Inward Investment And Technical Progress In The United Kingdom Manufacturing Sector

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Abstract

This paper investigates the impact of inward investment by foreign-owned companies on technical progress and hence labour productivity in the UK manufacturing sector. Using an industry-level panel data set we find that foreign-owned firms have a significant positive effect on the level of technical efficiency in domestic firms. There is evidence of significant intra-industry and inter-industry spillovers from inward investment. These findings remain robust even when other factors such as imports and domestic R&D expenditures are allowed for. Inward investment appears to be a much more important source of technical progress than foreign trade. We also find that the impact of inward investment varies according to the nationality of the investing firm.

Keywords: Inward investment, multinationals, technical progress, productivity

JEL Classification: F43, O30.

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1. Introduction

The Competitiveness White Paper issued by UK government in 1998 (DTI, 1998) argues that the creation and exploitation of knowledge are two of the key factors driving the growth process and suggests that foreign direct investment (FDI) is one of the main transmission mechanisms behind the diffusion of knowledge, both codified and tacit, across national borders. Previous Competitiveness White Papers had also suggested that the high level of inward investment into the UK during the 1980s helped to encourage the transfer of innovative production and managerial techniques to UK-owned companies. The potential importance of multinational companies is emphasised in the literature on endogenous growth (Romer, 1993) and supported by recent empirical evidence that international openness has helped to raise economic growth in the UK (Proudman and Redding, 1998; Barrell and Pain, 1997). The location of economic activity could thus be an important endogenous influence on national growth prospects.

The total stock of inward direct investment in the UK rose from 10½ per cent of GDP in 1978 to 25 per cent of GDP by 1998. In the manufacturing sector the stock of inward investment rose from 18¾ per cent of gross value added to 38½ per cent over the same period. This expansion of inward investment coincided with a pick-up in the growth of labour productivity, particularly in the manufacturing sector, where output per employee hour rose by 4 per cent per annum on average between 1981 and 1996, compared to 2.8 per cent per annum between 1966 and 1981. Our objective in this paper is to assess the arguments put forward in the Competitiveness White Papers by undertaking an econometric study of the effect of inward investment in a number of different UK manufacturing industries on technical progress in UK-owned companies, and hence labour productivity and economic growth. The manufacturing sector is chosen because industry level information on inward direct investment can be matched by information on the activities of foreign-owned firms from the *Census of Production*.

Popular discussion of inward investment and the focus of investment promotion agencies tends to centre around the gross number of jobs believed to be created or safeguarded by such investments. Whilst this can be of obvious importance for particular regions, for the economy as a whole it is arguably not an appropriate way of assessing the benefits of inward investment. For instance, account needs to be taken of possible displacement effects on domestic employment from the presence of foreign firms (Driffield, 1999). More fundamentally, differences in industrial structure because of inward investment do not provide evidence that the incomes of UK residents have been raised above the levels they would otherwise be at in the absence of any such investments. In an economy such as the UK with flexible real wages, inward investment should affect only the types of jobs available rather than the quantity, unless it can be shown that it has wider effects on the growth process. There would obviously be significant adjustment costs if all foreign firms suddenly left the economy, but ultimately employment could be expected to recover in the economy as a whole provided the real cost of labour fell. A more appropriate question is whether higher foreign investment raises national income. As technical change, rather than the accumulation of inputs into production, is known to be the main driver of economic growth in most of the advanced Western economies over the past fifty years (Crafts and Toniolo, 1996), it is thus natural to focus on whether inward investment affects technical progress.

The 1998 Competitiveness White Paper cites evidence from an earlier study by Barrell and Pain (1997). That study found evidence that the stock of inward FDI had a significant positive effect on the rate of technical progress in the manufacturing sector using a time series model of labour demand in the aggregate UK manufacturing sector over 1972-95. In this paper we attempt to assess the robustness of this finding by using a more disaggregated panel data set and including a number of other potential determinants of technical progress.

There are a number of important issues that we seek to investigate. First, there is a possibility that the econometric findings for the aggregate manufacturing sector reflect 'batting average' type effects rather than genuine spillovers from foreign to domestic firms; foreign firms in the UK are more productive on average than domestic ones (Pain, 2000) so a rising share of them within the total population of firms will raise the average level of productivity.

Second, the findings for the aggregate manufacturing sector reflect both intra-industry and inter-industry effects from inward investment on domestic firms. However in designing investment promotion schemes it is important to know whether the benefits from inward investment are simply felt by firms within the industry in which investment takes place, or whether there are important spillovers to firms in many different sectors.

Third, it is important to establish whether any estimated impact from foreign investment at the industry level is robust to the inclusion of other potential drivers of technical change. Thus we have also sought to test for potential effects from industry-level data on the volume of merchandise imports and the stock of R&D expenditures on technical progress. Foreign-owned firms now account for a growing proportion of the total R&D undertaken in the UK (Eltis, 1996; Pain, 2000), so that it may be the case that excluding R&D results in effects being attributed to inward investment in general rather than to inward investors who undertake research. Equally, new technologies developed overseas might be transferred directly through imports of machinery and equipment rather than indirectly from the arrival of foreign firms.

Finally there is also the issue of whether the impact of inward investment varies according to the nationality of the investor. If it does, then there are further potentially important implications for the design of investment promotion schemes.

To evaluate these questions we test for an impact from the activities of foreign-owned firms on the behaviour of domestically owned firms in a panel data set of two-digit manufacturing industries. The manufacturing sector is used as it is possible to separate foreign and domestically owned firms at the industry level. The remainder of this paper is as follows. In the next section we outline the basic model used and a number of important econometric issues. Section 3 contains the main empirical results for the impact of inward investment, imports and R&D on technical efficiency. Section 4 contains the results that examine whether the size of spillovers varies according to the nationality of the investor. Some concluding comments are given in Section 5.

2. Methods and Data

Micro-economic evidence from a number of different countries confirms that there can be important spillover benefits for domestic companies from inward investment (Blomström and Kokko, 1998; Blomström *et al*, 2000). Such investments provide a channel through which new ideas, technologies and working practices can arrive in host economies. The potential for such externalities provides one reason why governments and regional development agencies frequently seek to offer investment incentives. Spillovers can arise through many routes, including contact with local suppliers, learning by doing and observation, and the movement of knowledge with workers leaving foreign firms for domestic ones. These may take some time to emerge, but all shift the production possibility frontier of the economy outwards.

There is some indication from qualitative survey evidence that new technologies and standards have been adopted by UK producers as a result of inward investment. In a study of the impact of technology transfer by US multinational companies Mansfield and Romeo (1980) found that over half of the UK-owned firms in their survey had introduced new products or processes more quickly because of a transfer of a new product or process by a US-based firm to its overseas subsidiary, with around two-thirds of the UK firms indicating that their technological capabilities had been raised by such transfers. More recent evidence suggests that inward investment in the UK has continued to bring about a significant improvement in the product quality of suppliers (Dunning, 1988; PACEC, 1995). The recent expansion of motor vehicle production in Britain following new foreign investments also suggests that there may be important continuing spillovers from foreign investment (Griffith, 1999).

Snapshots based on detailed company sector survey data provide a picture of the comparative advantages of foreign firms at particular points in time. A key question left unanswered is whether the build up of foreign investment over time consistently raises the level of labour productivity across the economy as a whole. If foreign firms help to close both idea and object gaps (Romer, 1993), then technical progress is endogenous, providing an explanation and a motive for the efforts made to attract new inward investment.

One common way of investigating the impact of absorbed technology on growth is to look at the determinants of total factor productivity (TFP), using an assumed Cobb-Douglas production function:

$$Q = A L^{\alpha} K^{\beta} \text{ with } \alpha + \beta = 1 \qquad [1]$$

where L, K and A represent labour, fixed capital and an indicator that will pick-up changes in technology and organisational efficiency. Equation [1] can be used to construct an estimate of TFP growth:

$$\Delta\ln(A) = \Delta\ln(Q) - \alpha\,\Delta\ln(L) - (1-\alpha)\,\Delta\ln(K) \qquad [2]$$

with α given by the share of labour in national income. Since the weights on capital and labour are imposed to sum to unity, measures of TFP constructed in this fashion will include any scale economies. They may also include the impact of gradual changes in organisational efficiency that raise the level of output produced with given inputs and technologies. Hence TFP may be very different from technical progress. The constructed measure of TFP can be regressed on a number of factors which are thought to determine it. Coe and Helpman (1995) provide one widely cited example of this approach, with TFP levels related both to domestic R&D and foreign R&D embodied in trade.

There are a number of difficulties with this method. One general problem is that the Cobb-Douglas function imposes an elasticity of substitution of unity. If this is invalid, then the constructed measures of TFP will be biased if a discrete time index is used. Use of a Cobb-Douglas function also forces technical progress to be neutral and excludes the possibility of factor biased technical change. Rodrik (1998) demonstrates that there are significant biases involved in using a Cobb-Douglas function (or its translog relatives) to derive TFP when the elasticity of substitution is less than one and technological change has a labour saving bias. Conventional estimates of TFP, derived from [2], then under-estimate the contribution of technical change, with the extent of mismeasurement rising with the degree of labour-saving bias and the growth of the capital-labour ratio, but falling the closer the elasticity of substitution is to unity.

The TFP calculation also makes the assumption that firms are always on their production frontier. In practice firms face adjustment costs, such as hiring and firing impediments and delays in ordering investment goods. In the short-term, demand fluctuations arising from the business cycle can be met by varying utilisation rates and hours worked, implying that factors such as productivity per head may well vary from time to time across industries and countries for reasons that have nothing to do with technological or organisational advances.

An alternative approach is to allow for endogenous technical progress within estimated dynamic factor demand equations consistent with a particular underlying production structure. In this paper we follow the methodology used by Barrell and Pain (1997) and examine the impact of international linkages on technical change using an estimated labour demand model consistent with an underlying CES production function of the form:

$$Q = \gamma\left[s(K)^{-\rho} + (1-s)\left(Le^{\lambda t}\right)^{-\rho}\right]^{-(v/\rho)} \qquad [3]$$

Here v denotes returns to scale, γ and s are production function scale parameters, and the elasticity of substitution (σ) is given by 1/(1+ρ). Technical progress is assumed to be labour-augmenting at rate λ_t. We assume that labour is appropriately measured in terms of employee hours, rather than by just the number of employees.

The first-order condition that the marginal product of each input should equal its real price can be used to derive a log-linear 'desired' labour demand equation of the form:

$$\ln(L^{*}) = \frac{1+\sigma(v-1)}{v}\ln(Q) - \sigma\ln(w/p) - (1-\sigma)\lambda t + k \qquad [4]$$

where k denotes a constant. The coefficient on the real producer wage (w/p) provides a direct point estimate of the elasticity of substitution, allowing the technical progress parameter(s) and returns to scale to be identified.[1] One additional feature of interest apparent from [4] is that a finding of a unit output elasticity could stem from either a unit elasticity of substitution (σ=1) or from constant returns to scale (v=1). Three restrictions

[1] There is also a 'desired' capital demand equation corresponding to [4] in which capital can be expressed as a function of output, the real user cost of capital and technical progress. Our assumption that technical progress is in fact labour-augmenting can be tested only through joint estimation of the two factor demand equations. This is complicated by the absence of capital stock and user cost data at the two-digit level for foreign and domestic firms. Changes in the capital stock and the user cost will still affect labour demand in [4] because of their effect on output and the price of value added.

are required on [4] to yield a relationship consistent with a Cobb-Douglas production function, a unit elasticity on output and real wages and a zero coefficient on the proxy for technical progress. Imposing these gives a constant factor share (wL/pQ = k). These restrictions can be tested jointly in any empirical exercise using a factor demand relationship of this kind.

Many studies of labour demand typically capture technical progress (λt) either by a deterministic time trend or a stochastic one. The former implies that technical progress is exogenous, rising at a constant rate over time. The latter provides a means of capturing any underlying change in the rate of technical progress, but does not provide an explanation of why it has occurred. However our main interest lies in explicitly testing whether technology transfers and other spillovers from inward investment affect the pace of technical change in domestic firms and hence economic growth. We endogenise technical progress by allowing the level within any given industry to be dependent on various factors, including indicators of the scale of the activities of foreign-owned firms (F), imports (M), the R&D stock (R) as well as an exogenous deterministic time trend (T):

$$\lambda t = \lambda_T T + \lambda_F \ln(F) + \lambda_M \ln(M) + \lambda_R \ln(R) \qquad [5]$$

This specification implies that technical progress will proceed at a constant rate if the key driving factors also grow at a constant rate. The parameters of the technical progress function can be estimated jointly with those of the labour demand schedule by substituting [5] into [4].

We allow for adjustment lags arising from factors such as hiring and firing costs by estimating a dynamic model for employment in which the factor demand expression implied by the combination of the marginal productivity condition [4] and the technical progress function [5] is embedded as the long-run steady-state solution. This has the form:

$$\Delta \ln(L_t) = \beta_0 + \beta_1 \Delta \ln(Q_t) + \beta_2 \ln(L_{t-1}/L^*_{t-1}) + \varepsilon_t \qquad [6]$$

Failure to allow for any cyclical effects would imply the strong assumption that companies always use the minimum inputs necessary to produce a given level of output.

The model was estimated jointly across a number of industries in a panel model with industry-specific fixed effects. Instrumental variable estimators were used both to allow for the endogeneity of current-dated terms in output growth and to allow for the bias that might otherwise result from the inclusion of a lagged dependent variable in a fixed effects model with a comparatively small time dimension.[2] The diagnostic tests described in Barrell and Pain (1999) were used to check the reliability of the panel estimates. Returns to scale are freely estimated in all the models reported here.

Data

Data at the two-digit level on the value added, employment and labour compensation of domestically-owned firms were obtained from the Annual Census of Production by subtracting data on foreign-owned firms from that for the total population of firms.

The long-term trends in the share of foreign-owned firms in the UK manufacturing sector are summarised in Table 1. It can be seen that their share of total output, employment and investment has risen over time. The dominance of US controlled affiliates is clear. They account for over half of the value-added output produced in foreign-owned firms, even though their relative importance has declined over time as the share of Western European and, to a lesser extent, Japanese firms has risen.

Data for foreign-owned firms have been published annually since 1983, but are available only biannually prior to then in official publications.[3] An additional hurdle is that the Standard Industrial Classification has changed over time. Although we experimented with linking SIC(80) based data for 1983-92 onto SIC(92) data for 1993-96 using an unpublished concordance supplied by the Office for National Statistics, we could not reject the presence of a significant structural break in the link year 1993. Hence the

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[2] Higher order lags of employment, output, wages and aggregate manufacturing sector capacity utilisation were used as instruments.

[3] Data for individual establishments are available on the Annual Business Inquiry database maintained by the ONS at Newport (Griffith, 1999), but we have not sought to utilise this source in our present research.

sample used in this paper runs only from 1983-92. We use 15 two-digit industries in all, two of which are formed from the combination of two independent industry groupings. This gives a total sample size of 135 annual observations.

Some summary statistics are reported in Table 2. In each industry it was found that the labour productivity of foreign-owned firms was consistently above that of indigenous firms. The figures also confirm the stylised facts that foreign firms tend to be more capital intensive than domestic firms, with a higher share of non-operatives in their total labour force, and a higher proportion of intermediate inputs.[4] Another potential difference may be scale, with the average size of foreign establishments being larger than domestic ones.[5]

All these factors appear to be important, but cannot account fully for the productivity advantages of foreign-owned manufacturing firms. Oulton (2000) reports that greater usage of non-labour inputs can explain some 61 per cent of the higher labour productivity of US-owned establishments in the UK and 97 per cent of that of other foreign-owned ones. Girma *et al* (2000) find that after accounting for scale and industrial structure the labour productivity of foreign-owned companies between 1991-96 was 10 per cent higher than UK-owned ones, and the level of total factor productivity was 5¼ per cent higher. Both these differences were statistically significant, and considerably larger for US-owned firms than other foreign firms, especially Japanese ones.

Thus it seems clear that there are important firm-specific advantages over and above the scale of operations and the mix of measurable inputs that account for the comparatively higher labour productivity of foreign firms in the UK. These may reflect factors such as

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[4] It might be argued that the reported productivity differentials between domestic and foreign firms at the 2-digit level have more to do with a tendency of foreign firms to concentrate within higher productivity 3 and 4-digit industries rather than a general ownership effect. However Davies and Lyons (1991) show that the ownership effect is bigger than the compositional ('structural' in their terminology) effect and virtually identical whether using 2 or 3-digit level data.

[5] For instance, In 1992 there were 1,507 foreign-owned enterprises in the UK manufacturing sector employing some 784,200 workers and 129,481 UK-owned enterprises, employing 3,584,000 workers.

better organisational efficiency, greater exposure to international competition and the quality of knowledge-based assets.

Time series data on annual hours worked by industry were constructed using information from the *New Earnings Survey* and the benchmark estimates available in O'Mahony and Wagner (1994). Output prices were measured using two-digit producer price indices from the *Monthly Digest of Statistics*. In the absence of any information to the contrary we assumed that prices and hours were similar for domestic and foreign-owned firms in each industry. Data for the volume of imports at 1990 prices were obtained from the *Monthly Review of External Trade Statistics* and the *Annual Abstract of Statistics*, and converted from a SITC(2) basis into a SIC(80) basis. Annual flow data for R&D were obtained from the OECD ANBERD database and converted from the ISIC(2) classification into the SIC(80) basis. They were then deflated by the industry output price deflator. Estimates for the stock were generated by using a moving average of past flows over a nine-year period, assuming an annual depreciation rate of 11 per cent as in Carson *et al* (1994).

3. Results

3.1 Are There Spillovers From Foreign Firms?

The initial set of empirical results are summarised in Table 3. In the first column we report a simple conventional labour demand model which uses only a deterministic time trend as an indicator of technical change. This illustrates that our data set is broadly consistent with the sort of aggregate data set utilised in Barrell and Pain (1997), in that we obtain significant effects from the exogenous trend and the real wage. The elasticity of substitution is estimated to be a little over one-half, and there is some weak evidence of increasing returns to scale. The statistical adequacy of the panel was investigated using a test of first-order serial correlation (as annual data is being used). An auxiliary regression procedure was adopted, with the lagged own-industry residuals being added in as additional regressors.[6] In all the models reported here the coefficient on the lagged

[6] The use of lagged residuals implies that either the estimation period should be reduced by one year or that values should be supplied for 1983, since the estimation period begins in 1984. As the former course would result in the loss of fifteen observations we use the asymptotically valid

residuals was insignificant, suggesting that there is no evidence of significant serial correlation.

In the second column we introduce the lagged total net output of foreign-owned firms in the manufacturing sector (denoted F) as a measure of the scale of their operations. This allows for across-industry spillovers as well as intra-industry ones. Similar results were obtained using gross and net foreign output indicators, and so we summarise results using the latter here. The output of foreign-owned firms is found to be significant, and the size and significance of the coefficient on the deterministic time trend drops noticeably. It is also now possible to accept constant returns to scale, although this restriction has not been imposed in the reported regression. The implied technical progress parameter is large, with a 1 per cent rise in the total output of foreign-owned firms estimated to eventually raise technical progress by 1.05 per cent (standard error 0.44).[7] The exogenous rate of technical change is estimated to be 2.28 per cent per annum (standard error 1 per cent). These results confirm that inward investment has indeed had a positive effect on the performance of domestic firms and reject the hypothesis that the aggregate results reported by Barrell and Pain (1997) are due solely to a ‘batting average’ effect generated by a rising share of high productivity foreign firms within the manufacturing sector.

To investigate whether the externalities from inward investment are felt within the industry in which investment occurs, or whether they spread into many different sectors we split the foreign-output term into two components using a log transformation. Letting ΣF_j denote the total output of all firms:

$$\ln\left(\sum F_j\right) = \ln\left(F_i + \sum_{j \neq i} F_j\right) = \ln(F_i) + \ln\left(1 + \frac{\sum_{j \neq i} F_j}{F_i}\right) = \ln(F_i) + \ln(FS_i) \qquad [7]$$

procedure of setting the pre-sample residuals to zero, their value under the null of no serial correlation.

[7] This can be derived from Table 3 by obtaining the implied long-run parameter on the inward investment term and dividing it through by (1-σ).

The first term captures the within-sector impact of foreign firms, whilst the second allows for spillovers across sectors. The results from re-estimating the models using the two terms instead of the single aggregate foreign output term are shown in the third column of Table 3. Both terms have significant negative coefficients, and although that on the inter-industry spillover term (denoted FS_i) is marginally larger than that on the intra-sector term (denoted F_i), the hypothesis of common coefficients cannot be rejected [Wald(1)=0.07].

The robustness of this finding was checked in an alternative model in which foreign output in other sectors was weighted together using information on purchases of intermediate inputs from the 1990 Input-Output tables. This procedure gives bigger weights to those industries that are important suppliers to each particular industry, and implies that the source of any inter-industry spillovers differs across industries. The effect was to raise the point estimate of the impact of the inter-industry spillover term on technical progress, consistent with the hypothesis that linkages through the supply chain may be more important than other linkages, but it was still not possible to reject equal coefficients on the intra-industry and inter-industry terms.

3.2 The Impact Of Imports and R&D on Technical Progress

There are many other potential sources of technical change apart from inward investment. Two important channels which have been considered in earlier studies (Coe and Helpman, 1995) are domestic R&D and imports. We begin by discussing the results obtained from adding imports into the model used thus far, before describing the final, preferred specification. Rising import penetration is expected to raise technical progress by allowing greater opportunities for the assimilation of foreign technologies.[8]

Technical progress was initially allowed to depend on five different variables, the deterministic trend, the two inward investment terms and two equivalent variables for import volumes. The imposition of a common coefficient on the two inward investment

[8] An alternative argument might be that a rising volume of intra-industry imports is a sign of a lack of international competitiveness amongst domestic producers, with any improvements in labour productivity coming about through labour-shedding. However such effects should be already picked-up in our regressions by conditioning on the volume of output.

terms could not be rejected by the data [p-value 0.36], but the imposition of common coefficients on the import terms was [p-value 0.011]. There was evidence of a significant positive effect from intra-industry imports, but an insignificant one from the import spillover term. The results from including only the intra-industry term in imports (denoted M_i) are reported in the fourth column of Table 3.

These indicate that there are significant effects from both forms of international openness, but that they are much larger from inward investment than from imports. A 1 per cent rise in intra-industry import volumes is estimated to raise the level of technical progress by 0.31 per cent (standard error 0.14 per cent), whereas a 1 per cent rise in intra-industry inward investment raises technical progress by 0.82 per cent (standard error 0.39 per cent). Thus including imports does have an important effect on the other key production function coefficients, but it does not result in the disappearance of the inward investment effects. One implication of the finding that inter-industry effects from inward investment are important, whereas those from imports are not, is that the former may be reflecting the diffusion of new ideas and working practices rather than new technologies.

An equivalent general equation was initially specified for the model including the stock of R&D expenditures (at constant prices). In contrast to the findings for imports, the own industry (denoted R_i) and the inter-industry spillover (denoted RS_i) R&D terms were jointly significant [Wald(2)=21.65], although neither were individually significant at conventional levels. This suggests that technical progress in manufacturing industries is partly dependent on R&D activities, but it is difficult to determine whether it arises from intra-industry R&D or whether there are important spillover effects from R&D in other industries. These effects are large, but with a large standard error, suggesting that there may well be considerable variation across sectors. This imprecision may stem from the need to construct proxies for the stock of R&D. A 1 per cent rise in the intra-industry stock of R&D, is estimated to raise the level of technical progress by 2.92 per cent (standard error 1.84 per cent).

The inclusion of the R&D terms again acts to reduce the size of the coefficients on the inward investment terms, but both remain significant, and the imposition of a common coefficient on the two inward investment terms can still be accepted [Wald(1)=1.65]. The results imply that a 1 per cent rise in the output of foreign firms in a particular industry will raise technical progress by 0.53 per cent (standard error 0.21 per cent) in domestic firms in that industry, while a 1 per cent rise in the spillover term will raise technical progress by 0.65 per cent (standard error 0.26 per cent). It has clearly been important to include the additional terms in imports and R&D since they have reduced the size of the estimated effect from inward investment by almost a half. However it remains considerably larger than that obtained by Barrell and Pain (1997), suggesting either that the effects have strengthened over time, or that the panel analysis has highlighted factors obscured by a single analysis for the manufacturing sector as a whole.

Our findings confirm that policies which help to raise the level of inward investment may have a long-term impact on the size of the UK economy. The evidence of significant inter-industry spillovers suggests that policies designed to facilitate the dissemination of new business practices across a wide range of industries and improve the attractiveness of the UK as a business location for potential investors are likely to be of greater benefit than policies that just offer investment incentives in selected industries.

It is interesting to note how some of the other parameters have also changed as imports and R&D have been introduced. The deterministic trend has become insignificant, suggesting that the R&D and imports variables effectively capture the effects previously modelled as exogenous. The point estimate of returns to scale has declined consistently, and by the fifth column there is only marginal evidence of increasing returns.

Our results also have wider modelling implications. Studies of the determinants of either total factor productivity or labour productivity often assume that the production process is Cobb-Douglas (for example, Coe and Helpman, 1995). In our framework it is possible to test the joint restrictions that must hold if the production process can be described by a Cobb-Douglas function. These set of restrictions were consistently rejected by the data, implying that use of a Cobb-Douglas function may be unduly restrictive and generate biased estimates of TFP.[9]

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[9] For example in column 2 of Table 3 four restrictions are required – long-run unit output and wage elasticities and zero coefficients on the time trend and foreign firms variable. These are jointly rejected by the data [Wald(4)=42.28].

4. Do Spillovers Vary By Nationality Of The Investor?

In designing investment promotion schemes it is of interest to know whether the impact of inward investment varies according to the nationality of the investor. For instance, in a comparison of inward investment by US companies in the 1950s and Japanese companies in the 1980s Dunning (1988) argues that the former largely sought to transfer product and marketing innovations to the UK, whereas the latter were more concerned to transfer the managerial practices and quality standards used by the parent company. There are distinct differences in the pattern of inward investment by nationality, as shown in Table 1. The United States has historically been the most important source of inward investment, but investments from other EU economies have risen rapidly in more recent years, partly as a result of the Single Market Programme in Europe (Hubert and Pain, 2000).

To investigate whether nationality matters we construct data at the aggregate manufacturing level for the level of output attributed to firms from North America (the United States plus Canada), the EU and the rest of the world (primarily the Asia-Pacific countries) and test whether the effects from any single set of investors differ significantly from the others. We use a version of the fourth equation in Table 3 in which we impose the data-acceptable restriction of a common coefficient on the two inward investment terms. This is because we do not have data that would allow us to distinguish intra-industry and inter-industry spillovers by nationality. The resulting equation is shown in the first column of Table 4. We then re-estimate this equation with an additional term in (the log of) the level of net output produced by firms from each region. If the additional term is significant, then we can conclude that the impact of inward investment from the particular region differs significantly from the impact of investments from other regions.[10]

[10] There are two alternative ways of testing this hypothesis. Suppose A and B denote the output produced by firms of two different nationalities and T denotes total output. One option is to use a transformation like [7]; moving from a regression with one term for total output to a regression with separate terms, we can write:

$$\gamma \ln(A+B) = \gamma_1 \ln(A) + \gamma_2 \ln(1 + B/A)$$

and test whether $\gamma_1=\gamma_2$. Alternatively, noting that B=(T-A), we can write:

The resulting estimates are shown in columns [2]-[4] of Table 4. In the second column we show that additional inward investment from firms with North American parent companies has a smaller point impact than that of other investors, but it is not possible to reject the hypothesis of a common effect, since the coefficient on the separate term in the output of North American firms (denoted F_{NA}) is not statistically significant.[11] In contrast, there is clear evidence that the impact of EU-based firms (whose output term is denoted F_{EU}) is significantly smaller than that of other foreign firms, as shown in the results reported in the third column. It is also apparent that making this distinction results in a significant improvement in the overall fit of the equation. For firms from other non-EU and non-North America locations (denoted F_{RW}) the results are again inconclusive, as shown in the fourth column. But the point estimates of the coefficients do imply that inward investment from this relatively heterogeneous group of investors may have had larger effects than inward investments from elsewhere. Taken as a whole, the results in Table 4 provide some evidence in favour of greater targeting of investment promotion activities on potential investors from outside the European Union.

An obvious question of interest is whether our findings with respect to the impact of inward investment from the EU are generic to all European investors or specific to those from particular countries. To investigate these we consider separately the impact of investments from France (denoted F_{FR}), Germany (F_{GE}), the Netherlands (F_{NL}) and Belgium (F_{BG}) using a model similar to that in Table 4. The results are reported in Table 5. These reveal clear differences between different European investors.

$$\gamma \ln(A+B) = \gamma_1 \ln(A) + \gamma_2 \ln(T/A) = \phi \ln(A) + \gamma_2 \ln(T)$$

where $\phi = \gamma_1 - \gamma_2$, and test whether $\phi=0$. We follow the second course here.

[11] This does not mean that the elasticities of technical progress with respect to the output of North American and other investors are identical, since they will vary over time according to the share of each type of investor in total inward investment. Maintaining the notation used in footnote 9, and using an equation of the form:

$$\ln(Y) = \phi \ln(A) + \gamma_2 \ln(A+B)$$

$$\delta \ln(Y) / \delta \ln(A) = \phi + \gamma_2 [A/(A+B)]$$

$$\delta \ln(Y) / \delta \ln(B) = \gamma_2 [B/(A+B)]$$

The findings for France and Germany are similar to the aggregate result for the EU in Table 4, with spillovers from investors from these countries being significantly smaller than those from other investors. In contrast, spillovers from Netherlands-owned firms are significantly larger than the average from all other investors, and much closer to those from non-EU investors, whilst those from Belgian-owned firms are not significantly different from others.

One explanation for the results we observe may lie in the impact of the collective drive towards deeper economic integration in Europe over the past fifteen years. The Single Market Programme has reduced barriers to the internal movement of goods and capital within the European Economic Area. Non-European investors have chosen to transfer knowledge into UK-based operations which are designed to serve as production bases for the EEA-wide market in order to bypass external barriers to market entry (Barrell and Pain, 1999). EEA members have instead chosen to rationalise the labour-intensive parts of their production and have been attracted largely by the comparatively flexible labour market in the UK. Investments from the Netherlands and Belgium may differ from those from France and Germany in part because the former countries act as financial intermediaries and are host to management and co-ordination centres which are used to channel intra-company investments into many different locations. Thus the nationality of the ultimate beneficial owner may differ from that of the parent company recorded in the *Census of Production*.

Of course this is just one of many possible explanations and further work will be required to try and establish the reasons for the findings we report. An obvious extension would be to use disaggregated industry data on inward investment by nationality.

5. Concluding Comments

For many years successive UK governments have emphasised the potential beneficial effects of inward investment on the UK economy. However, to date, there has been relatively little quantitative econometric evidence as to the extent to which such investments have affected the growth process. Our general findings indicate that the benefits of inward investment have indeed been felt in the manufacturing sector and have helped to improve the productive efficiency of domestic companies. These findings appear to be robust to the presence of other potential determinants of growth such as imports and domestic R&D expenditures. They do not indicate that inward investment is the only source of technical change in the UK economy, but they do indicate that it is an important and significant one, and one which should play an important part in the explanation of the improved productivity seen in the manufacturing sector in the last two decades.

The evidence points to significant externalities from the scale of operations of foreign firms on the behaviour of domestic firms. Spillovers from non-EU companies are found to be significantly larger than those from the EU, especially those from France and Germany. We obtain significant within-industry effects and evidence of significant inter-industry spillovers from foreign firms located elsewhere in the manufacturing sector. The finding of significant across-industry spillovers suggests that at least some inward investors help to bring ideas and working practices that can be applied across a wide range of industries. Studies that seek solely to identify intra-industry spillovers may therefore under-estimate the externalities from inward investment. The challenge for future research is to seek to pin down the factors that govern the size, speed and distribution of spillovers from inward investors and to investigate further whether they are generic or confined to particular types of investors or investors in specific industries and geographic locations.

References

Barrell, R. and Pain, N. (1997), 'Foreign direct investment, technological change and economic growth within Europe', *Economic Journal*, 107, pp.1770-1786.

Barrell, R. and Pain, N. (1999), 'Trade restraints and Japanese direct investment flows', *European Economic Review*, 43, pp.29-45.

Blomström, M. and Kokko, A. (1998), 'Multinational corporations and spillovers', *Journal of Economic Surveys*, 12, pp.247-278.

Blomström, M., Kokko, A. and Globerman, S. (2000), 'The determinants of host country spillovers from foreign direct investment: a review and synthesis of the literature', in Pain (2000).

Carson, C.S., Grimm, B.T. and Moylan, C.E. (1994), 'A satellite account for research and development', *Survey of Current Business*, 74, 11, pp.37-71.

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

Crafts, N. and Toniolo, G. (1996), *Economic Growth In Europe Since 1945*, Cambridge University Press.

Davies, S.W. and Lyons, B.R. (1991), 'Characterising relative performance: the productivity advantage of foreign owned firms in the UK', *Oxford Economic Papers*, 43, pp.584-595.

Driffield, N. (1999), 'Indirect employment effects of foreign direct investment into the UK', *Bulletin of Economic Research*, 51, pp.207-221.

DTI (1998), *Our Competitive Future: Building The Knowledge Driven Economy*, The Competitiveness White Paper: Analysis and Background, Department of Trade and Industry, London.

Dunning, J.H. (1988), 'US and Japanese manufacturing affiliates in the UK: comparisons and contrasts', in Dunning J.H., *Explaining International Production*, Harper Collins.

Eltis, W. (1996), 'How low profitability and weak innovativeness undermines UK industrial growth', *Economic Journal*, 106, pp.184-195.

Girma, S., Greenaway, D., Wakelin, K. and Sousa, N. (2000), 'Host country effects of FDI in the UK: recent evidence from firm level data', in Pain (2000).

Griffith, R. (1999), 'Using the ARD establishment level data to look at foreign ownership and productivity in the United Kingdom', *Economic Journal*, 109, pp.F416-F442.

Hubert, F. and Pain, N. (2000), 'Fiscal incentives, European integration and the location of foreign direct investment', presented to NIESR Macro Users Group, October 2000.

Mansfield, E. and Romeo, A. (1980), 'Technology transfer to overseas subsidiaries by US based firms', *Quarterly Journal of Economics*, 95, pp.37-750.

O'Mahony, M. and Wagner, K. (1994), 'Changing fortunes: an industry study of British and German productivity growth over three decades', NIESR Report Series No.7.

Oulton, N. (2000), 'Why do foreign-owned firms in the UK have higher labour productivity?', in Pain (2000).

PACEC (1995), *Assessment of the wider effects of foreign direct investment in manufacturing in the UK*. Report by PA Cambridge Economic Consultants for Department of Trade and Industry.

Pain, N. (2000) (ed.), *Inward Investment, Technological Change And Growth: The Impact Of Multinational Corporations On The UK Economy*. Palgrave Press.

Proudman. J. and Redding, S. (eds.) (1998), *Openness And Growth*. Bank of England.

Rodrik, D. (1998), 'TFPG controversies, institutions and economic performance in East Asia' in Hayami, Y. and Aoki, N. (eds.) *The Institutional Foundations of Economic Development in East Asia*, Macmillan, London.

Romer, P. (1993), 'Idea gaps and object gaps in economic development', *Journal of Monetary Economics*, 32, pp.543-573.

Table 1 Foreign-Owned Firms In UK Manufacturing (Annual Averages)

	1973-79	**1981-89**	**1990-97**
Share of Foreign-Owned Firms (%)			
Gross value added	17.4	18.5	23.9
Net capital expenditure	18.1	22.2	30.9
Total employment	12.8	13.8	17.4
Employment of operatives	12.0	12.8	16.0
Employment of non-operatives	15.2	16.4	19.9
Nationality of investor (%)			
United States	72.9	65.2	53.1
Western Europe	18.7	20.3	29.8
Japan	0.1	1.0	6.6
Rest	8.3	13.5	10.5

Sources: ONS *Census of Production Summary Volume PA1002*, various issues.

Note: Nationality shares based on share of gross value added. Employment data by occupation not available for 1997.

Table 2. Characteristics of Foreign Firms, 1983-92 Average (Domestic Firms=100)

Industry	SIC(80)	Labour Productivity	Share of non-operatives	Investment-Output Ratio	Gross-Net Output Ratio
Basic metals industries	22	111.1	102.6	99.8	122.1
Non-metallic mineral products	24	107.8	111.6	93.2	101.5
Chemicals and man-made fibres	25+26	110.8	114.1	103.7	102.5
Metal manufacturing	31	140.0	122.4	132.2	116.6
Mechanical engineering	32	128.1	119.3	112.1	113.7
Electrical engineering and office machinery	33+34	133.8	105.3	153.0	135.2
Motor vehicles	35	142.5	105.3	177.3	150.4
Other transport equipment	36	104.2	76.6	188.5	95.3
Instrument engineering	37	124.2	110.8	119.1	122.1
Food, drink and tobacco	41+42	173.0	127.9	96.6	98.1
Textiles	43	128.4	136.0	149.7	110.9
Footwear and clothing	44	150.3	131.8	81.5	103.3
Timber and wooden furniture	46	142.6	139.8	297.0	107.1
Paper and publishing	47	132.6	102.2	124.0	108.2
Plastics and rubber	48	133.0	117.1	80.5	96.8

Source: calculations from *Census of Production*.

Table 3. Panel Data Results For Industry Labour Demand

Dependent Variable: $\Delta \ln(L_{it})$; Sample Period 1984-92

	[1]	[2]	[3]	[4]	[5]
$\Delta \ln(Q_{it})$	0.2650 (3.6)	0.2490 (3.1)	0.2426 (2.9)	0.2880 (3.9)	0.3753 (5.7)
$\ln(L_{i,t-1})$	-0.3202 (4.9)	-0.2541 (4.4)	-0.2519 (4.4)	-0.2664 (4.5)	-0.3060 (5.7)
$\ln(Q_{i,t-1})$	0.2450 (4.8)	0.2245 (4.6)	0.2234 (4.8)	0.2573 (5.5)	0.3039 (6.6)
$\ln(W_{i,t-1}/P_{i,t-1})$	-0.1709 (2.3)	-0.1196 (4.6)	-0.1188 (4.7)	-0.1309 (5.2)	-0.1525 (6.4)
TIME	-0.0088 (3.4)	-0.0031 (1.9)	-0.0030 (1.9)	-0.0017 (1.1)	0.0076 (1.3)
$\ln(F_{t-1})$		-0.1413 (3.2)			
$\ln(F_{i,t-1})$			-0.1450 (3.2)	-0.1107 (2.7)	-0.0807 (2.2)
$\ln(FS_{i,t-1})$			-0.1483 (3.3)	-0.1212 (3.1)	-0.0993 (3.7)
$\ln(M_{i,t-1})$				-0.0424 (2.3)	-0.0493 (2.6)
$\ln(R_{i,t-1})$					-0.4494 (1.6)
$\ln(RS_{i,t-1})$					-0.4910 (1.8)
$\bar{R}^2$	0.692	0.730	0.727	0.743	0.761
Standard Error	2.62%	2.43%	2.45%	2.37%	2.29%
Serial Correlation	Chi(1)=1.61	Chi(1)=0.04	Chi(1)=0.06	Chi(1)=0.13	Chi(1)=0.90
Returns to scale (v)	2.019 (0.312)	1.281 (0.276)	1.272 (0.276)	1.071 (0.219)	1.016 (0.243)
Elasticity of substitution (σ)	0.534 (0.021)	0.471 (0.023)	0.472 (0.024)	0.492 (0.025)	0.498 (0.026)

Notes: heteroscedastic-consistent t-statistics in parentheses, apart for returns to scale and the elasticity of substitution which are long-run standard errors.

Table 4. Panel Data Results For Nationality of Investor

Dependent Variable: $\Delta \ln(L_{it})$; Sample Period 1984-92

	[1]	[2]	[3]	[4]
$\Delta \ln(Q_{it})$	0.2821 (3.9)	0.2568 (3.1)	0.3551 (5.3)	0.2471 (3.0)
$\ln(L_{i,t-1})$	-0.2727 (4.7)	-0.2751 (4.8)	-0.3073 (5.4)	-0.2777 (4.9)
$\ln(Q_{i,t-1})$	0.2571 (5.1)	0.2323 (3.9)	0.2957 (6.3)	0.2236 (3.8)
$\ln(W_{i,t-1}/P_{i,t-1})$	-0.1324 (5.1)	-0.1268 (4.5)	-0.1508 (6.0)	-0.1253 (4.6)
TIME	-0.0017 (1.1)	0.0012 (0.4)	-0.0091 (3.1)	0.0004 (0.2)
$\ln(M_{i,t-1})$	-0.0386 (2.2)	-0.0432 (2.4)	-0.0371 (2.0)	-0.0425 (2.4)
$\ln(F_{MF, t-1})$	-0.1145 (2.9)	-0.2231 (2.0)	-0.1952 (3.6)	-0.0219 (0.4)
$\ln(F_{NA, t-1})$		0.1174 (1.2)		
$\ln(F_{EU, t-1})$			0.1199 (2.8)	
$\ln(F_{RW, t-1})$				-0.0582 (1.9)
$\overline{R}^2$	0.743	0.738	0.757	0.743
Standard Error	2.37%	2.40%	2.31%	2.38%
Serial Correlation	Chi(1)=0.05	Chi(1)=0.004	Chi(1)=1.34	Chi(1)=0.12
Combined inward investment effect		US: -0.1057 (2.7)	EU: -0.0753 (2.0)	RW: -0.0801 (2.0)
Returns to scale (v)	1.125 (0.222)	1.405 (0.423)	1.080 (0.199)	1.551 (0.471)
Elasticity of substitution (σ)	0.486 (0.023)	0.461 (0.031)	0.491 (0.022)	0.451 (0.029)

Notes: see Table 3

Table 5 Panel Data Results For EU Investors

Dependent Variable: $\Delta \ln(L_{it})$; Sample Period 1984-92

	[1]	[2]	[3]	[4]
$\Delta \ln(Q_{it})$	0.3198 (4.8)	0.3016 (4.0)	0.2328 (3.3)	0.2627 (3.4)
$\ln(L_{i,t-1})$	-0.2878 (5.3)	-0.2905 (4.9)	-0.2460 (4.1)	-0.2623 (4.3)
$\ln(Q_{i,t-1})$	0.2705 (6.0)	0.2785 (5.2)	0.2288 (4.3)	0.2466 (4.6)
$\ln(W_{i,t-1}/P_{i,t-1})$	-0.1396 (5.8)	-0.1422 (5.2)	-0.1187 (4.4)	-0.1272 (4.6)
TIME	-0.0075 (3.0)	-0.0051 (2.1)	-0.0040 (1.9)	-0.0010 (0.6)
$\ln(M_{i,t-1})$	-0.0357 (2.0)	-0.0393 (2.1)	-0.0406 (2.2)	-0.0378 (2.2)
$\ln(F_{t-1})$	-0.1631 (3.4)	-0.1438 (3.7)	-0.0550 (1.0)	-0.1117 (2.7)
$\ln(F_{FR,\,t-1})$	0.0499 (2.7)			
$\ln(F_{GE,\,t-1})$		0.0596 (2.1)		
$\ln(F_{NL,\,t-1})$			-0.0787 (2.2)	
$\ln(F_{BG,\,t-1})$				-0.0052 (0.7)
$\overline{R}^2$	0.759	0.751	0.736	0.737
Standard Error	2.29%	2.34%	2.42%	2.41%
Serial Correlation	Chi(1)=0.60	Chi(1)=0.09	Chi(1)=0.76	Chi(1)=0.002
Combined inward investment effect	FR: -0.1131 (2.9)	GE: -0.0842 (1.9)	NL: -0.1337 (3.4)	BG: -0.1169 (3.0)
Returns to scale (v)	1.132 (0.215)	1.088 (0.209)	1.155 (0.265)	1.132 (0.235)
Elasticity of substitution (σ)	0.485 (0.022)	0.490 (0.023)	0.483 (0.027)	0.485 (0.024)

Notes: See Table 3.