01)**
fdi	.3322(5.99)**	.2391(3.06)**	.3359(3.82)**	.2388(4.07)**
x	.227(4.55)**	.0463(.751)	-.0016(-.02)	-.0618(-.1.353)
m	-.3763(-7.65)**	.1226(2.42)*	.1886(3.83)**	-.0090(-0.28)
k	.4139(46.98)**	.3301(29.84)**	.2807(24.76)**	.0852(9.74)**
l	.5160(48.15)**	.4319(25.96)**	.1593(6.92)**	.7154(34.86)**
Overall R^2	.8791	.8705	.8232	.8497
NT	2205	2205	2205	2205
Tests		LM	HS	HS
Degrees of freedom		1	5	17
Statistics		2013.69**	589.19**	38.54**

** Significant at the 1% level, *Significant at the 5%.t-ratios in parentheses

Figure 4.1: Trend of technology shocks in LSDV



Column (3) table 4.1; The Hausman statistic is large enough to suggest endogeneity of the industry specific effect therefore VC is inconsistent. The statistically versatile model is the LSDV. In which an increase in FDI by 100% is estimated to raise value added in UK industries on average by 33.59 %(ceteris paribus) and by 23.88% in the model that accounts for Macro-shocks captured by time dummies; Column (4). They are all significant at the 1% level and greater than import displine transfers in Column (3) of 18.86% in case import penetration increases by 100% the impact of imports is also significant at the 1% level. There seems to be no evidence of the learning by exporting hypothesis in the static model.

Table 4.2 Distributed Lag Model (DLM) results for a sample of 190 industries, 1979-1991

Dependent variable: Value added

Variables	(1) VC	(2) LSDV	(3) VC with time dummies	(4) LSDV with time dummies
Constant	3.16(64013)**	3.918(50.76)**	2.893(62.12)**	2.893(62.12)**
fdi	.1479(1.64) c	.3537(3.73)**	.1916(2.98)**	.1168(1.8) c
fdi_{t-1}	.2290(2.38)*	.1499(1.69) c	.2727(4.01)**	.2566(4.02)**
fdi_{t-2}	-.0143(-.017)	-.1287(-1.65) c	-.0675(-1.16)	-.0859(-1.56)
x	-.0966(-1.28	-.0161(-.021)	.0564(1.07)	.0221(0.42)
x_{t-1}	-.2496(-3.02)**	-.3695(-4.75)**	.0468(0.81)	-.0029(-.05)
x_{t-2}	.2521(3.43)**	.0976(1.42)	.0428(0.85)	.0166(.35)
m	.0300(.56)	.1943(3.55)**	-.1606(-4.32)**	-.1161(-3.14)**
m_{t-1}	.0890(1.78) c	.2347(4.53)**	-.2071(-5.79)**	-.1548(-4.32)**
m_{t-2}	.3000(6.00)**	.3457(7.28)**	.045(1.33)	.077(2.37)*
k	.3209(29.72)**	.2657(23.52)**	.1356(15.84)**	.086(9.91)**
l	.4800(28074)**	.2594(10.34)**	.7412(49.31)**	.7127(35.04)**
R^2	.8680	.8105	.8759	.8556
NT	2205	2205	2205	2205
Tests	LM	HS	LM	HS
Degrees of freedom	1	11	1	23
Statistics	2120.88**	1324**	4279.22**	123.91**

** Significant at the 1% level. *Significant at the 5% level. c significant at the 10% level. t-ratios in parentheses

In table 4.2 the estimates from the distributed lag model are presented to ascertain whether technology transfers are more pronounced in such a setting. The discussion is limited to the LSDV model that is statistically preferred owing to the Hausman

specification test in columns (2) and (4). In the one-way error component model column (2) the instantaneous effect of FDI is more pronounced than the lagged effect. The evidence seems to suggest that most of the knowledge that MNCs posses is instantaneously passed on to the industries in which they enter. The estimated gains are larger than in the static model with positive and significant elasticities from current FDI at the 1% level of 0.35 and 0.14 from FDI of the previous year significant at the 10% level. In the two-way error component model; column (4) FDI of the previous year is more pronounced with a positive elasticity of 0.26 significant at the 1% level.

The evidence suggests negative gains from exports of the previous year to a tune of –36.94% when export propensity increases by 100%; this effect is significant at the 1% level. The rest of the coefficients on exports are insignificant. This not only raises the doubt on any gains from exports but also tilts the bout in favour of FDI or imports.

There are significant and positive gains from imports. The Total gains in the three years a whooping 77.47% increase in Value added from a 100% increase in import propensity. However these effects change signs and when time dummies are included. In general we cannot be confident about the gains from trade with such an erratic change in signs of the parameters whenever the estimation technique is altered to yield better estimates.

It can be said that FDI levels are more positively correlated and more consistent in sign and significance with respect to value added as compared to trade. Therefore FDI is more important than trade in transferring technology across borders.

Figure 4.1 shows the estimated time dummies in column (4) of tables 4.1 and 4.2. They suggest that UK industries have experienced positive macro technology shocks since 1983 whose coefficient is positive and significant at the 5% level. The coefficients are negative in the previous years. There after all the time dummies have positive and statistically significant coefficients at t he 1% level. However the economy seemed to have headed for another recess in 1990. When time dummies are included; the coefficient on capital expenditure drops drastically from 0.27 to 0.09 while that on labour increases

tremendously from 0.26 to 0.71, all are significant at the 1% level. An ambitious explanation would be that the inclusion of time dummies helps the sight of the capital expenditure shocks that improve the efficiency of labour tremendously or simply captures possible economies arising from the increased activity in the sample period.

In table 4.3 the dynamic panel suggests the existence of negative gains from imports, significant at the 1% level. As expected value added is highly persistent. FDI and export propensity are insignificant. However, it should be said that the Sargan statistic of the validity of instruments was too large to be reported here. Remedial attempts to yield relevant estimates by including additional potentially exogenous instruments following Anderson and Hsiao (1981) were all futile as the computed Sargan statistic was off the mark by far. This is perhaps due to the irrelevance of the past values as value added evolves. All other instruments like FDI and the factors of production are potentially endogenous and would need to be instrumented in a more elaborate model. A remedy to all these problems would have been the potentially more efficient Arrelano and Bond (1991) estimator but software limitations could not permit. That means that the estimates cannot be relied upon to make any meaningful inference.

Table 4.3 **Results from dynamic model with robust t-ratios** **Dependent variable** Δy_t	
Δy_{t-1}	0.7473(2.43)*
Δfdi_t	-0.1192(-1.13)
Δfdi_{t-1}	.1076(0.83)
Δx_t	-0.1153(-.89)
Δx_{t-1}	.5576(2.19)*
Δm_t	-0.1712(-3.49)**
Δm_{t-1}	-0.3005(-5.18)**
Δk	.0241(1.201)

Δl	.4715(2.35)*
NT	1766

5 CONCLUSIONS AND RECOMMENDATIONS

Due to the flaws in the much anticipated dynamic panel, it seems plausible to rely on the estimates of the long run relationship that suggests FDI to be more important than trade in the transfer of technology across borders. It can be said that the UK government is justified in spending public funds to attract foreign firms, which raise the productivity of industries they enter. Due to technology transfers and the potential competition they bring that upsets collusions often associated with x-inefficiency. The correlation between foreign presence and value added is positive and strong enough to suggest that foreign firms raise the productivity of industries they occupy. This evidence is consistent with other findings that studies using industrial level data find.

However, due to self-selection, the truncated distribution of entrants and composition effects, it is hard to argue strongly for the existence of spillovers, despite sounding like a two-handed economist. It is difficult to separate the technology transfer hypothesis from that of spillovers as noted by Caves (1974). The latter seems to occur as a certainty; so implicitly there are bound to be spillovers for foreign presence to exhibit such influence on value-added.

There seems to be no evidence for the learning by exporting hypothesis, the evidence on import displine is also slim as compared to that of FDI.

This study could be extended by exploiting the implicit evidence on the impact of FDI on derived labour demand alongside trade. An interesting extension would also be to appeal to the latent variable models in micro econometrics that would avoid assumptions about the measurement of technology, and how it enters the Cobb-Douglas production function. Macro econometricians can exploit the VAR literature by arguing that FDI could affect

the level of imports as well as exports and thus the systems short run and long run relationship can be studied without assuming the exogeneity of FDI or trade.

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