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Investment, Capital and Foreign Ownership in UK Manufacturing

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CONTENTS

ABSTRACT

This paper studies physical investment in UK manufacturing from the viewpoint of the individual establishment, i.e. business or plant. It uses the new longitudinal database of the Census of Production, the ARD. I construct a sample of 1,752 establishments which survived over 1973-93 and estimate their capital stocks. These survivors accounted for about a third of manufacturing employment. From production function estimates, the neo-classical view that the elasticity of output with respect to capital is equal to capital's share cannot be rejected. Capital intensity varies widely across establishments even in the same SIC80 Class. It is 50% higher in foreign-owned establishments which are also more human capital intensive. Value added per worker is 38% higher in foreign-owned establishments. Human and physical capital intensity differences are a significant determinant of productivity gaps between establishments. Even after allowing for their higher capital intensity, US-owned (but not other foreign-owned) establishments have an additional productivity advantage of between 9 and 20%.

Keywords *Capital, investment, productivity, foreign ownership*

JEL codes *D24, J24, L60*

Introduction[1]

To what extent is the growth of labour productivity due to the growth of physical capital per worker? This is an old question but typically it has been addressed at the aggregate level, at least in Britain. But once we recognise that investment decisions are taken at the company or business level, further questions suggest themselves. Are there systematic differences between businesses in the rate of investment and in the growth rate of capital per worker? Are there systematic differences also in the *level* of capital per worker? If so, what explains these differences? In this paper, I attempt answers for manufacturing using data at the level of the individual business (establishment). These data derive from the new database of the Annual Census of Production known as the ARD. In an earlier paper using the ARD I found that the bulk of labour productivity growth in manufacturing in the 1980s was due to growth within surviving establishments (Oulton 1998b). The present paper builds on that one by attempting to explain the observed growth. It goes further too by analysing the reasons for the large differences between businesses in the *levels* of labour productivity.

The aggregate picture

Table 1 shows investment in manufacturing in constant (1990) prices for the period 1970-96. Investment in plant and machinery accounts for 75-80% of the total and investment in buildings for about 15%. The remainder is investment in vehicles, ships and aircraft (not shown). Charts 1-6 show the course of investment over time on two different bases, firstly as investment plain and simple and secondly as investment per employee (per head). Machinery investment (charts 1 and 2) behaves erratically in the 1970s, falling in the recession following the first oil shock and rising from 1976 onwards. After 1979 there is a very steep fall followed by a strong recovery which reaches an all time peak of £13.6 billion in 1989. Then follows another fall until recovery recommences in 1994. Despite this, in 1995 and 1996 machinery investment was lower than it had been in 1979.

[1] This research has been supported by the Department of Trade and Industry to whom I owe thanks. I am grateful to Martin Baily, Peter Hart, Nicholas Owen and Martin Weale for helpful comments and to the staff of the ONS at Newport for assistance in using the ARD. The usual disclaimer applies.

Table 1 **Investment in UK manufacturing, £m 1990 prices, 1970-96**

Year	*IP*	*IB*	*IT*	*Y*	*L*	*K*
	£1990 m	*£1990 m*	*£1990 m*	*1990=100*	*1990=100*	*£1990 m*
1970	9,116	2,901	13,022	85.9	157.1	n.a.
1971	8,375	2,540	12,190	85.0	152.0	n.a.
1972	7,236	2,099	10,591	86.8	147.1	n.a.
1973	7,963	2,030	10,998	94.8	147.9	114,349
1974	9,005	2,003	12,153	93.6	148.4	117,926
1975	8,384	1,857	11,214	87.2	141.9	120,296
1976	8,123	1,523	10,641	88.8	137.5	121,914
1977	8,322	1,648	11,074	90.5	137.8	123,845
1978	9,457	1,848	12,838	91.1	138.4	127,395
1979	10,038	1,889	13,558	90.8	137.7	131,398
1980	9,312	1,525	12,307	83.0	130.1	133,850
1981	7,408	1,112	9,985	77.9	118.7	133,796
1982	7,231	1,020	9,518	77.8	111.8	133,280
1983	7,261	872	9,413	79.4	106.3	132,697
1984	8,557	1,272	10,975	82.4	104.9	133,719
1985	9,883	1,560	12,710	84.8	104.4	136,400
1986	9,844	1,440	12,097	85.8	102.1	138,267
1987	9,000	1,530	12,641	89.8	101.2	140,538
1988	11,169	1,837	13,846	96.3	102.4	143,844
1989	11,996	2,044	14,984	100.2	102.7	148,040
1990	11,531	1,907	14,227	100.0	100.0	151,164
1991	10,333	1,900	12,803	95.0	92.3	152,629
1992	9,547	1,671	11,828	95.1	86.8	153,010
1993	8,957	1,593	11,230	96.4	83.8	152,764
1994	9,510	1,837	11,997	100.9	83.4	153,304
1995	10,275	2,291	13,181	102.5	84.2	154,987
1996	9,613	2,055	12,442	102.9	85.1	155,805

Source Datastream and (for *K*) own calculations.
Note *IP*: investment in plant and machinery (ONS code DFQP)
IB: investment in buildings (ONS code DFQQ)
IT: total investment (ONS code DECV)
Y: output (ONS code DUDM)
L: employment (ONS code DMWB)
K: capital stock (cumulated IT, assuming depreciation at 7.5% p.a.)

CHART 1

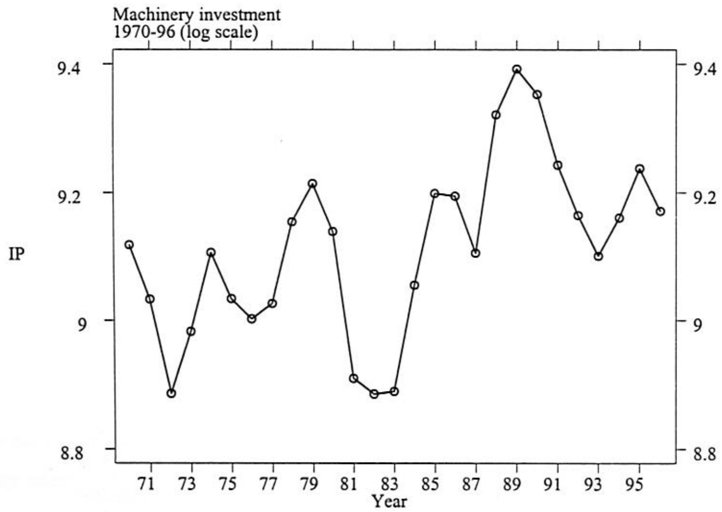


CHART 2

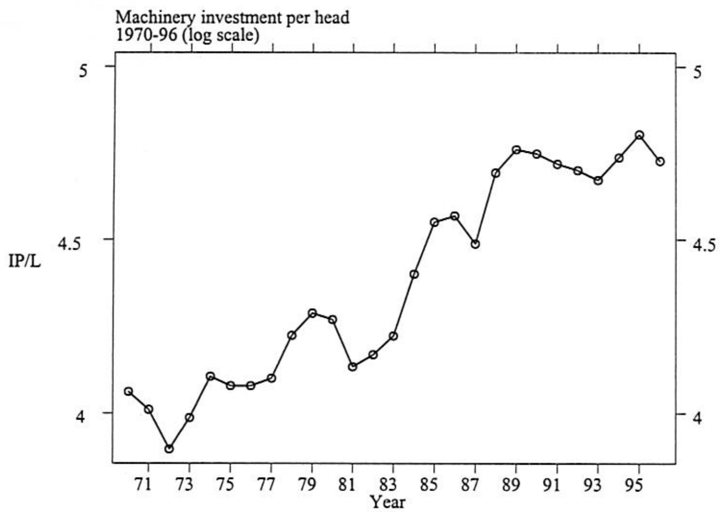


CHART 3

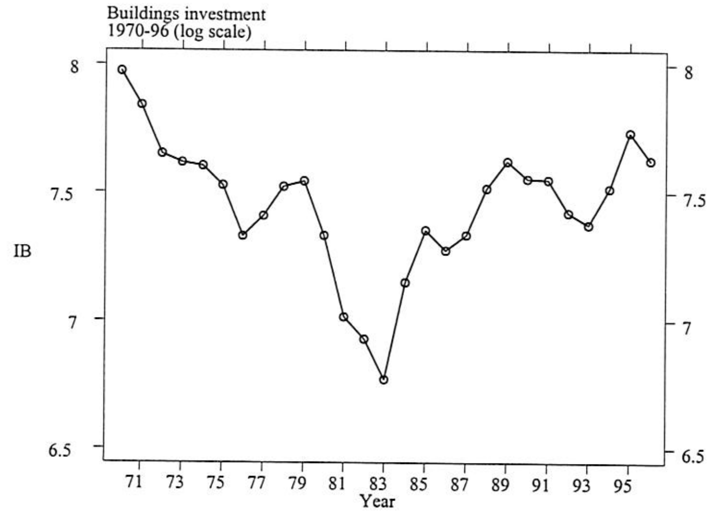


CHART 4

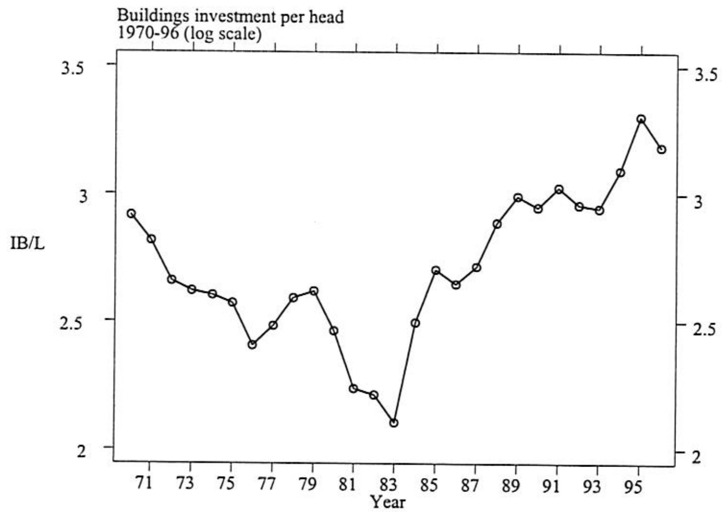


CHART 5

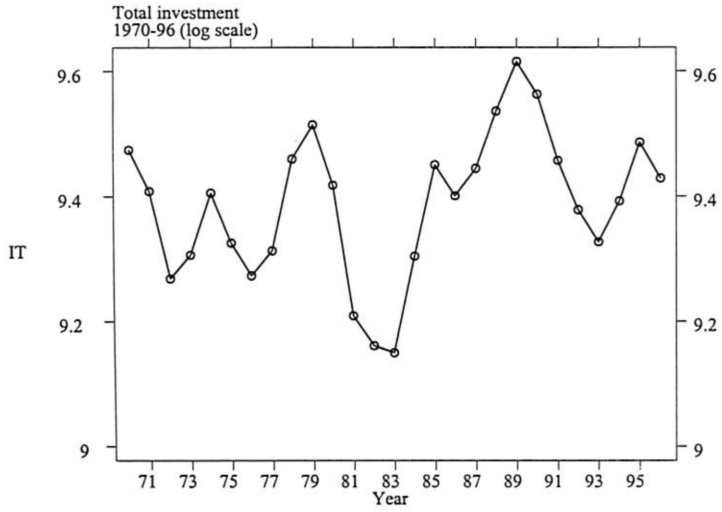
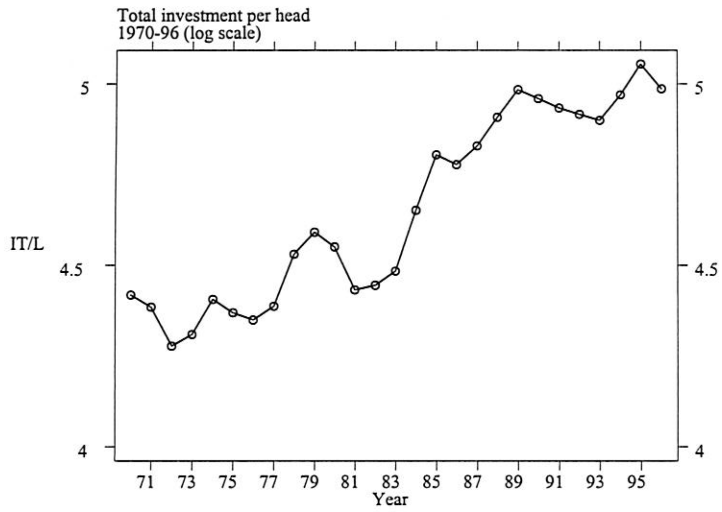


CHART 6



A rather different picture presents itself if we look at investment per employee (chart 2). The effects of the three serious recessions in 1974-75, 1980-81 and 1990-92 are still apparent but now we see a general upward trend, at least until 1989. In 1989 machinery investment per employee was 48% higher than in 1973. The contrast between these two views of investment is of course due to the fact that employment has been falling almost continuously and especially rapidly in the 1980s.

Investment in buildings shows a quite different, V-shaped pattern with the trough in 1983 (charts 3 and 4). In absolute terms it was lower at the end of the period than it had been at the beginning, though higher in per employee terms. The picture for total investment is very similar for that of its major component, machinery investment (charts 5 and 6).

The investment-output ratio in constant prices is depicted in charts 7 and 8. The machinery investment ratio shows an upward trend in the 1970s and 1980s which however does not persist into the 1990s. The total investment ratio seems to be fairly constant, though clearly highly cyclical.

For many purposes, we are interested in the capital stock rather than investment. The capital stock is simply cumulated investment after allowing for depreciation. Depreciation measures the decline in the stock due to physical wear and tear, gradual obsolescence, and scrapping or retirement. U.S. research suggests that depreciation rates much higher than those assumed by the ONS for their "net stock" estimates are appropriate (Fraumeni 1997). In line with these results, I assume an annual rate of depreciation of 7.5%. The resulting estimates of the capital stock are shown in Chart 9 and of the capital-labour ratio in Chart 10.[2] Except in 1981-83, the capital stock has risen steadily over this period. The capital-labour ratio has also risen steadily though it appears to have flattened off after 1993. The average manufacturing worker in 1996 had more than twice the capital of his counterpart of 1973.

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[2] I am grateful to my colleague Mary O'Mahony for supplying me with benchmark figures for the capital stock and employment in manufacturing in 1973.

CHART 7

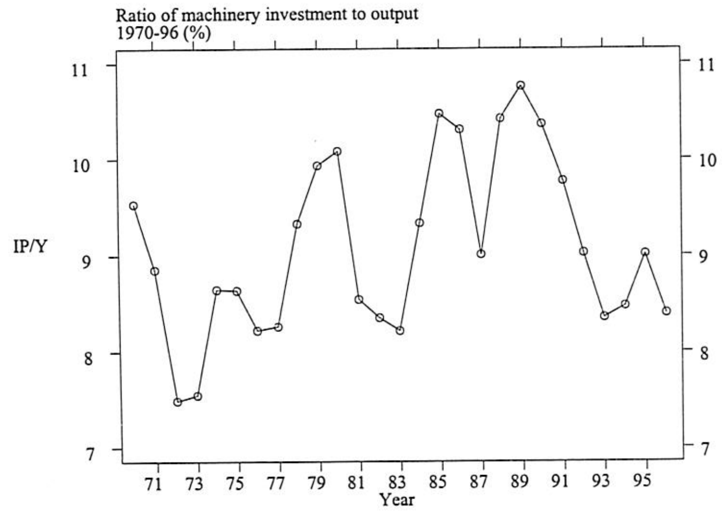


CHART 8

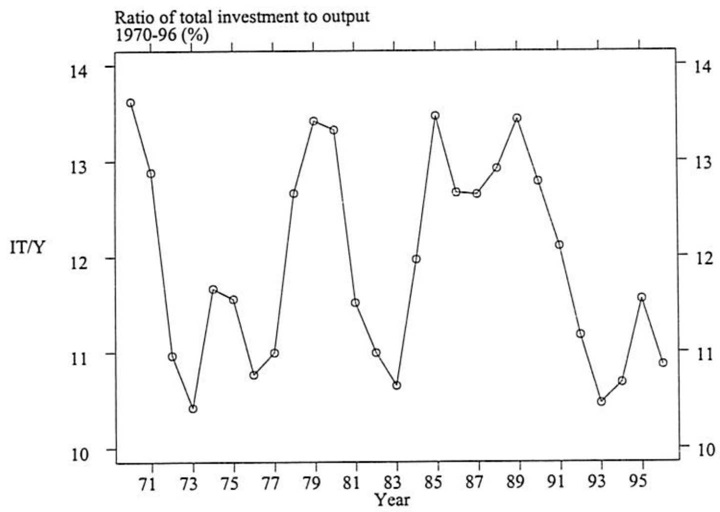
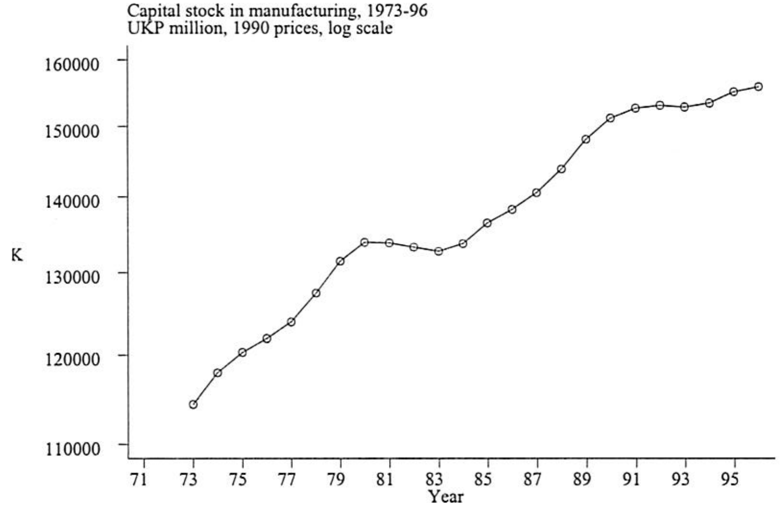
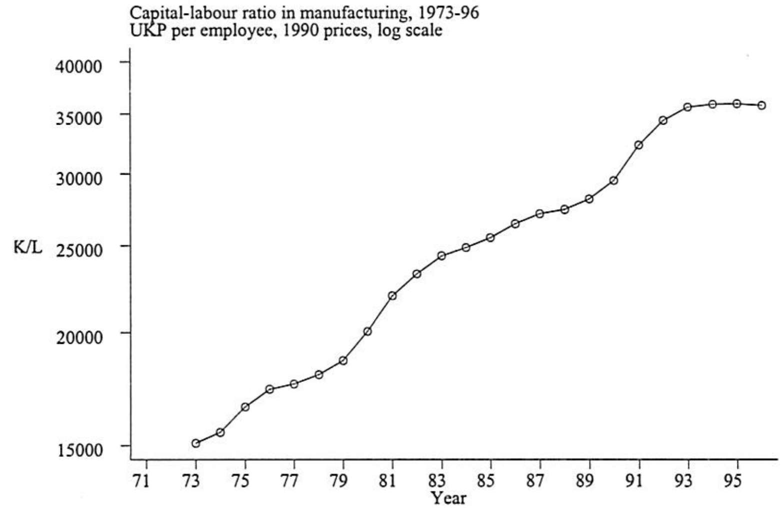


CHART 9



Source Table 1. Capital stock is cumulated total investment, assuming a depreciation rate of 7.5%.

CHART 10



Source Table 1. Capital stock is cumulated total investment, assuming a depreciation rate of 7.5%.

Some of the rise in the capital-labour ratio is due to the steady reduction in the manufacturing labour force. However, this is not the whole story, as Chart 9 illustrates: the capital stock rose by 36% between 1973 and 1996. These estimates make no allowance for accelerated scrapping in the 1980-81 recession which is often alleged to have occurred. But with such a rapid rate of depreciation the effect of any reasonable estimate of such scrapping is likely to be small. Suppose that 20% of the capital stock was scrapped in 1980-81, over and above "normal" depreciation. This would certainly affect estimates of the stock for these years but would have little effect on the figures for the second half of the 1980s and later. The reason is that with depreciation at 7.5% per annum, a reduction of 20% of the current stock occurs after 3 years anyway.[3]

Outline of the paper

The next section describes our data source, the ARD, since its strengths and weaknesses will condition the type of analysis we are able to carry out. It also describes how a sub-set of the ARD, consisting of those establishments which are continuously present from 1973 to 1993 inclusive, was constructed. For this sub-set we are able to make estimates of the capital stock. In section 3 we look at the pattern of investment first amongst all establishments and secondly amongst survivors. In section 4 we fit production functions for survivors. Here the aim is to estimate the responsiveness (elasticity) of output with respect to increases in the capital stock. Then in section 5 we consider systematic reasons for differences in capital intensity between establishments located in the same industry, in particular the role of foreign ownership. It turns out that there are large differences between domestic and foreign-owned establishments and section 6 discusses a number of different explanations for this fact. It also considers whether macroeconomic instability has had more impact on UK-owned establishments. Section 7 concludes.

[3] For further discussion of the estimation of the capital stock see Oulton and O'Mahony (1994, chapter 3).

2. The ARD

The ARD, or ABI Respondents Database to give it its full name, is an electronic database of the Annual Census of Production (ACOP). In principle, it includes all the data collected under ACOP from 1970 to the present. It covers the whole of the production sector, manufacturing plus mining and quarrying and, for recent years, construction (see Oulton 1997b for a full description). In the present paper I use only the data for manufacturing.

The most basic unit in the ARD is the "local unit", defined as a plant or office at a single location. Above that is the establishment, which is the reporting unit. An establishment consists of at least one local unit (itself) and may consist of more. In recent years a bit under half of employment in selected establishments has been in establishments consisting of just one local unit and nine tenths in establishments with no more than 10 local units. Most of the data in the ARD (e.g. GVA) relate to the establishment as a whole. The establishment may or not be a company in the legal sense. In 1987, "company-based reporting" was introduced into the Census and the reporting units are now referred to as "businesses". But the larger companies continued to be split up into smaller units.[4]

Three measures of output are available from the ARD. In descending order of size these are: gross output, net output and gross value added. For the production function estimates to be reported later I use gross output. For comparisons of labour productivity I use gross output and also gross value added (GVA), the latter mainly because it is additive across establishments and industries. Gross output and GVA which are reported in current prices were converted to 1990 prices using producer price indexes for each Class of the 1980 SIC (of which there are 22 within manufacturing: see the Appendix).[5] For the period studied here, industry is recorded in the ARD under the 1980 SIC.

[4] It is not clear without further research how much difference this change made. For clarity, and because most of the data used here were collected before the change to company-based reporting, I continue to use the term "establishment". Note that in American usage an establishment is a plant and this should be borne in mind when comparing the present results with US ones.

[5] For Classes 21, 36 and 44 no PPI exists so the PPI for manufacturing as a whole was used. These deflators were obtained from Datastream.

Under the heading of investment, ACOP and the ARD distinguish four categories: (1) new building work; (2) land & existing buildings; (3) plant & machinery; and (4) vehicles. For the last three categories, both acquisitions and disposals are recorded separately. From 1992, only total acquisitions and total disposals are recorded and the breakdown by type is no longer available at the establishment level.[6] (Figures for each category continue appear in the ARD for 1992 and later but these were assigned by applying ratios and so do not represent genuine micro data). A further difficulty is that prior to 1979 the four categories are only recorded in the ARD for a minority of establishments; the reason for this is not clear. The upshot is that a breakdown by category is only available for the period 1979-91 inclusive.

Investment is recorded gross of depreciation. From 1988, investment includes assets acquired under financial leasing. Prior to 1988, financial leasing was omitted. It is important to note that though asset disposals are given as well as acquisitions, "the figures for disposals exclude amounts written off for capital assets which are scrapped" (Introduction to the *Summary Volume* of the Census of Production, various issues). In other words, scrapping is not recorded.

Except for new buildings, I use acquisitions less disposals as the investment measure. This means that investment can be, and frequently is, negative for an individual establishment. Total investment is the sum over these four categories and it too can be negative.

Investment in the ARD is also in current prices. It was deflated to 1990 prices by the implicit deflator for manufacturing investment (the latter obtained by dividing total manufacturing investment in current prices by investment in constant 1990 prices, both from the Blue Book via Datastream).

6 Total capital expenditure (acquisitions net of disposals) was collected at the local unit level as well as at the establishment level up till and including 1992. But for practical reasons these data are at the moment present in the ARD only for 1984, 1989 and 1992.

Two measures of labour input are available from the ARD: the number of operatives and the number of administrative, technical and clerical employees (ATCs).[7] No data on hours worked are available at the establishment level. Apart from the split into operatives and ATCs, there are no data on skills. However, average wages for each group are given and these may be used as proxies for relative skills or human capital at a point in time.

To estimate a gross output production function as we do below, we require real intermediate input but the ARD contains only nominal intermediate input. We deflate the latter, defined as nominal gross output minus nominal GVA, by the Producer Price Index for materials and fuel for each SIC80 Class.

For the analysis of economic growth, productivity and living standards, we are usually more interested in the capital stock, rather than in investment. Of course, the capital stock can only grow if there is investment but the latter is not of interest in itself. So it may be more important to explain the growth and level of the capital stock over relatively long periods. Here we run up against a difficulty. The ARD contains no data on capital stocks, not even book values. So we must estimate stocks by cumulating investment flows. To do so, we have to assume an initial, year zero, capital stock. If the year zero is sufficiently far in the past, and the depreciation rate sufficiently high, the stock estimates for later years will not be too sensitive to the assumed initial stock. But thousands of establishments are entering and leaving the ARD every year. Capital stock estimates based on only a few years of cumulated investment will be too unreliable to use.

Our strategy to deal with this problem is to create a dataset of survivors, in this case establishments who are continuously present in the ARD from 1973 to 1993. We proceed as follows. We start with a benchmark capital stock in 1973 for each establishment. We then estimate the stock K in subsequent years by the standard perpetual inventory method:

7 In addition there is the small category of "working proprietors". Where available this has been amalgamated with ATCs.

$$K_t = I_t + (1-\delta)K_{t-1}$$

where I is real investment and δ is the depreciation rate, assumed equal to 0.075 (7.5%, see above). To get the initial capital stock for each establishment, we multiply each establishment's 1973 employment level by the capital-labour ratio for the SIC80 Class to which the establishment belongs.[8]

3. Investment at the establishment level

Overall

We start by looking at the overall pattern of investment for all establishments in the ARD. As a descriptive tool, we fit an autoregressive, panel model of the following form for the log of investment (I):

$$\ln I_{it} = \beta_1 \ln I_{t-1} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where μ_i are the fixed effects, the λ_t represent time period effects, and ε_{it} is an error term. This model is fitted separately for smaller establishments with employment of 100 or less and larger establishments with employment exceeding 100, over the 20 year period 1974-93 (Table 2).

For smaller establishments it is clear that the degree of persistence in investment is negligible. The estimated value of β, though statistically significant, is only 0.0397. The year dummies, which encapsulate all common macro effects, though again statistically significant, clearly have little explanatory power. So overall explanatory power is low (R^2=0.074). This is perhaps not too surprising when we see that on average a smaller establishment only appears in the ARD for 4½ years. For larger establishments, the average duration in the ARD is more than twice as long, 9.62

[8] I am grateful to my colleague Mary O'Mahony for supplying me with these capital-labour ratios. The initial capital stocks for each Class have been derived by the perpetual inventory method using similar but more detailed assumptions about depreciation rates to the one in the text.

Table 2 Panel regression results for smaller and larger establishments, 1974-93: dependent variable is log of investment (ln I)

	Smaller establishments (100 employees or fewer)	*Larger establishments (more than 100 employees)*
$\ln I_{-1}$	0.0397**	0.2712**
	(0.0035)	(0.0028)
$N \times \overline{T}$	108,270	139,878
N	24,370	14,538
$\overline{T}$	4.44	9.62
R^2	0.074	0.530

Note Model of equation (1) fitted with fixed effects and year dummies; these coefficients not reported. N: number of establishments. $\overline{T}$: average number of years for which each establishment present.

** Significant at the 1% level

years, and for them persistence is much higher too: the estimated β is 0.2712.[9] Over half the variance in the log of investment is now accounted for. For both large and small establishments the fixed effects are significant. Adding an additional lag does little to change the picture.

Nevertheless the degree of persistence even for larger establishments is fairly low (the same model fitted for log employment yields a coefficient of 0.8035 and an R^2 of 0.937). Clearly, there is a huge amount of variation at the establishment level and it may be impossible to develop a satisfactory model of year to year changes in investment.[10]

Survivors

There are 1,752 establishments which are present throughout the period 1973-93 (the latest available year when this research began[11]). In 1973 employment in these

[9] The estimate of β will be biased downwards in such a relatively short panel (Nickell 19891) but this is not relevant here since the panel regressions are only used as a descriptive tool.
[10] For an attempt at doing so which emphasises slow adjustment of actual to optimal stock, see Caballero *et al.* (1995).
[11] The earliest year in the ARD is 1970 but the data for the years 1970-72 are not currently in a form amenable to analysis.

survivors was nearly 1.8 million and constituted 29.6% of all employment recorded in the ARD. In 1993, the corresponding figures were just over 1 million or 34.5% of total ARD employment. These survivors exhibited a wide range of size (Table 3). In 1973, the largest size (7,500 or more employees) accounted for 24.9% of employment in survivors; by 1993 this share had halved to 12.8%.

Table 3 Distribution of 1973-93 survivors by employment size in 1973 and 1993

	1973				1993			
	Estab-lishments	*Employment*			*Estab-lishments*	*Employment*		
Employment size (range)	*No.*	*No.*	*Share (%)*	*Cumulative share (%)*	*No.*	*No.*	*Share (%)*	*Cumulative share (%)*
≤49	20	789	0.0	0.0	15	497	0.0	0.0
50-74	35	2,290	0.1	0.2	32	2,002	0.2	0.2
75-99	56	4,879	0.3	0.4	65	5,799	0.6	0.8
100-199	291	44,888	2.5	2.9	450	66,135	6.4	7.2
200-499	542	173,806	9.7	12.6	672	212,495	20.6	27.8
500-999	387	271,569	15.2	27.8	319	219,755	21.3	49.0
1,000-1,499	164	200,067	11.2	39.0	87	105,801	10.2	59.3
1,500-1,999	83	142,659	8.0	46.9	32	54,034	5.2	64.5
2,000-2,999	76	180,582	10.1	57.0	42	102,318	9.9	74.4
3,000-3,999	29	102,481	5.7	62.7	12	41,376	4.0	78.4
4,000-4,999	15	66,732	3.7	66.4	11	49,446	4.8	83.2
5,000-7,499	26	155,839	8.7	75.1	7	40,970	4.0	87.2
7,500+	28	445,599	24.9	100.0	8	132,380	12.8	100.0
Total	1,752	1,792,180	100.0	—	1,752	1,033,008	100.0	—

Source ARD.

Even for survivors, investment was negative in 1,390 cases out of the total number of observations of (1,752 x 21 =) 36,792, i.e. 4% of cases. Investment tends also to be more variable than employment or output. Since investment will obviously tend to be larger the larger the establishment, we compare investment per person employed with output per person employed. For all 21 years taken together, the log standard deviation of investment per employee is 1.21, compared with 1.08 for the log standard deviation of labour productivity. Investment also tends to be less persistent than output or employment. Suppose we fit the model of equation (1) for each of investment, employment and output for the maximum possible period, 1974-93. The year dummies will of course account for any common, cyclical effects. The results are in Table 4.

Table 4 Panel regression results for survivors, 1974-93

Dependent variable (in logs)	*Estimate of β*	*t ratio*	R^2	$N \times \overline{T}$	$\overline{T}$
Total investment	0.3572	66.2	0.6308	32,661	18.64
Employment	0.8967	339.2	0.9783	35,040	20.00
Gross value added	0.6342	145.1	0.9065	34,783	19.85

Note Model of equation (1) fitted with fixed effects and year dummies; these coefficients not reported. *N*: number of establishments (1,752). $\overline{T}$: average number of years for which each establishment present (<20 for investment and GVA since some values of these variables were negative and so could not b logged).

Clearly, investment is less persistent than output, which in turn is less persistent than employment. R^2 is also substantially lower for investment, indicating that there is substantially more idiosyncratic variation for this variable than the other two.

Charts 11-14 show kernel density estimates of the log of investment per employee for selected years. The density is unimodal and shows little change in overall shape over time; it is somewhat more peaked than a normal distribution. However neither the mean nor the dispersion across establishments of investment per employee have been constant over time (Charts 15 and 16). The mean rises strongly in the 1980s, just as aggregate investment per employee does (Chart 6). The time series for the standard deviation of the log of investment per employee shows a somewhat different pattern. After fluctuating in the 1970s and 1980s it has been rising steadily since 1989. A possible reason is that the average employment size of these establishments has been shrinking and investment is more variable amongst smaller establishments. But this explanation does not fit the facts since size was shrinking in the early 1980s too but variability did not increase then.

CHART 11

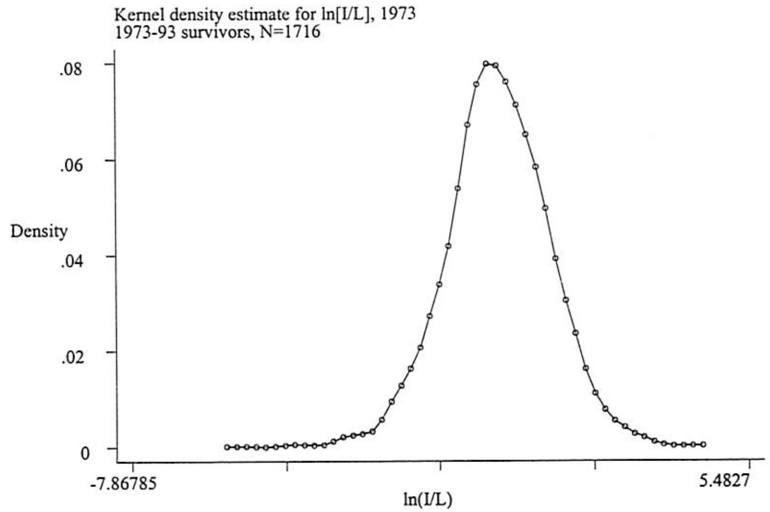


CHART 12

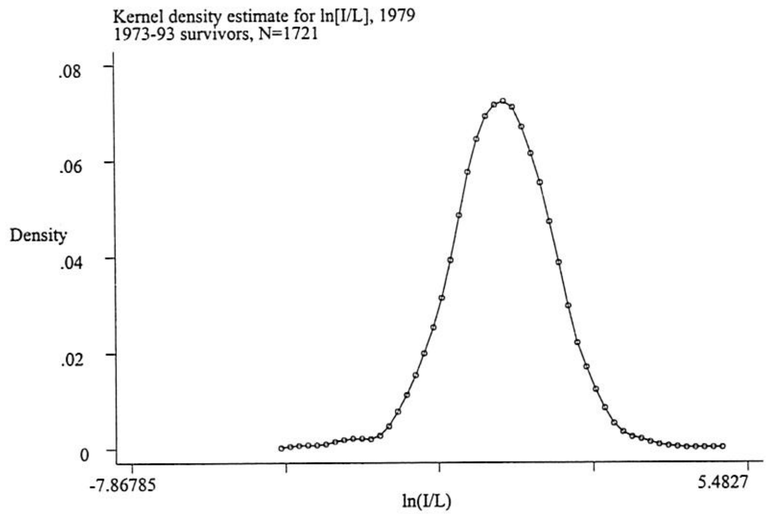


CHART 13

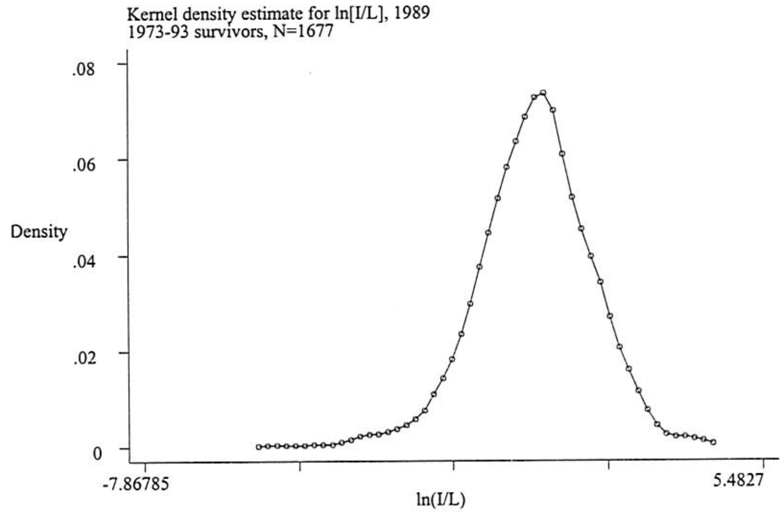


CHART 14

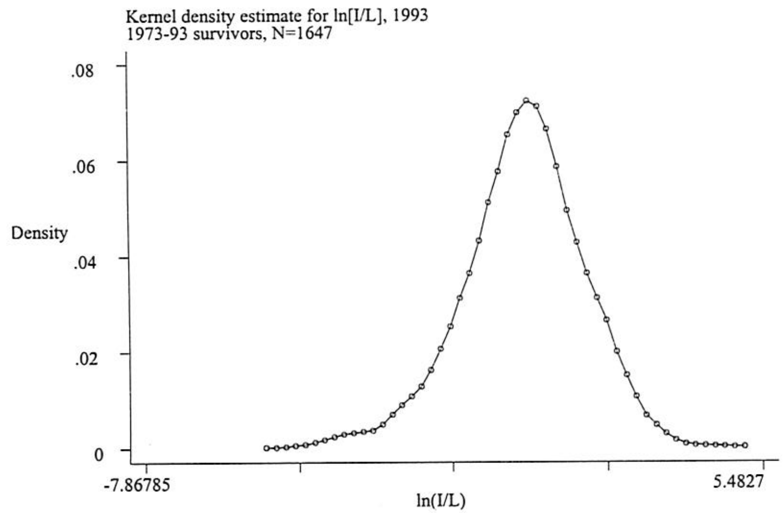


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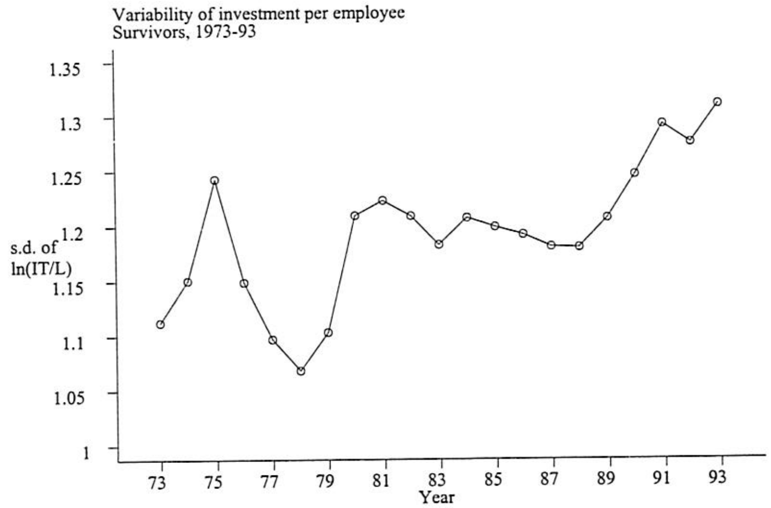
CHART 16



4. Production function estimates for survivors

The model

We assume a Cobb-Douglas production function which can be written in logs for the ith establishment at time *t* as:

$$\ln Y_{it} = \ln A_{it} + \beta_1 \ln K_{it} + \beta_2 \ln ATC_{it} + \beta_3 \ln OP_{it} + \beta_4 \ln M_{it} \qquad (2)$$

where Y is gross output, K is capital, ATC is administrative, technical and clerical employees, OP is operatives, M is intermediate input, and A indexes the level of technology. Taking differences and adding an error term ε, the model can be written:

$$\Delta_s \ln(Y_{it}/OP_{it}) = \Delta_s \ln A_{it} + \beta_1 \Delta_s \ln(K_{it}/OP_{it}) + \beta_2 \Delta_s \ln(ATC_{it}/OP_{it})$$
$$+ \beta_4 \Delta_s \ln(M_{it}/OP_{it}) + (\beta_1 + \beta_2 + \beta_3 + \beta_4 - 1)\Delta_s \ln OP_{it} + \varepsilon_{it} \qquad (3)$$

The expression $\Delta_s z_{it}$ is to be read as $\Delta_s z_{it} = z_{it} - z_{i,t-s}$, for any variable z. We expect the βs, which are the elasticities of gross output with respect to each input, to be positive. Under the assumption of constant returns to scale, $\beta_1 + \beta_2 + \beta_3 + \beta_4 = 1$ and the term in $\Delta_s \ln OP_{it}$ vanishes. If constant returns holds, each β should equal the share of the corresponding input in the value of gross output; e.g. β_1 should equal the share of profit in nominal gross output.

Establishments with initially low levels of productivity have more opportunity to learn from other, more successful ones, so we expect the change in technology term to be proportional to the initial productivity level. Also, there may well be transitory factors influencing productivity which would also support the inclusion of a term in initial productivity.[12] In accordance with this, we may write

$$\Delta_s \ln A_{it} = \theta_0 + \theta_1[\ln(Y_{i,t-s}/L_{i,t-s}) - \ln Q^{*}_{t-s}] \qquad \theta_1 < 0$$

[12] See Oulton (1998a) for economy-wide evidence from company accounts data documenting the importance of transitory factors.

where L is the total labour force and Q^{*}_{t-s} is the productivity level at the frontier in the base period (which may well differ between industries). Substituting this into (1) our specification becomes:

$$\Delta_s \ln(Y_{it}/OP_{it}) = \beta_0 + \beta_1 \Delta_s \ln(K_{it}/OP_{it}) + \beta_2 \Delta_s \ln(ATC_{it}/OP_{it})$$
$$+ \beta_4 \Delta_s \ln(M_{it}/OP_{it}) + (\beta_1 + \beta_2 + \beta_3 + \beta_4 - 1)\Delta_s \ln OP_{it} + \beta_5 \ln(Y_{i0}/L_{i0}) + \varepsilon_{it} \qquad (4)$$

and we expect $\beta_5 < 0$. Here Q^{*}_{t-s} has been absorbed into the constant term β_0. In the empirical results below, we include industry dummies which in effect allow the constant term and so the productivity frontier to vary between industries.

The results

We estimate equation (4) as a cross-section regression for a number of different time periods:

(a) peak to peak — 1973-79 and 1979-89;
(b) peak to trough — 1973-76, 1979-82, 1989-93;
(c) trough to peak — 1976-79 and 1982-89;
(d) overall — 1973-93.

It might be asked why we do not estimate the model in level form as a panel over the whole period. There are several disadvantages to panel analysis here. First, if the model is estimated over the whole period then the strong assumption is being made that the coefficients are time invariant. Second, we expect a great deal of noise in the data so the use of long differences may be superior (Griliches and Mairesse 1995). We are particularly interested in the capital stock variable and mismeasurement is clearly a worry here. First, the initial benchmark figure for 1973 is only rough. Second, the depreciation rate is a guess. Third, the deflator for investment is crude. The effect of these measurement errors can be reduced by using growth rates over long periods rather than levels in the analysis to follow.[13]

A possible drawback to cross-section estimation is that a common constant has to be imposed. Any establishment-level fixed effects are absorbed into the error term but if these effects are correlated with the regressors the coefficients on the latter will be biased. We include dummies for SIC80 Class as one precaution. We also check to see whether the residuals from one cross-section regression are correlated with the residuals from the subsequent time period.

The model of equation (4) was estimated by OLS using the sample of 21 year survivors. The results appear in Table 5. $\Delta_s \ln OP_{it}$ has been dropped from these regressions since it was usually insignificant and the estimated coefficient was small. In other words, the assumption of constant returns cannot be rejected. A constant and dummy variables for SIC80 Class were included but for brevity are not reported.

The coefficient on capital per operative is always highly significant and varies remarkably little in size between the two peak to peak periods and over the whole 21 year period. It is of the order of 0.11-0.13. Over shorter periods it remains highly significant although somewhat smaller. This however is to be expected. Over shorter periods measurement error in the capital stock will be more important and will tend to lower the estimated coefficient. The coefficients on the other two inputs are also highly significant and fairly similar as between time periods.

The catch-up term is also highly significant. It tends to be larger, the shorter the time period. Taking the estimate for 1973-93, its size indicates that the initial productivity gap is closed at the rate of 0.8% per annum.

As mentioned above, these results might be spurious if there exist establishment-level fixed effects which are correlated with the regressors. E.g. some establishments might be inherently dynamic for some reason and it is this dynamism which is driving the

[13] The level of the capital stock is sensitive to the depreciation rate assumed but the growth rate is much less so. In fact if investment has been growing at a constant rate for a long time the growth rate of the stock is the same as that of investment and independent of the depreciation rate.

Table 5 **Cross section regressions for 1973-93 survivors, various periods: dependent variable is growth rate of output per operative**

	1973-79	*1979-89*	*1973-93*	*1973-76*	*1976-79*	*1979-82*	*1982-89*	*1989-93*
$\Delta_s \ln(K/OP)$	0.1067**	0.1050**	0.1278**	0.1240**	0.0971**	0.1273**	0.1057**	0.1150**
	(0.0182)	(0.0133)	(0.0130)	(0.0198)	(0.0283)	(0.0222)	(0.0148)	(0.0362)
$\Delta_s \ln(ATC/OP)$	0.0873**	0.1010**	0.1061**	0.1107**	0.0765*	0.1185**	0.0863**	0.1594**
	(0.0160)	(0.0142)	(0.0129)	(0.0224)	(0.0323)	(0.0158)	(0.0159)	(0.0262)
$\Delta_s \ln(M/OP)$	0.5379**	0.6249**	0.5778**	0.5272**	0.4901**	0.5566**	0.6570**	0.4967**
	(0.0270)	(0.0226)	(0.0220)	(0.0280)	(0.0373)	(0.0315)	(0.0218)	(0.0756)
$\ln(Y_{i,t-s}/L_{i,t-s})$	-0.0146**	-0.0069**	-0.0075**	-0.0166**	-0.0229**	-0.0219**	-0.0076**	-0.0122**
	(0.0026)	(0.0012)	(0.0010)	(0.0042)	(0.0034)	(0.0035)	(0.0022)	(0.0028)
N	1745	1739	1731	1748	1746	1746	1741	1733
R^2	0.704	0.830	0.837	0.667	0.588	0.760	0.809	0.725

Note The model is equation (4), fitted by OLS. Constant and dummies for SIC80 Class included but not reported. Robust standard errors are in parentheses. Maximum possible number of observations is 1,752 but a few observations are lost due to missing values. All growth rates measured at annual rates, i.e. the log difference is divided by the length of the period. For 1973-93, one outlier was excluded; when included, it raised the coefficient on capital per operative to 0.1536.

* Significant at the 5% level
** Significant at the 1% level

increase in both capital and output per operative. If so, the residuals in successive time periods should be positively correlated. However, the correlation between the residuals for 1973-79 and for 1979-89 is -0.05. Over successive shorter periods the correlations are also small and generally negative.

Table 6 shows the shares of each of the inputs in the value of gross output. It will be seen that the estimated coefficient on the capital variable is remarkably close to capital's share. This is despite the fact that capital's share is calculated using only nominal values which are reasonably well measured while, as has already been emphasised, the estimates of the capital stock cannot be regarded as very precise. If the coefficient and the share nevertheless seem quite small, remember that these are shares in gross output. Expressed as a share of value added, the share of capital is about a third. So an increase in capital of 1%, holding other inputs constant, is estimated to raise gross output by approximately 0.13% and value added by 0.31%.

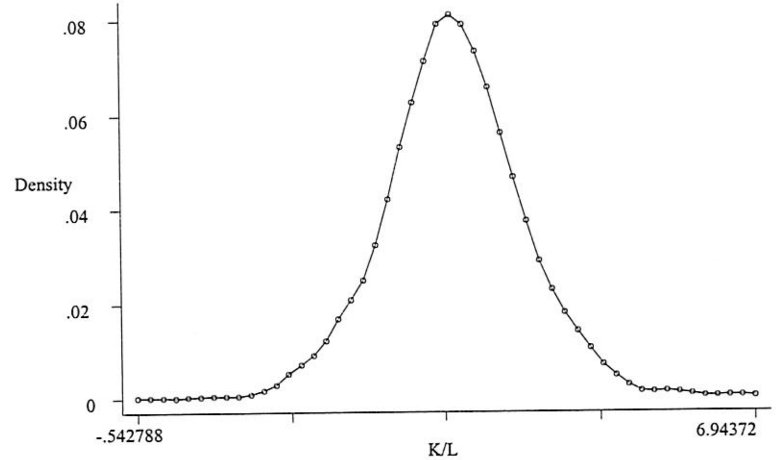
Table 6 Shares of inputs in nominal value of gross output: cross-establishment means of 1973-93 survivors (*N*=1,752)

Year	*Capital*	*Operatives*	*ATCs*	*Intermediate*	*Total*
1973	0.170	0.185	0.088	0.557	1.000
1979	0.132	0.191	0.093	0.583	1.000
1989	0.133	0.173	0.101	0.592	1.000
1993	0.107	0.176	0.113	0.604	1.000
Average, 1973-93	0.136	0.181	0.099	0.584	1.000

Note The share of capital is the profit share. Profits are calculated as nominal gross value added *less* the wage bills of ATCs and operatives, outworkers' remuneration, and employers' National Insurance contributions. Operatives' share is the operative wage bill plus outworkers' remuneration plus these workers' share of employers' National Insurance contributions, divided by nominal gross output. ATC share is defined analogously. Intermediate input share is [nominal gross output – nominal gross value added]/nominal gross output.

The estimated coefficients on intermediate input and on ATC labour are also very close to the corresponding shares. In other words, these data support the hypothesis that manufacturing operates under competitive conditions with constant returns to scale. Establishment-level data are therefore consistent with the conclusions already reached using UK industry-level data (Oulton and O'Mahony 1994, chapter 7) or indeed aggregate data (e.g. Oulton and Young (1996) and Oulton (1997a)). [14]

CHART 17



[14] Despite the reservations mentioned above, some experiments were also made with panel estimation. Equation (4) was estimated as a first difference model (s=1) with year dummies added, first of all by OLS and secondly by IV using lagged levels of the inputs as instruments (the Anderson-Hsiao method). The IV estimates were hopeless, e.g. a negative coefficient on capital, no doubt because the instruments were very inefficient (due to very low correlations between the first differences and the lagged levels). In the OLS estimates the coefficient on capital growth was low (around 0.04 to 0.06, depending on whether a catch-up term was included), while that on the growth of operative labour was significantly negative (-0.13 to -0.15). So apparently there are diminishing returns to scale. This is very implausible as a long run hypothesis for manufacturing. However in the short run there may appear to be diminishing returns because some inputs, e.g. capital, may not be fully adjustable. If constant

5. The importance of being foreign-owned

We are able to estimate a production function only because the rates of growth of capital (and other inputs) vary across establishments. That these differences are cumulative and not just transitory can be seen from Table 7 which shows the standard deviation of the log of the capital-labour ratio by SIC80 Class in 1993; see also the kernel density estimate in Chart 17. Analysis of variance shows that most of the overall variation of this variable, 59%, is due to variation within Classes, not between them. This is rather remarkable given that the capital estimates assume that in 1973 the capital-labour ratio was identical for every establishment in a given Class.[15] The question then arises, are there any systematic factors behind these differences in capital stock growth rates and the eventual differences in levels to which they give rise? In this section, we consider the possible role of foreign ownership.

It has long been known from the published results of ACOP that foreign-owned firms tend to have higher labour productivity than domestically-owned ones. Only a part of this disparity can be explained by a relative concentration of foreign-owned firms in high productivity sectors (Davies and Lyons 1991). What has not been so clear is the source of the foreign-owned firms' advantage.

Of the 1,752 surviving establishments, 176 were US-owned and a further 235 were owned by non-US foreign interests in 1993 (the latest year available).[16] The US-owned firms accounted for 16.6% of total employment and the foreign, non-US ones for 14.1%. Thus getting on for a third of employment amongst survivors was in foreign-owned firms. Table 8 first documents that the productivity gap between UK-

returns are imposed by dropping the growth of operative labour from the regression, the results are similar to those of Table 5.

[15] If we disaggregate further, industrial structure will of course explain more of the variation. The 1,752 survivors fall into 198 4 digit Activity Headings. Analysis of variance using Activity Headings instead of Classes shows that industrial structure can explain 58% of the variance of the log of capital intensity in 1993. But the average number of establishments per Activity Heading is now less than 9 so the additional explanatory power is rather spurious. If we could disaggregate still further, eventually everything could be explained by industrial structure.

[16] Foreign-owned establishments include those deemed to be controlled by enterprises incorporated overseas, as well as those which are wholly owned.

Table 7 Capital intensity (*K/L*) amongst 1973-93 survivors: by SIC80 Class, 1993

Class	*N*	*Mean*	*Median*	*s.d. of ln(K/L)*
22	73	58,990	48,805	0.698
24	98	45,633	34,182	0.741
25	164	83,732	59,240	0.686
31	130	28,058	24,429	0.544
32	214	28,413	22,704	0.611
34	122	28,414	21,573	0.621
35	47	48,983	37,800	0.885
36	41	31,029	26,361	0.608
37	32	22,125	19,184	0.563
41	86	47,103	24,748	0.871
42	84	63,993	49,736	0.613
43	143	24,180	21,054	0.589
45	96	6,732	5,960	0.554
46	51	15,809	12,056	0.497
47	245	37,996	29,792	0.599
48	75	39,179	32,013	0.536
49	23	26,144	24,674	0.547
All classes[a]	1,747	39,140	27,276	0.827

Note Capital intensity is *K/L* where *K* is the capital stock in 1990 £ and *L* is total employment. 5 Classes omitted due to zero or small numbers. See the Appendix for the names of the Classes.

a. Including omitted Classes (23, 26, 33 and 44).

and foreign-owned firms applies to survivors, as well as to manufacturing as a whole. In 1993, value added per employee was 55% higher in US-owned establishments and 25% higher in non-US foreign-owned establishments than in UK-owned ones. These huge gaps are similar in size to the cross-country gaps which are estimated to exist between UK labour productivity in aggregate manufacturing on the one hand and US, Japanese or European productivity on the other.

We can also see from Table 8, and here we are able to go beyond what was previously known, that the average worker in a US-owned establishments had 54% more capital to work with, and the average worker in other foreign-owned establishments 47% more, than did their counterparts in UK-owned ones. We can also note that the proportion of employment which is white collar (ATCs) is 7-10 percentage points higher in foreign-owned establishments. White collar workers on average earn more than blue collar ones and we can also see that within each category wages are higher in foreign-owned establishments. For operatives, wages are 16-24% higher and for ATCs, 12-20% higher. Since companies do not pay higher wages out of the goodness of their hearts, this suggests that workers in foreign-owned establishments are more skilled. Thus it appears to be the case that foreign-owned establishments, particularly US ones, employ substantially higher physical and human capital per worker.

Because the ARD allows us to look at the history of individual establishments, we can also compare growth rates by type of ownership (Table 9). Again the performance of foreign-owned establishments stands out. Value added per employee and capital per employee have both been rising much more rapidly in foreign-owned establishments. The capital stock of UK-owned establishments grew on average at only 1.04% p.a. over 1973-93, while that of US-owned ones grew at 2.86% p.a. and that of other foreign owned ones at 2.23%. However, there is an important contrast between US and other foreign establishments. In US-owned establishments, value added has been rising while in other foreign owned ones it has been falling, as it has too in UK-owned establishments. Furthermore, while employment has been falling in all types of establishment, it has done so most in other foreign-owned plants and least in US-owned ones.

Table 8 Descriptive statistics in 1993 for 1973-93 survivors: by ownership

Variable	*Ownership*	*N*	*Mean*	*Ratio to UK-owned mean*	*S.D.*	*Median*
Y/L	Foreign, non-US	235	95,542	1.52	84,985	75,824
	US-owned	176	105,185	1.68	77,606	81,059
	UK-owned	1336	62,781	1.00	67,898	47,006
V/L	Foreign, non-US	235	28,316	1.25	18,839	24,434
	US-owned	176	35,008	1.55	22,924	29,191
	UK-owned	1336	22,615	1.00	16,929	19,306
K/L	Foreign, non-US	235	51,358	1.47	47,154	39,264
	US-owned	176	54,073	1.54	45,695	36,911
	UK-owned	1336	35,024	1.00	47,906	24,538
L	Foreign, non-US	235	619	1.16	1,037	351
	US-owned	176	975	1.82	2,375	485
	UK-owned	1336	535	1.00	1,290	270
W_{OP}	Foreign, non-US	233	14,935	1.17	3,936	14,595
	US-owned	176	16,078	1.26	5,149	15,627
	UK-owned	1324	12,736	1.00	4,074	12,627
W_{ATC}	Foreign, non-US	235	19,876	1.12	4,628	19,090
	US-owned	176	21,858	1.24	6,863	20,475
	UK-owned	1336	17,668	1.00	5,157	17,127
ATC/L	Foreign, non-US	235	0.389	1.20	0.188	0.338
	US-owned	176	0.407	1.26	0.182	0.370
	UK-owned	1336	0.323	1.00	0.189	0.281
M/L	Foreign, non-US	232	72,395	1.70	79,215	54,398
	US-owned	174	74,851	1.75	68,785	56,058
	UK-owned	1325	42,671	1.00	59,314	28,742

Note *Y*: Gross output (1990 £k); *V*: gross value added (1990 £k); *L*: total employment (number); *ATC*: Administrative, technical and clerical employees (number); *K*: Capital stock (1990 £k); W_{OP}: operative wage (£, current prices); W_{ATC}: ATC wage (£, current prices); *M*: intermediate input (1990 £k).

Table 9 **Growth rates of output, employment and capital, 1973-93: 1973-93 survivors, by ownership in 1993 (% p.a.)**

Variable	*Ownership*	*N*	*Mean*	*S.D.*	*Median*
V/L	Non-US	232	2.19	3.09	2.15
	US	173	2.23	3.30	1.93
	UK	1326	1.76	2.92	1.82
K/L	Non-US	235	4.60	3.17	4.56
	US	176	4.27	3.41	4.38
	UK	1336	2.85	3.36	2.84
K	Non-US	235	2.23	3.90	2.20
	US	176	2.86	4.06	2.40
	UK	1336	1.04	3.89	0.63
L	Non-US	235	-2.38	3.79	-2.52
	US	176	-1.41	3.56	-1.33
	UK	1341	-1.82	3.95	-1.66
V	Non-US	232	-0.16	4.46	-0.07
	US	173	0.89	4.64	0.65
	UK	1326	-0.06	4.78	0.08

Note *L*: total employment; *V*: gross value added (1990 prices); *K*: Capital stock (1990 prices).

Table 10 **Output and capital per employee, wages, and the ATC proportion: ratio of mean amongst foreign-owned establishments to mean amongst UK-owned establishments in 1993, 1973-93 survivors, by SIC80 Class**

Class	*N*	*K/L*	*Y/L*	*V/L*	W_{OP}	W_{ATC}	*ATC/L*	*M/L*
22	74	1.168	2.150	1.488	1.101	1.037	1.124	2.407
24	95	1.193	1.064	1.112	1.107	1.075	1.395	1.041
25	160	1.018	1.314	1.254	1.155	1.153	1.106	1.340
31	133	1.757	2.043	1.647	1.328	1.247	1.019	2.371
32	213	1.033	1.251	1.134	1.093	1.041	1.157	1.349
34	121	1.340	1.389	1.257	1.201	1.106	1.115	1.459
35	48	1.567	1.668	0.908	1.134	1.136	1.094	2.346
36	43	0.996	1.452	1.032	1.182	0.778	1.218	1.796
37	31	1.336	1.338	0.993	1.013	0.978	0.908	1.475
41	86	1.525	2.070	2.588	1.207	1.370	1.352	2.014
42	84	1.081	0.827	1.028	1.143	1.228	0.841	0.761
43	145	1.076	1.191	1.228	0.996	1.070	1.460	1.167
45	97	1.226	1.431	1.231	1.066	0.936	1.266	1.563
46	49	1.000	1.103	1.022	1.081	1.027	1.226	1.146
47	243	1.412	1.194	0.946	0.998	1.077	0.914	1.401
48	82	1.534	1.681	1.225	1.280	1.120	0.999	2.008
49	20	1.249	1.326	1.075	1.200	0.983	0.894	1.515
All Classes[a]	1,747	1.500	1.588	1.379	1.211	1.173	1.226	1.721

Note *Y*: Gross output (1990 prices); *L*: total employment; *V*: gross value added (1990 prices); *K*: Capital stock (1990 prices); W_{OP}: operative wage (current prices); W_{ATC}: ATC wage (current prices); *ATC*: Administrative, technical and clerical employees; *M*: intermediate input (1990 prices). Classes 23 and 44 do not appear since they contained no foreign-owned survivors. Classes 21, 26 and 33 are omitted because the number of establishments was zero or very small. See the Appendix for the names of the Classes.

That these differences cannot be dismissed as due solely to differences in industrial structure as between foreign and domestic establishments is shown by Table 10. In 13 out of 17 Classes foreign-owned establishments have substantially higher capital per employee and in 12 out of 17 they have substantially higher value added per employee. UK-owned establishments have substantially higher value added per employee in only one Class (35).

However, we should also note from Table 8 that foreign establishments, particularly US ones, tend to be larger than domestic ones. It is believed that larger establishments pay higher wages than smaller ones and have higher labour productivity. So the foreign advantage might be an artefact. Hence we carry out a cross section, multiple regression analysis of the following model:

$$Z = \beta_0 + \beta_1 Foreign + \beta_2 \ln(L) + \sum_{j=1}^{S-1} \beta_{j+2} Class_j + \varepsilon \qquad (5)$$

where Z is alternately capital per employee (K/L), the operative wage (W_{OP}), the ATC wage (W_{ATC}), the ATC proportion (ATC/L), intermediate input per employee (M/L), and value added per employee (V/L); all these variables are in logs. *Foreign* is a dummy variable taking the value 1 if the establishment is foreign-owned; we also use separate dummies for US-owned (*US*) and foreign, non-US-owned (*Non-US*). The *Class* variables are dummies for membership in each of the *S* classes within SIC80 manufacturing. In practice S=21 since there are no observations in Class 21; see the Appendix for the names of the Classes.

Table 11 shows the results. All the major differences noted above between foreign and UK-owned establishments turn out to be statistically highly significant, even when we correct for size and industrial structure. Both US and non-US owned foreign establishments have higher productivity, a higher ATC proportion, higher wages, and higher capital per worker than their domestic counterparts. The size variable is significant in the equations for wages, the ATC proportion and intermediate input but has little effect on the coefficients on the ownership dummies. In any case, one might argue that size should be excluded since it is under the control of management. By

Table 11 Comparison of foreign and UK-owned establishments: cross section regressions, 1973-93 survivors, 1993

(a) Dependent variable: ln(*K/L*)				
Foreign	0.2703**	0.2752**	—	—
	(0.0368)	(0.0370)		
ln(*L*)	0.0172	—	0.0176	—
	(0.0189)		(0.0189)	
US	—	—	0.2565**	0.2643**
			(0.0527)	(0.0526)
Non-US	—	—	0.2801**	0.2832**
			(0.0448)	(0.0450)
N	1747	1747	1747	1747
R^2	0.427	0.427	0.427	0.427
(b) Dependent variable: ln(*ATC/L*)				
Foreign	0.0836**	0.0928**	—	—
	(0.0282)	(0.0280)		
ln(*L*)	0.0319*	—	0.0314*	—
	(0.0134)		(0.0135)	
US	—	—	0.1010**	0.1149**
			(0.0390)	(0.0384)
Non-US	—	—	0.0713*	0.0768*
			(0.0341)	(0.0341)
N	1752	1752	1752	1752
R^2	0.285	0.283	0.285	0.283

Table 11, continued

(c) Dependent variable: $\ln(W_{OP})$

Foreign	0.1084**	0.1239**	—	—
	(0.0163)	(0.0165)		
ln(*L*)	0.0547**	—	0.0541**	—
	(0.0077)		(0.0077)	
US	—	—	0.1257**	0.1499**
			(0.0242)	(0.0241)
Non-US	—	—	0.0960**	0.1050**
			(0.0194)	(0.0195)
N	1733	1733	1733	1733
R^2	0.350	0.329	0.350	0.330

(d) Dependent variable: $\ln(W_{ATC})$

Foreign	0.0950**	0.1063**	—	—
	(0.0143)	(0.0145)		
ln(*L*)	0.0395**	—	0.0385**	—
	(0.0071)		(0.0071)	
US	—	—	0.1261**	0.1431**
			(0.0209)	(0.0211)
Non-US	—	—	0.0730**	0.0796**
			(0.0169)	(0.0170)
N	1747	1747	1747	1747
R^2	0.182	0.168	0.184	0.170

Table 11, continued

(e) Dependent variable: ln(*M/L*)

Foreign	0.4189**	0.4322**	—	—
	(0.0381)	(0.0381)		
ln(*L*)	0.0464*	—	0.0465*	—
	(0.0185)		(0.0185)	
US	—	—	0.4151**	0.4356**
			(0.0552)	(0.0552)
Non-US	—	—	0.4216**	0.4297**
			(0.0451)	(0.0448)
N	1752	1752	1752	1752
R^2	0.327	0.324	0.327	0.324

(f) Dependent variable: ln(*V/L*)

Foreign	0.1609**	0.1949**	—	—
	(0.0312)	(0.0311)		
ln(*L*)	0.1142**	—	0.1121**	—
	(0.0159)		(0.0159)	
US	—	—	0.2244**	0.2756**
			(0.0451)	(0.0443)
Non-US	—	—	0.1158**	0.1362**
			(0.0381)	(0.0379)
N	1736	1736	1736	1736
R^2	0.294	0.266	0.296	0.269

Note Model fitted by OLS is equation (5). Constant and dummies for 20 out of 21 SIC80 Classes included but not reported. Robust standard errors are in parentheses. Maximum possible number of observations is 1,752 but a few observations are lost for some dependent variables due to missing values. *US*=1 if US-owned; *Non-US*=1 if foreign-owned but not US-owned.

* Significant at the 5% level
** Significant at the 1% level

comparing the coefficients on the ownership dummies with the crude, percentage gaps in Table 8, we see that industrial structure does matter. But after adjustment, we still find large differences between foreign and UK-owned establishments. The largest adjusted difference is in intermediate input per employee: 55% for US-owned and 54% for other foreign owned establishments.[17]

We now see how much of the differences in productivity between establishments can be explained by differences in human and physical capital and whether there is still a residual role for ownership by fitting the following model:

$$\ln(V/L) = \beta_0 + \beta_1 \ln(K/L) + \beta_2 \ln(ATC/L) + \beta_3 \ln(W_{OP}) + \beta_4 \ln(W_{ATC}) + \beta_5 US + \beta_6 Non-US + \sum_{j=1}^{S-1} \beta_{j+6} Class_j + \varepsilon \qquad (6)$$

The results of fitting this model for 1989 and 1993 appear in Table 12. 1993 is used because it is the latest year available and the influence of the starting values for the capital stock estimates will be minimised. On the other hand 1993 is a recession year while 1989 is a peak. The results for the two years are in fact very similar though slightly stronger for 1989.

We can explain about half the variance of labour productivity across establishments. Capital per worker is highly significant though the size of the coefficient is sensitive to the other variables included. The variables measuring human capital per worker are also highly significant. Including the wage variables adds considerably to the explanatory power. But because the wage variables might be also picking up rent-sharing or union power, results are shown as well with these variables excluded.

[17] Doms and Jensen (1998) and Globerman *et al.* (1994) report similar findings for the US and Canada respectively, namely that foreign-owned firms have higher labour productivity, higher capital intensity and use more skilled labour and that these differences remain after controlling for industrial composition and size. As regards the role of capital intensity, note that these authors are forced to use proxies: book value in the case of Doms and Jensen and energy input in the case of Globerman *et al.* In this respect, the results in the present paper may be regarded as stronger. Doms and Jensen are able to break down their domestically-owned (i.e. US) firms into those which are multinationals and those which are not. They find that for the US the real difference is between multinationals and non-multinationals, not foreign and domestically owned firms. Whether the same would be true for the UK remains to be determined.

Table 12 Regressions explaining productivity differences amongst survivors: dependent variable is log of value added per employee, 1989 and 1993

	1993	*1993*	*1993*	*1989*	*1989*	*1989*
ln(*K/L*)	0.1448*	0.2948*	0.1441**	0.1582**	0.2937**	0.1569**
	(0.0244)	(0.0221)	(0.0242)	(0.0199)	(0.0251)	(0.0199)
ln(*ATC/L*)	0.0830**	0.1150**	0.0795**	0.1105**	0.1764**	0.1094**
	(0.0235)	(0.0242)	(0.0235)	(0.0213)	(0.0218)	(0.0214)
$\ln(W_{OP})$	0.6342**	—	0.6315**	0.6380**	—	0.6357**
	(0.0597)		(0.0598)	(0.0427)		(0.0427)
$\ln(W_{ATC})$	0.3053**	—	0.2987**	0.2620**	—	0.2601**
	(0.0454)		(0.0451)	(0.0455)		(0.0456)
US	0.0895*	0.1834**	—	0.1337**	0.1889**	—
	(0.0399)	(0.0418)		(0.0332)	(0.0354)	
Non-US	-0.0012	0.0432	—	-0.0243	0.0074	—
	(0.0325)	(0.0355)		(0.0368)	(0.0399)	
US years	—	—	0.0054*	—	—	0.0081**
			(0.0023)			(0.0022)
Non-US years	—	—	0.0026	—	—	0.0021
			(0.0024)			(0.0029)
N	1717	1731	1717	1739	1744	1739
R^2	0.475	0.379	0.476	0.512	0.415	0.511

Note Model fitted by OLS is equation (6). Constant and dummies for 20 out of 21 SIC80 Classes included but not reported. Robust standard errors are in parentheses. Maximum possible number of observations is 1,752 but a few observations are lost due to missing values. *US*=1 if US-owned; *Non-US*=1 if foreign-owned but not US-owned. *US years*: number of years in US ownership. *Non-US years*: number of years in other foreign ownership.

* Significant at the 5% level
** Significant at the 1% level

The dummy for US ownership is significant but that for other foreign ownership is not. In other words, non-US foreign ownership leads to higher physical and human capital, but no further effect on productivity. But US-owned plants seem to have some additional advantage, over and above greater capital per worker of both types. This might be superior management, better process technology or better products (i.e. products able to command a higher price in the market). Whatever the source, US ownership conferred an additional advantage of between 9 and 20% in 1993 (14–21% in 1989).[18] However, since our analysis is confined to survivors we cannot allow for the impact of the more recent Japanese and Korean multinationals, who have made large, green field investments. If these could be included, we might need to take a more favourable view of non-US foreign ownership.

A possible way of minimising the effect of foreign ownership is to argue that foreign companies are just particularly good at picking winners. According to this view, the foreign-owned establishments would have been successful anyway. Perceiving the likelihood of success, foreign companies took them over. The problem with this argument is that it requires remarkable prescience on the part of the foreign companies, since many of these establishments have been in foreign ownership for much of the period studied. For example, 176 of the 1,752 survivors were in US ownership in 1993. Of these, three quarters had been US-owned for 15 years or more and over half for 20 years or more. (Other foreign ownership tends to be more recent. One half of the 235 establishments in this category in 1993 had been so for 6 years or less and less than a third for 15 or more.)

As an alternative to a dummy variable for current ownership, we can also measure the impact of ownership by the number of years in US or other foreign ownership. This is a rather different concept from current ownership status since some establishments may have been in US ownership for part of our period even though currently they are not. In fact, 183 establishments ceased to be US-owned and 193 became US-owned at some point over 1973-93. Altogether 305 establishments experienced some period of

[18] If size (log employment) is included as an additional regressor in equation (6), its coefficient is significant and positive except in 1989 when wages are included. Its inclusion has little effect on the coefficient on capital intensity. The US ownership dummy remains significant, except in 1993 with

US ownership. Changes in and out of other foreign ownership were of similar frequency: 156 establishments ceased to be in this category while 327 entered it.

Instead of the ownership dummies, we can enter years under US ownership and years under other foreign ownership into the regression of equation (6). The third and last columns of Table 12 show the results. Years of US ownership are significant, while years of other foreign ownership are not. Each year under US ownership raises labour productivity by between 0.5 and 0.8%. The conclusion is that more than just picking winners is involved in the superior performance of US-owned firms.[19]

We can now employ the estimates reported in Table 11 and 12 to decompose the productivity gap between foreign and UK-owned establishments into an explained and an unexplained portion. From Table 11(f), we see that, after controlling for industrial structure, US ownership confers an advantage in value added per worker of (exp[0.2756]-1 =) 31.7%. Other foreign ownership confers an advantage of 14.6%, again after controlling for industrial structure. These figures should be compared with the unadjusted gaps of 55% and 25% respectively (Table 8). The contribution of each measured input to the US advantage is calculated as its estimated coefficient in the regression for $\ln(V/L)$, from Table 12, multiplied by the estimated coefficient on the US ownership dummy in the regression with this input as the dependent variable (from Table 11). For example, the contribution of capital to explaining the US advantage in 1993, if the wage variables are excluded, is 0.2948 x 0.2643 = 0.0779 which expressed as a percentage is 8.1%. The contribution of each input to the other foreign advantage is calculated analogously.

The estimated contributions appear in Table 13. If the wage variables are excluded, capital intensity explains 26% of the US advantage and 60% of the other foreign advantage. With wages included, the contribution of capital is halved, to 12% and

wages included, but reduced in size. This suggests that part of the reason for US success may be that US owned establishments are larger (see Table 8).

[19] These results are thus in line with a large literature stressing the productive effects of foreign investment (e.g. Barrell and Pain 1997).

Table 13 Contribution of measured inputs to explanation of productivity gap between foreign and UK-owned establishments, 1993 (1973-93 survivors)

	US		*US*		*Non-US*		*Non-US*	
Input	*Contribution*	*% of total*	*Contribution*	*% of total*	*Contribution*	*% of total*	*Contribution*	*% of total*
K/L	3.90	12.29	8.10	25.54	4.19	28.69	8.71	59.67
ATC/L	0.96	3.02	1.33	4.19	0.64	4.38	0.89	6.08
W_{OP}	9.97	31.43	0.00	0.00	6.89	47.19	0.00	0.00
W_{ATC}	4.47	14.07	0.00	0.00	2.46	16.86	0.00	0.00
Total measured	19.30	60.82	9.43	29.73	14.17	97.12	9.59	65.75
Non-specific[a]	9.36	29.51	20.13	63.44	0.00	0.00	0.00	0.00
Total explained	28.66	90.32	29.56	93.16	14.17	97.12	9.59	65.75
Unexplained	3.07	9.68	2.17	6.84	0.42	2.88	5.00	34.25
TOTAL	31.73	100.00	31.73	100.00	14.59	100.00	14.59	100.00

Note Source: Coefficient estimates in Tables 11 and 12. See text for explanation.
a. The non-specific advantage is the estimated coefficient on the US or non-US ownership dummy in equation (6).

29% respectively. Interpreting the wage variables and the ATC proportion as measuring labour quality, between them they account for 49% of the US advantage and 68% of the other foreign advantage. All told, the measured inputs, including labour quality, account for 61% of the US advantage and 97% of the other foreign one.

6. Interpreting the findings: three alternatives

The obvious question to ask is, if foreign-owned establishments, located in Britain and employing British workers, use high capital intensity to achieve high productivity, why don't British-owned establishments do the same? There are a number of possible explanations.

First, UK-owned companies may face a higher cost of capital than foreign-owned ones. Financial constraints are now widely believed to be an important influence on investment (Caballero 1997; Chirinko 1993; Hubbard 1998). Foreign companies are not presumably constrained to acquire funds for investment from the UK financial system, or at least not to the same extent as UK ones, so deficiencies in the UK system may be hindering investment by UK companies. Foreign companies may also have a lower cost of internal funds (Miles 1993). An obvious objection to this is that large UK companies are themselves multinationals and face the same global capital market as foreign multinationals. However, the argument may have some force for smaller companies.

Second, UK firms may face a less favourable risk-return trade-off than foreign ones and consequently may prefer less capital-intensive technologies. UK companies, even the large multinational ones, almost certainly make a higher proportion of their sales in the UK than do foreign companies. They may be heavily influenced in their investment decisions by the memory of bad experiences in the three long recessions of the last 25 years (the working lifetime of the people now running UK manufacturing companies). If the UK is perceived as having greater macro instability than other countries, then even if UK firms are no more risk averse than foreign ones, they will perceive their overall risk level as higher. By contrast, the large foreign multinationals which operate in UK manufacturing may be better able to balance the risk of poor outcomes in the UK against the chance of good ones elsewhere. Consequently, their preferred capital-labour ratio may be higher. This argument assumes that capital intensive technologies are riskier. This in turn may be justified if investment in physical capital is at least partially irreversible while labour and other inputs may be adjusted at relatively low cost.

Finally, as a third hypothesis, foreign companies may be using superior technology and business methods which happen to be more intensive in both capital and skilled labour. UK companies may just be slow to learn from and apply the best foreign practice, for several possible reasons. First, the relevant knowledge may be commercially confidential or located in the heads of foreign managers. Second, there may be work force resistance to change. In the latter case, it might not pay for an established firm to adopt the superior technology because of the upfront cost of strikes, etc. This will be all the more likely if the firm is a satisficer rather than a maximiser.[20]

Objections can be raised against this last explanation too. It would seem rather odd if superior technology is in general more intensive in both capital and skilled labour. Some superior business methods, e.g. just in time, require less (inventory) capital not more. Also, the larger UK companies at least must be well aware of their foreign rivals' technology and could hire foreign managers if they so desired. And how potent is work force resistance after the trade union reforms of the 1980s? It has not stopped surviving UK companies from reducing their employment by 31% between 1973 and 1993 (see Table 9).

None of the above objections is decisive since all require quantification. It is beyond the scope of the present paper to take the argument further, except in one respect: the role of macroeconomic instability.

Foreign ownership and macroeconomic instability

The first two explanations rely essentially on deficiencies in the UK financial system: British companies find it harder to finance investment. One way in which this might occur is if companies which are damaged by a recession are unable to invest as much as comparable companies which have been less damaged. A recession may drain a company's financial resources and make it more dependent on an unsympathetic capital market. But foreign-owned companies may be able to rely on the strength of their parent or on a supposedly more sympathetic foreign capital market.

[20] Baily and Gersbach (1995) argue that the crucial factor in inducing firms to adopt best practice technology is exposure to global, not just local or regional, competition.

Unfortunately, the ARD does not contain any balance sheet variables which would enable us to measure a company's financial health directly. However we can measure the size of the shock that an establishment suffers in a recession by, for example, the change in output. This suggests testing the following equation:

$$\Delta_s \ln(K_{it} / L_{it}) = \beta_0 + \beta_1 \Delta_r \ln y_{i,t-s} + Controls + \varepsilon_{it} \qquad (7)$$

The dependent variable is the growth in capital intensity during the course of a boom taking place from time *t-s* to *t*. The main explanatory variable is the growth of gross output over the preceding recession from *t-s-r* to *t-s*. The controls used are the SIC80 Class dummies and a foreign ownership dummy (*FOR*=1 if foreign-owned). The growth of capital intensity is used in preference to the growth of capital since a fall in output may indicate not just bad luck but poor prospects for the company. Such a company might rationally wish to invest less. But there seems no reason, other than financial difficulties, why a company which survives should use a less capital intensive technique just because its future growth prospects are not so good as they may once have appeared. Nevertheless, results are presented also for capital stock growth as the dependent variable.

The hypothesis to be tested is $\beta_1 > 0$: the greater the fall in output during a recession, the lower the rise in capital intensity in the subsequent boom. But we also allow for the possibility that β_1 differs between foreign and domestically-owned companies by interacting the output growth variable with the foreign ownership dummy (i.e. we assume $\beta_1 = \beta_2 + \beta_3 FOR$). If foreign-owned companies are less affected by recessions, then the coefficient on this interaction variable will be negative.

The results of estimating this equation over two boom-recession periods are in Table 14. The first boom is 1975-79, following a recession from 1973-75. The second is 1981-89, following the 1979-81 recession. It will be seen that β_1 is significantly

Table 14 **Effect of recessions on capital stock growth in subsequent booms**

	Dependent variable			
	1981-89		*1975-79*	
	Growth of capital stock	*Growth of capital intensity*	*Growth of capital stock*	*Growth of capital intensity*
FOR	0.072*	0.149**	0.045*	0.030
	(0.029)	(0.031)	(0.018)	(0.018)
$\Delta_t \ln y$	0.297**	0.110*	0.220**	0.179**
	(0.045)	(0.048)	(0.026)	(0.027)
*FOR**$\Delta_t \ln y$	-0.047	-0.010	-0.014	-0.100
	(0.095)	(0.101)	(0.058)	(0.060)
N	1700	1700	1752	1752
R^2	0.110	0.080	0.101	0.077

Note OLS estimates of equation (7). Constant and dummies for SIC80 Class included but not reported. The output growth variable ($\Delta_t \ln y$) is the growth in output during the preceding recession, 1979-81 in the case of the 1981-89 boom and 1973-75 in the case of the 1975-79 boom. *FOR*=1 if foreign-owned. For 1981-89, 52 establishments which switched their SIC80 Class over this period were excluded.

* Significant at the 5% level
** Significant at the 1% level

positive so macroeconomic instability does indeed appear to damage investment, whether capital intensity or capital growth is the dependent variable. However, the interaction variable in Table 14 is never significant. In other words, foreign-owned firms reduce their investment just as much as UK-owned ones as a result of bad experiences during a recession. This is evidence *against* the view that the difference in capital intensity between foreign and UK-owned companies is due to the UK financial system.[21]

7. Conclusions

We have developed a dataset of 1,752 establishments which appear continuously in the ARD from 1973 to 1993 inclusive. For each of these survivors, we have been able to estimate the capital stock. Of course these survivors are atypical by virtue of the fact simply that they have survived. Nevertheless, they make up about a third of the employment recorded in the ARD, they contain a wide range of sizes (the average is 590 employees), and have a foreign-owned proportion which is similar to the overall figure. Based on this dataset, our main results are as follows:

1. By estimating a gross output production function at the establishment level, we found that the elasticity of output with respect to capital is about the same as capital's share in output (the profit share). A similar conclusion holds for the other inputs (operatives, ATCs, and intermediate input). In other words, the neo-classical view that manufacturing operates under constant returns to scale and competitive conditions seems to be a good description of reality. An implication is that the private and social returns to physical investment are about equal.
2. However, not everything in the garden is lovely. We also found that there are large differences in capital intensity, the capital-labour ratio, between establishments located in the same 2-digit Class (of which there are 22 in manufacturing). These current differences in capital intensity arise solely from differences in cumulated investment over the period 1973-93, since the capital intensity of all establishments in a given Class was of necessity assumed to be identical in 1973. The production function estimates suggest that a 10% rise in the capital-labour

[21] The conclusion is not altered if separate dummies are introduced for US and non-US ownership. Note that during the 1979-81 recession the mean fall in output was about the same for foreign as for

ratio would raise value added per worker by about 3%. So if establishments with low capital-intensity emulated those with high capital intensity there would clearly be scope for substantial improvements in productivity.

3. The differences between establishments in productivity and capital intensity are not just random. There are systematic factors at work as well. Foreign-owned establishments, and in particular US-owned ones, substantially outperform UK-owned ones. On average foreign-owned establishments operate with 50% more capital per worker and achieve 38% higher value added per worker. Their labour forces are more white collar and considerably better paid. These disparities in performance cannot be dismissed as due simply to the concentration of foreign ownership in high productivity or high capital intensity sectors.
4. We found that physical and human capital intensity are significant determinants of productivity at a point in time. Our cross section regressions, which control for industrial structure as well, can account for about a half of the variation across establishments in value added per worker. In addition, US-ownership is found to confer a productivity advantage of between 9 and 20%, over and above the advantage conferred by higher capital intensity in US-owned establishments.
5. The total US advantage in value added per worker is 31.7%, after controlling for industrial structure. The measured inputs, capital intensity and labour quality, can explain 61% of this gap. In the case of other foreign owned establishments, the labour productivity advantage is lower, 14.6% after controlling for industrial structure, and the measured inputs account for 97% of this gap.

Three possible explanations for the higher capital intensity and higher productivity of foreign-owned establishments were suggested:

1. UK-owned companies face a higher cost of capital than foreign-owned ones
2. UK-owned companies are more exposed to the volatile UK market while foreign-owned companies are better able to spread risks globally
3. Foreign-owned companies have access to superior technology and business systems which happen to be more capital intensive. For a variety of reasons, UK-owned companies do not employ these superior systems.

UK establishments.

These explanations are not mutually exclusive. As we have seen, one can raise objections against each of the three. But none of the objections is decisive since all require quantification to be sustained. However some evidence was presented against the first two hypotheses. Establishments which suffered more severely in the two recessions of 1973-75 and 1979-81 increased their capital intensity less in the subsequent booms than did more fortunate establishments. However, there was no difference in this respect between foreign and UK-owned establishments. In other words, macroeconomic instability seems to have had some adverse effects on investment, but no more so for domestic than for foreign companies. This is evidence against the view that the shortfall in investment by UK-owned companies is due to the UK financial system.

Nevertheless, the issue is far from settled and much more research will be needed to establish the degree of truth in any of these three explanations. For the moment, the difference in capital intensity, matched by a similar difference in labour productivity, between foreign-and UK-owned establishments must remain startlingly large.

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APPENDIX
The 22 Classes of SIC80 within manufacturing

Class	*Name*
Division 2	
21	Extraction and preparation of metalliferous ores
22	Metal manufacturing
23	Extraction of minerals not elsewhere specified
24	Manufacturing of non-metallic mineral products
25	Chemical industry
26	Production of man-made fibres
Division 3	
31	Manufacture of metal goods not elsewhere specified
32	Mechanical engineering
33	Manufacturing of office machinery and data processing equipment
34	Electrical and electronic engineering
35	Manufacture of motor vehicles and parts
36	Manufacture of other transport equipment
37	Instrument engineering
Division 4	
41 & 42	Food, drink and tobacco manufacturing industries
43	Textile industry
44	Manufacturing of leather and leather goods
45	Footwear and clothing industries
46	Timber and wooden furniture industries
47	Manufacturing of paper and paper products; printing and publishing
48	Processing of rubber and plastics
49	Other manufacturing industries