DO OWNERSHIP AND BOARD COMPOSITION MATTER? EFFICIENCY AND CORPORATE GOVERNANCE IN SOME UK PRIVATISED FIRMS

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Abstract

The main aim of this paper is to analyse the role of privatisation and corporate governance reform and modification in the firm's organisation for the efficiency of the sample firms. Data Envelopment Analysis estimation will be used to understand the level of efficiency achieved by the Management Decision Unit and the stochastic frontier approach will analyse inefficiency in its components (i.e. if inefficiency is due to an adverse state of the world - statistical noise - or if it can be explained with the determinant of other factors such as corporate governance).

Keywords: corporate governance, privatization, board of directors, UK companies

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1.1 Introduction

Efficiency estimation is a topic that has been studied by several economists. It is already half a century that authors such as Debreu (1951), Koopmans (1951), Farrel (1957) and many others more recently (Leibenstein 1966, Varian 1985, Bauer 1990) introduced the analysis of efficiency estimation into the economics literature. From then on, there has been a very large number of works devoted to the measurement of productive efficiency. Between them, the measurement of efficiency has widely been associated with the use of production frontier functions. Several techniques to calculate these frontier functions have been used, some of them parametric, others non-parametric. In this work, I will use them jointly to estimate the impact of privatisation and corporate governance on efficiency.

The choice of estimation method has been an issue of debate (see Berger 1993, Seiford and Thrall 1990) since every method has its advantages and disadvantages. The main disadvantage of non-parametric approaches (i.e. as Data Envelopment Analysis, DEA) is their deterministic nature. Using this kind of non-parametric technique it is not possible to distinguish if the lack of efficiency (that the method is fully able to recognise) is due to technical inefficiency or to statistical noise effects. On the other hand, parametric frontier functions require the definition of a specific functional form for the technology (i.e. a production function with constant returns to scale or variable returns to scale) and for the inefficiency error term. To decide which kind of functional form to use could cause both specification and estimation problems even if several packages now allow estimating both functional forms. It is actually not possible to say wich methodology is better than the other. But this paper shows that they can be jointly used to compensate the lack of each one in the analysis of the results.

The main aim of this paper is to analyse the role of privatisation and corporate governance reform and modification in the firm's organisation for the efficiency of the firm. The DEA estimation will help to understand which level of efficiency has been achieved by our Management Decision Unit and the stochastic frontier approach will analyse inefficiency in its components (i.e. if inefficiency is due to an adverse state of the world - statistical noise - or if it can be explained with the determinant of other factors such as corporate governance).

The paper is organised as follows: in Section 1.2 there are some general notes on the data set used in the two estimations. Section 1.3 explains the general characteristic of the Data Envelopment Analysis technique and the details of the specific model used in this study. In Section 1.4 there are the results of the estimation for all the firms in the sample and in Section 1.5 there is a general summary of the results and some general comments. Section 1.6 introduces the Stochastic Frontier approach while Section 1.7 gives a detailed explanation of the three step estimation needed to perform the search. Section 1.8 illustrates some specificities of the data needed to apply this technique and the meaning of "control variables" in stochastic frontier. In Section 1.9 there are the results of the estimation. These results are compared in Section 1.10 with the results obtained with DEA technique and finally, Section 1.11 concludes.

1.2 Data: a general issue for the two models

The common way in which the two techniques are used is with panel data. Given the nature of the firms considered here and in accord with the work of Boussafiane, Martin and Parker (1997) to carry on a panel data analysis is not possible. In fact, mainly all the sample firms are in a monopoly position in their market, or, even if they are not monopolist, there are no other firms in the internal market that can be considered as facing the same technical conditions.

So, in this work, rather than comparing several organisations at a single point of time I will adopt a longitudinal analysis of decision making unit (DMU) of the same firm to assess changes in technical efficiency related to privatisation and corporate governance (via the use of proxy variables). The idea is to consider the different years of each firm's life as a different DMU and to analyse the relevant changes in efficiency as the result of changes in the control variables on privatisation and corporate governance. The reason to adopt this approach is that, for instance, British Telecom, even if it is no more a monopolist in the telecommunication services cannot be compared with other firms in the same telecommunication market since it is too much bigger than its rivals. The same applies to British Airways, British Gas, British Aerospace.

The other point that is important to consider is that this study will try to give some answers on the effectiveness of privatisation and corporate governance in general. We cannot consider British Gas or British Airways a monopolist anymore but they were monopolist at the time they were privatised. So, now it could be easily done an analysis of efficiency based on panel data for the airways sector or for the gas sector or for the telecommunications sector. But this will not help us to answer the question: does privatisation and corporate governance influence efficiency ? Before each estimate I will provide an explanation of the data used on inputs and outputs for each of the organisations studied.

1.3 The Data Envelopment Analysis model

The non-parametric method used to estimate efficiency in privatised firms is a Data Envelopment Analysis (DEA). To assess the efficiency of decision making units we use a linear programming technique. This method is very useful when we need to consider a framework characterised by several inputs and several outputs. In this case we consider a model with just one output and a variable number of inputs given the nature of the firm considered. Charnes, Cooper and Rhodes (1978) introduced this method for the first time in 1978.

Since than there have been several works using DEA (e.g. Lovell 1993, Ganley and Cubbin 1992, Coelli and Perelman 1996, Murillo-Zamorano and Vega-Cervera 2000). The basic idea of DEA is to evaluate a distance function for a group of firms in the same industry or for a group of decision making units (i.e. if we use a time series for just one firm). In a general case we consider data on K inputs and M outputs (in our case 1) for each of the N firms (or decision making units) considered. For i-th firm these are represented by the column vectors x_i and y_i, respectively.

The full set of data are so represented by the matrix KxN for the inputs and the MxN matrix for the output. In our case this matrix will be just a vector with i dimension where i represent the different decision making units over time N.

Data Envelopment Analysis can be explained using a ratio form. For each firm we need to obtain a measure of the ratio of all outputs over all inputs such us $\frac{\alpha y_i}{\beta x_i}$ where α and β are two vectors of size Mx1 for α and Kx1 for β where again M is the number of output (1 in our case) and K is the number of inputs. To find the optimal values of the parameters α and β we need to solve the problem stated in Case 1 of Table 1.

Table 1. The model

Case 1	Case 2	Case 3
$\max_{\alpha,\beta} \frac{\alpha y_i}{\beta x_i}$ subject to: $\frac{\alpha y_j}{\beta x_j} \le 1$ $u, v \ge 0$	$\max_{\psi,\zeta} \psi y_i$ subject to $\zeta x_i = 1$ $\psi y_j - \zeta x_j \le 0$ $\psi, \zeta \ge 0$	$\min_{\theta,\lambda} \theta$ subject to $-y_i + Y\lambda \ge 0$ $\theta x_i - X\lambda \ge 0$ $\lambda \ge 0$

The previous envelopment form is usually associated with constant returns to scale (CRS) assumption. In this study I have done the estimation even for the assumption of variable returns to scale (VRS) for two reasons. First, this assumption seems to explain better some features of the organisation studied[1]; and second by conducting a CRS and a VRS DEA upon the same data allows us to decompose the technical efficiency (TE) scores obtained into two components, one due to scale inefficiency and one due to "pure" technical inefficiency (i.e. wrong input mix or managerial inefficiency). If we have a difference between the two TE scores for a specific Decision Making Unit this indicates that the Decision Making Unit has scale inefficiency and we can calculate this inefficiency using the difference between the VRS TE score and the CRS TE score. Further details will be given when I will comment on the results. To apply a variable return to scale assumption to the previous envelopment form some slight modification are needed. In particular I am referring to the need of adding the convexity constraint to the previous model to obtain:

$$\min_{\theta,\lambda} \theta$$
subject to
$$-y_i + Y\lambda \ge 0$$
$$\theta x_i - X\lambda \ge 0$$
$$\lambda \ge 0$$
$$N1'\lambda = 1$$

where N1 is a Nx1 vector of ones. This approach forms a convex hull of intersecting planes which envelope the data points more tightly than the CRS conical hull. This is the main reasons why the TE scores obtained with VRS are greater than or equal to the one obtained with CRS.

[1] I have done a preliminary DEA with a constant return to scale assumption but the results obtained with a variable return to scale assumptions seems to catch a bit more elements. However there is not considerable difference in the results obtained with the two assumptions. So, just to clarify, the comments will be based on the VRS assumptions even if i will provide the estimation for the CRS.

1.4 Estimations

In this section we provide the estimations obtained with the CRS and VRS for British Gas, British Aerospace, Rolls-Royce, British Telecom and British Steel. Before each estimation I will provide some explanations on output, input, year of privatisation. As a general disclaim I would like to specify that there are several studies (i.e. see Martin and Parker 1997) that perform an estimation considering a period of five year before and after the privatisation. In this work I use all the information available at the time of the study for each one of the firms. This means that for some firms the number of observations before and after privatisation is different. This will only add information in the process of understanding if privatisation was effective in terms of efficiency gain. Furthermore, it will provide a subsequent check on the level of performance obtained by the firm several years after privatisation. This means that it will not be very useful sometimes to talk about "average efficiency" obtained under public ownership and "average efficiency" obtained under private ownership even if we can calculate these averages without any problem. Problems with the accuracy of measuring capital (Martin and Parker: 1995) are usually a big obstacle. In this study, as cost of capital, will be considered the total costs of depreciation. This is just a "crude" indicator for capital cost but, even trying to correct it in some ways (Bishop and Thompson 1992) the results that follow are based on qualitative comments (Martin and Parker 1995).

1.4.1 British Gas

For British Gas we have 22 observation from 1976 to 1997. British Gas was privatised in 1986. The variables considered are one output and four different inputs. All the values are expressed in constant (1990) prices. The output here is turnover while the inputs considered are prime materials, salaries, depreciation and other costs. In 1992 more competition was introduced into the market. From 1996 more competition was introduced into the domestic market.

There are the estimations of efficiency with constant return to scale (CRSTE) and variable return to scale (VRTSE) in Table 2. The column

SCALE accounts for scale inefficiency. Scale inefficiency is calculated using the difference between the VRS TE score and the CRS TE score. If there is a difference between the two scores it means that the DMUs has scale inefficiency. We can build an index of this scale inefficiency equal to CRSTE/VRSTE. At the same time it is possible to specify if we are in a situation of increasing return to scale (irs) or decreasing return to scale (drs). The average of the index of efficiency under public ownership (11 observation) is 89.88% while under private ownership (11 observations) it is equal to 93.4%. So the average efficiency for British Gas is higher under private ownership. Two things to point out: even if the average is higher under private ownership, we have 5 frontier DMU (efficiency=1) under public ownership while 4 under private ownership. Looking at the data, the decline under public ownership began in 1979 till 1983 when measures to allow privatisation of British Gas were implemented. When British Gas was privatised the index of efficiency was at a maximum. Until 1992 the performance of British Gas was convincingly positive. The years from 1993 till 1996 were strongly influenced by a very inefficient contract.

The so-called “take or pay” contract seriously affected efficiency in terms of profitability of British Gas. To ensure adequate supplies and not foreseeing the current glut in the gas market, the company entered into so-called “take or pay” contracts with gas producers under which it contracted to pay for supplies whether they were required or not. In the past resulting losses would have been more easily met by cross-subsidisation from elsewhere in the monopoly business but the new competitive environment limited such strategy. British Gas is trying now to renegotiate the contracts but, to make the things even worse, Transco, which now yields much of the company’s earnings, faced a stringent price review by Ofgas in 1996. This adds some further explanations to the bad financial performance of British Gas in recent years.

Table 2. British Gas: efficiency summary

DMU (year)	CRSTE	VRSTE	SCALE	DMU(year)	CRSTE	VRSTE	SCALE
1 (1976)	1.000	1.000	1.000	13 (1988)	0.877	0.965	0.909 irs
2 (1977)	1.000	1.000	1.000	14 (1989)	0.930	1.000	0.930 irs
3 (1978)	0.971	1.000	0.971 drs	15 (1990)	1.000	1.000	1.000
4 (1979)	0.877	0.889	0.986 drs	16 (1991)	0.944	1.000	0.944 drs
5 (1980)	0.830	0.841	0.987 drs	17 (1992)	0.949	0.953	0.996 irs
6 (1981)	0.769	0.771	0.997 drs	18 (1993)	0.800	0.857	0.934 drs
7 (1982)	0.697	0.701	0.995 irs	19 (1994)	0.754	0.789	0.956 drs
8 (1983)	0.728	0.728	0.999 drs	20 (1995)	0.761	0.782	0.973 drs
9 (1984)	0.937	0.957	0.979 irs	21 (1996)	0.957	0.985	0.971 irs
10 (1985)	1.000	1.000	1.000	22 (1997)	1.000	1.000	1.000
11 (1986)	0.974	1.000	0.974 drs	mean	0.895	0.916	0.977
12 (1987)	0.934	0.943	0.990 irs				

Note: crste = technical efficiency from CRS DEA (model 1); vrste = technical efficiency from VRS DEA (model 2); scale = scale efficiency = crste/vrste; irs=production function showing increasing return to scale; drs=production function showing decreasing return to scale. Note also that all subsequent tables and comments for British Gas refer to VRS results.

Under public ownership the most “inefficient of the inputs seems to be input 4 (other costs) while, quite surprisingly, the period 1993-1996 is characterised by slack in all inputs but labour.

At this point it is better to give some explanation of the importance and the meaning of “peers”. What are “peers”? “Peers” define the relevant part of the production frontier for a DMU. If a DMU is not fully efficient, given the previous and following estimation we can calculate which is the target (i.e. produced output given the used inputs) that the DMU could aim at if efficient. An example will make it clear. Let’s say that DMU1 has a Technical Efficiency value of 0.8. This mean that for that DMU could be possible to reduce the consumption of all inputs by 20% without reducing output. At the same time, it means that the considered DMU is located not on the frontier of production but at an internal point. If we draw a vector between the origin of the axis and this point we will cross the production frontier. The point on the production frontier that we will obtain is the target of our firm and we can express this point as a linear combination of some other DMUs that are on the frontier and that will represent the “peers” of the DMU. The weights in this linear combination are the λ’s that we obtain from our estimation.

Table 3 and 4 give us an idea of which are the DMUs in the production frontier and which are the most fashionable DMU (the DMU that the non-efficient firms see as a reference point). For instance, from Table 3we can see that DMU13 has as peers, or relevant DMUs on the frontier, DMU15 and DMU1 with a weight of 0.894 for DMU 15 and 0.106 for DMU 1.

Table 3. Summary of peers

MDU (year)	Peers (weight)	MDU (year)	Peers (weight)
4 (1979)	15(0.3) 22(0.155) 2(0.545)	13 (1988)	15(0.894) 1(0.106)
5 (1980)	22(0.2619 15(0.327) 2(0.412)	17 (1992)	22(0.019)15(0.953) 1(0.028)
6 (1981)	2(0.163) 1(0.324) 15(0.477) 22(0.035)	18 (1993)	3(0.144) 15(0.856)
7 (1982)	1(0.121) 22(0.151) 15(0.727)	19 (1994)	15(0.647) 3(0.339) 22(0.015)
8 (1983)	2(0.071) 22(0.080) 3(0.007) 15(0.842)	20 (1995)	15(0.518) 3(0.131) 22(0.351)
9 (1984)	1(0.068) 10(0.627) 15(0.306)	21 (1996)	15(0.659) 22(0.341)
12 (1987)	15(0.914) 1(0.024) 10(0.063)		

Note: DMUs that are on the frontier have as a peer just themselves. In the table we did not report these DMUs.

At the same time we see that the DMUs on the frontier are DMU 1, 2, 3, 10, 11, 14, 15, 16 and 22. From Table 4 we can see that even if there are 9 DMUs on the frontier, only 6 of them are used as "peers" (DMU 1,2,3,10,15,22). Several public DMUs (i.e. DMU 4, 5, 6, 7) have as "peers" private DMUs with a relevant weight while the opposite is not true (the highest weight of a public DMU for a private DMU is for DMU 19 where DMU 3 has a weight of 0.339). This could be interpreted as a need for public DMUs to have a private behaviour to increase economic efficiency.

Table 4. British Gas: peer count summary

DMU	Peer count:	DMU	Peer count:
1	6	10	2
2	4	15	13
3	4	22	9

The most "fashionable DMU" is 15, relative to year1990 and under private ownership. In 1990 the turnover of British Gas was, in constant price, 9491 £m and the profit was 245 £m (constant price).There were 13 other DMUs using it as a peer. We need to specify that when DMU 15 is a "peer" with other DMU, the proportional weight of this unit is the highest. So DMU 15 can be seen, in a wide sense and given the methodology used, as the most efficient unit of the panel used. Even DMU 22 and 1 are "quite fashionable" but the proportional weight that they have is relatively small compared with that of DMU 15.

1.4.1.1 British Gas: some conclusions

The first proposal for privatisation of British Gas came in 1980 with the suggestion that British Gas showrooms should be sold. Plans that are more ambitious gained credibility in the 1984. This is due even to the regained efficiency (95.7%) of the firm at this time. Two acts of intervention caused serious suffering in the gas industry, the fine tuning of the 1980s and the "take or pay" contract. The government imposition of 30% real rise in domestic prices during the 3 years from 1980 was something really unusual in the British Gas history. If we observe the results obtained for 1981, 1982 and 1983 in Table 2 we see that they are the lowest obtained in all the period studied (results in line with the one obtained by Boussafiane et al. 1997). In fact, the efficiency was 77% in 1981, and fell to around 70% for 1982 and 1983. This confirm that such fine tuning of an industry's price structure was quite unusual and of a considerable amount. Furthermore, it was a measure that completely tilted the pricing balance of the market supplied. Probably this represented an improvement in efficiency terms, reversing the favourable treatment of the domestic market but the profitability of British Gas suffered from this measure.

The Government announced the decision to privatise British Gas in May 1985. At this time British Gas was fully efficient (TE=1) The firm's profitability was an asset that the government pointed out a lot during the privatisation plan. In fact, from 1979 till 1984 the TE scores were under the maximum value. From 1985 till 1991 British Gas has scored very well with several DMUs on the boundary and very good results even in cases were the TE score was not at the maximum. However, in 1992 we can observe a reverse in the trend of the score: something important changed. The Secretary of State forced the company to open its contract market to competitors and in few years there were 42 independent gas marketing companies supplying contract customers in the commercial and industrial markets. In 1994 and 1995 British Gas scored the lowest ratio on efficiency during private ownership (around 78%). This was the beginning of an uneasy story of regulation. The strict regulation imposed on British Gas probably reduced profitability of the firm but, at the same time, increased the welfare of million of customers that observed a drastic fall in the price of domestic gas. Why was British Gas unable to react in an efficient way to this regulation? The fact that really caused troubles to British Gas was the "timing" of regulation and not the regulation itself. As we saw, in these years British Gas was facing a "take or pay" contract. The mistake of the management was that they signed a contract without considering the increasing competition and the reduced necessity of supplies in the gas market. The amount of this contract was worth about £16 billion over 5 years. In the past resulting losses would have been more easily met by cross-subsidisation from elsewhere in the monopoly business but the new competitive environment limits such strategy. British Gas is trying now to renegotiate the contracts but, to make the things even worse, Transco, which now yields much of the company's earnings, faced a stringent price review by Ofgas in 1996. This adds some further explanations to the bad financial performance of British Gas in the last few years.

The effectiveness of privatisation for British Gas is controversial. The reason for this controversy is basically due to two reasons. It is true that several DMU's scores had a better value and trend during public ownership but this is mainly due to the very favourable environment that British Gas was facing before privatisation and to the several constraint and regulatory policy that the Government implemented after the privatisation of the firm.

It is clear that the new competitive environment and some bad management decisions have not been good for British Gas but we cannot talk of a clear failure of privatisation for the community since consumers gained several advantages from the increased competition in the gas sector

1.4.2 British Aerospace

For British Aerospace we have 20 observations from 1978 to 1997. British Aerospace was privatised in 1981. The variables considered are one output and four different inputs. All the values are expressed in constant (1990) price. The output here is sales while the input considered is prime materials salaries, depreciation and other costs. It was not possible to obtain previous data on BAe because it was organised as British Aerospace just in that year.

During the years there has been an increase in the level of competition for defence contracts. The average under public ownership (4 observations) is 100% while under private ownership (16 observations) it is 98.7%. Again under public ownership efficiency is slightly higher than under private but here there are at least two major features to point out. The number of observations under public ownership is extremely lower that under private ownership. This is not due to a lack of data but just to the fact that British Aerospace was created in 1977 and privatised in 1981. If we use only the first 4 values of the index after privatisation we obtain a value of 99.5% that shows that the difference in performance is extremely small.

Table 5. British Aerospace: efficiency summary

DMU (year)	CRSTE	VRSTE	SCALE	DMU (year)	CRSTE	VRSTE	SCALE
1 (1978)	1.000	1.000	1.000	11 (1988)	0.910	0.910	1.000
2 (1979)	1.000	1.000	1.000	12 (1989)	0.978	0.978	1.000
3 (1980)	1.000	1.000	1.000	13 (1990)	1.000	1.000	1.000
4 (1981)	0.962	1.000	0.962 irs	14 (1991)	1.000	1.000	1.000
5 (1982)	1.000	1.000	1.000	15 (1992)	0.933	0.940	0.993 drs
6 (1983)	1.000	1.000	1.000	16 (1993)	1.000	1.000	1.000
7 (1984)	1.000	1.000	1.000	17 (1994)	0.955	1.000	0.955 drs
8 (1985)	0.983	0.983	1.000	18 (1995)	1.000	1.000	1.000
9 (1986)	1.000	1.000	1.000	19 (1996)	1.000	1.000	1.000
10 (1987)	1.000	1.000	1.000	20 (1997)	1.000	1.000	1.000
				Mean	0.984	0.990	0.995

Note: crste = technical efficiency from CRS DEA (model 1); vrste = technical efficiency from VRS DEA (model 2); scale = scale efficiency = crste/vrste; irs=production function showing increasing return to scale; drs=production function showing decreasing return to scale. Note also that all subsequent tables and comments for British Aerospace refer to VRS results.

I would like to stress here that I am avoiding stating when I find very high value of the index that the efficiency is the maximum possible. The nature of data does not allow this conclusion. We could instead say that given the nature of the sector studied some DMU are more efficient than others. This is because we do not have panel data with several different firms but data on the same firms for different periods of time. So each DMU is relatively more efficient than others but we cannot say anything in terms of absolute efficiency (several organisations studied were monopolies at the time of privatisation).

To do an analysis of type of peers chosen is quite difficult this time since the level of relative efficiency achieved is very high for several DMU.

No one of private DMUs, however, has a public DMU as peer. This is a quite common feature for all the firms studied in this work. There are about 16 DMUs on the frontier but just 8 of them are chosen as peers.

Table 6. British Aerospace: summary of peers

DMU (years)	Peers (weight)
8 (1985)	9(0.072) 7(0.376) 6(0.522) 10(0.030)
11 (1988)	10(0.012) 14(0.266)7(0.507) 16(0.216)
12 (1989)	20(0.001) 10(0.135) 13(0.850) 16(0.014)
15 (1992)	14(0.236) 10(0.218) 13(0.102) 16(0.445)

*Note: DMUs that are on the frontier have as a peer just themselves. In the table we did not report these DMUs.

Even if the most fashionable DMU here is number 10 (see Table 7), referred to 1987 and private ownership, with a turnover of 5052 m£ (constant price), the very low weight that it has in every peer set does not help us to conclude that it can be taken as an example for the others. Firm 16 is taken as an example 3 times but with higher weights. We could think that given different situation (market, demand etc.) the DMU were rearranging strategy of production. However, not surprisingly, DMU 16 represents the 44.5% of the "behaviour" of DMU 15. This gives a hint on the process of improvement done from one year to another.

Table 7. British Aerospace: summary of peer count

DMU	Peer count:	DMU	Peer count:
6	1	13	2
7	2	14	2
9	1	16	3
10	4	20	1

1.4.2.1 British Aerospace: some conclusions

To answer the question if privatisation enhanced efficiency in British Aerospace is not an easy task.. Since privatisation the company has been deeply unstable, unable to cope with its industrial scale and deep-seated financial weaknesses. The company has also suffered from disruptive changes in management. In 1988 and 1989 the efficiency index scores the lowest value of the whole series. Given the fact that this index has a quite homogenous trend, the fact that the value for 1988 is 91% is quite worrying and extremely significant. The reasons for this poor performance are connected with the Board troubles and with Rover acquisitions in 1988. In September 1989, even if the company's share price reached a high level the recession doomed the CEO strategy. Airlington Properties was purchased at the peak of the property boom and now the scope for developing surplus company property and selling it off for huge gains dissolved as the property market slumped. Furthermore, car sales were also considerably depressed. The value of the efficiency index for the year is relatively low.

The large losses of the early 1990s led to a major rationalisation of the company including the sale of Rover in 1994. Since 1992, the company has been trying to integrate parts of the business where gains can be made by putting together business units to achieve management and scale economies. But the value of the efficiency index for 1992 is only 93%, again, a relatively low value in a very homogenous series. However, the trend of the index estimated with the stochastic frontier analysis (see section 1.9.2) seems to better explain this situation.

1.4.3 Rolls Royce

For Rolls-Royce we have 20 observations from 1978 to 1997. Rolls-Royce was privatised in 1987. The variables considered are one output and two different inputs. All the values are expressed in constant (1990) price. The output here is The output here is turnover while the input considered are salaries and depreciation.

In the sector there has been growing competition for defence contract. In Table 8 there are the estimations for the efficiency index for Rolls Royce. The observations under public and private ownership are 10 each. The average of the index under public ownership is 95,37% while under private ownership it is equal to 93,6%. It seems that Rolls-Royce DMU were more effective under public ownership. We can point out that the period 1992-1995 has strongly affected the "poor" performance of private DMU.

Table 8. Rolls-Royce: efficiency summary

DMU (year)	crste	vrste	scale	DMU (year)	crste	vrste	scale
1 (1978)	0.847	1.000	0.847 irs	11 (1988)	0.882	0.900	0.980 irs
2 (1979)	0.800	1.000	0.800 irs	12 (1989)	1.000	1.000	1.000
3 (1980)	0.947	0.982	0.965 irs	13 (1990)	0.987	1.000	0.987 drs
4 (1981)	1.000	1.000	1.000	14 (1991)	1.000	1.000	1.000
5 (1982)	1.000	1.000	1.000	15 (1992)	0.897	0.897	0.999 drs
6 (1983)	0.784	0.928	0.844 irs	16 (1993)	0.901	0.902	0.999
7 (1984)	0.778	0.918	0.848 irs	17 (1994)	0.804	0.804	1.000
8 (1985)	0.822	0.900	0.913 irs	18 (1995)	0.893	0.894	1.000
9 (1986)	0.864	0.864	1.000	19 (1996)	0.999	1.000	0.999 drs
10 (1987)	0.949	0.949	1.000	20 (1997)	0.929	0.966	0.961 drs
				mean	0.904	0.945	0.957

Note: crste = technical efficiency from CRS DEA (model 1); vrste = technical efficiency from VRS DEA (model 2); scale = scale efficiency = crste/vrste; irs=production function showing increasing return to scale; drs=production function showing decreasing return to scale. Note also that all subsequent tables and comments for Rolls-Royce refer to VRS results.

We have to note from Table 8 that basically, for Rolls-Royce there have been two periods of unsuccessful management: the period from 1983 till 1987 and the period from 1992 till 1995. In the three years 1985, 1986 and 1987 the index of efficiency was relatively low compared with the other one achieved. The first period is the one before privatisation while the second one is a private ownership period. Something happened in these two periods. Before going deeper in this analysis it is worth considering the peer analysis. There are 10 DMUs on the frontier but only 6 of them are considered as peers. For Rolls-Royce there are some unique features of this analysis. In fact, here it is uncommon for public DMU to have DMUs as privately-owned peers. The opposite is true. In fact DMU5 is seen as a peer for several private DMU (15,16,18 and etc.). It is interesting to note that in this year there has been a sort of crisis (as the efficiency scores indicate) and that the peer that is considered as a reference point is a public one.

Table 9. Rolls-Royce: summary of peers

Firm	Peers (weight):	Firm	Peers (weight):
3 (1980)	4(0.823) 1(0.125) 2(0.052)	15 (1992)	19(0.729) 5(0.271)
6 (1983)	2(0.784) 5(0.042) 4(0.174)	16 (1993)	19(0.610) 5(0.390)
9 (1986)	5(0.995) 19(0.005)	17 (1994)	5(0.674) 19(0.326)
10 (1987)	12(0.228) 5(0.614) 4(0.158)	18 (1995)	19(0.582) 5(0.418)
11 (1988)	5(0.687) 4(0.210) 2(0.103)	20 (1997)	12(0.445) 19(0.540) 5(0.014)

Note: DMUs that are on the frontier have as a peer just themselves. In the table we did not report these DMUs.

From Table 10 we also have to realise that the most fashionable DMU is DMU5 and that only two privately owned DMU are seen as peers (DMU12 and DMU19).

Table 10. Rolls-Royce: peers count summary

DMU	Peer count:	DMU	Peer count:
1	1	5	9
2	3	12	2
4	4	19	6

1.4.3.1 Rolls Royce: some conclusions

For Rolls-Royce the analysis conducted, instead of using three inputs uses two inputs only. This is because the data obtained as other costs were not clear enough to be used in an understandable way. The use of just two inputs gives us a less clear result in term of scale. In fact, if we observe the data of the index obtained, we notice important difference between the results obtained using constant return to scale and the results obtained using variable return to scale. May be that Rolls-Royce experience sensible variable returns compared with the other institutions but, another possible explanation is technical and it is called in the literature “discrimination”. In fact, following Boussafiane et al 1997, we observe that the larger is the number of inputs and outputs, for a given number of DMU, the less discriminatory the model becomes. Usually, a satisfactory discrimination is obtained if the number of units present in the assessment set is three times the number of inputs times the number of outputs (see Boussafiane et al. 1997). Technically, for

Rolls-Royce we do not have discrimination but, again, given the relevant difference with the other organisation, we are more suspicious in commenting on the results. Observing the efficiency ratings pre- and post-privatisation, there is not a clear difference between the score obtained. The average, as we saw, is in favour of public ownership by 1.7%. The company seems to have come through the latest recession more strongly than that of the early 1980s. In fact, the low values obtained between 1992 till 1995 are the values that strongly affect the average. The surprising fact is that, if we compare these results with the one achieved in the previous indices analysis, the story is completely different. There we spoke of Rolls-Royce as a successful story of privatisation in terms of profitability, financial indicators and factor productivity. Here the analysis provides more contrasting results since the average DEA score under public ownership is 95.37 while the average DEA score under private ownership is 93.60.

1.4.4 British Telecom

For British Telecom we have 17 observations from 1982 to 1998. British Telecom was privatised in 1985. The variables considered are one output and three different inputs. All the values are expressed in constant (1990) price. The output here is The output here is turnover while the input considered are salaries, depreciation and other costs.. In the sector there has been during the years a strong growing competition and a stiff regulation by Oftel.

In Table 11 there are estimations the efficiency index for British Telecom. We have to realise that the period under public ownership considered are four while under private ownership are thirteen.

Table 11. British Telecom: efficiency summary

DMU (year)	crste	vrste	scale	DMU (year)	crste	vrste	scale
1 (1982)	1.000	1.000	1.000	10 (1991)	0.980	1.000	0.980 drs
2 (1983)	0.935	0.942	0.993 drs	11 (1992)	0.974	0.995	0.979 drs
3 (1984)	0.934	0.941	0.993 drs	12 (1993)	1.000	1.000	1.000
4 (1985)	1.000	1.000	1.000	13 (1994)	1.000	1.000	1.000
5 (1986)	0.998	1.000	0.998 drs	14 (1995)	0.988	0.989	0.999 drs
6 (1987)	0.981	0.992	0.989 drs	15 (1996)	0.999	1.000	0.999 irs
7 (1988)	0.956	0.974	0.981 drs	16 (1997)	1.000	1.000	1.000
8 (1989)	0.950	0.986	0.964 drs	17 (1998)	1.000	1.000	1.000
9 (1990)	0.974	1.000	0.974 drs	mean	0.981	0.989	0.991

Note: crste = technical efficiency from CRS DEA (model 1); vrste = technical efficiency from VRS DEA (model 2); scale = scale efficiency = crste/vrste; irs=production function showing increasing return to scale; drs=production function showing decreasing return to scale. Note also that all subsequent tables and comments for British Telecom refer to VRS results.

The average of the index under public ownership it is 97.1% while under private ownership it is 99.4 that shows how British Telecom "private" DMU are relatively more efficient than "public" DMU". As we saw in the firm's history, this is probably due to an increased competition in the sector after privatisation.

In Table 12 we can see that while private non-efficient DMUs have as peers just private DMUs, for the public DMUs it is not true. In fact DMU 5 enters twice as a peer for DMU2 and DMU 3. However we note that DMU5 is the first private DMU so it can be seen strongly correlated with the previous four. DMU 5 is the most fashionable DMU and this could be a signal of a good restructuring program under public ownership but again, several time the weight that DMU 5 has on the peer set is low.

In Table 13 there is the peer count of British Telecom. As we already noticed, DMU 5, the first private DMU is the most fashionable. Again, public DMUs see as a peer public and private DMUs while private DMUs see as a peer only private DMUs.

Table 12. British Telecom: peer summary

DMU (year)	Peers (weight)	DMU (year)	Peers (weight)
2 (1983)	4 (0.184) 1(0.352) 5 (0.464)	8 (1989)	9(0.864) 5(0.136)
3 (1984)	5(0.512) 1(0.168) 4(0.320)	11 (1992)	10(0.597) 12(0.403)
6 (1987)	17(0.031) 10(0.430) 16(0.057) 5(0.482)	14 (1995)	5(0.057) 13(0.320) 10(0.051) 16(0.573)
7 (1988)	5 (0.135) 10(0.780) 12(0.084)		

*Note: DMUs that are on the frontier have as a peer just themselves. In the table we did not report these DMUs.

Table 13. British Telecom: peer count summary

DMU	Peer count	DMU	Peers count
1	2	12	2
4	2	13	1
5	6	16	2
9	1	17	1
10	4		

There are 10 DMUs on the frontier and 9 of them are used as peers even if 3 of them just once. It seems that BT is quite able to change way of production when there is a change in circumstances.

1.4.4.1 British Telecom: some conclusions

British Telecom was separated from the Post Office in 1981 and became a free-standing corporation though still publicly-owned. The efficiency index for 1983 and 1984 indicates that there was not a situation of full efficiency. In fact the values of about 94% are a clear indicator that something could be done to improve the situation. Even the years between 1987 and 1990 do not show a maximum value for the index. However, the value of the index for these years is relatively high. The small lack in efficiency can signal a minor problem in the reorganisation of the company once it was facing stronger competition. From then on the score achieved is at the maximum or close to the maximum in 1992 and in 1995. Again, it is important to notice that, under public ownership British Telecom was basically a monopolist in the sector, after privatisation the sector has been opened to competition in many services for customer. The only "private" year in which we observe some input slacks is 1992 while during public ownership the situation about possible input slack is a bit more complex. In the previous analysis we concluded saying that privatisation was for sure a good way to increase competition in the sector and, probably, to increase welfare for the customers. Here we can say even that British Telecom, during its private years, was quite effective in facing greater competition.

1.4.5 British Steel

For British Steel we have 21 observations from 1978 to 1998. British Steel was privatised in 1988. The variables considered are one output and four different inputs. All the values are expressed in constant (1990) prices. The output here is turnover while the inputs considered are raw materials, staff costs, depreciation and other costs. In this sector during the year there has been strong international competition. In the European Union the steel quotas existed from 1980. During the years there has been a gradual removal. In Table 14 we can see the efficiency summary for British Steel.

Table 14. British Steel: efficiency summary

DMU (year)	crste	vrste	scale	DMU(year)	crste	vrste	scale
1 (1978)	0.976	1.000	0.976 drs	12 (1989)	0.979	0.984	0.994 drs
2 (1979)	1.000	1.000	1.000	13 (1990)	1.000	1.000	1.000
3 (1980)	0.990	1.000	0.990 drs	14 (1991)	0.922	0.937	0.983 irs
4 (1981)	0.931	0.936	0.994 irs	15 (1992)	0.881	0.953	0.925 irs
5 (1982)	0.933	0.936	0.997 irs	16 (1993)	0.891	1.000	0.891 irs
6 (1983)	0.947	0.949	0.997 irs	17 (1994)	0.956	1.000	0.956 irs
7 (1984)	1.000	1.000	1.000	18 (1995)	0.978	1.000	0.978 irs
8 (1985)	0.993	1.000	0.993 drs	19 (1996)	1.000	1.000	1.000
9 (1986)	1.000	1.000	1.000	20 (1997)	0.949	0.956	0.993 drs
10 (1987)	1.000	1.000	1.000	21 (1998)	0.928	0.951	0.977 drs
11 (1988)	1.000	1.000	1.000	Mean	0.964	0.981	0.983

Note: crste = technical efficiency from CRS DEA (model 1); vrste = technical efficiency from VRS DEA (model 2); scale = scale efficiency = crste/vrste; irs=production function showing increasing return to scale; drs=production function showing decreasing return to scale. Note also that all subsequent tables and comments for British Steel refer to VRS results.

Table 15. British Steel: summary of peers

DMU (year)	Peers (weight)	DMU (year)	Peers (weight)
4 (1981)	7(0.623) 2(0.058) 13(0.139) 9(0.180)	14 (1991)	13(0.717) 16(0.145) 17(0.001) 18(0.137)
5 (1982)	9(0.118) 2(0.189) 13(0.443) 7(0.251)	15 (1992)	13(0.284) 10(0.011) 16(0.705)
6 (1983)	7(0.709) 2(0.002) 13(0.063) 9(0.226)	20 (1997)	8(0.025) 19(0.956) 1(0.019)
12 (1989)	9(0.033) 13(0.68) 19(0.288)	21 (1998)	13(0.532) 19(0.468)

*Note: DMUs that are on the frontier have as a peer just themselves. In the table we did not report these DMUs.

Again we see that while the non-efficient DMUs under public ownership have as peers some private DMUs (especially 13, 7 and 9 are quite fashionable), the DMUs under private ownership that are not fully efficient have as peers only other private DMUs.

Table 16. British Steel: peer count summary

DMU	Peer count	DMU	Peer count
1	1	13	7
2	3	16	2
7	3	17	1
8	1	18	1
9	4	19	3
10	1		

Another relevant aspect to be noted here is that there are 13 DMUs on the frontier but just 11 are used as peers Furthermore we can see that some of them (DMU 1,8,10,17 and 18) are used just once and with a relatively very low weight.

1.4.5.1 British Steel: some conclusions

The previous analysis could help to understand if privatisation was for the Government an efficient tool to achieve some scheduled targets. As we said in the "step by step" conclusions highlighted at the end of each firm's study, in certain cases there has been an improvement in the performance of the firm, in other cases this improvement has not been so clear or relevant. The important point here is to understand if we can talk of a failure or of a success of privatisation. To give an answer to this question we have to keep in mind what were the objectives of privatisation. To improve efficiency has been seen as the only objective of privatisation. If this was the objective then we have to point out two things: not all the privatisations were successful in regard to this target and, more important, the same target could be probably obtained even under public ownership.

If we observe British Steel data, we realise that a serious improvement in performance was obtained prior to privatisation. Here the MacGregor group of managers was perfectly able to behave in a "private" way to achieve important improvements in performance and a restructuring of the firm. However, probably this was a single case. In all the other cases that I analysed, I was not able to recognise a "pattern" in the data that could suggest a possible "private behaviour" of a "public manager".

1.5 A summary and some general comments on results

Given the DEA results obtained, at this stage of the work is it possible to give more evidence on the fundamental question: has privatisation enhanced efficiency? Before giving some comments on the issue a note on the methodology is needed.

Table 17. Average Dea scores under public and private ownership

	Average DEA under public ownership	Average DEA under private ownership
British Gas	89.88	93.4
British Aerospace	100	98.7
Rolls-Royce	95.37	93.6
British Telecom	97.1	99.4
British Steel	98.4	97.8

The usual way in which DEA is used and is more effective is with panel data. In this study it was not possible to carry on a study with panel data basically for one reason: the firms considered are or were monopolist at the time of privatisation and several of them are still monopolist at least in the internal market. An international comparison could be useful but at the same time the different macroeconomic conditions between different states and the different costs of inputs all over the world will lead to further complications. This is the main reason why a DMU analysis is more effective even if in this case to talk of efficient firms is somewhat misleading. With this kind of analysis we can see if some DMUs are more efficient than others but we cannot say anything on the general efficiency of the firm. So we can see if privatisation has increased efficiency of DMUs but we cannot say anything on the efficiency of the firm overall. For this reason I conducted a further analysis on some financial and economics ratios at the end of each firm study. This kind of extra analysis is useful to understand which were the sectors where efficiency increased and if a small difference in the efficiency index is very significant or not.

The case of Rolls-Royce is probably the most significant. If we use only the average of the efficiency index of Table 17 under public or private ownership we could conclude that "public" Rolls-Royce was more efficient than "private" Rolls-Royce. The very small difference in the two values (95.3% against 93.7%) could require a further investigation. Again the fundamental difference in objectives under public and private ownership is crucial. Maximum profit sometimes is not the main target for public firm so, considering this issue, the firm can be efficient as well in pursuing the given objectives.

For other firms the case is much clearer. British Gas shows, after privatisation, a clear increase in performances in the DEA analysis and, British Telecom seems to be the most flexible firm in changing environments and another case of privatisation with a successful outcome. British Steel has a higher value of the efficiency index under public ownership but for this firm the MacGregor period under public ownership was a time when efficiency increased considerably. For British Aerospace probably the observations under public ownership are not enough to give a final judgement. Probably for British Aerospace the Rover acquisition was a bad management decision and, in terms of efficiency, this caused private ownership to be less effective than the public one.

The aim of the second part of this work is the estimation of a stochastic frontier. With this method, we will try to understand, for the same institutions, if elements connected to corporate governance could explain some efficiency scores that show a lack in efficiency that is not due to random factors.

1.6 Models for stochastic frontier approach

The parametric approach is naturally sub-divided into two main classes of approaches: deterministic and stochastic models. The main difference between these two broad categories is that deterministic models envelope all the observations, identifying the distance between the observed production and the maximum feasible production given the quantity of input used and identifying this distance as technical inefficiency. Stochastic parametric models instead permit one to distinguish between technical inefficiency and statistical noise. Given the nature of the paper the methodology that will be used for the parametric approach will be the stochastic model.

The stochastic frontier production function is a method of estimating efficiency for a group of firms over time proposed by Aigner, Lovel and Schmidt (1977) and Meeusen and van den Broeck (1977). In its original specification it involved a production function specified for cross-sectional data, which had an error term that is composed of two different components. The first of the two components is used to account for random effects (in a principal-agent framework these random effects can be related to the bad state of the world that the manager is facing when he is trying to maximise the principal objective-function), while the second effect is used to account for technical inefficiency (in this case it is a measure of manager inability to perform the assigned tasks in the best possible way).

So, we can express the model in the usual form $Y_i = \beta x_i + u_i$ and taking in to account the previous point we can split the error term in its two components V and U so that we have:

$$Y_i = \beta x_i + (V_i - U_i)$$

where i is the index that consider the number of firms, Y is the production (or the log of the production), x is a kx1 vector of the input quantities (or the log of the input quantities) and β is a vector of unknown parameters. As said, V are random variables that are assumed to be independent and identically distributed (i.i.d.). $N(0,\sigma_v^2)$ and are independent of the U that are non-negative random variables which are assumed to account for the technical (or managerial in this case) inefficiency in production and are assumed to be iid $N(0,\sigma_u^2)$. In the literature there are several variants of the previous model allowing for different distributions of the U and V term as for instance a half-normal distribution, a truncated distribution or two-parameters gamma distributions (see Kalirajan and Shand 1999) for a survey).

Probably the two most interesting variations of this kind of model are the one of Battese and

Coelli (1992) in which the inefficiency effects U are non-negative random variables, which are assumed to be i.i.d. as truncations at zero of the N(n,σ^2_u) distribution and n is a parameter to be estimated and the one proposed by Kumbhakar, Ghosh and McGukin (1991) who proposed that the inefficiency effects (U) are expressed as an explicit function of a vector of firm specific variables and a random error. Battese and Coelli (1995) adapted these two models in a way in which allocative efficiency is imposed, the first order profit maximising conditions removed and panel data is permitted and this is the most useful for our purpose. The model that I considered, following the example of Battese and Coelli (1995), has the following form:

$$Y_{it} = \beta x_{it} + (V_{it} - U_{it})$$

where Y, x and b are defined as before and V are random variables which are assumed to be iid N(0,σ^2) and independent of the U which are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the N($m,\sigma^2\upsilon$) distribution where $m_{it} = z_{it}d$ where z is a px1 vector of variables which may influence the efficiency of a firm and d is an 1xp vector of parameters to be estimated.

1.7 The method: a three step estimation

The procedure to estimate efficiency with a stochastic frontier approach is based on a three step procedure. This three steps process will proceed to estimate the maximum likelihood estimates of the parameters of a stochastic frontier production function. In details, the three steps are the following:

i. Estimates of the function are obtained with an Ordinary Least Squares. At this point, all the estimators (β) with the exception of the intercept (β_0) will be unbiased.

ii. A grid search on γ is conducted[2]. The values for the parameters β (except for β_0) are set to the OLS values. The parameters *d* are set to zero at this stage. The grid search across the parameter space of γ considers values for γ ranging from 0.1 to 0.9 in increments of size 0.1.

iii. The values selected in the grid search are used as a starting value in an iterative procedure[3] to obtain the final maximum likelihood estimates. The routine here starts with the grid search values and the program then updates the vector of parameter estimates by the Davidson-Fletcher-Powell method and it stops the search when the convergence criterion is satisfied. In this work the convergence criterion is satisfied if the proportional change in the likelihood function and each of the parameters is less than 0.00001.

1.8 The data used and the control variables

Before showing the results of estimations, it is important to specify some important features on the nature of data used. Here, as a result of the estimation we will finish with two set of estimators, βs and δs. The betas are the parameters of the inputs used for each firm plus an intercept term usually labelled $\beta0$. The set of inputs considered for each firm is exactly the same of the previous estimation. This mean that, for example, if for British Gas in the DEA analysis the four inputs were prime materials, salaries, depreciation and other costs, for the stochastic frontier estimation $\beta(1)$ is referred to prime materials, $\beta(2)$ to salaries, $\beta(3)$ to depreciation and $\beta(4)$ for other costs. As said, $\beta(0)$ is an intercept term. The set of delta estimators is referred to the vector of variables used to "explain" some of the inefficiency of the *i* firm. For each firm we estimate three deltas (plus an intercept term). The three variables used to control *Ui* are an index accounting for the "quality" of the Board (delta1), a dummy considering if the position of Chairman and CEO are held by the same person (delta2) and a time trend (delta3) accounting for technological progress.

1.8.1 Some details on delta 1

The index accounting for the quality of the Board it is a variable between 0 and 1. It is formed by the aggregation of three factors that I have considered as influencing the "quality" of Board. Each of the factors has the same weight in the index. The first factor is the percentage of non-executive in the Board. Basically all the codes of corporate governance around the world regard the role played by non-executive Director as vital for a good effectiveness of corporate governance. In the Combined Code of CG in Great Britain we

[2] It can be useful at this stage to define gamma following the approach of Battese and Corra 1977. $\sigma^2 = \sigma^2_V + \sigma^2_U$ so we can define $\gamma = \frac{\sigma^2_U}{\sigma^2_V + \sigma^2_U}$ or $\frac{\sigma^2_U}{\sigma^2}$

[3] This procedure uses the Davidson-Fletcher-Powel Quasi-Newton method: see Coelli and Perelman (1996).

can read "The Board should include a balance of executive and non-executive Directors (including independent non-executives) such that no individual or small group of individuals can dominate the Board's decision taking" (Combined Code of CG 2000 pg.3) and again "The Board should include non-executive Directors of sufficient calibre and number for their views to carry significant weight in the Board's decisions. Non-executive Directors should comprise not less than one third of the Board. The majority of non-executive Directors should be independent of management and free from any business or other relationship which could materially interfere with the exercise of their independent judgement. Non-executive Directors considered by the Board to be independent in this sense should be identified in the annual report" (Combined Code of CG 2000 p.6). So, to include in the index of goodness a proxy representing the role (at least in numbers) played by non-executives is important.

The second factor considered is the number of "young" Directors present on the Board. The age to discriminate "young" Directors from old Directors is 65 years.

The third and last factor is about "non-busy" Directors present on the Board. If a Director serves at the same time in more than three Boards it is considered "busy" and this affects negatively his potential performance on the Boards:

$$\text{Index} = \frac{\alpha\%\text{non} - \text{exec} + \varepsilon\%\text{young} + \rho\%\text{nonbusy}}{3}$$

$$\alpha = 1 \;;\; \varepsilon = 1 \;\; \rho = 1$$

where the weights alpha, epsilon and rho are kept equal to 1. Since in the codes of corporate governance the role of non-executive is regarded as very important another possible combination of weight could be the following one:

$$\text{Index} = \alpha\%\text{non} - \text{exec} + \varepsilon\%\text{young} + \rho\%\text{nonbusy}$$

$$\alpha > \varepsilon \geq \rho$$

$$\alpha + \varepsilon + \rho = 1$$

I have done some estimation with the index calculated as a weighted average of the three factors but the results were not different from the other. So, to keep the things clear, the index used was with the weights set equal to 1.

1.8.2 Some details on delta 2

Delta2 is a dummy considering if the position of Chairman and CEO are held by the same person. In the Combined Code of CG we read "There are two key tasks at the top of every public company - the running of the Board and the executive responsibility for the running of the company's business. There should be a clear division of responsibilities at the head of the company which will ensure a balance of power and authority, such that no one individual has unfettered powers of decision.

A decision to combine the posts of chairman and chief executive officer in one person should be publicly justified. Whether the posts are held by different people or by the same person, there should be a strong and independent non-executive element on the Board, with a recognised senior member other than the chairman to whom concerns can be conveyed. The chairman, chief executive and senior independent Director should be identified in the annual report." (Combined Code of CG 2000 pg. 5). Delta 2 is used to control if efficiency is influenced by this separation of roles or if this separation is required only to provide a safer environment for the shareholders.

1.9 Empirical results

In Table 18 there is a legend to make clear the meaning of each of the estimated parameters. The betas usually are connected with the production inputs, the deltas are connected with the control variables accounting for the explanation of inefficiency. In Table 19 there is the expected sign of the parameters used.

Table 18. Meaning of the parameters

Parameter	Variable connected	Parameter	Variable connected
beta 0	Intercept term	Delta 1	Index accounting for the "quality" of the Board
beta 1	Prime Materials	Delta 2	A dummy considering if the position of Chairman and CEO are held by the same person
beta 2	Salaries	Delta 3	Time trend accounting for technological progress
beta 3	Depreciation		
beta 4	Other Costs		

Table 19. Expected signs of the parameters

Parameter	Expected sign	Parameter	Expected sign
beta 1	+ The factor contributes in a positive way to production	delta 1	if the index of goodness of Board increases, inefficiency has to reduce
beta 2	+ The factor contributes in a positive way to production	delta 2	+ if the Chairman and the CEO are the same person this is seen as a source of inefficiency by basically all the corporate governance rules so a value of 1 in this dummy will increase the level of inefficiency
beta 3	+ The factor contributes in a positive way to production	delta 3	- if the technological progress increases then inefficiency can decrease
beta 4	The factor contributes in a positive way to production		

1.9.1 British Gas

Table 20 estimates the parameters for British Gas. All the parameters have the expected sign except for beta 4 (Other costs) and they are all significant for the Betas while they are significant only for Delta 1 on the set of control variables. So, in the case of British Gas the quality of the Board composition matters as an issue to reduce inefficiency while it seems that the fact that the same person holds the position of Chairman and CEO is irrelevant. Also the time trend is not significant.

Table 20. British Gas: final maximum likelihood estimation

	Coefficient	Standard-error	t-values
Beta 0	1.272	0.590	2.153
Beta 1	0.318	0.148	2.138
Beta 2	0.369	0.107	3.454
Beta 3	0.330	0.129	2.552
Beta 4	-0.430	0.207	-2.072
Delta 1	-0.996	0.314	-3.166
Delta 2	0.136	0.155	0.877
Delta 3	-0.035	0.042	-0.845
Sigma ^{2}	0.050	0.024	2.105
Gamma	0.182	0.721	0.252

The log likelihood function has a value of 0.34566301E+02 for a number of 20 iterations. The LR test of the one-sided error has a value of 0.61231691E+01 with 5 restrictions [note that this statistic has a mixed chi-square distribution]. As we said, the “index of quality” of the Board is important. In fact, if we have an increase in this index, this will reduce inefficiency by a similar amount (the value of the parameter is –0.99). Adding non-executive Directors, adding “young” Directors and finally adding “non busy” Directors is a way to reduce inefficiency. The fact of keeping separate the position of Chairman and Chief Executive seems not to have any effect on efficiency. The value of the t-test is not significant. Probably this “separation” of role aims at increasing something different from efficiency and more directly connected with shareholders protection. Also the fact that the time trend is not significant is another signal that efficiency is something “structural” and not merely dependent on the “constant” evolution of technology.

Given the previous estimation, the efficiency index deriving from a stochastic frontier estimation for British Gas is the following (see Table 21):

Table 21. British Gas: technical efficiency estimates

DMU (year)	Efficiency estimations	DMU (year)	Efficiency estimations
1 (1976)	0.991	13 (1988)	0.999
2 (1977)	0.971	14 (1989)	0.999
3 (1978)	0.981	15 (1990)	0.997
4 (1979)	0.922	16 (1991)	0.996
5 (1980)	0.916	17 (1992)	0.976
6 (1981)	0.915	18 (1993)	0.993
7 (1982)	0.887	19 (1994)	0.928
8 (1983)	0.942	20 (1995)	0.921
9 (1984)	0.990	21 (1996)	0.936
10 (1985)	0.990	22 (1997)	0.993
11 (1986)	0.997	Average	0.965
12 (1987)	0.997		

From the results obtained it is possible to note that British Gas had two periods of crisis: the first one between 1979 and 1983 and another one from 1994 till 1997.

The explanation of this crisis is the same that we analysed in section 1.4.1. We can here summarise that two acts of intervention caused serious suffering in the gas industry, the fine tuning of the 1980s and the “take or pay” contract of the mid-1990s.

The average value of the index under public ownership is of 0.949 while under private ownership it is 0.975. Even for this index it seems that for British Gas privatisation led to an increase in efficiency.

For comments on the comparison of the two methods see Section 1.10.

1.9.2 British Aerospace

In Table 22 there is the estimation of the parameters for British Aerospace. All the Betas have the expected sign except for beta 2 (Salaries). In the set of control variables none are significant. Delta1 could be considered significant at 11%. If we are happy with this level of significance, we notice that again, the quality of Board matters to reduce inefficiency. Adding a no-executive Director or a non busy Director helps to reduce inefficiency. So we find a direct connection between level of efficiency and corporate governance. Again, the level of significance is not “as good as usual (11%)” but it is quite good if we compare it with the one obtained in other studies that use the stochastic frontier method (see for instance Coelli 1995).

Table 22. British Aerospace: final maximum likelihood estimates

	Coefficient	Standard-error	t-ratio
Beta 0	1.943	0.862	2.252
Beta 1	0.332	0.164	2.027
Beta 2	-0.323	0.168	-1.919
Beta 3	0.367	0.112	3.251
Beta 4	0.347	0.094	3.674
Delta 1	-0.364	0.193	-1.887
Delta 2	0.210	0.384	0.548
Delta 3	0.063	0.188	0.336
$Sigma^2$	0.094	0.040	2.333
Gamma	0.999	0.180	5.525

The log likelihood function has a value of 0.28659034E+02. The LR test of the one-sided error has a value of 0.73562862E+01 with 5 restrictions for a number of 10 iterations. Given the previous estimation, the efficiency index deriving from a stochastic frontier estimation for British Aerospace is in Table 23.

Here we can see that the period between 1992 and 1996 was a difficult one in terms of efficiency. The relatively large inefficiency of the early 1990s led to a major rationalisation of the company including plant closure, and the sale of the Rover car that has been previously identified as one of the major problem for British Aerospace management. Since 1992, the company has been trying to integrate parts of the business where gains can be made by putting together business units to achieve management and scale economies.

It has to be noted that the “best” year for efficiency for BAe were those following the privatisation (1982 to 1987). This is probably due to a good programme of privatisation and to an efficient management during the early stage of BAe as a private company. The Rover acquisition is seen instead as a major mistake and with the stochastic frontier method this is much more evident than with the DEA method. For further details on comparing the two methods see 1.10.

Table 23. British Aerospace: technical efficiency estimates

DMU	Efficiency estimations	DMU	Efficiency estimations
1 (1980)	0.864	11 (1990)	0.993
2 (1981)	0.888	12 (1991)	0.945
3 (1982)	0.957	13 (1992)	0.847
4 (1983)	0.986	14 (1993)	0.870
5 (1984)	0.978	15 (1994)	0.907
6 (1985)	0.975	16 (1995)	0.875
7 (1986)	0.993	17 (1996)	0.948
8 (1987)	0.942	18 (1997)	0.958
9 (1988)	0.822	average	0.927
10 (1989)	0.935		

The low value in the index for 1988 is an interesting signal. In 1988 and 1989 there were some troubles on the Board of British Aerospace. The reasons for these troubles were two: the first one was connected to some fights between the top managers of British Aerospace to get the chairmanship. The second and much more significant one is that after this diversification and as a consequence of this program, British Aerospace acquired Rover cars in 1988 from the government, on what were highly favourable terms (the government paid to British Aerospace about £500 millions to take Rover off its hands); even Arlington Properties was another acquisition done with the logic of diversification. As we saw in the other three analyses, this diversification was not effective at all and the stochastic frontier efficiency score put this in evidence very well. The average of the index under public ownership it is 87.6% while under private ownership it is 87.88 that shows that efficiency in British Aerospace, after privatisation, is substantially unchanged.

1.9.3 Rolls-Royce

As we can see in Table 24 all the betas and deltas, excluding the two intercepts, have the expected sign and they are all significant. We have to note that for Rolls-Royce there were data on just two inputs so I restricted the number of delta to two as well. However we have to point out that for Rolls-Royce it was very rare to have the Chairman and CEO position held by the same manager.

Table 24. Rolls-Royce: final maximum likelihood estimates

	Coefficient	Standard-error	t-ratio
Beta 0	0.669	0.577	1.158
Beta 1	0.390	0.184	2.119
Beta 2	1.001	0.334	2.991
Delta 1	-0.878	0.292	-3.003
Delta 3	-0.356	0.172	-2.060
Sigma ^{2}	0.824	0.337	2.441
Gamma	0.999	0.022	44.157

The log likelihood function has a value of 0.17402710E+02. The LR test of the one-sided error has a value of 0.73562862E+01 with 2 restrictions for a number of 10 iterations. Delta 1 is significant so, again, the quality of Board matters to decrease inefficiency in a firm. Adding a non-executive Director helps to protect shareholders and, at the same time, reduces inefficiency of the DMU. The same happens if we increase the number of non-busy Directors and the number of "young" Directors. Delta 2 does not appear in this estimation since only one DMU concentrated the role of Chairman and CEO in the same person. The time trend is also not significant.

Table 25. Rolls-Royce: technical efficiency estimates

DMU (year)	Efficiency estimations	DMU (year)	Efficiency estimations
1 (1978)	0.769	11 (1988)	0.787
2 (1979)	0.737	12 (1989)	0.914
3 (1980)	0.767	13 (1990)	0.989
4 (1981)	0.758	14 (1991)	0.961
5 (1982)	0.729	15 (1992)	0.985
6 (1983)	0.776	16 (1993)	0.970
7 (1984)	0.797	17 (1994)	0.968
8 (1985)	0.813	18 (1995)	0.972
9 (1986)	0.844	19 (1996)	0.978
10 (1987)	0.804	20 (1997)	0.971

From Table 25 we see that from 1978 till 1987, the year of privatisation, the stochastic frontier analysis results for efficiency score are much lower than the ones from 1987 till 1997. This is very interesting because while when we used the DEA the difference between the two periods was not so clear and we needed to carry on another analysis of other ratios and indexes to say that Rolls-Royce was a successful story of privatisation. If we observe the results obtained with the stochastic frontier method we can arrive at this conclusion without any doubt at all. This result is basically the same obtained with the indices analysis and with the total factor productivity growth analysis. In fact, the average of the index under public ownership it is 77.90% while under private ownership it is 94.90 that shows how Rolls-Royce "private" DMU are more efficient than "public" DMU". If we observe only the average scores obtained we note that privatisation was a successful story of improving performances. But since the difference with the DEA estimation is relevant this lead us to make some comparison of the results obtained with the two different techniques (see Section 1.10).

1.9.4 British Telecom

In Table 26 there is the estimation of the parameters for British Telecom. All the parameters have the expected sign except for Delta 2 (Chairman/CEO). All the Betas are significant. In the set of control variables the only one that is not significant is Delta3 while the others are significant. Delta2 has not the expected sign. So, in the case of British Telecom the quality of the Board composition is significant, increasing the quality of the Board reduces inefficiency. Furthermore, it matters as an issue to reduce inefficiency the fact that the same person holds the position of Chairman and CEO. The time trend is not significant and again this prove the fact that efficiency depends on structural variables more than on a linear increase of technical progress.

Table 26. British Telecom: final maximum likelihood estimates

	Coefficient	Standard-error	t-ratio
Beta 0	0.895	0.359	2.488
Beta 1	0.255	0.082	3.088
Beta 2	0.235	0.123	1.911
Beta 3	0.279	0.127	2.196
Delta 0	0.527	0.483	1.090
Delta 1	-0.688	0.273	-2.512
Delta 2	-0.256	0.064	-3.965
Delta 3	-0.160	0.074	-2.158
Sigma ^{2}	0.043	0.020	2.076
Gamma	0.978	0.115	8.494

The log likelihood function has a value of 0.52478070E+02. The LR test of the one-sided error has a value of 0.22514289E+02 with 5 restrictions for a number of 10 iterations. Given the previous estimation, the efficiency index deriving from a stochastic frontier estimation for British Telecom is in Table 27.

Table 27. British Telecom: technical efficiency estimates

DMU (year)	Efficiency estimations	DMU (year)	Efficiency estimations
1 (1982)	0.919	10 (1991)	0.997
2 (1983)	0.883	11 (1992)	0.985
3 (1984)	0.918	12 (1993)	0.992
4 (1985)	0.981	13 (1994)	0.997
5 (1986)	0.991	14 (1995)	0.992
6 (1987)	0.985	15 (1996)	0.997
7 (1988)	0.972	16 (1997)	0.998
8 (1989)	0.972	17 (1998)	0.995
9 (1990)	0.995	Average	0.975

1982, 1983 and 1984 were years in which efficiency was relatively low while after this period, if we exclude a very small drop in 1988 and 1989, the efficiency score was relatively high and close to one. The results obtained are in line with the one obtained with DEA. The programme of restructuring of BT started to give effect after 1985. In 1985 the new legislation enabled British Telecom to become more responsive to competition in UK and to expand its operations globally. Commercial freedom granted to British Telecom allowed it to enter into new joint ventures and, if it so decided, to engage in the manufacture of its own apparatus. As we can see from the index, after 1985 the values are close to the maximum. In 1987, 1988 and 1989 the efficiency indicator is under the maximum value. The average of the index under public ownership it is 90.66% while under private ownership it is 98.92 that shows how British Telecom "private" DMU are relatively more efficient than "public" DMU". When we did the profitability analysis we noted that there was not a clear increase in profit. Now we can state that competition here is requiring new measures to be efficient, as the market need.

1.9.5 British Steel

There is the estimation of the parameters for British Steel in table 28. The parameters have the expected sign except for beta 2 (Salaries) but this parameters is not significant. All the other Betas are significant except for the intercept. In the set of control variables the only one that is significant is Delta2 while the others are not significant even if they have the expected sign. So, in the case of British Steel the quality of the Board composition it is not significant while it matters as an issue to reduce inefficiency the fact that the same person holds the position of Chairman and CEO. In fact, British Steel is one exception on this issue since is the only firm in the considered sample that actually is keeping these two positions in the same person. Also the time trend is not significant.

Table 28. British Steel: final maximum likelihood estimates

	Coefficient	Standard-error	t-value
Beta 0	0.280	0.667	0.419
Beta 1	0.800	0.117	6.800
Beta 2	-0.113	0.103	-1.093
Beta 3	0.382	0.182	2.092
Beta 4	0.399	0.199	2.002
Delta 1	-0.195	0.515	-0.378
Delta 2	0.148	0.063	2.339
Delta 3	-0.033	0.042	-0.782
Sigma ^{2}	0.019	0.008	2.385
Gamma	0.002	0.013	0.218

The log likelihood function has a value of 0.38505953E+02. The LR test of the one-sided error has a value of 0.15933080E+01 with 5 restrictions for a number of 20 iterations. Given the previous estimation, the efficiency index deriving from a stochastic frontier estimation for British Steel is in Table 29.

From the data it is possible to see that the more interesting period for British Steel to be examined is the one from 1979 till 1984. Here the efficiency of the firm was relatively low but with the MacGregor period of chairmanship the situation changed and after MacGregor's cure British Steel corporation had a long period of very high efficiency. It is clear that the average of the index under public ownership was lower than the one under private ownership. But the big shake-out on British Steel has been the MacGregor period. Here the foundation of the new efficient course was built. We refer to MacGregor's time as "the private behaviour of a public manager".

Table 29. British Steel: technical efficiency estimates

DMU (year)	Efficiency Estimation	DMU (year)	Efficiency Estimation
1 (1978)	0.987	12 (1989)	0.994
2 (1979)	0.984	13 (1990)	0.998
3 (1980)	0.960	14 (1991)	0.998
4 (1981)	0.962	15 (1992)	0.997
5 (1982)	0.959	16 (1993)	0.986
6 (1983)	0.971	17 (1994)	0.996
7 (1984)	0.992	18 (1995)	0.993
8 (1985)	0.998	19 (1996)	0.998
9 (1986)	0.975	20 (1997)	0.998
10 (1987)	0.998	21 (1998)	0.997
11 (1988)	0.998	Average	0.987

It is worth exploring the possible meaning and interpretation of the non-significance of the parameter connected to the quality of the Board. In a Board in which often the Chairman is also the CEO the different mixing between executive and non-executive Directors is irrelevant. Every code about corporate governance suggests that the two positions have to be kept separated. If this is not the case the Board will be strongly influenced from a person that has to be controlled from the Board. This is probably the reason why the quality of Board composition does not really matter in the case of BSC. However, every time that there is this situation in the Board, following the Corporate Governance code, the Board has to specify the reason of this in the Annual Report: and British Steel Corporation has done it every time. The average of the index under public ownership it is 98.03% while under private ownership it is 99.55 that shows how British Steel "private" DMU performed just a little better than "public" DMU". So, the signal that we receive form British Steel privatisation is not a clear increase in performance. This is due to the big shake-out operated by MacGregor management in the years before privatisation. So, the lesson form this analysis can be that is not fundamental to privatise to increase efficiency if we implement an effective programme of restructuring as MacGregor did with British Steel.

1.10 Comparing the two methods: similarities and differences

At this point, it is necessary to compare the results obtained with the two methods. In
The Dea method (see Table 30) shows us that the privatisation was more effective in increasing efficiency in British Gas and British Telecom and the situation of British Steel was substantially unchanged. The SF method signals a clear increase in efficiency in British Gas and British Telecom, a small increase in British Steel and, differently from the DEA, a clear increase in Rolls-Royce.

Table 30. Average scores of DEA and SF under public and private ownership

	Average Dea under public ownership	Average Dea under private ownership	Average SF under public ownership	Average SF under public ownership
British Gas	89.88	93.4	94.9	97.5
British Aerospace	100	98.7	87.6	87.88
Rolls-Royce	95.37	93.6	77.90	94.90
British Telecom	97.1	99.4	90.66	98.92
British Steel	98.4	97.8	98.03	99.55

Giving a more detailed look at the data we observe that, for British Gas (see Table 31), the trend of the two indices is quite similar but the magnitude of the values is different. In fact, for the years 1976, 1977, 1978 the DEA gives a maximum value while the Stochastic Frontier (SF) gives a slightly decreasing trend even for high scores. In1979 the DEA index drops quite consistently and maintains this decreasing trend till 1982, starting to raise in 1983 and going back to high value in 1984 to 1991. The trend of the SF index is similar but the variations are smoother. In fact, in the SF index the period between 1979 and 1982 included, is a period of "crisis" as already indicated from DEA estimation. The differences in the results are on the level of variation of efficiency. In fact, we observe small differences between the considered DMUs in the SF results while the DEA scores suggests that the efficiency in 1979 was 88% while in 1982 was 70%. Something similar happened in the period between 1991 and 1996 where again the trend is similar with the exception of 1993 but again SF gives us much smoother results. The two indices indicate a clear improvement in performances before privatisation and at the same times they show that the contract for the supply of gas signed in 1993 was not a good management decision in terms of efficiency.

Table 31. Comparing the two methods

	British Gas		British Aerospace		Rolls-Royce		British Telecom		British Steel	
DMU	DEA	SF	DEA	SF	DEA	SF	DEA	SF	DEA	SF
1976	1.000	0.9896	------	------	------	------	------	------	------	------
1977	1.000	0.9695	------	------	------	------	------	------	------	------
1978	1.000	0.9788	1.000	------	1.000	0.7697	------	------	1.000	0.9895
1979	0.889	0.8998	1.000	------	1.000	0.7371	------	------	1.000	0.9877
1980	0.841	0.8931	1.000	0.8525	0.982	0.7677	------	------	1.000	0.9626
1981	0.771	0.8928	1.000	0.8886	1.000	0.7581	------	------	0.936	0.9642
1982	0.701	0.8853	1.000	0.9874	1.000	0.7291	1.000	0.9197	0.936	0.9615
1983	0.728	0.9651	1.000	0.9964	0.928	0.7768	0.942	0.8835	0.949	0.9739
1984	0.957	0.9882	1.000	0.9786	0.918	0.7979	0.941	0.9183	1.000	0.9978
1985	1.000	0.9879	0.983	0.9753	0.900	0.8136	1.000	0.9818	1.000	0.1000
1986	1.000	0.9951	1.000	0.9934	0.864	0.8443	1.000	0.9910	1.000	0.9771
1987	0.943	0.9950	1.000	0.9626	0.949	0.8040	0.992	0.9857	1.000	0.1000
1988	0.965	0.9970	0.910	0.8021	0.900	0.7878	0.974	0.9726	1.000	0.1000
1980	1.000	0.9970	0.978	0.9378	1.000	0.9141	0.986	0.9727	0.984	0.1000
1990	1.000	0.9950	1.000	0.9933	1.000	0.9892	1.000	0.9953	1.000	0.1000
1991	1.000	0.9946	1.000	0.9659	1.000	0.9611	1.000	0.9975	0.937	0.1000
1992	0.953	0.9743	0.940	0.8476	0.897	0.9857	0.995	0.9858	0.953	0.1000
1993	0.857	0.9907	1.000	0.8706	0.902	0.9706	1.000	0.9928	1.000	0.9888
1994	0.789	0.9265	1.000	0.9070	0.804	0.9683	1.000	0.9979	1.000	0.9981
1995	0.782	0.9192	1.000	0.8754	0.894	0.9722	0.989	0.9923	1.000	0.1000
1996	0.985	0.9345	1.000	0.9489	1.000	0.9784	1.000	0.9972	1.000	0.1000
1997	1.000	0.9916	1.000	0.9586	0.966	0.9715	1.000	0.9983	0.956	0.1000
1998	------	------	------	------	------	------	1.000	0.9959	0.951	0.9999

For British Aerospace the situation is reversed. The DEA index has a much smoother trend while the SF index has a great variability. Something interesting to note here is the period between 1993 and 1997. In fact, while the DEA index has a maximum value for each of the considered DMUs, the SF index shows an improving situation but at a level of efficiency that is between 87% and 95%. If we give a look at BAe's history (see D'orio 2003) it seems that the SF analysis is able to better understand and explain the facts. The large losses of the early 1990s led to a major rationalisation of the company including plant closure, redundancies and the sale of the Rover car division to the German Company BMW in 1994. In fact, the SF index shows a value of 84% in 1990, a value of 87% in 1993 and an increasing trend from 1994 (sale of Rover) to 1997.

For British Telecom the two indices give basically the same results with the exception in magnitude for the years 1983 and 1984. Again there is evidence that the efficiency improves consistently before privatisation. So, the process of rationalisation that usually happens before privatisation seems to be very effective.

British Steel has two major features: the private period shows the same results with the exception of 1991 and 1992 when the DEA index drops to 93% and 95% and the other feature is that during the public ownership period while the DEA shows again a drop in 1981, 1982 and 1983, the SF has again a smoother trend. At the same time, for the years between 1978 and 1981, while the DEA index shows a maximum value, the SF does not. Given the story of MacGregor appointments as Chairman (see 1.4.5 for details) it seems again that the SF method is able to describe more precisely what happens.

Finally, for Rolls-Royce the results of the two estimations are quite different. In this case the SF index seems to indicate a relatively good situation between 1992 till 1997 while the DEA shows some relatively inefficient DMUs in 1992, 1994, 1995. We have to note that the DEA index jumps to 100% in 1996 and this seems a bit to excessive if we consider that it was at a value of 89% in 1995. Again SF is smoother but for Rolls-Royce several trends are different. Even from 1978 till 1983 there are some big differences so Rolls-Royce requires further analysis.

1.11 Conclusions

This paper shows a parametric and a non-parametric estimation of efficiency index for some privatised firms in United Kingdom. There are some main points to highlight as conclusions. First, the two methods give us some clear indications on the fact that for every institution considered there is a relevant increase in performance just before privatisation. The process of rationalisation that precedes privatisation it is usually quite effective. This gives us a very important suggestion: a private behaviour of a public management is effective if there is a shift on the objectives that the manager has to pursue. British Steel is a very good example of this kind of behaviour and from the two methods used it is possible to note that for all the studied firms (or DMUs) the period before privatisation has been a period in which efficiency increased. The DEA estimation gave us some useful suggestions on which DMUs are seen as peers from inefficient DMUs. The interesting point to note is that while inefficient public DMUs had as a peer efficient private DMUs, the opposite occurred in rare cases.

This could be seen as a more "private" behaviour (that basically means to have the maximisation of profit or shareholders revenue as objective) required for inefficient public DMUs while usually the inefficient private DMUs were looking to efficient private DMUs, to increase efficiency they do not regard as useful a "public" behaviour from the management but they think that more "private" measures are required. The SF technique helps us to point out that quality of Board matters to reduce inefficiency. For all the firm studied the sign of Delta 1 was negative as expected even if in one case the t-ratio was not significant. In general, to increase the quality of Board in the way suggested by the codes of corporate governance[4] matters to increase efficiency.

As final point of this conclusions we need to point out that the parametric and non-parametric methods give extremely similar results. This is a good proof that the results obtained are quite robust.

However, the SF method gives much smoother results than the DEA and at the same time it seems to better describe some major events that occurred during the firm's life. So, it seems that the parametric method explains more on the level of efficiency achieved while the non-parametric gives more interesting suggestion about the lack in some inputs and some direction on the role of peer DMU. A possible future next step of this kind of research could be to carry out a similar analysis on a panel data of firms in the same industry. This could help to solve some of the problems connected with the nature of data and with the relative DMUs efficiency scores. However, the very detailed nature of data (basically on Board composition) needed makes this task quite difficult; but it is a challenge for future work.

[4] Increase the number of non-executives, keep the Chairman position to a different manager than the CEO, avoid that Directors have several appointments in different firms and so on.

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