PRODUCTIVITY AND FOREIGN OWNERSHIP IN THE UK CAR INDUSTRY

Rachel Griffith

THE INSTITUTE FOR FISCAL STUDIES
Working Paper Series No. W99/11

Productivity and foreign ownership in the UK car industry

Rachel Griffith

Institute for Fiscal Studies

April 1999

Abstract

Many sectors of the UK economy experienced rapid productivity growth over the 1980s. This coincided with an increase in the flow of inward investment. Studies using macro data have linked these two events. This paper investigates what has happened in one industry at the microeconomic level and asks whether foreign-owned establishments in the UK car industry more productive than domestic-owned ones. Production functions are estimated using a new panel data set at the plant level. The findings suggest that, while foreign-owned establishments have higher output and value-added per worker, these differences appear to be largely explained by different levels of factor usage. Foreign-owned firms invest more in physical capital and use more intermediate goods. They also pay their workers higher wages. Differences in levels of total factor productivity still exist but they are relatively small.

Keywords: foreign direct investment, productivity, multinational firms.

JEL classification: D24, F21, L23.

Acknowledgements

I would like to thank Orazio Attanasio, Alan Auerbach, James Banks, Richard Blundell, Stephen Bond, Gavin Cameron, Ian Crawford, Michael P. Devereux, Costas Meghir, Stephen Redding, John Van Reenen, Helen Simpson, Frank Windmeijer and participants at seminars at Bristol and the IFS for helpful comments. I would also like to thank the Leverhulme Trust for funding this research and the ESRC Centre for Microeconomic Analysis of Fiscal Policy at the Institute for Fiscal Studies for financial support in setting up the ARD data. All errors and omissions remain the responsibility of the author.

Correspondence

Rachel Griffith, IFS, 7 Ridgmount Street, London WC1E 7AE, UK; rgriffith@ifs.org.uk

Executive Summary

Output per worker rose rapidly over the 1980s in the UK, both relative to previous decades and relative to other countries. Total factor productivity also increased. This growth in productivity coincided with many changes in the UK economy, but one of particular interest was the increase in foreign direct investment. It has long been noted that multinational firms are more productive than domestic firms, and that they are concentrated in knowledge-intensive industries. This suggests that multinationals may have played a role in increasing productivity levels in UK industry as higher productivity foreign-owned production replaced lower productivity domestic production. This has been suggested by studies using data at the industry or country level.

This paper uses data on individual establishments located in the UK over the period 1980 to 1992 in the motor vehicle and parts industry to estimate production functions. The empirical results suggest that foreign-owned establishments in this industry have significantly higher levels of output per worker (over twice as high as domestic-owned establishments). However, these differences can be almost entirely explained by differences in input levels. Foreign-owned establishments invest more in physical capital, use a higher level of intermediate inputs and pay their workers higher wages. This last result is particularly interesting, and can be interpreted as suggesting either that foreign-owned establishments hire workers with greater skill or ability or that foreign-owned establishments pay their workers higher wages and thus get more out of them (called an efficiency wage effect). The puzzle is why domestic-owned establishments are not investing in capital or paying their workers at the same level as foreign-owned establishments.

1. Introduction

The 1980s saw a rapid growth in output per worker and total factor productivity in many sectors of the UK economy, both relative to the previous decade and relative to the US.[1] Many alternative theoretical and empirical explanations have been offered. This period of productivity growth coincided with many changes to the UK economy - the weakening of labour unions, rapid shakeouts of firms in the early 1980s recession, computerisation and increases in the quality of the labour force. It has also been noted that rapid productivity growth coincided with an increase in the inward flow of foreign investment. From the early literature of Vernon (1966), Dunning (1977) and Caves (1974) it has been suggested that multinational firms are more productive and are concentrated in knowledge-intensive industries. This suggests that an increase in the presence of multinationals in the UK may have played a role in increasing productivity levels in UK industry as higher productivity foreign-owned production replaced lower productivity domestic production. The entry of multinational firms may also affect productivity levels in other ways – by bringing new ideas or increasing the level of competition in the market.

The endogenous growth[2] and new trade literatures[3] focus on the role multinational firms play in transferring technology from the frontier to technologically more backward economies. A large theoretical literature has evolved that attempts to explain the determinants and effects of foreign investment on productivity and growth. Empirical work, largely at the aggregate level, has identified correlations between the openness of an economy and growth in productivity or export performance.[4] An alternative explanation is offered by Nickell (1995) who argues that productivity increases in the UK over the 1980s were due more to management innovation and the reorganisation of production than to a surge in the rate of technological or scientific advance.[5] In contrast, Dougherty and Jorgenson (1997) argue that differences in output growth

---

[1] See O'Mahony (1998), Dougherty and Jorgenson (1997), Nickell et. al. (1992), Layard and Nickell (1989), Oulton and O'Mahony (1994), Mayes (1996), Cameron, Proudman and Redding (1998), van Ark (1996), Lansbury (1995) and Oulton (1998).

[2] See, inter alia, Barro and Sala-i-Martin (1995), Aghion and Howitt (1998), Grossman and Helpman (1991).

[3] See, inter alia, Krugman (1991a,b,1994), Venables (1994), Smith (1994) and Edwards (1998).

[4] These studies have genearlly used labour productivity, see, for example, Bernard and Jones (1996a,b), Barrell and Pain (1997); Cameron, Proudman and Redding (1998) look at TFP; studies using micro-data include Blomstrom and Persson (1983), Davies and Lyons (1991), Globerman (1979).

[5] See Layard and Nickell (1989), Bean and Symons (1989) and Bean and Crafts (1995).

across the G7 countries can be almost entirely explained by differences in the levels and growth rates of investment in physical, human and knowledge capital.

This paper considers whether the stylised fact that multinational firms are more productive than domestic firms is borne out empirically. The specific question addressed is whether there are differences between domestic and foreign-owned establishments and what role foreign-owned establishments that have chosen to produce in the UK have played in increasing the level of labour and total factor productivity. A general descriptive analysis of the differences between all domestic and foreign-owned production establishments in the UK is given and a detailed analysis of one industry is carried out. The car industry is chosen for a number of reasons - it has a large level of foreign involvement, this level increased over the period under consideration and it is also one of the industries that experienced a rise in output per worker.

The predominant model of why multinational firms exist focuses on the role played by intangible assets. This theory is based on the presumption that it is costly to operate abroad, relative to domestically.[6] Local firms have better knowledge of local markets, consumer preferences and business practices. Foreign firms must therefore have some other advantage over domestic firms in order to compete. This can be in the form of higher productivity levels, or through greater market power. Foreign ownership can come about either when a foreign firm sets up a green field site, or by purchasing an existing establishment. This paper examines whether establishments that are foreign-owned through either of these routes have higher productivity levels than those that are domestic-owned.

In the theoretical literature there are many mechanisms by which investment from abroad can affect productivity. Most empirical work investigating the impact of foreign investment on productivity has used an aggregate measure of foreign direct investment (FDI) and has remained fairly agnostic as to what is the precise mechanism by which this affects productivity. FDI measures a flow of financial capital from one country to another. But in the theoretical literature the main concept is one of control of productive assets and the flow of ideas. Here it is argued that a better proxy for this is foreign ownership.

Increases in industry level productivity as a result of foreign ownership may occur for a number of reasons. The average level of productivity in an industry could rise because *composition* effects

---

[6] See, inter alia, Caves (1974), Dunning (1981), Graham and Krugman (1991).

mean that higher productivity foreign firms replace lower productivity domestic firms. Following from the theoretical reasons why multinational firms exist, in order for the foreign firm to want to enter the domestic market it must expect a higher return than domestic firms (since costs are presumed cheaper for domestic firms). These higher returns could be because the foreign-owned firm is more productive. *Demonstration* effects mean that domestic firms may be able to imitate the technology used by foreign firms. This would affect both the average industry level of productivity and also the level of productivity in individual domestic-owned establishments. Similarly, foreign firms may introduce *competition* into a previously uncompetitive domestic product market, and they may broaden the market size by opening up access to foreign markets. Foreign firms may hire and *train* workers who then either earn higher wages or go to work for other (domestic) firms who then benefit through higher labour productivity. They may also open up access to higher quality capital inputs, e.g. through access to foreign factor markets. This paper considers only the first of these effects – have higher productivity foreign-owned establishments replaced lower productivity domestic-owned establishments and thus led to growth in UK productivity levels through composition alone?

The structure of this paper is as follows. Section 2 discusses some methodological issues involved in measuring total factor productivity. In section 3 the establishment level data is described and some preliminary analysis presented. Econometric estimates of the parameters of the production function of establishments in one industry – motor vehicles - are presented in Section 4. A final section summarises.

2. Methodology

Solow (1957) formalised the idea of interpreting the time series of the residual in a production function as reflecting technological change or TFP growth. Similarly, a comparison of total factor productivity can be made between different establishments at the same point in time. This difference in TFP is interpreted here as the difference in output that is not explained by a difference in inputs.

There are two main approaches to measuring TFP, the index number approach and econometric estimation. The index number approach is the one that is more commonly taken. It has the attractive property that it does not involve specification of the precise form of the production function or estimation of the structural parameters. Caves et. al. (1982) develop superlative indices for inputs, outputs and thus for productivity. A superlative index number is one that is derived from a specific aggregator function (so is said to be exact for that function) and where the aggregator function has a flexible functional form.[7] Taking an index approach observed factor shares can be used to calculate TFP. However, for index numbers to yield unbiased estimates of TFP a number of assumptions are required. These include: constant returns to scale technology, competitive input and output markets, full utilisation of all inputs and instantaneous adjustment of all inputs to their desired demand levels.[8]

Econometric estimation allows the possibility of relaxing these assumptions, although it presents its own challenges. Which of these assumptions can be relaxed in practice depends largely on the richness of the data used for estimation. Practical requirements generally mean imposing a stricter set of assumptions about the functional form of the production technology and the stability of parameters across time. However, a dynamic production function, as specified below, allows many of these assumptions to be relaxed and provides a useful tool for analysing their empirical importance, though only under the maintained hypothesis that the functional form is correct.

In this paper, establishment level TFP measures are obtained by estimating production functions for the UK car industry. Emphasis is placed on allowing for dynamics so productivity shocks are allowed to take a very general form. Thus the gains over the index number approach are that the constant return to scale, full capacity utilisation and instantaneous adjustment assumptions can be relaxed. The cost is that more restrictions are placed on the functional form.

Consider an establishment *i* that produces a single output at time *t* with a Cobb-Douglas gross output production function of the form

$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{\beta} X_{it}^{\gamma} \tag{1}$$

where Y is output, A is a Hicks-neutral productivity shift parameter, K is capital input, L is labour input, X is intermediate inputs, α, β, γ are the elasticities of output with respect to the relevant factor. $\alpha + \beta + \gamma = 1$ implies that the production technology is constant returns to scale.

The production function (1) can be estimated in log-linear form

$$y_{it} = \alpha k_{it} + \beta l_{it} + \gamma x_{it} + a_{it} \tag{2}$$

---

[7] Caves et. al. (1982) define flexible functions as those which can provide a second order approximation to an arbitrary aggregator function.

[8] See Caves et. al (1982), Nadiri and Prucha (1998) and Diewert and Nakumura (1998).

where variables in lower case are logs. The residual, a_{it}, can be interpreted as TFP and decomposed into the following components,

$$a_{it} = \eta_i + t_t + e_{it} \quad (3)$$

where η_i captures establishment-specific differences in productivity which are fixed over time (such as location, managerial ability or permanent differences in the establishment's ability to benefit from spillovers, for example because of their activities in other parts of the world, and other permanent unobserved factors), t_t captures common macro productivity shocks, e_{it}, captures establishment-specific time-varying productivity shocks which are initially assumed to be idiosyncratic. These shocks are interpreted here as being known to the establishment but not the econometrician, so they do not explicitly incorporate any uncertainty faced by the establishment. One of the difficulties in interpreting TFP that has been measured as a residual comes in knowing what portion is attributable to technological or other spillovers and externalities and what portion is measurement error.

This paper is concerned with testing whether one group of establishments (foreign-owned) has a higher level of total factor productivity than another (domestic-owned). This is done by comparison of the mean of η_i across the two groups – the mean for domestic establishments, $\overline{\eta}_i^d$ is compared with the mean for foreign establishments, $\overline{\eta}_i^f$. If $\overline{\eta}_i^d < \overline{\eta}_i^f$ this would suggest that foreign-owned establishments on average have higher levels of TFP and that there could have been a composition effect. As the proportion of output accounted for by foreign-owned establishments rose over time this could have led to a rise in the average level of TFP in the UK.

Care must be taken in interpreting any differences in productivity levels. They do not necessarily imply a causal relationship between being foreign-owned and being more productive. It may be that both groups of establishments are drawn from the same distribution but that only the best foreign-owned establishments have chosen to locate in the UK. This would mean that the observed distribution of foreign-owned establishments located in the UK was truncated on the left. Domestic-owned establishments may include a left-hand tail of poorly performing establishments (i.e. those that are just setting up or just going out of business). It could also be the case that foreign firms locating in the UK select only the most productive establishments.

One concern is that the static specification considered so far may be mis-specified. For example, the establishment-specific productivity, e_{it}, may persist over time.[9] This can be captured by allowing this component of the error term to be serially correlated

$$e_{it} = \rho e_{it-1} + u_{it} \tag{4}$$

where u_{it} is an idiosyncratic error term.

Lagging (2) by one period and multiplying through by ρ gives

$$\rho y_{it-1} = \rho\alpha k_{it-1} + \rho\beta l_{it-1} + \rho\gamma x_{it-1} + \rho a_{it-1}. \tag{5}$$

Subtracting (5) from (2) yields a dynamic form of the production function with a well behaved error term

$$y_{it} = \lambda_1 y_{it-1} + \lambda_2 k_{it} + \lambda_3 k_{it-1} + \lambda_4 l_{it} + \lambda_5 l_{it-1} + \lambda_6 x_{it} + \lambda_7 x_{it-1} + \eta_i^* + t_t^* + u_{it} \tag{6}$$

where $\lambda_1 = \rho, \lambda_2 = \alpha, \lambda_4 = \beta, \lambda_6 = \gamma$, $\eta_i^* = (1-\rho)\eta_i$, $t_t^* = t_t - \rho t_{t-1}$ and the common factor restrictions,

$$\lambda_3 = -\rho\alpha, \lambda_5 = -\rho\beta, \lambda_7 = -\rho\gamma \tag{7}$$

can be imposed or tested.

Another concern about the production functions shown in equations (2) and (7) is that they do not allow for the fact that workers or capital may be heterogeneous in ability or quality and that establishments may employ workers of differing abilities or purchase capital of different ages and qualities. Suppose workers were of two different qualities, skill (LS) and unskilled (LU) then they could be entered into the production function separately and the elasticities allowed to vary so that equation (1) would be rewritten

$$Y_{it} = A_{it} K_{it}^{\alpha} \left(LS^{\phi_s} LU^{\phi_U}\right)_{it}^{\beta} X_{it}^{\gamma}. \tag{8}$$

If wages and the rental price of capital are assumed to reflect quality, and the cost index for this factor is assumed to be constant returns to scale, $\phi_s + \phi_U = 1$, then cost shares could be used as weights and the different qualities could be aggregated into a single index. An alternative

[9] This could reflect an omitted variable, for example knowledge capital, or it could reflect the fact that establishments do not instantaneously adjust.

approach is to scale labour inputs by the average wage of workers of each type in each establishment (ws_{it}, wu_{it}), relative to the average wage in the establishment's industry ($\overline{ws}_{it}, \overline{wu}_{it}$), so that the production function becomes

$$Y_{it} = A_{it} K_{it}^{\alpha} \left(\frac{ws}{\overline{ws}} LS \right)_{it}^{\beta_1} \left(\frac{wu}{\overline{wu}} LU \right)_{it}^{\beta_2} X_{it}^{\gamma} \tag{9}$$

which can be estimated in log-linear form[10] (and allowing the coefficient on the relative wage to vary from that on labour),

$$y_{it} = \alpha k_{it} + \beta_1 ls_{it} + \beta_2 lu_{it} + \beta_3 \ln\left(\frac{ws}{\overline{ws}} \right)_{it} + \beta_3 \ln\left(\frac{wu}{\overline{wu}} \right)_{it} + \gamma x_{it} + a_{it}\,. \tag{10}$$

The coefficients on the relative wage terms could also be interpreted in other ways, for example, as reflecting an efficiency wage effect.[11] In principle the same can be done for capital and intermediate inputs, though in practice much less information is available on their rental cost.

Before turning to a description of the data used in empirical analysis consider what are some of the advantages of using micro panel data. Most of the empirical work that looks at international investment behaviour and the activities of multinational firms has used macro (country or industry) level data.[12] However, there are many advantages to using micro data in this context.

First, using micro panel data it is possible to control for unobservable characteristics which are specific to the individual and may be correlated with the other regressors. These have been shown to be important in many econometric studies.[13] Secondly, the theory upon which most of these empirical studies draw is based on the profit maximising behaviour of firms. Explicitly aggregating these models will not necessarily yield a model of the same form as implied by the disaggregated version. Using aggregate data to estimate models describing firm behaviour will also introduce aggregation bias simply for the reason that $\sum_{i=1}^{N} \ln x_i \neq \ln \sum_{i=1}^{N} x_i$.[14] A final problem arises if a dynamic model is being estimated with aggregate data in that the composition

---

[10] Oulton (1998) estimates an equation of a similar form to (10) imposing CRS but interprets it as a reduced form description of the variation in labour productivity.

[11] See, inter alia, Levine (1992).

[12] Exceptions to this include Hines (1996) and Cummins and Hubbard (1994).

[13] See, inter alia, Attanasio and Weber (1991), Stoker (1998) and Blundell and Stoker (1998).

[14] See, inter alia, Attanasio and Weber (1991).

of firms in the industry or country at time t and t-1 will not be the same. This means that changes over time reflect both changes in composition and changes in behaviour and that using lagged values as regressors or instruments may become invalid.[15]

3. Data

The data used to estimate the production functions comes from the ARD dataset. ARD is the establishment level data that is collected under the Annual Census of Production.[16] The unit of response is the establishment, which can be a single plant or a group of plants. All production establishments located in the UK with more than 100 employees are sampled every year. Below 100 employees a stratified sample is taken. Only production establishments are surveyed. Production includes manufacturing, mining and quarrying, construction, electricity, and gas and water supply. As an example consider Figure 2, which depicts a UK-based multinational which is engaged in both production and non-production activities.

The main ARD data set would contain two entries for this enterprise (firm), one for each of the production establishments outlined in bold. The smallest entity reported in ARD is a local unit which is effectively a plant (it is a single address). The number of local units accounted for by each establishment varies but is reported, as is the number of employees in each local unit. An enterprise code is also given which indicates which establishments are linked through common ownership. There is no information on non-production establishments (including head office) or establishments located in foreign countries. When collecting the data the ONS asks that all non-production activities undertaken within the production establishments be excluded.

Output, investment, employment and intermediate inputs are reported in nominal terms for each establishment. The country of residence of the ultimate owner of the establishment is also given. Price deflators for output and intermediate goods are available at the 4-digit industry level. Price indices for investment in plant and machinery are available at the 2-digit level and for investment in buildings, land and vehicles at the aggregate level. The retail price index is available at the aggregate level. Capital stock data is not available and is constructed using the perpetual inventory method with the initial value of the capital stock estimated using industry level data.

15 See Pischke (1995).

16 See Griffith (1999) for more details.

Table 1a shows the proportion of output from selected establishments that is accounted for by foreign-owned establishments in a selection of 2-digit industries for the years 1980, 1985, 1990 and Table 1b for 1995. These industries are chosen because they are among the larger industries and they are the ones with the largest proportion of foreign ownership. Comparisons at the industry level between 1990 and 1995 are difficult because of the change in industry coding in 1992, so the breakdown for 1980, 1985 and 1990 is presented using SIC80 and for 1995 using the most comparable industry.

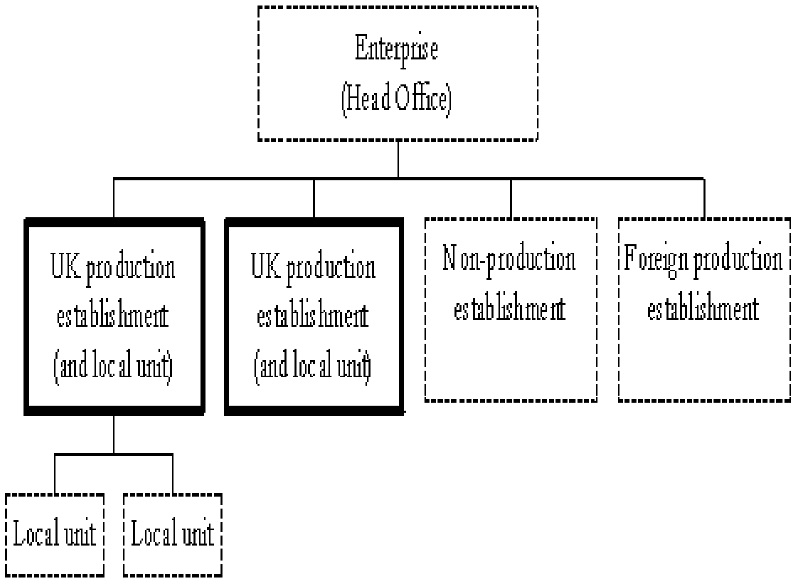

Figure 2: Example of reporting for UK-based multinational

The proportion of value-added accounted for by foreign-owned establishments in the chemicals industry has remained fairly constant, increasing slightly from around 32% in 1980 to around 37% in 1995. Establishments in the mechanical engineering industry (SIC80=32) go into two different 1992 SIC categories – manufacture of metal products (28) and manufacture of machinery (29) and again the proportion of output accounted for by foreign-owned establishments remains fairly constant at around 30%. Similarly, establishments in the electrical and electronic engineering industry go into two 1992 SIC classifications – manufacture of electrical equipment (31) and manufacture of electronic products (32). For these two industries aggregated foreign-owned establishments account for around 30% of value-added, while for the electronics industry on it's own they account for a much larger proportion, over half as shown for 1995.

Table 1a: Proportion of value-added in selected establishments by industry and ownership, 1980, 1985, 1990

SIC80	chemicals (25)	mechanical engineering (32)	electrical and electronic engineering (34)	motor vehicles and parts (35)	instrument engineering (37)
1980					
Domestic	0.675	0.720	0.770	0.576	0.547
Japanese	.	.	0.002	.	.
North American	0.245	0.240	0.141	0.409	0.387
EU	0.026	0.004	0.057	0.014	0.034
Other	0.054	0.037	0.031	0.001	0.032
1985					
Domestic	0.619	0.719	0.799	0.574	0.732
Japanese	.	0.002	0.008	.	0.001
North American	0.283	0.234	0.117	0.407	0.201
EU	0.033	0.008	0.045	0.017	0.031
Other	0.065	0.037	0.031	0.001	0.035
1990					
Domestic	0.625	0.696	0.766	0.488	0.698
Japanese	0.003	0.010	0.042	0.010	0.006
North American	0.262	0.236	0.110	0.391	0.245
EU	0.043	0.012	0.040	0.100	0.023
Other	0.066	0.046	0.042	0.011	0.028

Table 1b: Proportion of value-added in selected establishments by industry and ownership, 1995

SIC92	chemicals (24)	manuf. of metal products (28)	manuf. of machinery (29)	manuf. of electrical equip. (31)	manuf. of electronic products (32)	motor vehicles and parts (34)	manuf. of instrumen ts (33)
1995							
Domestic	0.626	0.728	0.661	0.732	0.463	0.326	0.723
Japanese	0.002	0.005	0.022	0.012	0.212	0.067	0.021
North American	0.267	0.082	0.190	0.098	0.254	0.359	0.188
EU	0.067	0.148	0.087	0.154	0.063	0.238	0.037
Other	0.037	0.038	0.041	0.004	0.008	0.011	0.030

The motor vehicles industry is one which has seen an increase in foreign-ownership, going from around 40% in 1980 to nearer 70% in 1995. Instrument engineering seems to have gone the other way, from around 45% foreign ownership in 1980 to under 30% in 1995.

3.1 Characteristics of foreign versus domestic-owned establishments

Table 2 shows the ratio of the mean value of output and inputs in foreign-owned establishments to the mean in domestic-owned for the years 1980, 1984, 1988 and 1992. The means are calculated over all establishments with at least 100 employees. In 1980 foreign-owned establishments were on average around two and a half times the size of domestic-owned establishments in terms of output and investment and twice as large in terms of value added. They produced 77% more output and 50% more value-added per employee and used similarly higher proportions of inputs – employees, investment and intermediate inputs. They also employed around 30% more administrative, technical and clerical workers (ATCs) and paid both ATC and operative workers just over 10% more than domestic-owned establishments. These are on the whole quite large differences.

Table 2: Ratio of characteristics of foreign to domestic-owned establishments

	1980	1984	1988	1992
establishments with ≥ 100 employees				
number observations: foreign, domestic	*1218, 7302*	*1155, 6335*	*1074, 6361*	*1326, 5558*
Output	2.46	2.24	2.20	1.92
Value-added	2.03	1.89	1.71	1.53
Investment	2.61	1.96	1.77	1.32
Employment	1.51	1.35	1.24	1.32
Output/employee	1.77	1.60	1.73	1.63
Value-added/employee	1.50	1.48	1.46	1.37
Investment/employee	1.75	1.55	1.57	1.81
Intermediate inputs/employee	1.53	1.54	1.64	1.69
% employees ATC	1.34	1.30	1.32	1.29
% wage bill ATC	1.31	1.26	1.25	1.23
average wage ATC	1.12	1.13	1.11	1.12
average wage Ops	1.13	1.15	1.17	1.17

Note: Variable definitions with ARD variables numbers are: gross value-added (q837), net capital expenditure (q844), employment (q845), proportion of wage bill accounted for by administrative, technical and clerical workers (q301/(q301+q304)), average wage of administrative, technical and clerical workers (q301/q202). Non-manufacturing plants have been excluded.
Source: Author's calculations using ARD.

The differences in size have declined somewhat over time, and by 1992 foreign-owned establishments were more like one and a half to two times larger than domestic-owned. Foreign-owned establishments still produced over 50% more output per employee and around 40% more value-added. Inputs levels, as indicated by both capital investment and intermediate inputs, were between 70% an 80% higher in foreign-owned establishments. Differences in employment patterns and average wages between foreign and domestic-owned remained similar over the period.

Table 3: Percentage difference between domestic and foreign-owned establishments

Characteristic:	French		German		Japanese		US	
	1980	*1992*	*1980*	*1992*	*1980*	*1992*	*1980*	*1992*
Output/worker	-	55	27	56	102	61	34	51
Value-added/ worker	-	39	22	32	-	-	29	41
investment/ worker	-	67	46	103	333	209	39	79
intermediate input/worker	-	68	35	79	175	96	41	57
ATC/worker	-	24	31	23	-	-12	29	27
average wage ATC	-	-	-	8	-	-	10	13
average wage OPs	-	25	-	10	-	-	9	16

Source: Authors' calculations using ARD. Reported differences are calculated from a regression of ln(characteristic) on year, time and foreign-ownership dummies. The reported proportional difference is $\exp(\beta - 1)$ *where* β *is the coefficient on the foreign-ownership dummy.*

One reason that these differences could arise is because foreign-owned establishments could be located in more productive industries. Table 3 investigates this possibility by looking at the proportional differences between the characteristics of domestic and foreign-owned establishments conditional on their industry. These difference are calculated by regressing the log of the characteristic on 2-digit industry, time and country dummies. The omitted category is domestic-owned establishments so $\exp(\beta - 1)$, where β is the coefficient on a country dummy, gives the proportional difference from domestic-owned establishments conditional on industry and year. This is what is reported in Table 3 for those coefficients that are significantly different from zero for the other four G5 countries.

Output per worker is higher in all but French-owned establishments in 1980, while value-added per worker is only higher in German and US-owned establishments and French-owned in 1992. Investment and intermediate inputs per worker are higher in all cases. French, German and US-owned employ a higher proportion of administrative, technical and clerical workers (ATC) while Japanese employ a lower proportion. Average wages for both operative and ATC workers are higher in US-owned establishments in both years and in German in 1992, while operatives in French-owned establishments are paid higher wages in 1992.

The question is whether these differences in input levels account for the differences in output, or is there evidence that foreign firms are more productive even after conditioning on these differences. To investigate this question the production characteristics of establishments in the UK motor vehicle industry are analysed in detail. This industry is chosen because it has one of the highest shares of foreign ownership in the UK, with on average less than half of output coming from domestic-owned establishments. US-owned establishments account for the largest proportion of foreign-owned output.

3.2 The motor vehicles and parts industry

The increase in foreign-ownership was not the only change to the structure of the UK car industry. The period under consideration was a time of great change in UK labour relations. In the early 1980s the UK car industry had a very high strike rate, almost ten times the national average. Some foreign firms such as Nissan entered during this time and negotiated strike-free deals.[17] The impact of differences in organisational structure such as this on output may be captured in higher wages for employees or in TFP measures. Care needs to be taken in interpreting differences in TFP – higher levels of TFP do not necessarily reflect differences in technology (nor will differences in technology necessarily be reflected in differences in TFP – they may, for example, be embodied in capital).

It is worth emphasising that the what is being consideration here is not foreign direct investment but foreign ownership.[18] Figure 3 shows the difference between the two for the transport equipment industry. This includes both the motor vehicle industry (35) and the much smaller manufacture of transport equipment industry (36). Panel 3a shows the time series pattern of investment made by domestic-owned establishments in 1980 pounds sterling in these two industries. Panel 3b shows foreign direct investment (FDI) from the US and capital expenditure by US-owned establishments, panel 3c for Japan and panel 3d for other foreign. It is noticeable that FDI is much more volatile than the capital expenditure series. A similar picture arises if FDI is compared with total expenditure or output by foreign-owned establishments.

The motor vehicle and parts industry is made up of three 3-digit industries one of which is made up of three 4-digit industries. The motor vehicles and engines industry (SIC 1980 code equals

[17] See Bassett (1986).

[18] Auerbach and Hassett (1993) also emphasise this difference.

351) is the largest and has the largest proportion of foreign owned establishments. Motor vehicle parts (353) is also a large industry, while the other 3-digit industry, motor vehicle bodies (352), is fairly small and largely domestic-owned, but is made up of three 4-digit industries: motor vehicle bodies (3521), trailers (3522) and caravans (3523).

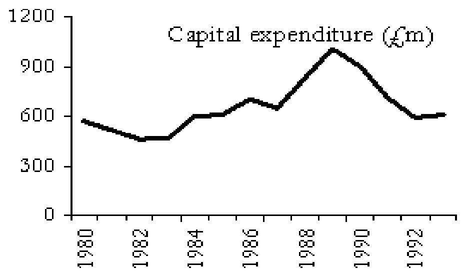

Figure 3a: Domestic-owned

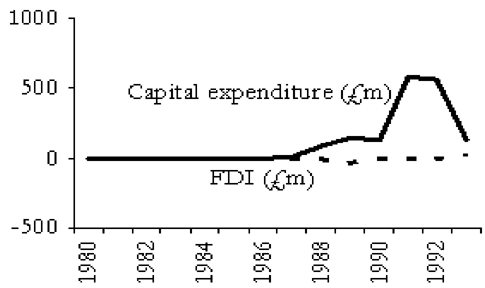

Figure 3c: Japanese-owned

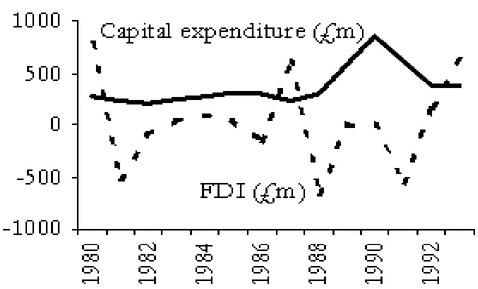

Figure 3b: USA-owned

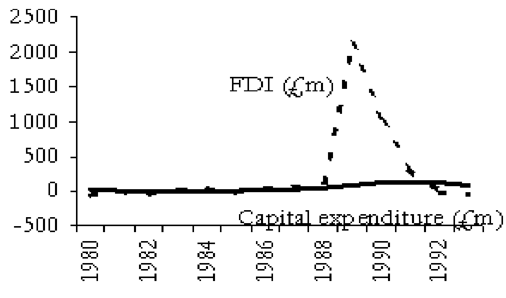

Figure 3d: Other foreign-owned

Value-added per worker in the motor vehicles and engines industry (351) rose markedly over this period, as shown in Figure 4.[19] Value-added is used because output can not be aggregated to the industry level since the output of one establishment may be an input for another establishment in the same industry. This figure uses the ARD data aggregated up to the 3-digit industry level. All values are expressed in 1980 pounds sterling. In the motor vehicles and engines industry (351) value-added per worker rose from just over £7,000 in 1980 to almost £20,000 in 1993. Value-added per worker also rose in the other two 3-digit industries, rising by around 75 per cent between 1980 to 1993 in the motor vehicle parts industry (353), and just about doubling in the motor vehicle bodies industry (352). There is a dramatic dip in output per worker over the 1990-

[19] Value-added is deflated by a 4-digit industry output price deflator, see Oulton and O'Mahony (1994) for a discussion of the bias this creates.

91 recession in the motor vehicle and engines industry (351). This could be due to lower levels of capacity utilisation.

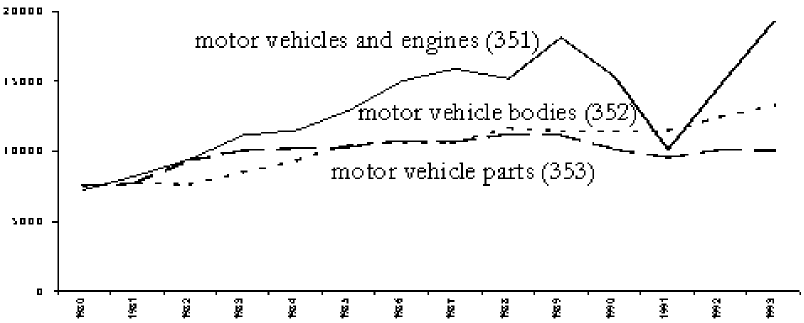

Figure 4: Aggregate value-added per worker in the motor vehicle industry

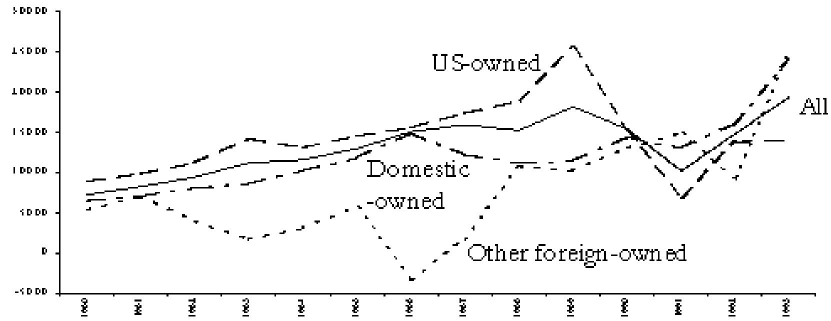

Figure 5: Aggregate value-added per worker in the motor vehicle and engines industry (351) by ownership

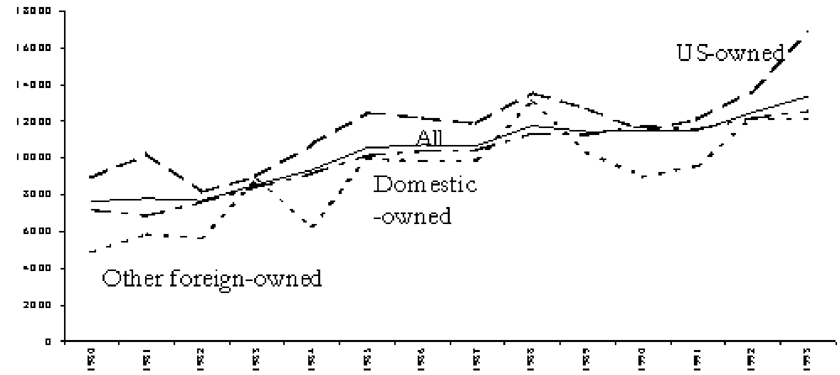

Figure 6: Aggregate value-added per worker in the motor vehicle parts industry (353) by ownership

Figures 5 to 6 show the same aggregate series for each 3-digit industry as well as this series split by ownership for the two main 3-digit industries. In the motor vehicles and engines industry (351) value-added per worker for US-owned establishments was higher than for all others until 1990, and after that was lower. It is interesting to note that at the establishment level this lower value-added per worker is in contrast to output per worker which was significantly higher because foreign-owned establishments use a large proportion of intermediate inputs (see below for discussion). Other foreign-owned establishments had a lower level of value-added per worker than domestic-owned establishments.[20] In the motor vehicle parts industry (353) US-owned establishments have higher value-added per employee throughout and it nearly doubles over the period.

Table 4: Percentage of foreign-ownership in ARD selected data on the motor vehicle industry in 1980 and 1992

SIC80	Motor vehicles and engines (351)		Motor vehicles bodies (352)		Motor vehicle parts (353)	
	1980	*1992*	*1980*	*1992*	*1980*	*1992*
Establishments	19	30	6	4	17	22
Output	57	76	14	7	31	34
Value-added	51	62	10	4	33	31
Employment	45	65	13	7	29	26
Investment	50	81	6	6	42	52

Source: Author's calculations from ARD.

Table 4 shows the proportion of establishments, output, value-added, employment and investment that is accounted for by foreign-owned establishments in each 3-digit industry in the first and last years of the sample - 1980 and 1992. Foreign-owned establishments accounted for around half of output, value-added and investment in the motor vehicles and engines industry (351) while only accounting for 20% of establishments in 1980. By 1992 they accounted for 30% of establishments. Foreign-owned establishments are much larger thn domestic-owned and thus account for 76% of output 62% of value-added, 65% of employment and 81% of investment. Motor vehicle bodies (352) has a very small level of foreign involvement and it declines over the period. The motor vehicle parts industry (353) is dominated by domestic-owned establishments.

[20] One other foreign-owned establishment is excluded because its value-added per worker goes up by a factor of 4 in 1987 and then back down again. If this establishment is included the other-foreign owned is higher in that year and the remaining years look similar.

Foreign-owned accounted for around one-third of output and value-added and one-quarter of employment but over a half of investment by 1992.

The aggregate series discussed so far are constructed from data on all selected establishments in the ARD data. The ARD selected data includes 5,314 observations on 1,176 establishments in the motor vehicle industry over the period 1980 to 1992.[21] Of these, 2,092 observations can not be used for econometric estimation of the production function either because they do not contain sufficient information or because there are not at least four contiguous time series observations for the establishment. In a small number of cases value-added is negative, these observations have also been excluded. Requiring four contiguous years of data means that many of the smaller establishments are not included, since establishments with under 100 employees are not a census but are sampled so it is much less likely that they appear in four contiguous years. This is only really an issue in the motor vehicle parts industry (353), as not many motor vehicle and engine establishments (351) are small. While it also affects motor vehicle bodies (352) this is a very small industry.

Table 5: Proportion of output covered by ARD selected data and sample

SIC80	Motor vehicles and engines (351)	Motor vehicle bodies (352)	Motor vehicle parts (353)
Output in 1992 (£m)	14,679	707	3,026
% of population in ARD selected data	98	67	85
% of population in sample	92	53	68

Note: Population totals are reported in PACSTAT from 1986 and before that are available from the ONS. They are calculated by the ONS by grossing up the ARD data. The proportion is the average over the year 1980 to 1992.

Table 5 shows the proportion of total output that was accounted for by both the ARD selected data, and the sample (of those establishments with at least four contiguous observations) used in the analysis of production functions later in this paper. The ARD selected data accounts for 98% of output in the motor vehicle industry (351), and the sample used in empirical application below accounts for 92%. This high proportion of output accounted for by the sample reflects the fact that a few very large establishments in this industry account for most of output, while there are only a small number of establishments with fewer than 100 employees. In the other two 3-digit

[21] While ARD contains data up to 1995 there is a break in the data that makes it difficult to match establishments from 1993 to 1994. In addition, there was a change in sampling and collection in 1993 that makes comparison between 1992 and 1993 problematic. For this reason the analysis in the rest of this paper uses data from 1980 to 1992.

industries there are a higher proportion of small establishments and thus both the ARD selected data and the sample represent a smaller proportion of total output. On average a higher proportion of these smaller establishments are domestic-owned so the sample contains a somewhat higher proportion of foreign-owned establishments in the motor vehicle parts industry (353) than in the full population.

Table 6: Descriptive statistics of the sample of establishments in the motor vehicle and engines industry (351)

	Domestic-owned	Foreign-owned	Ratio of foreign to domestic: All years	1980	1992
number of observations	*259*	*141*	*141 foreign, 259 domestic*	*5 foreign, 19 domestic*	*12 foreign, 11 domestic*
Output[a]	123,363	436,408	3.54	6.14	2.76
Value-added[a]	34,219	75,458	2.21	4.75	1.36
Investment[a]	8,746	26,444	3.02	4.31	2.22
Capital stock[a]	115,984	317,230	2.74	5.49	2.47
Employment	3,530	7,076	2.00	3.48	1.68
Output/employee[a]	33,172	57,378	1.73	1.08	1.51
Value-added/employee[a]	8,039	9,611	1.20	0.75	1.15
Investment/employee[a]	1,014	3,833	3.78	2.63	5.28
Capital stock/employee[a]	23,828	46,477	1.95	1.16	2.05
Intermediate inputs/employee[a]	25,133	47,767	1.90	1.35	1.69
% employees ATC	30	30	1.00	0.89	0.87
% wage bill ATC	34	39	1.15	1.03	0.95
Average wage ATC[b]	7,286	9,585	1.32	1.26	1.24
Average wage Ops[b]	5,865	6,430	1.10	1.04	1.02

[a] *In 1980 £'000s. Price deflator for output and value-added are at 4-digit level, for investment a combination of 3-digit and aggregate, wages are deflated by the RPI. See Griffith (1999) for details.*
[b] *In 1980 £s.*
Note: Variable definitions with ARD variables numbers are: gross value-added (q837), net capital expenditure (q844), employment (q845), proportion of wage bill accounted for by administrative, technical and clerical workers (q301/(q301+q304)), average wage of administrative, technical and clerical workers (q301/q202).
Source: Author's calculations using the ARD data.

Table 6 contains a set of descriptive statistics on sampled establishments in the motor vehicle and engine industry (351) split by ownership. The differences are pronounced. The first two columns give the mean values for domestic and foreign-owned establishments across all years. Column three shows the ratio of foreign to domestic-owned (i.e. column two divided by column one) while the fourth and fifth column show the same ratio for the first and last years of the sample.

Foreign-owned establishments were between two and three are larger than domestic-owned ones. They produced on average 73% more output per worker though only 20% more value-added.

They invested more and had a larger capital stock per worker. Foreign and domestic-owned establishments used about the same proportion of ATC workers though they paid them more on average, hence ATC workers constituted a larger part of the total wage bill in foreign-owned establishments.

In 1980 there were 19 domestic-owned and 5 foreign-owned establishments in the motor vehicle and engines industry (351). The foreign-owned establishments were over six times as large on average as the domestic-owned and produced almost five times as much value-added. Foreign-owned establishments invested and employed around four times as much as domestic-owned. However, average output per worker was at similar levels and value-added per worker was slightly higher in domestic-owned establishments. This is in contrast to the aggregate figures which suggested that foreign-owned establishments had slightly higher value-added per worker. This implies that larger foreign-owned establishments have higher value-added per worker than smaller ones. Foreign-owned establishments invested over two and a half times as much per worker and used around 35% more intermediate goods. Administrative, technical and clerical workers represented a slightly smaller proportion of the workforce in foreign-owned establishments, though they were paid around 25% better on average so that they represent around the same proportion of the total wage bill. Operative workers were paid at about the same levels on average in foreign and domestic-owned establishment.

By 1992 there were over twice as many foreign-owned establishments and fewer domestic-owned. The difference in size between the two groups was smaller with foreign-owned being less than three times as large as domestic-owned. Value-added was only 36% higher (down from nearly five times as much in 1980) and investment was just over and employment just under twice as much. The fall in the average numbers employed from 1980 to 1992 is dramatic. Output per employee is 50% higher and value-added around 15% higher in foreign-owned establishments in 1992.

While differences in the level of investment declined from 1980 to 1992, investment per employee was over five times as high in foreign-owned establishments as in domestic-owned in 1992, more than in 1980. Foreign-owned used around 70% more intermediate inputs in 1992 relative to 35% more in 1980. Foreign-owned establishments employed a slightly lower proportion of administrative, technical and clerical workers but their wages were about 25% higher than in domestic-owned establishments, as they were in 1980, and operative workers were paid about the same in domestic and foreign-owned establishments. These differences are quite large.

Table 7 presents the same set of descriptive statistics for the motor vehicle parts industry (353). The differences between domestic and foreign-owned are smaller in this industry, although they still exist. Foreign-owned establishments were just over 40% larger than domestic-owned and invested nearly twice as much as foreign-owned. They produced more per employee but also used more intermediate inputs and invested more per employee. The differences seen with aggregate data are greater because larger establishments are more productive and foreign-owned establishments are on average larger. Administrative, technical and clerical workers made up a slightly higher proportion of the wage bill in foreign-owned establishments, while being paid around 10% more in foreign-owned than in domestic-owned establishment. These differences have remained fairly stable over time.

Table 7: Descriptive statistics of establishments by ownership and size in the motor vehicle parts industry (353)

			Ratio of foreign to domestic		
	Domestic-owned	Foreign-owned	All years	1980	1992
number observations	*1,563*	*376*		*29 foreign, 98 domestic*	*36 foreign, 93 domestic*
Output[a]	11,537	16,612	1.44	1.40	1.43
Value-added[a]	5,236	7,143	1.36	1.45	1.36
Investment[a]	518	987	1.91	3.08	2.16
Capital stock[a]					
Employment	468	572	1.22	1.23	1.27
Output/employee[a]	25,052	31,529	1.26	1.11	1.27
Value-added/employee[a]	11,233	12,876	1.15	1.14	1.10
Investment/employee[a]	1,068	1,670	1.56	2.46	2.22
Capital stock/employee[a]					
Intermediate inputs/employee[a]	13,819	18,654	1.35	1.12	1.35
% employees ATC	24	28	1.17	1.08	1.26
% wage bill ATC	29	34	1.17	1.07	1.20
Average wage ATC[b]	6,789	7,365	1.08	1.13	1.03
Average wage Ops[b]	4,969	5,526	1.11	1.14	1.12

[a] *In 1980 £'000s. Price deflator for output and value-added are at 4-digit level, for investment a combination of 3-digit and aggregate, wages are deflated by the RPI. See Griffith (1999) for details.*
[b] *In 1980 £s.*
Note: Variable definitions with ARD variables numbers are: gross value-added (q837), net capital expenditure (q844), employment (q845), proportion of wage bill accounted for by administrative, technical and clerical workers (q301/(q301+q304)), average wage of administrative, technical and clerical workers (q301/q202).
Source: Author's calculations using the ARD data.

This descriptive analysis has shown that there are significant differences between domestic and foreign-owned establishments in terms of output per worker and factor usage. Foreign-owned establishments appear to produce more but also to use more capital and intermediate inputs per worker than domestic-owned establishments and to pay their workers higher wages.

The next section examines whether there are also differences in TFP levels, that is whether the differences in factor usage fully explain differences in output levels, or whether there are also unexplained differences between domestic and foreign-owned establishments.

4. Production function estimates

Using the ARD data estimates of TFP can be recovered and properties of the production function can be examined. Estimating production functions of the form of (2) and (6) is not without difficulty. If the individual specific productivity effects, η_i, are correlated with the other regressors, l_{it}, k_{it}, x_{it}, then OLS estimates of the coefficients will not be consistent. The within groups estimator will be biased in panels of this length. The usual solution to this problem is to use the GMM first-differenced estimator.[22] This will yield consistent estimates, however, recent work has shown that in certain (common) situations it will yield estimates that suffer from large finite-sample bias due to weak instruments.

Griliches and Mairesse (1997) point out that panel data estimates of production functions that attempt to control for unobserved heterogeneity and simultaneity have not yielded very satisfactory results. Blundell and Bond (1998a,b) argue that this is because of a weak instruments problem. Lagged values of the variables of interest are only weakly correlated with growth rates (differences). They show that in their sample of firms the series for sales, capital and employment are all highly persistent and thus provide weak instruments in a first-differenced GMM setting. They propose a systems estimator which uses an additional set of moment conditions - first differences are used as instruments for levels as well as the usual levels as instruments for first differences. They show that this estimator gives better results on efficiency grounds.[23] These additional moment conditions are only valid under a set of additional assumptions that the growth rate of the variable is uncorrelated with the fixed effect, that the series is stationary and that the initial observation is drawn from the same process.

---

[22] See Arellano and Bond (1991).

[23] See also Arellano and Bover (1995).

Blundell and Bond also stress that it is important to allow for an autoregressive component in the production function error term. This autoregressive error term will capture features of the production process such as the fact that adjustment may not be instantaneous but may occur with some time lag. It will also control for unobserved characteristics that are not fixed but that do persist over time – for example, managerial ability or expenditure on research and development.

The establishment level data used in this analysis exhibit similar properties to those discussed by Blundell and Bond (1998) in that the series are highly persistent. Table 10 shows estimates of the AR(1) coefficient on output, labour, capital and intermediate inputs using OLS, within groups, first-differenced and the systems estimator. If the mean of the process varies across establishments (i.e. there is a fixed effect) then the OLS estimates will be biased upwards while the within groups estimates will be biased downwards. The first difference estimator will be consistent but may suffer from weak instruments. The systems estimates should fall somewhere in between the OLS and within groups estimates. For all four series the systems estimator indicates an AR(1) coefficient over 0.9. The highly persistent nature of the data suggests that lagged levels will provide weak instruments for differences and thus the systems estimator is more appropriate than the first-differenced estimator.

There is some worry about the capital series which is a constructed series. The ARD data contains information on investment (both cost of acquisition and proceeds from disposal, though not scrapping). In the ARD investment is available separately for plant and machinery, buildings and land and vehicles. There is no data on capital stocks or depreciation rates. Estimates of the initial capital stock are obtained using industry level data for each type of capital separately using economic depreciation rates of 11.097 percent for plant and machinery, 2.91 per cent for buildings and land and 28.1 percent for vehicles.[24]

[24] See Oulton and O'Mahony (1994).

Table 8: AR(1) coefficients

	OLS	Within groups	Differenced	System	System
Output (y_{it})			y_{t-2}	$y_{t-3}, \Delta y_{t-2}$	
y_{it-1}	0.989	0.679	0.488	0.932	-
	0.003	*0.026*	*0.123*	*0.034*	-
m1	-0.889	-9.817	-4.808	-10.260	
m2	-1.285	-1.600	-1.769	-1.570	
Sargan (p-value)	-	-	0.212	0.067	
Difference-Sargan (p-value)	-	-	-	0.121	
Employment (l_{it})			l_{t-3}	$l_{t-3}, \Delta l_{t-2}$	
l_{it-1}	0.980	0.766	0.558	0.918	-
	0.003	*0.025*	*0.111*	*0.042*	-
m1	4.886	-8.378	-4.918	-8.388	
m2	0.966	-1.447	-1.363	-1.604	
Sargan (p-value)	-	-	0.243	0.097	
Difference-Sargan (p-value)	-	-	-	0.080	
Capital Stock (k_{it})			k_{t-2}	$k_{t-3}, \Delta k_{t-1}$	$y_{t-3}, \Delta y_{t-2}$, $l_{t-3}, \Delta l_{t-2}$, $x_{t-3}, \Delta x_{t-2}$
k_{it-1}	1.002	0.919	0.369	1.114	0.949
	0.003	*0.018*	*0.290*	*0.042*	*0.022*
m1	4.815	-3.888	-1.939	-3.733	-4.045
m2	3.356	0.414	1.382	0.375	0.392
Sargan (p-value)	-	-	0.516	0.283	0.020
Difference-Sargan (p-value)	-	-	-	0.742	0.305
Intermediate inputs (x_{it})			x_{t-2}	$x_{t-3}, \Delta x_{t-2}$	
x_{it-1}	0.989	0.630	0.383	0.952	-
	0.004	*0.032*	*0.104*	*0.029*	-
m1	-2.909	-8.758	-4.836	-8.789	
m2	-1.096	-0.385	-0.553	-0.177	
Sargan (p-value)	-	-	0.486	0.214	
Difference-Sargan (p-value)	-	-	-	0.248	

Note: standard errors in italics are one-step robust from DPD, m1 and m2 are the N(0,1) test statistics for first and second order serial correlation (see Arellano and Bond (1991, 1998), Sargan and Difference-Sargan are the p-values from these tests, all regressions include a full set of time dummies.

Establishment net capital stocks are estimated using 3-digit industry level capital stock estimates from Oulton and O'Mahony (1994). The initial capital stock for each establishment is obtained by allocating the industry capital stock between establishments using the share of each establishment's energy usage in total energy usage. This allocation rule is used as energy and capital equipment are compliments and thus energy usage is likely to provide a good proxy for the size of the capital stock. The perpetual inventory method (PIM) is then used at the establishment level. The value of the capital stock of each type of capital for each establishment in the first observed period is given by,

$$\hat{K}_{i1} = p_{it}^{K} I_{i1} + (1-\delta) w_i K_{j0} \frac{p_{it}^{K}}{p_{it-1}^{K}},$$

where p^K is the price of capital inputs, I_{it} is investment, δ is the geometric depreciation rate, w_i is the allocation rule and K_{j0} is the industry capital stock in the period before the establishment is first observed. In period t, $t > 1$ the capital stock is given by,

$$\hat{K}_{it} = p_{it}^{K} I_{it} + (1-\delta) \hat{K}_{jt-1} \frac{p_{it}^{K}}{p_{it-1}^{K}}.$$

This method of estimating the capital stock introduces measurement error in the series of a form that is declining over time (since the initial condition is measured with error). This means that the series violates the assumption that the initial observation is drawn from the same process. The estimates of the lagged capital stock coefficient shown in the fifth column of Table 8 are obtained using lags of output, employment and intermediate inputs as instruments on the assumption that these are orthogonal to the error term. These results suggest that the capital series follows much the same process as the other three series, as would be expected.

Estimates of the coefficients of the static Cobb-Douglas production function are presented in Table 9. A full set of time dummies is included in all columns to control for productivity shocks that affect all establishments. The OLS estimates in column (1) suggest that, on average, US-owned establishments have higher total factor productivity than domestic-owned establishments, but that there is no significant difference for establishments of any other nationality of foreign-ownership. This result has been found in other work using this data.[25] Constant returns to scale (CRS) is rejected and the test statistics indicate that the error term is serially correlated. The OLS coefficients will be biased if unobserved individual specific factors are correlated with the regressors. The within groups estimator, shown in column (2) will also be biased in short panels (the length of the panel used here varies from 4 to 13 years).

---

[25] See Oulton (1998) and Harris (1999).

Table 10: Static Cobb-Douglas production function

Dependent variable: output, y_{it}	(1) OLS	(2) within groups	(3) diff	(4) system	(5) system	(6) system CRS	(7) system
instruments (see notes)	-	-	$t-2$	$t-2, \Delta t-1$	$t-3, \Delta t-2$	$t-3, \Delta t-2$	$t-3, \Delta t-2$
employment, l_{it}	0.361	0.324	0.203	0.296	0.336	0.319	0.505
	0.016	*0.025*	*0.071*	*0.057*	*0.066*	*0.045*	*0.056*
capital stock, k_{it}	0.049	0.057	-0.043	0.061	0.079	0.076	0.048
	0.013	*0.023*	*0.092*	*0.029*	*0.030*	*0.033*	*0.031*
intermediate inputs, x_{it}	0.601	0.607	0.631	0.638	0.600	-	0.527
	0.018	*0.024*	*0.087*	*0.035*	*0.040*		*0.035*
US	0.049	-	-	0.048	0.036	0.048	0.008
	0.015			*0.032*	*0.027*	*0.019*	*0.029*
German	0.087	-	-	0.072	0.091	0.078	0.154
	0.061			*0.052*	*0.057*	*0.048*	*0.074*
Other foreign	0.003	-	-	-0.001	-0.005	0.003	-0.004
	0.031			*0.033*	*0.031*	*0.030*	*0.039*
Sargan (P-value)	-	-	0.248	0.029	0.052	0.078	0.094
CRS (P-value)	0.011	0.628	0.018	0.867	0.620	-	
m1	9.414	-8.827	-8.216	-8.954	-9.036	-8.978	-9.107
m2	8.227	-2.269	-2.256	-2.482	-2.536	-2.553	-2.529

Note: The sample is an unbalanced panel of 414 establishments from 1980-1992 with 3,259 observations; all regressions are estimated in DPD; numbers in italics are one-step robust standard errors; all regression include a full set of time dummies; m1 and m2 are N(0,1) distributed tests for first and second order serial correlation (see Arellano and Bond (1991, 1998)); Sargan and CRS are p-values; difference and system estimates are GMM with instruments dated in column (3) l_{it-2}, x_{it-2}*, in column (4)* $l_{it-2}, x_{it-2}, \Delta l_{it-1}, \Delta x_{it-1}$*, in column (5) and (6)* $l_{it-3}, x_{it-3}, \Delta l_{it-2}, \Delta x_{it-2}$ *and in (7)* $l_{it-3}, k_{it-3}, x_{it-3}, \Delta l_{it-2}, \Delta k_{it-2}, \Delta x_{it-2}$ *and earlier.*

As discussed above, the first-difference GMM estimates presented in column (3) will be consistent, but will suffer from finite sample bias due to the fact that the levels of the regressors are weak instruments for differences. One empirical issue that has to be addressed in using difference or system estimators is what dated instruments to use. The Sargan statistic provides a test of the validity of the instruments. The Sargan statistic in column (3) does not reject the validity of the instruments, although the test statistics indicate that there is evidence of both first and second-order serial correlation.

The systems estimates shown in columns (4) to (7) will not suffer from the weak instruments problem and will yield consistent estimates under the assumptions discussed earlier. In columns (4) to (6) the capital stock variable is dropped from the instrument set because of concerns about measurement error discussed above, while in column (7) it is included. In column (4) levels of employment and intermediate inputs dated $t-2, t-3, t-4$ are used as instruments for the difference equations and differences dated $t-1$ are used for the levels equation. The Sargan statistic rejects the validity of these instruments. In column (5) levels instruments dated one year earlier, $t-3, t-4, t-5$ and differences $t-2$, are used. The Sargan statistic still rejects the validity of these instruments. The serial correlation tests suggest that this static model may be mis-specified and that the dynamic form shown in equation (6) may be a more appropriate model.

CRS is not rejected in column (5) and in column (6) estimates imposing CRS are included for comparison. In columns (4) and (5) the foreign-ownership dummies are insignificant. However, when CRS is imposed in column (6) both US and German-owned establishments appear to have higher levels of TFP. The estimates of the factor shares in columns (1), (2), (4), (5) and (6) are remarkably similar to each other, and are quite close to the observe factor shares which are:[26]

Factor:	**Mean share (standard deviation)**
Labour	0.261 (0.098)
Capital	0.147 (0.108)
Intermediate goods	0.592 (0.137)

The observed labour share is somewhat lower than that estimated and capital share higher. In column (7), when capital is included in the instrument set, the estimated factors shares change significantly, with labour share increasing and both capital and intermediate share declining. However, as mentioned, in all seven columns the serial correlation tests suggest that this static model is misspecified.

In Table 10 estimates of the dynamic Cobb-Douglas production function are presented in the same order as in Table 9. All columns indicate a high degree of persistence, with a coefficient on the lagged dependent variable significant of around 0.5. In the bottom part of the table estimates of the coefficients after imposing the common factor restrictions given in equation (7) are shown. As discussed above, the OLS and within groups estimates may be biased. Column (3) shows the first-differenced GMM estimates with instruments dated $t-2$ and earlier.

[26] These are the mean factor shares are across individuals and years; shares are of output, labour share is (q301+q304)/output; intermediate input share is (q733+q734+q838)/output; capital share is 1 – labour share – intermediate input share.

Table 10: Dynamic Cobb-Douglas production function

Dependent variable: output, y_{it}	(1) OLS	(2) within groups	(3) diff	(4) system	(5) system	(6) system CRS	(7) system
instruments	-	-	$t-2$	$t-2, \Delta t-1$	$t-3, \Delta t-2$	$t-3, \Delta t-2$	$t-3, \Delta t-2$
l_{it}	0.396	0.402	0.486	0.498	0.388	0.423	0.470
	0.027	*0.030*	*0.079*	*0.078*	*0.083*	*0.077*	*0.076*
l_{it-1}	-0.307	-0.212	-0.324	-0.314	-0.256	-0.272	-0.221
	0.026	*0.026*	*0.077*	*0.066*	*0.074*	*0.073*	*0.070*
k_{it}	0.060	0.017	-0.116	0.025	-0.004	0.098	0.047
	0.024	*0.024*	*0.125*	*0.110*	*0.097*	*0.059*	*0.081*
k_{it-1}	-0.044	0.019	-0.037	0.008	0.058	-0.042	-0.014
	0.023	*0.025*	*0.130*	*0.104*	*0.094*	*0.056*	*0.078*
x_{it}	0.547	0.557	0.423	0.427	0.471	-	0.472
	0.023	*0.027*	*0.059*	*0.047*	*0.048*		*0.045*
x_{it-1}	-0.398	-0.140	-0.052	-0.081	-0.166	-	-0.219
	0.026	*0.027*	*0.057*	*0.043*	*0.069*		*0.057*
y_{it-1}	0.750	0.335	0.276	0.406	0.505	0.477	0.513
	0.019	*0.028*	*0.060*	*0.047*	*0.079*	*0.076*	*0.069*
US	0.014	-	-	0.073	0.028	0.025	0.001
	0.006			*0.025*	*0.019*	*0.013*	*0.018*
German	0.030	-	-	0.037	0.064	0.059	0.106
	0.020			*0.039*	*0.035*	*0.028*	*0.037*
Other foreign	0.008	-	-	0.033	-0.006	-0.004	-0.013
	0.014			*0.029*	*0.024*	*0.022*	*0.025*
Sargan (P-value)	-	-	0.161	0.068	0.103	0.122	0.093
CRS (P-value)	0.179	0.554	0.007	0.356	0.397	-	
m1	-6.318	-9.778	-7.562	-11.419	-9.021	-9.128	-9.634
m2	1.430	-0.178	-0.367	-0.341	0.105	0.105	0.174
l_{it}	0.371	0.368	0.441	0.444	0.369	0.379	0.500
	0.019	*0.025*	*0.071*	*0.062*	*0.074*	*0.056*	*0.062*
k_{it}	0.069	0.018	-0.066	0.032	0.084	0.118	0.086
	0.012	*0.021*	*0.095*	*0.033*	*0.045*	*0.036*	*0.036*
x_{it}	0.573	0.586	0.409	0.452	0.500	-	0.492
	0.017	*0.025*	*0.056*	*0.044*	*0.046*		*0.040*
y_{it-1}	0.762	0.378	0.374	0.503	0.590	0.572	0.537
	0.017	*0.024*	*0.042*	*0.034*	*0.059*	*0.052*	*0.059*
Comfac (P-value)	0.383	0.004	0.104	0.011	0.290	0.232	0.394

Note: The sample is an unbalanced panel of 414 establishments from 1980-1992 with 3,259 observations; all regressions are estimated in DPD; numbers in italics are one-step robust standard errors; all regression include a full set of time dummies; m1 and m2 are N(0,1) distributed tests for first and second order serial correlation (see Arellano and Bond (1991, 1998)); Sargan is the P-value from a test of the validity of the over-identifying restrictions for the GMM estimators; CRS is the P-value from a Wald test for constant returns to scale; coefficients in bottom part are one-step parameter estimates obtained using minimum distance estimator and imposing the common factor restrictions given by (8); Comfac is the P-value from a chi-squared test of the restrictions; difference and system estimates are GMM with instruments dated in column (3) l_{it-2}, x_{it-2}, *in column (4)* $l_{it-2}, x_{it-2}, \Delta l_{it-1}, \Delta x_{it-1}$, *in column (5)* $l_{it-3}, x_{it-3}, \Delta l_{it-2}, \Delta x_{it-2}$ *and in column (6)* $l_{it-3}, k_{it-3}, x_{it-3}, \Delta l_{it-2}, \Delta k_{it-2}, \Delta x_{it-2}$ *and earlier.*

In column (4) the systems estimator is used with levels instruments dated $t-2, t-3, t-4$ and differences $t-1$. As before capital is omitted from the instrument set in columns (3) to (6) and included in column (7). The Sargan statistic does not reject the instruments in columns (3) to (7) at the 5% level, but it does in column (4) at the 10% level. The test statistics indicate first-order but not second-order serial correlation, as would be expected from difference estimators.

The estimates in columns (5), (6) and (7) are remarkably similar to each other except that in column (7) the elasticity of output with respect to labour is higher. The results in all three columns indicate that only German-owned establishments appear to have permanently higher levels of TFP than domestic-owned, after conditioning on inputs and allowing for dynamics. The results for US-owned are less clear. In all specifications except (6), where CRS is imposed, there is no significant permanent difference in productivity levels between US-owned and domestic-owned establishments.

The descriptive statistics shown in Tables 6 and 7 highlighted the differences in the average wages paid by domestic and foreign-owned establishments. This raises the question of whether wage differentials reflect differences in skills or ability of workers. Table 11 presents estimates of the coefficients for the model that allows for heterogeneous workers, described in equation (10). In columns (1) and (2) labour is split into two types – administrative, technical and clerical workers (ATC) and operatives (OPS). In columns (3) and (4) the relative average wage of workers in each establishment is included. The relative average wage is defined as the log of the average wage for the establishment divided by the average wage across all establishments in that 4-digit industry in that year. The instruments used in columns (1) and (3) include capital, while in columns (2) and (4) capital is excluded from the instrument set. In all columns the levels instruments are dated $t-3, t-4, t-5$ and differences $t-2$. In the bottom part of the table (on the next page) estimates of the coefficients after imposing the common factor restrictions are given.

Operatives constitute a larger share of the workforce (around 70% – 75%) and the elasticities on the two types of workers vary with operatives having an elasticity about three times higher than ATCs. The coefficient estimates on capital, intermediate inputs and the lagged dependent variable do not change significantly. Relative wages enter significantly, though do not have a noticeable impact on the elasticity estimates. The relative wage terms indicating that establishments that pay higher wages have higher output levels. The positive coefficient on relative wages is interpreted here as indicating that workers are heterogeneous in their level of skill and ability.

Table 11: Heterogeneous workers

Dependent variable: output, y_{it}	(1)	(2)	(3)	(4)
instruments (see notes)	$t-3, \Delta t-2$	$t-3, \Delta t-2$	$t-3, \Delta t-2$	$t-3, \Delta t-2$
atc_{it}	0.103	0.093	0.128	0.120
	0.037	*0.040*	*0.031*	*0.034*
atc_{it-1}	-0.054	-0.078	-0.070	-0.094
	0.032	*0.033*	*0.027*	*0.029*
ops_{it}	0.367	0.308	0.342	0.292
	0.058	*0.059*	*0.046*	*0.047*
ops_{it-1}	-0.185	-0.185	-0.134	-0.140
	0.060	*0.060*	*0.049*	*0.050*
relative wage atc_{it}	-	-	0.082	0.107
			0.040	*0.044*
relative wage atc_{it-1}	-	-	-0.055	-0.075
			0.033	*0.033*
relative wage ops_{it}	-	-	0.265	0.262
			0.061	*0.067*
relative wage ops_{it-1}	-	-	0.033	-0.020
			0.057	*0.063*
k_{it}	0.025	-0.002	0.059	0.032
	0.071	*0.080*	*0.063*	*0.069*
k_{it-1}	0.014	0.063	-0.036	0.012
	0.068	*0.075*	*0.058*	*0.063*
x_{it}	0.490	0.495	0.504	0.506
	0.040	*0.043*	*0.033*	*0.035*
x_{it-1}	-0.198	-0.138	-0.089	-0.054
	0.055	*0.063*	*0.050*	*0.058*
y_{it-1}	0.479	0.437	0.292	0.286
	0.069	*0.073*	*0.066*	*0.072*
USA	0.003	0.035	0.026	0.052
	0.018	*0.020*	*0.015*	*0.020*
Germany	0.096	0.057	0.030	0.002
	0.037	*0.035*	*0.035*	*0.037*
Other foreign	-0.013	0.000	0.026	0.034
	0.025	*0.024*	*0.026*	*0.028*
Sargan (P-value)	0.154	0.175	0.044	0.342
m1	-10.080	-9.593	-9.393	-9.063
m2	0.053	-0.250	-0.532	-0.670

Table 11: Heterogeneous workers, continued

Coefficients imposing common factor restrictions	*(1)*	*(2)*	*(3)*	*(4)*
atc_{it}	0.101	0.072	0.116	0.093
	0.034	*0.037*	*0.026*	*0.029*
ops_{it}	0.367	0.296	0.331	0.285
	0.048	*0.053*	*0.039*	*0.044*
relative wage atc_{it}	-	-	0.063	0.073
			0.035	*0.037*
relative wage ops_{it}	-	-	0.257	0.286
			0.060	*0.064*
k_{it}	0.085	0.067	0.068	0.057
	0.033	*0.038*	*0.022*	*0.026*
x_{it}	0.515	0.521	0.515	0.519
	0.037	*0.040*	*0.028*	*0.032*
y_{it-1}	0.509	0.537	0.403	0.413
	0.060	*0.054*	*0.045*	*0.045*
Comfac (P-value)	0.574	0.242	0.318	0.431

Note: The sample is an unbalanced panel of 414 establishments from 1980-1992 with 3,259 observations; all regressions are estimated in DPD; numbers in italics are one-step robust standard errors; all regression include a full set of time dummies; m1 and m2 are N(0,1) distributed tests for first and second order serial correlation (see Arellano and Bond (1991, 1998)); Sargan is the P-value from a test of the validity of the over-identifying restrictions for the GMM estimators; CRS is the P-value from a Wald test for constant returns to scale; coefficients in bottom part are one-step parameter estimates obtained using minimum distance estimator and imposing the common factor restrictions given by (8); Comfac is the P-value from a chi-squared test of the restrictions; difference and system estimates are GMM with capital included as an instrument in columns (1) and (3) but excluded in columns (2) and (4) so the instruments are dated in column (1) $l_{it-3}, k_{it-3}, x_{it-3}, \Delta l_{it-2}, \Delta k_{it-2}, \Delta x_{it-2}$, *(2)* $l_{it-3}, x_{it-3}, \Delta l_{it-2}, \Delta x_{it-2}$, *(3)* $l_{it-3}, w_{it-3}, k_{it-3}, x_{it-3}, \Delta l_{it-2}, \Delta k_{it-2}, \Delta w_{it-2}, \Delta x_{it-2}$ *and in column (4)* $l_{it-3}, w_{it-3}, x_{it-3}, \Delta l_{it-2}, \Delta w_{it-2}, \Delta x_{it-2}$ *and earlier..*

As noted earlier, this variable could also be interpreted in different ways, for example as indicating an efficiency wage effect. Endogeneity might be a concern and because of this the variable is instrumented by lagged values.

The inclusion of the relative wage terms changes the coefficients on the foreign-ownership dummies. In column (1) Germany-owned establishments are seen to have higher permanent levels of productive (and in column (2) at the 10% level) than domestic-owned, while US-owned are the insignificantly different from domestic-owned. Once the relative wage variables have been included the coefficient on German-owned establishments falls into insignificance. This suggests that German-owned establishments hire workers with higher productivity levels, and pay them correspondingly more (or alternatively, they pay their workers more and thus get more out of them). In contrast to this, the US-owned dummy becomes significant after conditioning on relative wages. This suggests that US-owned establishments hire lower quality workers but still manage to get more output out of them, there is some unobserved factor that means that they are more productive.

5. Summary

This paper has investigated the differences between domestic and foreign-owned establishments in the UK motor vehicle and parts industry. Foreign-owned establishments were shown to have significantly higher levels of output and value-added per worker and correspondingly higher levels of factor usage, with foreign-owned establishments using higher levels of capital and intermediate inputs. Foreign-owned establishments also pay their workers higher wages, which may reflect differences in skill levels (or could reflect an efficiency wage effect). These differences in factor inputs appear to account for almost all of the differences in output levels.

The level of output per worker in foreign-owned establishments is of the order of two times larger than in domestic-owned establishments. After conditioning on differences in input levels in a static framework these differences reduce to around 10 per cent. Allowing for a general dynamic adjustment process reduces the difference further, and allowing for differences in wages (reflecting either differences in the quality of workers or an efficiency wage type effect) these differences all but disappear. There remains a small difference in the level of total factor productivity in US-owned establishments of around 5%, although this result is sensitive to the instruments used in estimation. These results imply that the reasons for high output per worker in foreign-owned establishments does not seem to be that they are operating on a higher technological frontier than domestic-owned establishments, as much of the recent literature suggests, but rather that they are operating at a point along the technological frontier using more intermediate and capital inputs.

The puzzle thus becomes why domestic-owned establishments are not investing in capital or paying their workers at the same level as foreign-owned establishments. It could be that they face some form of constraint (e.g. liquidity constraint) not faced by foreign-owned establishments. Another explanation is that in this sample the foreign-owned establishments are largely US-owned, and have been in the UK for a long time so therefore may no longer be at the technological frontier. Using more recent data it would be interesting to investigate further the differences with the newer Japanese-owned establishments. However, what this paper highlights is that it is important to understand what is driving differences in labour productivity. If these differences were due to differences in TFP, as is suggested by much of the theoretical and macro empirical literature, then policies that promoted technology transfer, e.g. through subsidising foreign investment, could be appropriate. However, if differences in the level of output per worker are largely explained by differences in investment patterns this has very different policy implications. It suggests that we need to understand better why firms face different incentives for investment and factor usage.

References

Aghion and Howitt (1998) *Endogenous Growth Theory*, Cambridge: MIT Press

Arellano, M and S.R. Bond (1991) "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations" *Review of Economic Studies*, 58, 277-297

Arellano, M. and S.R. Bond (1998) "Dynamic Panel Data Estimation using DPD98 for GAUSS" mimeo, Institute for Fiscal Studies, London

Arellano, M. and O. Bover (1995) "Another look a the instrumental-variable estimation of error-components models" *Journal of Econometrics*, 68, 29-52

van Ark, B (1996) "Productivity and competitiveness in manufacturing: a comparison of Europe, Japan and the United States", in Wagner, K and van Ark, B (eds) *International productivity differences: measurement and explanations*, North-Holland: Amsterdam, 23-52.

Attanasio, O. and Weber, G. (1991) "Consumption Growth, the Interest Rate and Aggregation" *Review of Economic Studies*, 60, 631-649

Auerbach, A.J. and K. Hassett (1993) "Taxation and foreign direct investment in the United States: a reconsideration of the evidence" in A.Giovannini. R.G. Hubbard and J. Slemrod eds. *Studies in International Taxation*, Chicago: University of Chicago Press, 119-147.

Barrell and Pain (1997) "Foreign Direct Investment, Technological Change, and Economic Growth Within Europe", *The Economic Journal*, Volume 107:445

Barro, R and Sala-i-Martin, X (1995) *Economic Growth*, McGraw Hill: NewYork

Bassett (1986) Strike Free: New Industrial Relations in Britain, MacMillan: London

Bean and Crafts (1995) "British economic growth since 1945: relative economic decline .. and renaissance?" CEPR Discussion Paper No. 1092

Bean and Symons (1989) "Ten Years of Mrs. T." *NBER Macroeconomic Annual*, Vol 4, 13-61

Bernard, A and Jones, C (1996a) "Productivity across industries and countries: time series theory and evidence" *Review of Economics and Statistics*, 78:1, 135-46 etc.

Bernard, A and Jones, C (1996b) "Comparing apples to oranges: productivity convergence and measurement across industries and countries", *American Economic Review*, December, 216-238

Blomstrom and Persson (1983) "Foreign investment and spillover efficiency in an underdeveloped economy: evidence from the Mexican manufacturing industry" World Development, 11: 493-501

Blundell, R. and Bond, S.R. (1998a) "Initial conditions and moment restriction in dynamic panel data models" *Journal of Econometrics* 87:1, 115-144

Blundell, R. and S.R. Bond (1998b) "GMM estimation with persistent panel data: an application to production functions" mimeo, Institute for Fiscal Studies

Blundell, R. and Stoker, T. (1998) "Models of aggregate economic relationships that account for heterogeneity", forthcoming in Blundell, R., Heckman, J. and Leamer, E. (eds.) *Handbook of Econometrics*, Amsterdam: North-Holland.

Cameron, G., Proudman, J. and Redding, S. (1998) "Openness and its association with productivity growth in UK manufacturing industry" in Proudman, J and Redding, S. (eds) *Openness and Growth*, London: Bank of England

Cas, A. and Rymes, T (1991) *On concepts and measures of multifactor productivity in Canada*, Cambridge University Press: New York

Caves, R. (1996) *Multinational Enterprise and Economic Analysis*, 2nd edition, Cambridge, England: Cambridge University Press

Caves, R. (1982) *Multinational Enterprise and Economic Analysis*, Cambridge, England: Cambridge University Press

Caves (1974) "Multinational firms, competition and productivity in host-country markets" *Economica*, 41: 176-193

Caves, D. L. Christensen and W. E. Diewert (1982) "Multilateral comparisons of output, input, and productivity using superlative index numbers" *The Economic Journal*, 92, 73-86

CSO (1996) Business Monitor MA4 Overseas Direct Investment HMSO

Cummins, J.G. and Hubbard, R.G. (1994) "The Tax Sensitivity of Foreign Direct Investment: Evidence from Firm-Level Panel Data" *NBER Working Paper* No. 4703

Davies and Lyons (1991) "Characterising relative performance: the productivity advantage of foreign owned firms in the UK" *Oxford Economic Papers*, 43 (October) 584-595

Denison, E. (1989) *Estimates of productivity change by industry*, Brookings: Washington DC

Diewert, I. and Nakamura, A. (1998) "A survey of empirical methods of productivity measurement and analysis", forthcoming in Blundell, R., Heckman, J. and Leamer, E. (eds.) *Handbook of Econometrics*, Amsterdam: North-Holland.

Dougherty, C and Jorgenson, D (1997) "There is no silver bullet: investment and growth in the G7", National Institute Economic Review, 57-74(CSO, 1996)

Dunning, J. (1977) "Trade, location of economic activity and MNE: a search for an eclectic approach", in B. Ohlin, P.O. Hesselborn and P.M. Wijkman eds. *The International Allocation of Economic Activity*, London:McMillan, 395-418.

Dunning, J. (1981) *International Production and the Multinational Enterprise*, George Allen & Unwin: London

Edwards, S (1998) "Openness, productivity and growth: what do we really know?", *The Economic Journal*, Vol. 108, No. 447, 383-98

Froot and Stein (1991) "Exchange rates and foreign direct investment: an imperfect captial markets approach", *Quarterly Journal of Economics*, 106, 1191-1217

Gerschenkron, A (1962) *Economic Backwardness in Historical Perspective*, Cambridge: Belknap Press

Globerman (1979) "Foreign direct investment and spillover efficiency benefits in Canadian manufacturing industries" *Canadian Journal of Economics*, 12: 42-56;

Graham and Krugman (1991) *Foreign Direct Investment in the United States*, Second Edition, Institute for International Economics, Washington DC

Griffith, R. (1999) "Using the ARD establishment level data: an application to estimating production functions" forthcoming in *Economic Journal Features*

Griliches, Z and Mairesse, J. (1997) "Production functions: the search for identification" in Strom (ed.) *Essays in Honour of Ragnar Frisch*, Cambridge: Cambridge University Press

Grossman and Helpman (1991) *Innovation and Growth in the Global Economy*, Cambridge: MIT Press

Hall, R and Jones, C (1999) "Why do some countries produce so much more output per worker than others?", *Quarterly Journal of Economics,* Vol. CXIV, 83-116

Harris, R (1999) "Efficiency in UK plants", University of Portsmouth mimeo

Hines, J.R. (1996) "Altered States: taxes and the location of foreign direct investment in America", *American Economic Review*, 86, 1076-1094.

HMSO (1997) *Industrial Development Act 1982 Annual Report* by the Secretaries of State for Trade and Industry, Scotland and Wales for the year ended 31 March 1997, HMSO: London

Hulten, C. (1993) "Panel discussion: implications of BEA's treatment of computer prices and productivity measurement" in Foss, M., Manser, M and Young, A. (eds.) *Price measurements and their uses*, University of Chicago Press: Chicago

Jorgenson, D. (1966) "The embodiment hypothesis", *Journal of Political Economy*, 74,1, February, 1-17

Jorgenson, D. and Griliches, Z. (1967) "The explanation of productivity change", *Review of Economic Studies*, 34 (July), 249-280

Jorgenson, D., Gollop, F and Fraumeni, B. (1987) *Productivity and US economic growth*, Cambridge MA: Harvard University Press

Klette, T. and Griliches, Z. (1996) "The inconsistency of common scale estimators when output prices are unobserved and endogenous", *Journal of Applied Econometrics*, 11, 343-361

Krugman, P.R. (1991a) "Increasing returns and economic geography" *Journal of Political Economy*, 99, 483-499.

Krugman, P.R. (1991b) *Geography and Trade*, Cambridge,USA: MIT Press.

Krugman, P.R. (1994) *Rethinking International Trade*, Cambridge,USA: MIT Press.

Lansbury, M. (1995) "UK manufacturing employment since Beveridge: the chemical and motor vehicle industries", NIESR Discussion Paper No. 83

Layard and Nickell (1989) "The Thatcher Miracle?" *American Economic Review (Papers and Proceedings)*, Vol. 79, 215-9

Levine, D. (1992) "Can wage increases pay for themselves? Tests with a production function", *The Economic Journal*, 102, 1102-1115

Marsden, Morris, Willman and Wood (1985) *The car industry: labour relations and industrial adjustment*

Mayes, D. (ed.) (1996) *Sources of productivity growth*, Cambridge University Press: Cambridge

Morck and Yeung (1992) "Internalisation: an event study test" *Journal of International Economics*, 33, 41-56

Nadiri, M.I. and Prucha, I. (1998) "Dynamic factor demand models and productivity analysis", NBER mimeo

Nickell, S.J. (1995) *The performance of companies*, Oxford: Blackwell

Nickell, S.J. (1996) "Competition and corporate performance" *Journal of Political Economy*, 104: 724-746

Nickell, S.J. (1995) "Does doing badly encourage management innovation?" paper presented at IFS conference, May 1995

Nickell, S.J. Wadhwani, Sushil B and Wall, Martin (1992) "Productivity Growth in UK Companies, 1975-1986" *European Economic Review*, 36, 1055-85

O'Mahony, M. (1998) "Britain's relative productivity performance, 1950-1996: a sectoral analysis", NIESR mimeo

Oulton, N. (1998) "Investment, capital and foreign ownership in UK manufacturing", NIESR Discussion Paper 141

Oulton, N. and O'Mahony, M (1994) *Productivity and Growth: a study of British industry 1954-1986*, NIESR: London

Pischke, J. "Individual income, incomplete information, and aggregate consumption" *Econometrica*, 63:4, 805-840

Smith, A. (1994) "Strategic trade policy in the European car market" in Krugman, P. and Smith, A. (eds) *Empirical Studies of Strategic Trade Policy*, Chicago: Chicago University Press

Solow, R. (1957) "Technical change and the aggregate production function", *Review of Economics and Statistics*, 39,3, August, 312-320Sobel, R. and Garrett, T. (1997) "Taxation and product quality: new evidence from generic cigarettes" *Journal of Political Economy*, 105(4): 880-887

Stoker, T. (1998) "Empirical approaches to the problem of aggregation over individuals" *Journal of Economic Literature*, Vol XXXI, pp 1837-1874

Venables, A. (1994) "Trade policy under imperfect competition: a numerical assessment" in Krugman, P. and Smith, A. (eds) *Empirical Studies of Strategic Trade Policy*, Chicago: Chicago University Press

Vernon, R. (1966) "International Investment and International Trade in the product Cycle," *Quarterly Journal of Economics*, LXXX, 190-207