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Privatisation and Performance: A Study of the British Steel Industry under Public and Private Ownership

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Abstract
Privatisation is intended to lead to a marked improvement in economic performance. Here the performance of British Steel is assessed both before and after privatisation in December 1988. Performance is measured in terms of trends in labour and total factor productivity and profitability and by comparing the technical efficiency of the UK steel industry with technical efficiency in six other major steel producing countries using data envelopment analysis (DEA). The results confirm the existence of efficiency gains before privatisation but since then performance has been more lacklustre.

1. Introduction[2]

Privatisation is expected to lead to an improvement in economic performance. Yet a number of theoretical and empirical studies have questioned the relationship between ownership and efficiency (eg. Kay and Thompson, 1986; Vickers and Yarrow, 1988; Martin and Parker, 1997). This paper is concerned with the performance of British Steel under public and private ownership. The UK steel industry was nationalised in 1950 but denationalized shortly afterwards. In 1967 the major steel producers were renationalised to form the British Steel Corporation.

During the 1970s and early 1980s British Steel suffered changes in performance linked to the state of the business cycle. In particular, large financial losses were recorded in the early 1980s during the depths of a recession. Between 1979 and 1985 losses totalled £2.5bn., resulting in a large-scale programme of plant rationalisation and job cuts. These scaled British Steel back from producing 17.3 million tonnes of liquid steel a year in 1979 to 13 million tonnes by 1985. Over the same period employment in the corporation fell even more sharply, from 191,500 to 67,800. The new Conservative Government after 1979 blamed nationalisation for a large part of British Steel's economic problems.

The British Steel Corporation was established on 28 July 1967 from fourteen of the UK's largest steel companies representing about 90 per cent of steel making capacity. A 1973 White Paper, *British Steel Corporation: 10 Year Development Strategy*, advocated expansion of production, but the world oil crisis from 1974 led to steeply rising production costs and large financial losses. In response there were some output cuts but the major rationalisation of the Corporation began in earnest only following the further rise in energy prices in 1979-80 and the resulting economic recession. The difficulties facing British Steel after 1979 were compounded by a three-month strike over pay in 1980 and by over-capacity in the European steel making industry, which led to the introduction of EC steel-output quotas. The average capacity utilisation of EC steel firms fell to below 60 per cent and prices fell by 13 per cent during the first few months of 1980 (Glais, 1995, p.229).

The capacity rationalisation programme was orchestrated by a new chairman, Ian MacGregor who was appointed by the government to impose commercial goals. Job losses and plant closures, along with a recovery in the demand for steel, meant that by 1986 British Steel was back in profit. In December 1988 British Steel was privatised when the entire share capital was sold via a public issue. Since that time the company has been viewed as one of the more successful of the UK privatisations. *The Economist* recently concluded: 'The transformation of British Airways, British Aerospace and British Steel into world-class firms bears witness to the power of privatisation' (*The Economist*, 1996).

It does not appear, however, that the claim of superior performance under private ownership has been subjected to serious study. How well has British Steel actually performed since privatisation? Also, how well does British Steel now rate in terms of economic performance in relation to other major steel producers? This study is concerned with answering these two questions. The central hypothesis is that if state ownership impacts adversely on economic performance, this should be reflected in an appreciable improvement in British Steel's technical efficiency and perhaps in its technical efficiency ranking when compared with other major steel producers.

The study first considers the performance of British Steel from 1979 (the election of the Conservative Government and the start of the UK privatisation programme) to 1995 using mainly labour productivity and total factor productivity measures. The study then attempts to shed light on British Steel's technical efficiency through a cross-country analysis. This part of the study also considers comparative labour productivity. The steel industry presents an excellent opportunity for a comparative study of economic performance before and after privatisation because the industry is international in its technology, choice of products, raw materials and markets. Steel making technology crosses national boundaries easily, and the product is usually similar or undifferentiated, which facilitates international comparison. However, there are also data problems when undertaking international study. The ideal would be to compare British Steel with comparable foreign steel companies, but there are major problems when comparing steel companies because of different accounting and reporting conventions. This makes the creation of an international data set complex, whereas a data set at the industry level could be more readily constructed. Therefore, here the UK steel industry as a whole is compared with certain overseas steel industries. The result is an indirect approach to comparing British Steel and producers outside the UK.

Comparable data were collected up to 1991 on steel output and the main steel inputs, including capital stock, for a number of different countries in the OECD, namely France, West Germany (henceforth, for convenience referred to simply as Germany), the USA, Canada, Japan and Australia, as well as the UK. Aggregate annual data on the value and quantities of inputs and outputs of the steel industry for each of the countries studied were constructed from different sources, particularly the publications of the United Nations and of the International Iron and Steel Institute. From these sources it proved possible to derive consistent data for the period 1967 to 1991 so as to enable comparisons to be made. The year 1991 was the last for which the international data are complete.[3] The countries studied produced more than 55 per cent of the world's steel in 1967 and 38.8 per cent in 1991. Data accessibility precluded comparisons of the UK steel industry with some other important steel producers, such as the former Soviet Union and China, several newly industrialised countries, like South Korea, Mexico, Brazil and Taiwan, and some European countries, notably Italy, Belgium, and Spain.Although the results in this part of the study do not compare British Steel with other steel companies, they do provide an indication of British Steel's relative performance because the UK steel sector throughout the period studied was dominated by British Steel. British Steel accounted for 91 per cent of UK crude steel production in 1968 and 56.7 per cent of finished steel products as late as 1990/91 (Pryke, 1981, p.194; British Steel, *Annual Report and Accounts 1990/91*, p.15). UK steel industry figures therefore heavily reflect the fortunes of British Steel. Moreover, since late 1988 the whole of UK steel production has been in the private sector so the international comparisons before and after 1988 do provide an insight into how well the UK steel industry performed when it was mainly state owned and how well when it was entirely privately owned.

The level of technical efficiency in each country's steel industry and across the seven countries over the period from 1967 to 1991 was assessed using data envelopment analysis (DEA). Instead of specifying a parametric frontier production or dual cost function (Aigner et al, 1977), this non-parametric method measures the technical efficiency at every data point. The use of DEA means that there is no need to specify either the fixed form of the production function or the fixed weights for the different inputs and outputs used. The technique is also capable of handling multiple, incommensurate inputs. These are important considerations when comparing steel industries which may have different production functions and input constraints.

2. Labour and total factor productivity in British Steel

The study begins by considering the growth in labour and total factor productivity within British Steel since 1979. This year was chosen as the starting date as it was the year when the new Conservative Government was elected and when rationalisation of the industry became pressing. An earlier study of British Steel in the 1960s and 1970s by Rowley and Yarrow (1981) using various performance measures concluded that nationalisation in 1967 had led to significant declines in market share and in the rate of diffusion of new steel-making technologies, but '... with some ambiguity concerning the highly important productivity variable'. A study by Pryke (1981, ch.11) of the nationalised steel industry reported 'serious weaknesses' in investment programmes, low labour productivity and an 'inability to meet.... customers' requirements'. However, a more recent study, of restructuring of the steel industry in the UK and West Germany in the 1980s, suggested that ownership may not be a critical factor in explaining change (Bacon et.al., 1991). The problems facing publicly and privately-owned steel producers in the UK and West Germany were similar, as were their responses. Aylen (1988, p.3) catalogued the dramatic improvement in British Steel's performance after 1980 and concluded, provocatively, 'At first sight there seems to be no case, on efficiency grounds at least, for privatising British Steel..... Nor is there systematic evidence from other industries to suggest that British Steel would achieve lower costs or higher total factor productivity under private ownership.' Knobel (1988) using labour productivity, capacity utilisation and cost indices found that all three improved significantly in British Steel in the mid-1980s. However, this study and that by Aylen did not consider how well British Steel performed after privatisation took place.

The performance of British Steel is first assessed in terms of changes in labour and total factor productivity from 1979 to 1995, although profitability figures are also included for completeness and as a comparison. In so far as privatisation is intended to raise the efficiency with which inputs are converted into outputs (technical efficiency) this can be captured in a productivity growth series. Here labour productivity is measured by changes in the volume of output in relation to changes in the volume of labour input. Output is tonnes of liquid steel produced, as given by British Steel in its annual reports. Labour input is measured as the average number employed in British Steel each year adjusted by the average hours worked in the steel industry. Total factor productivity (TFP) is measured using the same output but taking into account four inputs, namely capital, energy and raw materials used as well as labour. The capital input was measured on the basis of British Steel's recorded depreciation to represent the flow of capital services and a rental charge to reflect the opportunity cost of assets invested in the business. The annual rental charge was based upon a real rate of return of 8 per cent (see Spackman, 1991, for a justification in terms of the opportunity cost of invested funds). Other figures ranging from 5 per cent (the required rate of return for nationalised industries from 1978 - later raised to 8 per cent) and 12 per cent (closer to the real return in riskier, competitive industries) were tried but did not affect the results materially.

A translog production function was assumed and TFP growth was measured as:

$$\log(TFP_t / TFP_{t-1} = \log(Q_t / Q_{t-1}) - \sum_{i=1}^{4} [0.5(V_{it}+V_{i,t-1})\log(N_{it}/N_{i,t-1})]$$

where Q = output; t = time period; V_i = the share of input i in total expenditure and N_i = the amount of input i employed.

This method measures TFP as a weighted index of the growth rate of outputs in relation to inputs based on a Tornqvist index.[4] An input price index was constructed to deflate annual total expenditure based on unit labour costs, capital costs, the input producer price index for metal manufacturing for material costs, and the input producer price index for manufacturing for other costs. By using revenue and expenditure shares as weights this approach to measuring TFP is restrictive though commonly used (Millward and Parker, 1983, pp.225-9). In particular, in terms of inputs the correct weights are the proportional increase in output that a given proportional increase in inputs will provide. Only under strong assumptions will expenditures correspond with these elasticities. However, the TFP series is but one performance indicator reported in this paper and its robustness can be compared with the results from the labour productivity and DEA analyses.

Table 1 reports the computed figures for annual labour productivity and TFP growth in British Steel from 1979 to 1995. Although the figures fluctuate sharply from year to year the trend is clear and most evident in the averages over the sub-periods given at the foot of the table. The figures confirm a rise in the growth rate for both labour productivity and TFP up until 1986. After this date growth begins to slow and after privatisation, in late 1988, the performance is particularly lacklustre until 1991/2 when positive growth is experienced again. Even then, the average growth rate for

Table 1: Productivity and Profitability of British Steel, 1979-95
% change p.a.

	Labour productivity	Total factor productivity	Rate of return on net assets
1979/80	-10.5	-11.5	-12.9
1980/81	5.4	-1.9	-23.16
1981/82	50.4	26.6	-10.62
1982/83	0.8	-5.4	-11.78
1983/84	42.5	29.7	-4.71
1984/85	7.7	-3.9	-1.82
1985/86	35.6	15.5	4.76
1986/87	-18.3	-12.6	6.64
1987/88	26.5	18.0	12.99
1988/89	1.2	-3.1	17.79
1989/90	-5.2	-9.6	18.32
1990/91	-7.1	-12.7	3.88
1991/92	10.4	4.5	-2.10
1992/93	4.1	-1.0	-3.05
1993/94	12.1	16.0	2.29
1994/95	9.2	7.8	13.29
Averages:			
1979/82	15.1	4.4	-15.6
1982/85	17.0	6.8	-6.1
1985/88	14.6	7.0	8.1
1988/91	-3.7	-8.5	13.3
1991/94	8.9	6.8	2.6

Notes: For computation of productivity see text. Profit is before interest and tax. All years are British Steel's financial year which is to around 31 March.

labour productivity of 8.9 per cent is not as high as between the period 1979 and 1988; while the growth rate of TFP is around the same as in the last few years of state ownership.In general, the figures confirm that British Steel's productivity performance improved dramatically during the restructuring ahead of privatisation.[5] The good growth record after 1979 resulted from rationalisation of the industry, which perhaps should have occurred earlier. The scope for large productivity gains was, therefore, larger pre-1988 than it has been since this time. Moreover, privatisation coincided with the start of an economic recession that followed a short period when European steel producers in general had returned to profit levels not seen since 1974 (Glais, 1995, p.231). The post-1989 recession led to a sharp fall in the demand for steel products, renewed excess capacity and steeply reduced profitability. UK consumption of steel fell from 15.1m tonnes to 11.6m in 1992, a decline of 23 per cent (global steel consumption fell by much less, just over 7 per cent in the same period, indicating that the decline in the UK was particularly severe (IISI, 1994)). British Steel's turnover had reached £5.1bn by the year to March 1990, but had declined to £4.2bn by 1993/94. Table 1 also reports profitability computed as the rate of return on net assets valued at historic cost.[6] Large losses in the early 1980s are clearly evident with profits returning only after 1984/85. Profitability then remained buoyant during and immediately after privatisation, but the recession saw profits fall again with losses recorded in 1991/92 and 1992/93. This led to a further cost-cutting programme. The rebound in performance since 1992/93 may, once again, simply reflect the stage of the business cycle. Since 1991/92 UK GDP and steel demand have recovered.

3. The Comparative Performance of the British Steel Industry

Much previous research on performance in steel industries has been confined to company-specific performance (see Wu, 1996). International studies are restricted by difficulties in data collection. To assess the relative performance of British Steel and other major world steel producers, as mentioned earlier, for this paper comparison had to be restricted to the national, industry level. Thus the performance of the UK steel industry (which British Steel dominates) was compared with steel making in France, Germany, the USA, Canada, Japan and Australia. Technical efficiency was assessed using data envelopment analysis (DEA) for the period 1967 to 1991, the last year for which comprehensive international data are available.

DEA is a non-parametric frontier-efficiency technique using a linear programming-based method of performance measure originally proposed by Charnes *et al* (1978). It is non-parametric because it requires no assumptions or estimates of the parameters of the underlying production function. The method assesses the relative efficiency of a set of decision making units (DMUs) which are engaged in performing the same function using a set of inputs to produce a set of outputs. DEA compares inputs and outputs of the DMUs with the purpose of identifying the relatively more efficient subset. Instead of fitting a regression plane through the centre of data, as in stochastic cost and production function models, DEA floats a piecewise linear surface resting on top of the observations. DEA simply requires an assumption of convexity of the production possibility set and uses empirical data to determine the best practice frontier (Farrell, 1957).[7] Since the initial development of DEA, although a number of studies have been published exploring both theory and applications of the technique in the public and private sectors (e.g. Banker, Charnes and Cooper, 1984; Banker and Morey, 1986; Boussofiane *et al*, 1991, 1997; Banker and Thrall, 1992), there have been very few applications involving the steel industry (exceptions are Ray and Kim, 1995; and Boussofiane and Campbell, 1995). The model proposed by Charnes *et al* (1978) involves the following linear programme:

$$\text{Max } h_0 = \sum_{r=1}^{t} u_r y_{rj0}$$

$$\text{subject to} \quad \sum_{i=1}^{m} v_i x_{ij0} = 100$$

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{t} u_r y_{rj0} \le 0 \quad j = 1,\dots,n$$

$$u_r \ge \varepsilon, \quad r = 1,\dots,t,$$

$$v_i \ge \varepsilon, \quad r = 1,\dots,m.$$

where v_i is the weight attached to input i, u_r is the weight attached to output r, x_{ij0} is the level of input i used by unit j_o, y_{rj0} is the level of output r produced by unit j_0 and ε a small number (of the order 10^{-6}) that ensures no input nor output is given a zero weight.

In the solution to the model M1, the relative efficiency (h_o/100) of unit j_o is maximized subject to the efficiencies of all units in the set having an upper bound of 100. The major advantage of DEA is that the weights u_r and v_i are treated as flexible so as to maximize the efficiency of the target unit j_0. The efficiency of unit j_0 will either equal 100, if it is efficient relative to the other units, or will be less than 100 if it is relatively inefficient.

Since the number of units is usually larger than the number of inputs and outputs, it will be computationally slower to solve the primal than the dual. Moreover, the dual is not only a construct for computational convenience, it can throw further light on the nature of the relative efficiency scores. The dual model (M2) is as follows:

$$\text{Min } 100Z_0 - \varepsilon\sum_{r=1}^{t} s_r^+ - \varepsilon\sum_{i=1}^{m} s_i^-$$

subject to

$$x_{ij0}Z_0 - s_i^- - \sum_{j=1}^{n} x_{ij}\lambda_j = 0.$$
$$i = 1,\ldots,m,$$
$$-s_r^+ + \sum_{j=1}^{n} y_{rj}\lambda_j = y_{rj0}$$
$$r = 1,\ldots,t,$$
$$\lambda_j, s_r^-, s_r^+ \geq 0$$
$$\forall_{j,r,i} \qquad Z_0 \text{ unconstrained}$$

where S_r^+ is the slack in the rth output and S_i^- is the slack in the ith input.

The M2 model seeks a combination of DMUs that will outperform the targeted unit j_0. The unit j_0 will be efficient if the slacks are equal to 0 and Z_0 is equal to 100 when no composite unit outperforming j_0 can be constructed. Conversely, if j_0 is inefficient Z_0 will be smaller than 100 and/or slacks will be positive. The optimal values of λ_i form a composite unit outperforming j_0 and providing targets for j_0 to identify sources of its inefficiency. Z_0 represents the maximum proportion of the input levels that unit j_0 should be expanding to secure at least its current output levels.

The DEA model solved identifies a combination of one or more efficient units (the DMU's peer group) which can secure the output levels of the inefficient DMU using a proportion of its inputs equal to its efficiency rating. The peer units for the targeted unit are those units that achieve 100 per cent relative efficiency while using the same weights as the targeted unit. The efficiency ratings indicate the maximum amount by which all inputs could be reduced without affecting the level of output (e.g. a rating of 90 would indicate that all inputs could be cut by 10 per cent). However, usually it is to be expected that it will be possible to reduce some inputs by more than others. These 'target gains' can be obtained from an examination of the peer group for each inefficient DMU. Target gains show the improvement in each input used that is necessary to achieve 100 per cent efficiency.

The DEA model can also be extended to consider returns to scale and thereby assess the scale as well as the technical efficiency of each unit. This is achieved by introducing the following convexity constraint into equation M2 (Banker *et al*, 1984):

$\Sigma\lambda_j = 1$

The new model yields a measure of the pure technical efficiency of the units assessed. DMUs are not now penalised for operating at a non-optimal scale (Banker *et al*, 1984; Banker and Thrall, 1992). It should be noted that the additional convexity constraint usually makes the technical efficiency ratings for all DMUs stay the same or become higher, because with the convexity constraint the composite unit is of similar scale size as unit j_0 and it is not an extrapolation of another composite unit operating at a different scale size.

In the following discussion, DEA is used to assess the aggregate technical efficiency of the steel industry in the seven countries detailed earlier and over the twenty-five year period, 1967-91. Each country's steel industry in each calendar year is treated as a separate DMU. Hence, there are in total 175 DMUs (7 industries over 25 years) for the cross-country comparison. One output and three inputs, labour, capital, and materials including fuel, are considered to reflect the necessary resources used by the steel industry to secure its output each year. The output measure adopted in this study is the tonnes of annual crude steel production summarised by the International Iron and Steel Institute (IISI). The labour input is measured in employee hours inputted in each steel industry. In the figures reported the capital cost is measured as an annual depreciation rate of 5 per cent, as adopted by Cockerill and Silberston (1974) in their study of steel, applied to the gross capital assets of the industry. This is a lower rate than the 8 per cent return on capital adopted in the above TFP analysis, but the latter was applied to net assets while the international data relate to gross assets, therefore the two rates are not so different. To allow for the fact that, given the technological evolution in steel making, there might be a different depreciation rate for each country's steel industry, several test runs using different depreciation rates of between 5 per cent and 10 per cent were tried. The pattern of results was not significantly affected. The material inputs included the cost of materials (including iron ore, coal, and scrap metals), supplies consumed and purchased fuels, gas and electricity.

All value based inputs were deflated by appropriate price indices,[8] and were converted into US dollars by the exchange rate adjusted by Purchasing Power Parity (PPP) to facilitate international comparison. Two DEA models were run, both including all seven countries over the sample period of twenty five years. The first model assumed constant returns to scale (CRS) and therefore DMUs would be penalised for operating at non-optimal scale. The second model adopted variable returns to scale (VRS) and the results therefore reflect pure technical efficiency. The results are reported in tables 2 and 3 respectively. As to be expected, the efficiency ratings are higher under VRS because scale inefficiencies are removed; however, the overall top and bottom rankings across the countries remain the same. Japan is identified as the most technically efficient steel producer and by a large margin. The results confirm that the Japanese steel industry has shown its superiority in efficiency from the late 1960s, and maintained its lead in almost all of the sample period. France, on the other hand, is identified overall as a relatively inefficient producer. The ranking in the two models is different in the middle range because Australia is a much more efficient producer of steel when scale effects are not penalised. Under both CRS and VRS the UK is ranked a lowly sixth based on the figures for the entire period studied.

Table 2: Relative technical efficiency across seven countries (constant returns to scale)

	Australia	Canada	France	Germany	Japan	UK	USA
1967	32.75	71.50	43.70	69.92	100	40.94	61.07
1968	31.85	78.64	45.15	72.90	97.28	38.02	59.44
1969	39.10	73	48.24	65.60	100	39.16	62.02
1970	37.15	76.73	44.72	58.05	100	42.03	60.61
1971	35.97	74.85	39.93	52.16	97.88	37.44	60.54
1972	39.25	75.55	39.61	52.29	96.56	38.50	64.16
1973	40.91	83.81	39.11	46.73	100	32.12	68.49
1974	38.23	78.59	41.15	49.51	96.85	28.21	67.18
1975	42.21	74.17	27.63	41.94	89.38	26.20	59.82
1976	42.94	77.80	30.34	43.47	92.71	33.24	62.45
1977	39.61	82	30.50	39.74	88.51	33.40	60.73
1978	45.26	88.12	31.87	39.39	87.78	31.14	65.47
1979	46.01	100	33.37	40.33	96.23	32.12	66.13
1980	36.22	86.64	33.62	41.77	98.70	24.08	61.54
1981	35.95	85.09	35.58	47.86	92.04	37.17	64.22
1982	38.59	76.60	36.58	48.86	94.05	43.64	60.21
1983	49.94	90.39	44.08	60.85	93.69	60.49	64.30
1984	50.93	98.89	48.94	65.04	99.82	68.15	65.95
1985	60.10	100	50.57	66.31	100	79.10	68.50
1986	62.29	100	45.01	56.42	94.58	62.91	71.90
1987	56.90	100	45.10	56.42	97.24	64.46	72.27
1988	55.17	89.68	45.89	60.76	97.40	60.32	73.88
1989	56.91	97.04	46.80	61.03	99.05	57.95	74.21
1990	59.21	90.74	44.47	56.20	100	56.35	78.01
1991	61.35	95.81	46.67	64.44	100	48.91	74.87
Ave.	45.40	85.80	40.70	54.30	96.40	44.60	65.90
Rank in 1991	5	2	7	4	1	6	3

Note: Years are calendar years

The results also show that the fluctuations in the relative technical efficiency of the UK steel industry over the sample period were the largest among the seven countries. Also evident is the sharp improvement in the performance of UK steel producers in the 1980s at the time of the major restructuring of the industry. From 1981 relative technical efficiency grows sharply, reaching over 87 per cent of the most efficient industries by 1985 (under conditions of VRS: 79 per cent under CRS). By contrast, the relative efficiency ratings before 1981 are generally very low, with the figures for 1974/75 and between 1978 and 1980 being especially low. This can be explained by the recession that hit the UK steel industry in those two periods. The 1980 figure is also affected by a three month strike

Table 3: Relative technical efficiency across seven countries (variable returns to scale)

	Australia	Canada	France	Germany	Japan	UK	USA
1967	81.15	100	43.77	76.63	100	42.13	64.41
1968	75.40	100	45.46	78.56	98.96	38.10	62.26
1969	77.30	100	49.51	68.96	100	39.41	81.26
1970	77.45	90.73	46.29	59.53	100	42.50	62.77
1971	73.60	89.73	40.45	56.25	97.95	37.84	60.67
1972	72.72	86.59	40.93	55.86	96.64	38.51	70.88
1973	66.07	87.20	39.14	47.19	100	32.13	100
1974	65.27	83.72	41.62	49.85	100	28.22	100
1975	68.46	76.60	27.70	42.06	95.68	29.16	64.41
1976	72.33	81.25	30.53	43.57	96.28	33.28	67.27
1977	74.64	84.25	30.60	40.06	90.82	35.43	66.33
1978	77.69	88.48	31.89	39.40	87.80	32.28	85.83
1979	76.07	100	33.78	41.36	99.60	32.37	88.99
1980	71.16	87.21	34.39	42.11	100	34.45	67.24
1981	67.63	85.12	35.74	48.58	92.76	40.34	69.74
1982	76.93	88.26	38.01	50.07	94.60	53.49	60.40
1983	100	97.74	48.72	62.08	94.09	68.63	67.53
1984	96.60	98.90	52.95	66.19	100	77.43	70.36
1985	100	100	55.40	67.45	100	87.59	69.05
1986	100	100	48.01	56.71	94.65	72.28	73.02
1987	97.43	100	48.01	57.05	97.31	65.63	72.52
1988	90.95	93.50	46.17	60.89	97.43	60.52	73.98
1989	94.92	100	47.15	61.06	99.07	58.13	74.25
1990	98.53	100	44.64	56.97	100	58.36	78.19
1991	100	100	47.51	65.20	100	49.05	75.17
Ave.	81.97	92.89	41.93	55.75	97.35	47.33	73.05
Rank in 1991	3	2	7	5	1	6	4

Note: Years are calendar years

in British Steel that had a serious impact on the whole UK steel sector.Both the CRS and VRS models provide similar results with business cycle effects evident in both series.

This finding of a significant rise in comparative technical efficiency in the UK steel sector in the early to mid-1980s is consistent with the findings of studies by Aylen (1988) and Knobel (1988). These studies show the performance of British Steel improving sharply prior to privatisation. However, the results from both the CRS and VRS models demonstrate that *relative* technical efficiency peaked in 1985 and even then remained well short of the levels attained in Japan and Canada (and Australia in the VRS model). The UK ranked seventh (bottom) in terms of technical efficiency in the 1970s and had improved to third or fourth position by the mid-1980s. This is an achievement; but this still left the UK steel industry well behind the best producers. Moreover, after 1985 relative efficiency *declined*. This is significant as these were the years immediately prior to and following privatisation. Hence, the years immediately before and after privatisation were associated with a deterioration in *relative* technical efficiency.

This finding needs to be compared with the earlier reported figures on labour productivity and TFP for British Steel. These showed labour productivity growth slowing pre-1988 and labour productivity and TFP falling between 1989 and 1991. The fact that productivity growth continued between 1985 and 1988, while internationally relative technical efficiency declined, suggests that either the performance in British Steel is unrepresentative of performance in the UK steel industry or that, although efficiency at British Steel was growing, its gains were outpaced by efficiency improvements in other steel producing countries. The latter is the interpretation favoured here. The dominance of British Steel in the UK sector and the fact that the whole industry figures closely reflect our understanding of performance while British Steel was under state ownership, suggest that the relative efficiency decline occurred because of gains in technical efficiency in competitor countries.[9]

By 1991 the UK's performance remained well behind that of Japan and Canada and had been overtaken again by the USA, Germany and Australia. The UK's performance remained only a fraction above that of France. The year 1991 was a particularly difficult one for steel producers, but taking the year 1988, a year before the on-set of recession, the UK's performance still looks disappointing in relative terms, having fallen back sharply from the level achieved in 1985. By 1991 the relative technical efficiency of the UK steel industry was below its level in 1982 (in the VRS model) and the UK ranked sixth compared to seventh in 1979. Only the French steel industry performed worse taking the whole period from 1979 to 1991. Of course, this unexpected result may be explained by factors other than ownership. In particular, the first years of private ownership coincided with a severe economic recession. But as the figures in tables 2 and 3 are *relative* efficiency ratings and the recession can be expected to have affected all steel producers to some degree, this is unlikely to explain the steep performance set back.[10] In Europe the German steel industry performed better than the UK steel industry over the same period. Interestingly, the figures in tables 2 and 3 also show that on nationalisation in 1967 the UK steel industry was already lagging well behind in terms of technical efficiency. In other words, the poor relative performance of the UK sector pre-dated state ownership; although clearly nationalisation did not reverse the trend. Indeed, after 1967 relative technical efficiency deteriorated further.

Table 4 (see Appendix) summarises data on target efficiency gains based on the VRS model (the results using the CRS model are similar and therefore are not reported). As a by-product of a DEA analysis, data are generated identifying the input-output levels that would make an inefficient DMU efficient by examining the peer group for that unit. The resulting 'target gains' need to be interpreted with caution since they are simply statements of values that ought to be feasible in principle. In practice, some inputs may be outside of management control, for example where there are government restrictions on manning and capital stock. Nevertheless, the data can provide useful information on the possible sources of inefficiency.

It is evident from the results in table 4 (see Appendix) that there is no single input which is primarily responsible for technical inefficiency over time within each industry or across the industries at any period in time. The results suggest that over-capacity leading to capital inefficiency in steel making is also associated with over-manning and waste in material inputs. By comparing the average rating for each input over the entire sample period, 1967-91, and for the sub-periods, 1967-79, 1980-91 and 1988-91 it is clear that input use became generally more efficient in all of the countries' steel industries in the 1980s compared with the 1970s, most of the gain occurring after 1982 (the exception is France where gains were slight). In the case of the UK, resource use improved up to the mid-1980s but deteriorated again after that date, reflecting the DEA results in table 3. The efficiency gains in the UK steel sector were matched and in some cases outpaced by improvements in competitor industries. The figures also show that from 1981 the major gains in resource use in UK steel making came first in terms of capital stock, reflecting the capacity rationalisation programme. Improvements in labour usage lagged behind and were most marked in the mid-1980s.

What these DEA results and the earlier productivity figures suggest is that the UK steel industry, of which British Steel is the largest part, does not seem to have achieved a lasting competitive advantage in the early to mid-1980s on the back of its massive restructuring, as often presumed. By 1991, the position of UK steel in terms of technical efficiency was once again weak in relative terms. This conclusion is at variance with the popular view of a reinvigorated and highly competitive UK steel sector.

A probable explanation for the difference between the popular view and our results is exchange rate movements. The rebound in British Steel's profitability after 1992/93 occurred at a time when a decline in the value of sterling on the international foreign exchange markets gave domestic suppliers a major price advantage in UK and export markets. By contrast, very recent problems facing British Steel have been related to the appreciation of sterling against the Deutschemark since 1996 (Lorenz, 1997). Similarly, difficulties after 1979 occurred at a time of a steep appreciation of sterling on the foreign exchanges. In other words, British Steel's perceived competitiveness is related to external exchange rate movements and not simply to improved technical efficiency. The role of exchange rates in the performance of British Steel (and some of the other privatised companies highly dependent on export markets such as Rolls Royce and British Aerospace) is worthy of more detailed study than can be undertaken here.

Looking across the international results (table 2, 3 and 4), the three European countries in the study - the UK, Germany and France - have a similar pattern of efficiency change from the 1970s: all suffered in the economic recession in the mid-1970s and the early 1980s, especially the UK steel industry, and all recovered gradually after 1981. Also, the effects of restructuring after 1980 are evident in the figures for all of the countries. It is true that the UK's improvement appears to be the most impressive, but the UK started from a low base. There was more catching up to be done. The steel industries in the other four countries - Japan, the USA, Canada and Australia - were also affected by the two world-wide slumps, but not so seriously. Japan's overwhelming superiority in production efficiency is confirmed by the high level of its technical efficiency rating throughout the boom and slump cycle.

Table 5: Labour productivity across the seven countries, US$ per employee-hour

	UK	France	Germany	Japan	USA	Canada	Australia
1967	15.75	17.94	7.11	5.87	24.53	22.17	18.31
1968	14.59	17.59	8.05	5.60	25.05	24.20	18.91
1969	15.16	19.58	9.78	7.11	25.30	25.03	19.03
1970	17.80	18.17	11.40	8.22	24.50	26.20	20.12
1971	15.16	16.02	11.49	8.79	26.33	28.09	20.87
1972	16.97	18.13	13.02	12.01	27.27	29.06	21.28
1973	18.85	25.74	16.52	17.07	26.79	33.03	25.48
1974	21.65	30.76	18.60	12.17	29.02	30.90	26.29
1975	16.73	27.18	15.75	16.51	26.48	27.29	31.60
1976	14.71	24.30	14.70	19.25	27.32	29.69	27.06
1977	11.93	22.77	17.79	23.28	27.31	28.31	25.25
1978	14.26	27.14	18.62	25.80	29.33	25.98	24.38
1979	14.19	29.66	21.57	30.58	28.57	26.20	24.65
1980	15.54	30.62	20.89	26.60	25.51	23.83	25.34
1981	16.40	21.46	15.76	25.66	26.08	24.62	23.70
1982	17.36	19.80	14.51	22.77	22.31	19.46	22.68
1983	15.09	17.17	20.36	21.88	24.81	23.06	20.90
1984	14.36	10.30	14.47	25.65	27.55	25.65	23.79
1985	14.22	10.23	15.38	27.92	28.03	25.36	18.59
1986	16.92	14.01	21.73	39.37	30.45	24.64	17.51
1987	22.78	16.07	27.16	53.11	34.76	27.66	18.88
1988	26.05	20.59	27.79	72.38	38.26	30.93	19.05
1989	24.61	21.11	29.24	70.10	36.61	33.45	17.36
1990	23.92	24.39	37.78	66.10	34.68	29.30	17.96
1991	22.12	22.41	36.15	75.42	31.43	32.86	16.30
Rank in 1991	6	5	2	1	4	3	7

Source: Data for MVA and employee numbers are from UNIDO.; average working hours per week in the steel industry are from the International Labour Office, Geneva.

Canada's ratings confirm that it has one of the most efficient steel industries in the world behind Japan.

As a final performance measure, labour productivity for each of the seven countries was computed. Unfortunately, insufficient information existed to compute figures for total factor productivity. The results for each of the seven industries are shown in table 5. The figures were computed by relating value added in manufacturing output to time worked.

Formally:

Labour productivity =

$$\frac{\text{Manufacturing value added (MVA)}}{\text{Employee-hours per year}}$$

Data on MVA for each country were obtained from the United Nations Industrial Development Organization (UNIDO) and were deflated by a price index available for each country, the producer price index for manufacturing, and converted into US dollars by a PPP index.

According to a study by Goldberg (1986), the average labour productivity of the Japanese steel industry was inferior to that of the British steel industry in the late 1960s and Japanese steel's labour productivity remained behind that of the major industrialised countries until the mid-1970s. This is confirmed by the figures in table 5, which show Japan gradually extending a productivity lead only from the end of the 1970s. In the second half of the 1980s the Japanese augmented the gap leading to an enormous competitive advantage in terms of labour productivity by 1991.

By 1991 the country next to Japan in productivity terms was Germany. From the figures in table 5, labour productivity in German steel was low before the mid-1970s but grew steadily afterwards, except for temporary declines in 1981-82 and 1984-85. By the early 1990s Germany had surpassed Canada steel and US steel in terms of labour productivity. By contrast, the steel industries of the UK, France and Australia had competitive labour productivity figures before the mid-1970s, but failed to keep pace with the other countries later. In particular, the UK steel industry's drastic fall in labour productivity after the oil crisis of 1974-5 is striking and stagnant productivity continued for the following ten years. Although both the UK and France improved their labour productivity in the second half of the 1980s, the gap with the leading producers, Japan, Germany, Canada, and the US remained.

The labour productivity results are very similar to those of the DEA study with Japan's steel industry in the lead, Germany, Canada and USA following, and the industries of France and the UK recording the poorest results. The main difference relates to Australia, whose steel industry has a poor labour productivity performance but a better DEA ranking. Although the earlier labour productivity calculations for British Steel (table 1) showed strong growth after 1981 up to the mid-1980s, it seems that this did not appreciably close the UK steel industry's productivity gap against competitor producers.[11] Moreover, some of the small gain disappeared after 1988. By 1989 the UK ranked only fifth out of seven in terms of labour productivity and by 1991 sixth (table 5).

4. Conclusions

Privatisation was intended to lead to improvements in economic performance. In this paper, the performance of one of the major enterprises privatised in the UK in the 1980s, the former British Steel Corporation, was assessed. Economic performance was measured in terms of labour productivity and total factor productivity in the years leading up to and in the years immediately following privatisation. Profit figures were also included as a comparison. Also, technical efficiency and labour productivity in UK steel making were then compared with technical efficiency and labour productivity of the steel industries of France, West Germany, the USA, Canada, Japan and Australia between 1967 and 1991. The results confirm that capacity rationalisation in the years preceding the privatisation of British Steel led to major gains in performance. By 1985 the UK steel industry had surpassed the steel industries of Germany, France and the USA in terms of technical efficiency.

This improvement did not last, however. Although productivity continued to grow, it seems to have grown less fast in UK steel making than in the other steel industries studied. In terms of relative technical efficiency, by 1991 the UK steel industry again ranked low. If privatisation raises performance it does so by introducing more effective capital market pressures to be efficient and by increasing product market competition (Vickers and Yarrow, 1988, chs.2 and 3). British Steel operated in a competitive international market for steel products when under state ownership. Therefore, privatisation did not alter the competitive environment. Privatisation did change the capital market faced by the firm's management from state funding to funding from private investors. The results presented in this paper suggest that the change in the capital market did not lead to obvious performance gains, although whether British Steel would have weathered the economic recession after 1989 worse (or better) under state ownership is, of course, impossible to know.

Overall, the results suggest that British Steel achieved considerable efficiency gains in the years immediately before privatisation. One interpretation is that the prospect of privatisation spurred management to improve performance. An alternative interpretation is that major efficiency gains can occur under state ownership, given a government and management determined to bring about change.

Endnotes

1. University of Aston and University of Birmingham respectively. The authors are grateful to two anonymous referees for helpful comments on an earlier version of this paper. Any remaining errors are their own responsibility.

2. The authors would like to acknowledge the contribution of Stephen Martin of the University of York to the calculation of labour and total factor productivity in British Steel.

3. All input variables except the capital input were taken from the Industrial Statistics Yearbook published by the United Nation Industrial Development Organization (UNIDO). Aggregate statistics were no longer collected after 1991 and it is this which prevented extending the sample period beyond that year.

4. Subject to certain assumptions this provides a measure of Hicks neutral technical progress (Diewart, 1976). Hicks neutral technical progress refers to technical change which leaves the ratio in which factor inputs are used unchanged if input prices remain constant.

5. As a cross-check on the productivity results, a DEA study was undertaken based on the inputs and output of British Steel between 1979 and 1995. The results confirmed improved performance during the 1980, deterioration in the early 1990s, though a recovery by 1995. Space precludes reproducing the figures but a full set of results can be obtained by writing to one of the authors, David Parker. DEA is explained below.

6. A movement to higher value added products, part of British Steel's recovery strategy from the early 1980s, may not be properly reflected in the productivity series. The output measure on which productivity is based is tonnes of liquid steel produced; no other consistent series for the output of British Steel was available. By contrast, profit figures should reflect changes in product composition if this is reflected in sales revenue and therefore profits.

7. DEA does, however, have the following limitations that should be born in mind when interpreting the results, and why it is wise, as here, to use it alongside other performance measures: (a) there is no random error; hence all variance is treated as inefficiency. One consequence is that even small measurement errors of the DMUs on the frontier can cause large cumulative effects on the efficiency rankings; and (b) DEA is a relative efficiency measure. The frontier is made up of those DMUs that are relatively the most efficient. Therefore a 100 rating does not imply perfect efficiency; there may still be slack, though less slack than in the lower rated DMUs.

8. The gross domestic fixed capital formation deflator for manufacturing industry was used to calculate capital cost at constant prices; materials costs were deflated by the producer price index for inputs to the steel industry.

9. It is known that, while British Steel was reducing its numbers employed in the early to mid-1980s so were other steel producers, if less sharply. In the EC the workforce in steel fell by over 30 per cent in the 1980s and in the USA and Japan by 32 and 27 per cent respectively. Also, see the discussion of target efficiency gains below.

10. Admittedly, the recession in the UK was especially severe.

11. The labour productivity gains in tables 1 and 5 for British Steel do not correspond. This is explained by the different time periods (calendar years and financial years) used and the different series for inputs and outputs used in the construction of the tables. However, the general productivity trends, as to be expected, are not dissimilar.

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Appendix

Table 4, see over.

Table 4: International Steel Industry - Target Gains % (variable returns to scale model)

Year	Australia Capital	Australia Labour	Australia Materials	Canada Capital	Canada Labour	Canada Materials	France Capital	France Labour	France Materials
1967	18.8	18.8	28.0	0.0	0.0	0.0	56.2	56.2	56.2
1968	24.6	24.6	24.6	0.0	0.0	0.0	54.5	54.5	54.5
1969	22.7	22.7	22.7	0.0	0.0	0.0	50.5	50.5	56.0
1970	25.5	25.5	25.5	9.3	9.3	9.3	53.7	53.7	58.3
1971	26.4	26.4	26.4	10.3	10.3	10.3	59.5	59.5	59.5
1972	27.3	27.3	27.3	13.4	13.4	13.4	59.1	59.1	61.7
1973	33.9	33.9	33.9	18.6	13.4	12.8	60.9	60.9	64.5
1974	34.7	34.7	34.7	16.3	16.3	26.3	58.4	58.4	66.2
1975	31.5	31.5	31.5	20.4	20.4	20.4	72.3	72.3	72.3
1976	27.7	27.7	27.7	19.5	18.8	18.8	73.2	69.5	69.5
1977	25.4	25.4	25.4	18.4	15.7	15.7	75.8	69.4	69.4
1978	22.3	22.3	22.3	11.5	11.5	15.9	75.1	68.1	68.1
1979	23.9	23.9	23.9	0.0	0.0	0.0	28.6	33.8	33.8
1980	28.8	28.8	28.8	12.8	12.8	19.0	34.4	34.4	28.1
1981	32.4	32.4	32.4	14.9	14.9	22.3	31.3	35.7	35.7
1982	23.1	23.1	23.1	11.7	11.7	11.7	32.4	38.0	38.0
1983	0.0	0.0	0.0	2.3	2.3	2.3	37.0	40.3	48.7
1984	3.4	3.4	3.4	1.1	1.1	4.3	35.8	46.8	53.0
1985	0.0	0.0	0.0	0.0	0.0	0.0	65.1	53.1	44.6
1986	0.0	0.0	0.0	0.0	0.0	0.0	65.7	54.7	52.0
1987	2.6	2.6	2.6	0.0	0.0	0.0	65.1	54.3	52.0
1988	9.9	9.9	9.9	17.5	6.5	6.5	57.9	53.8	53.8
1989	5.1	5.1	21.4	0.0	0.0	0.0	67.4	52.9	52.9
1990	2.4	1.5	17.1	0.0	0.0	0.0	70.1	55.4	55.4
1991	0.0	0.0	0.0	0.0	0.0	0.0	70.3	52.5	52.5
Average rating									
1967-91	18.1	18.1	19.7	7.9	7.1	8.4	56.4	53.5	54.3
1967-79	26.5	26.5	27.2	10.6	9.9	11.0	59.8	58.9	60.8
1980-91	9.0	8.9	11.6	5.0	4.1	5.5	52.7	47.7	47.2
1988-91	4.4	4.1	12.1	4.4	1.6	1.6	66.4	53.7	53.7

(continued)

Table 4 (continued)

Year	Germany Capital	Germany Labour	Germany Materials	Japan Capital	Japan Labour	Japan Materials	UK Capital	UK Labour	UK Materials	USA Capital	USA Labour	USA Materials
1967	35.0	64.5	23.4	0.0	0.0	0.0	57.9	66.9	67.5	35.6	42.2	35.6
1968	31.3	60.5	21.4	7.5	18.8	1.0	61.9	62.6	66.6	37.7	41.0	42.7
1969	31.0	52.5	31.0	0.0	0.0	0.0	60.6	62.7	70.1	18.7	21.4	18.7
1970	40.5	48.9	40.5	0.0	0.0	0.0	57.5	61.2	69.8	37.2	38.1	42.1
1971	49.1	62.4	43.7	23.5	2.1	2.1	62.2	65.7	65.9	41.8	39.3	39.3
1972	47.7	56.9	44.1	25.1	3.4	3.4	61.5	61.5	67.1	29.1	29.1	34.7
1973	53.9	52.8	52.8	0.0	0.0	0.0	67.9	67.9	67.9	0.0	0.0	0.0
1974	50.1	50.1	51.9	0.0	0.0	0.0	73.8	73.8	73.8	0.0	0.0	0.0
1975	57.9	57.9	57.9	4.4	4.4	32.5	70.8	72.1	70.8	35.6	35.6	44.3
1976	56.4	56.4	56.4	3.8	3.8	17.6	66.7	66.7	66.9	32.7	32.7	40.8
1977	59.9	59.9	59.9	9.2	9.2	14.2	64.6	70.6	64.6	33.7	33.7	45.5
1978	60.6	60.6	60.6	12.2	12.2	13.1	67.7	68.7	67.7	14.5	17.4	32.4
1979	58.6	58.6	58.6	1.0	0.4	0.4	67.6	67.6	67.6	11.0	20.5	35.9
1980	57.9	57.9	57.9	0.0	0.0	0.0	65.6	81.8	65.6	32.8	32.8	46.2
1981	57.1	51.4	51.4	7.3	7.3	7.7	59.7	72.7	60.6	30.3	30.3	41.9
1982	59.1	50.9	49.9	6.4	5.4	5.4	46.5	69.8	55.6	39.6	39.6	39.6
1983	51.3	37.9	37.9	8.2	5.9	5.9	31.4	63.0	53.2	32.5	32.5	33.7
1984	45.4	33.8	33.8	0.0	0.0	0.0	22.6	61.1	51.9	29.6	29.6	36.2
1985	45.3	32.5	32.5	0.0	0.0	0.0	12.4	60.2	49.6	40.7	30.9	30.9
1986	54.7	43.3	43.3	5.3	5.3	5.3	27.7	59.9	50.2	40.2	27.0	27.0
1987	61.1	43.0	43.0	13.9	2.7	2.7	34.4	46.4	51.9	41.8	27.5	27.5
1988	57.5	39.1	39.1	2.6	2.6	2.6	39.5	39.6	50.8	30.1	26.0	26.0
1989	40.3	61.1	61.1	0.9	0.9	0.9	41.9	41.9	51.1	27.4	25.8	25.8
1990	38.6	57.0	57.0	0.0	0.0	0.0	43.6	43.7	47.9	24.0	21.8	21.8
1991	54.9	34.8	34.8	0.0	0.0	0.0	51.0	51.0	51.0	31.2	24.8	24.8
Average rating												
1967-91	50.2	51.4	45.8	5.3	3.4	4.6	52.7	62.4	61.0	29.1	28.0	31.7
1967-79	48.6	57.1	46.3	6.7	4.2	6.5	64.7	66.8	68.2	25.2	27.0	31.7
1980-91	51.9	45.2	45.1	3.7	2.5	2.5	39.7	57.6	53.3	33.4	29.1	31.8
1988-91	47.8	48.0	48.0	0.9	0.9	0.9	44.0	44.1	50.2	28.2	24.6	24.6