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Strategic Responses to Companies' Own Past Performance: Why do some Firms Fare Better Than Others?

Geraint Johnes and Jill Johnes

The Department of Economics
Lancaster University Management School
Lancaster LA1 4YX
UK

STRATEGIC RESPONSES TO COMPANIES' OWN PAST PERFORMANCE: WHY DO SOME FIRMS FARE BETTER THAN OTHERS?

Geraint Johnes
Jill Johnes

Lancaster University Management School
Lancaster LA1 4YX
United Kingdom

T: +44 1524 594215
F: +44 1524 594244

G.Johnes@lancaster.ac.uk
J.Johnes@lancaster.ac.uk

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ABSTRACT

Recent work on business strategy considers the evaluation of company performance using frontier methods (Devinney *et al.*, forthcoming). The present paper builds on that work to examine the extent to which company performance in one period impacts on business practices and hence performance in subsequent periods. We investigate this using a panel of annual data on some 4280 firms over the period 1983-2003, drawn from the Osiris data set of Bureau van Dijk. A data envelopment analysis is conducted to evaluate the efficiency of firms in converting inputs – in the form of shareholders' funds, liabilities and costs - into sales. The efficiency scores are then modelled in a random parameter framework where one of the determinants of current period efficiency is the firm's own lagged efficiency. In a parsimonious model, we find that the extent to which lagged efficiency affects current efficiency varies considerably from firm to firm. Some firms maintain a relatively constant level of efficiency period after period, while the efficiency of other firms is much more variable over time. Companies with extreme values of the random parameter (either low or high) are less likely than others to have high efficiency scores. These results are used to inform a number of qualitiative case studies of companies. Our evidence suggests that firms for which the random parameter is high tend to be long established enterprises operating in narrowly and clearly defined markets, and enjoying sustained periods of market stability; firms for which the random parameter is low tend to have had a turbulent recent past involving either rapid growth (including merger activity) or decline. Meanwhile efficiency is determined in part by the industry and country with which a firm is associated, and also by the opportunities to exploit scale economies.

Keywords: frontier methods, business strategy
JEL Classification: C14, L10, M21

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NON-TECHNICAL ABSTRACT

Using international data drawn from a sample of over 4000 firms over the period 1983-2003, we examine the extent to which company performance in one period impacts on business practices and hence performance in subsequent periods. We evaluate performance using a measure of how efficiently firms convert inputs into outputs. We find that the performance of some firms is consistent over time, while other firms enjoy alternating periods of relatively good and relatively poor performance. A number of case studies suggests that firms with stable levels of performance tend to be long established enterprises operating in narrowly and clearly defined markets, and enjoying sustained periods of market stability. Firms whose performance is more volatile, meanwhile, tend to have had a turbulent recent past involving either rapid growth (including merger activity) or decline. Meanwhile efficiency is determined in part by the industry and country with which a firm is associated, and also by the opportunities to take advantage of economies of scale.

Introduction

A substantial literature has focused on the determinants of various definitions of company performance. Within this literature, debates have surrounded the relative importance of industry and firm-specific effects – and within the latter much emphasis has been given to the role played by business strategy. As Yip *et al*. (forthcoming) observe, it is rare for companies to achieve *sustained* high levels of performance over long periods of time; they argue that there are characteristics of these firms that ensure that their strategies develop in the interests of long term performance without the need for these strategies to be redefined in response to periodic crises. In this paper we develop a means whereby long term high performance can be identified, and we examine in some detail a number of companies that exhibit (and some that do not exhibit) such performance.

The data that we employ are drawn from Bureau van Dijk's OSIRIS data set. This provides comprehensive data on listed companies around the world. The data series covers a couple of decades, though of course some firms are 'born' and some 'die' within that period so the data have the character of an unbalanced panel. The data are more comprehensive for firms in the industrial production sector than in other sectors (such as services), and so we focus on the former industries in the analysis that follows. In order to ensure that country fixed effects are robustly estimated, we focus on the larger, developed economies. Earlier studies that draw upon data from OSIRIS include Yip *et al*. (forthcoming) and Devinney *et al*. (forthcoming).

The prevailing orthodoxy on company performance is based upon the structure-conduct-performance (S-C-P) model which has its roots in the work of Bain (1956). This view holds that industry structure affects the conduct/strategy of firms, and hence is the prime determinant of company performance. Disentangling company effects from industry effects is therefore hazardous, because the former are conditioned by the latter.

We know, however, that different firms in the same industry enjoy different levels of performance. This may be due to heterogeneity that is introduced either by product differentiation or variations in the methods and competence of managers. This has led many researchers to drill down into the different strategies employed by different firms as a further source of variation in performance. Hence, for example, Porter (1980) has emphasised the role of strategy as a determinant of performance.

More recently, Hawawini *et al*. (2003) have provided evidence to suggest that industry effects dominate – although their results have been challenged by McNamara *et al*. (2005). Meanwhile Spanos *et al*. (2004) find that, while industry effects are important, firm effects are more so. In particular they establish that hybrid strategies (where firms develop their strategy on the basis of a mixture of cost, marketing and technology considerations) are more successful than pure strategies (where only one of these dimensions is the subject of strategic deliberation) or no strategy. Likewise McGahan and Porter (2002) find that both industry and firm-specific effects are important determinants of profitability.

Nonetheless there does appear to be a long-term pattern of firm performance corresponding to what Tushman and Romanelli (1994) refer to as a pattern of punctuated equilibrium or what Johnson (1988) refers to as strategic drift. The argument goes that successful firms develop capabilities on which are the bases of their success because of the extent to which they provide differential advantage over competition (Barney, 1991). However, over time, there is a tendency for these capabilities to become embedded to the point that they are taken for granted and manifest themselves as core rigidities (Leonard-Barton,1992). Despite environmental change, firm strategies may therefore continue to develop incrementally around such capabilities resulting in "strategic drift". Such drift is exacerbated by the likelihood that managers will resist fundamental changes to strategy since they are likely to be wedded to successful strategies of the past and since performance effects as a result of drift may be lagged. The consequences of such drift are eventual crisis as a downturn in performance becomes evident and undeniable, at which stage there may be wholesale changes of personnel and very likely calls for major changes in strategy.

The overall picture, then, emerges as periods of success, followed by periods of drift and eventual crisis. Indeed Miller (1990) has shown that this tendency, which he terms the Icarus paradox, has been evident in the histories of many once highly successful firms.

Given such a pattern, there would appear to be four trajectories of strategy/ performance likely to be found. The first would be periods of success, followed by periods of downturn, followed by major strategic change and, perhaps, further success. The second would be periods of success, followed by downturn, followed by demise or acquisition. The third would be the avoidance of strategic drift; therefore sustained periods of relative success. The fourth, would be the avoidance of strategic drift but, nonetheless, major strategic changes (ie without the trigger of significant financial downturn). In their study of the long-term performance of 215 UK firms between 1983-2003 Yip et al (forthcoming) identified only 28 firms that could be categorized as following the third trajectory and just 6 that had followed the fourth. The first two trajectories were most common.

In the next section, we describe the methodology used in this paper. This is followed in turn by sections that concern the data set, the analytical results, and a selection of case studies. The paper ends with a conclusion.

Methodology

Our approach involves two stages. The **first stage** is simply to evaluate the efficiency of firms. This is done using the method of data envelopment analysis (DEA). DEA is a technique, based on linear programming, which has come to be used extensively in the analysis of efficiency evaluation of complex, multi-input and multi-output, organisations. Based on the early work of Farrell (1957), it was introduced into the literature by Charnes *et al*. (1978).

This earlierst variant of DEA is, after its authors, often referred to as the CCR model. It is a constant returns to scale model in which n decision-making units produce s distinct output types using m distinct inputs. The quantities of outputs and inputs which the kth decision-making unit produces and consumes respectively are denoted by Y^{rk}, r = 1, ... , s, and X^{ik}, i = 1, ... , m. The kth decision making unit then chooses its vector of input weights, v^{ik}, i = 1, ... , m, and output weights, u^{rk}, r = 1, ... , s, with the aim of maximising its weighted sum of outputs subject to the constraints that:

(a) the chosen weights are such that, when applied to the output and input vectors of *any* decision-making unit, the ratio of weighted output to weighted input should not exceed unity
(b) the weighted sum of inputs should equal unity
(c) the weight attached to each output should be non-negative, and
(d) the weight attached to each input should be non-negative.

This is a fairly simple linear programming problem. The complete specification of a DEA involves the simultaneous solution of n such programmes - one for each decision-making unit.

More formally, for each k,

$$\max h^k = \mu \Sigma u^{rk} Y^{rk}$$

subject to

$$\mu \Sigma u^{rk} Y^{rj} - \mu \Sigma v^{ik} X^{ij} \leq 0 ; j = 1, \dots , n$$

$$\mu \Sigma v^{ik} X^{ik} = 1$$

$$u^{rk} \geq 0 ; r = 1, \dots , s$$

$$v^{ik} \geq 0 ; i = 1, \dots , m$$

The optimal value of h^k is the efficiency score of the kth decision-making unit, indicating that this unit produces as much output as possible given its vector of inputs; this is therefore sometimes referred to as an output-oriented model. It must lie between zero and one; if $h^k = 1$, then k is technically efficient and lies on the efficiency frontier.

Variants on this DEA formulation have been developed. In particular, Banker *et al*. (1984) has proposed a modification to the above model which accommodates variable returns to scale; again, after the authors, this is often referred to in the literature as the BCC model. The BCC model allows separate calculation of measures of each decision-making unit's efficiency relative to: (i) its virtual peers on the efficiency frontier at the same scale level; and (ii) its virtual peers on the efficiency frontier regardless of scale. In the work reported below, we use the CCR specification since this provides us with a single measure of efficiency.

DEA is quite straightforward to conduct where the size of the sample is small, and several software packages exist that can aid in this task. In the present context, however, we have several tens of thousands of observations, and the evaluation of DEA efficiencies proved to be beyond any of the standard software packages. We therefore wrote a fortran program, CIDEA, which is capable of handling a problem of this size.[1]

The **second stage** of our analysis involves the construction of a model that can explain the variation of DEA efficiencies. We do this by way of a random parameter Tobit model. The Tobit approach is used in preference to an ordinary least squares estimator in recognition of the fact that DEA efficiencies are constrained to lie within the unit interval (Tobin, 1958). The random parameter approach is used for two reasons. First, it allows us to accommodate unobserved heterogeneity across firms. This is the conventional motivation for the choice of a random effects specification of a panel data model, where the constant term is allowed to vary. The second reason is motivated by our desire to investigate whether each individual firm responds differently to its own past performance. Our hypothesis is that some firms

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[1] CIDEA is freely available at http://www.lancs.ac.uk/people/ecagj/cidea.html.

respond to crisis by developing new strategies, so that their current performance is negatively related to past performance, while others do not need a crisis to prompt renewed strategies, and thus achieve consistent strong performance. We model this by including lagged efficiency as an explanatory variable in the model of efficiency, and allowing the parameter on the lagged efficiency term to be (rather than constant across all firms) distributed across firms following a normal distribution. Hence while some firms might be expected to choose strategies that lead to sustained high (or low) performance so that their parameter on lagged efficiency approaches unity, others might develop strategies that bring about strong performance only as a result of weak performance in earlier periods; the latter would have a negative parameter on lagged efficiency. The random parameter Tobit can readily be modelled using the Limdep software.

Data

Our data are drawn from the OSIRIS dataset produced by Bureau van Dijk. This provides detailed financial and other data on companies based in various countries over a period of more than 20 years. Since some companies are founded and some fail within any time span, the data necessarily present themselves as an unbalanced panel – we therefore have observations for all years for some companies, while data are missing in some years for others. It would of course be possible to produce a balanced panel either by confining our interest to those firms for which we have data over the whole period, or by shortening the period of interest and examining only firms for which data are complete over this shorter period. Either of these options would involve throwing away information, and so we prefer to work with the unbalanced panel. This presents no particular statistical difficulties.

The data available cover the period 1983 through 2003; since a major focus of our analysis is on the impact of lagged variables on current variables, our statistical analysis runs from 1984 through 2003. We select firms from a group of 12 developed countries for which data are available on an annual basis. The OSIRIS data provide information about, *inter alia*, total current liabilities, shareholders' funds, and cost of goods sold for all firms in the the production industries. While OSIRIS also provides some data about firms in other sectors, the set of variables available in these sectors is much more limited. We therefore confine our analysis to manufacturing. Since a major focus of our study is on the change in performance from one year to the next, we consider only firms for which we have data for a minimum of two consecutive years.

We therefore investigate a total of some 4280 companies over a period of 21 years. The unbalanced panel has a total of 41523 data points; excluding cases where there is only one year of data for a firm and excluding also the initial year (in order to use lags in the statistical model) leaves a sample size of 36856.

Descriptive statistics are reported in Table 1. Values are measured in thousands of constant US dollars. For each variable, the high value of the standard deviation in relation to the mean indicates the high degree of skewness in the data (given that the variables are all constrained to be non-negative), with a large number of small firms and a small number of very large firms.

The marked difference in the scale of operations across firms has implications for the form that our analysis can take. Owing to issues concerning machine precision, the variables used in the DEA need to be scaled in some way. A common way of dealing with this issue is to use standardised variables (that is, the variables are demeaned and compressed so that each has unit variance). In the present case, with a small number of very large firms, this method does not fix the problem. We therefore use an alternative method of scaling – we divide all variables by sales for each unit of observation. Consequently, the model used to evaluate the efficiencies is, in effect, a 'benefit of the doubt' model of the type discussed by Cherchye *et al*. (2007, p.121).

Analysis

We therefore proceed by using a vector of ones as the output variable, and three input variables – the ratios of liabilities, funds and costs respectively to sales. The distribution of efficiencies obtained by the DEA is reported in the histogram in Figure 1. This reveals a bunching of efficiencies around 0.2, with significant numbers of observations showing efficiency scores up to 0.5, but with very few above this. Indeed, of the 41523 observations, only 19 have an efficiency score of unity and only 237 have scores above 0.5. The results obtained from a parsimonious specification of a random parameter Tobit equation explaining variation in efficiency across data points are reported in Table 2. In this specification, the explanatory variables are a random effect and lagged dependent variable (which appears with a random parameter). It is readily observed that the standard deviation of the random parameter on lagged efficiency is significant, confirming our hypothesis that different firms respond differently to their own outturn efficiency. We plot a histogram of the random parameter in Figure 2. There are no firms for which the parameter is negative, and this suggests that businesses do not characteristically wait for a crisis before effecting a strategy aimed at good performance. The vast majority of coefficients lie between 0.6 and 0.7, but the range is from 0.405 to 0.930. Hence while, for some firms (those with a parameter close to unity), there is a great deal of persistence in performance from one year to the next, in the case of other firms performance is very much more stochastic.

The relationship between the DEA efficiencies (plotted for all years – up to 20 observations per firm) and the random parameter on the lagged efficiency term is investigated in the scatter diagram that appears in Figure 3. It is readily observed that the firms with the highest efficiencies tend to have non-extreme values of the random parameter. Firms with unusually low or high values of the random parameter are more likely to be less efficient – either they have no consistent strategy or are wedded to a suboptimal strategy.[2]

It is appealing to think of Figure 3 as being divided into four quadrants. In the northeast quadrant, we observe high efficiency firms that have a high measure of autocorrelation in their efficiency measures. These are perennially successful firms that do not need to change strategy in order to maintain their success. In the southwest quadrant, firms have low efficiency scores and a low value of the random parameter indicates that their scores in one period are not highly correlated with those in the next. Such firms, faced by their low efficiency, may be seeking to change their strategy as a means of securing improved future performance. In the southeast quadrant we observe perennially inefficient firms that are,

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[2] Some measure of caution is needed in interpreting this result, however. As noted above, the number of observations for which the efficiency score exceeds 0.5 is small, so estimates of the range of the random parameter obtained from a sample of observations of high efficiency are downwardly biased, explaining the compressed distribution of the random parameter at the top of the scatter diagram.

presumably, not effecting strategic changes in order to improve performance. Finally, in the northwest quadrant, we observe successful firms which, with a low value of the random parameter, are not maintaining that success from one period to the next.

In Table 3 we report the results obtained when we populate the model with further explanatory variables. We include dummy variables for industry at 3-digit level of the North American Industry Classification System (NAICS), country, and year. Some interesting results emerge. First, there are significant differences in efficiency across industries. The highest efficiencies are in NAICS 311, 312, 315, 316 and 337: food; beverage and tobacco products; apparel; leather and allied products; and furniture and related products. The coefficients on several industries are negative, notably in extraction and construction industries, and also in heavy manufacturing industries.

There are also some highly significant country effects. The largest positive (and highly significant) coefficient is for Germany, where efficiency is typically some 3 percentage points higher than in the omitted country (USA), other things being equal. The countries in which firms are typically least efficient, other things being equal, are Greece, Italy, Portugal and Canada. The negative and highly significant coefficient on Japan is striking; it should be borne in mind that our data cover the period both before and after the East Asian crisis.
Efficiency also varies somewhat from year to year, though it is difficult to detect any systematic trend. Indeed the highest efficiency is observed in 1984 (the omitted year) and there is little variation across other years in the sample.

Despite including the richer set of explanatory variables, the standard deviation of the random parameter attached to the lagged dependent variable remains highly significant; indeed the mean and standard deviation of this coefficient are remarkably similar to those obtained in the more parsimonious model.

Case studies

In this section, we examine in a little more detail the characteristics of companies that have unusually high or unusually low estimated values for the random parameter on lagged efficiency in the equation reported in Table 2. These are companies which, respectively, sustain a given level of performance (as measured by efficiency score) over time or those for which performance typically varies from period to period. The former might be regarded as firms that manage to maintain success without the need for periodic strategic change.

Three firms have exceptionally high values for the estimated random parameter (0.85 or above). These are:

- **Radeberger Gruppe AG**
  A large German brewing company with a history stretching back to the 19th century.

- **Nissin Electric Co Ltd**
  A Japanese manufacturer incorporated in 1917, Nissin produces electrical equipment used primarily in the electrical distribution industry, including items used in substations, computerised control equipment and the like. This involves manufacture of high-tech products.

- **Advantage Energy Income Fund**
  Created in 2001 (that is, during the observation window covered by this study) following the restructuring of an oil and gas company. The fund exists to hold (indirectly, through a subsidiary) assets in the form of oil and gas properties, and to distribute the ensuing cash flows. The limited number of years for which we have data for this firm render its inclusion in the category somewhat idiosyncratic. In 2009 the company changed its name to Advantage Oil and Gas Ltd.

The following firms all have estimated values of the random parameter of 0.45 or less:

- **Airflow Streamlines**
  A UK company which manufactured cabs and bodies for prototype and subsequently produced motor vehicles. It went into liquidation in 2002 after making substantial losses in that and the previous year. Its sales had fallen substantially since peaking in the mid-1990s, but costs had not been controlled and employment was still at close to mid-1990s levels.

- **Ventana Medical Systems Inc**
  Provides medical equipment, specifically to automate staining of slides used in laboratory work in the fields of pathology and drug discovery. The firm was set up in 1993 (so within the period covered by this study). Its customers include hospitals, biotechnology companies, medical research laboratories, and government laboratories; the portfolio of customers is broad, ensuring that the company is not vulnerable to any sharp decreases in demand from any one source. The company has grown steadily since inception, in terms of total assets and employment. It has a number of competitors, and profits are modest.

- **Quanex Corp**
  Produces steel and aluminium products, also some carbon and wood products, for the vehicle manufacturing and construction industries. The company was set up in 1927. At the very end of our period of analysis (late 2003) it engaged in some substantial merger and acquisition activity.

It is readily observed that firms with high values of the random parameter appear to be long established firms operating in well defined markets and enjoying considerable stability. Firms with low values of the random parameter appear to be either in a period of growth (following recent inception or broadening of activity perhaps through merger and acquisition activity) or decline.

A further group of companies is also of interest – those with moderate values of the random parameter and high values for efficiency. There are 19 firms with an efficiency score of 1, and these are concentrated heavily in the utilities (electricity, gas, water – NAICS 2211-3), and the manufacture of communications equipment, audio and video equipment, electronic components, and navigational, measuring, medical and control instruments (NAICS 3342-5). Many of these firms are located in Canada.[3] There are thus some strong industry and country

[3] This is an interesting finding in light of the negative coefficient on Canada in Table 3. The concentration of utilities companies (where firms tend to be efficient) appears to offset the tendency for Canadian firms to be relatively less efficient *ceteris paribus*.

fixed effects. However, three firms have an efficiency score of 1 and are not in the above industries. These are:

- **Brau und Brunnen AG**
  A major brewer and soft drinks manufacturer in Germany which originated in 1972 with the merger of the Dortmund HE Union brewery and Schultheiss AG, Berlin. The company achieves major economies of scale. The company's fortunes have, however, declined since the mid-1990s, and by 2003 total assets and employment were (at around $500m and 3000 respectively) about half of their peak values. This is reflected in the efficiency scores attached to the company – while in 2001 it achieved a score of 1, by 2003 this had declined to 0.49. The company was taken over by Radeberger in 2004.

- **Daimler-Chrysler AG**
  The German motor vehicle manufacturer produces a number of well known brands including Mercedes-Benz and Dodge. It produces in numerous locations worldwide, with an emphasis on strong brands and leadership in technology. Its assets amount to hundreds of billions of dollars and it employs almost 400000 workers. The two brands making up the company name parted company in 2007.

- **RPC Inc**
  RPC provides equipment and services to companies involved in oil and gas exploration and extraction. The company was created in 1984, and operates primarily in the United States. With its main facility located in Texas, the company has a well established source of demand for its products and services. Its total assets amount to almost a quarter of a billion dollars. The company operates in a capital intensive sector, and employment is correspondingly low, at around 1500.

Viewed alongside the companies in utilities and high-tech equipment that enjoy high efficiency scores, it appears that scale economies arising from high levels of investment in both capital and expertise, the corresponding concentration of industry, and the role of brand all likely play a part in explaining the efficiency of these firms.

Conclusion

Our analysis confirms findings elsewhere in the literature that sustaining good performance in the long term is a challenge for the typical firm, and that hence few firms achieve it. Long established firms operating in well defined markets with a narrow portfolio of products are more likely than others to benefit from persistence in performance. High efficiency is also characteristic of firms operating in industries where scale economies are prevalent and which are therefore highly concentrated. To the extent that these determinants of performance are defined by the characteristics of the industry, these results lend support to the S-C-P view. The importance of company longevity and the adherence to a strategy that emphasises maintenance of a well defined portfolio of activities qualify this view, however, and suggest that there is indeed some role to be played by firm-specific effects that are determined by strategy.

There is much scope for further research in this area. The results that emerge from our examination of case studies are suggestive, but it would be desirable to turn to a statistical analysis as a means of drawing upon the experience of all firms in order to explain the relationship between instantaneous efficiency scores and the persistence of performance. We recognise that a limitation of DEA is the sensitivity of results to the presence of outliers, and this is a further issue that we would like to investigate in future work. Finally, we would like to refine the set of controls used in the Tobit model, to include *inter alia* interactions between country dummies and the lagged efficiency score; this would allow us to investigate the impact on our results of different countries having firms the distribution of whose performance is more or less skewed.

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Figure 1

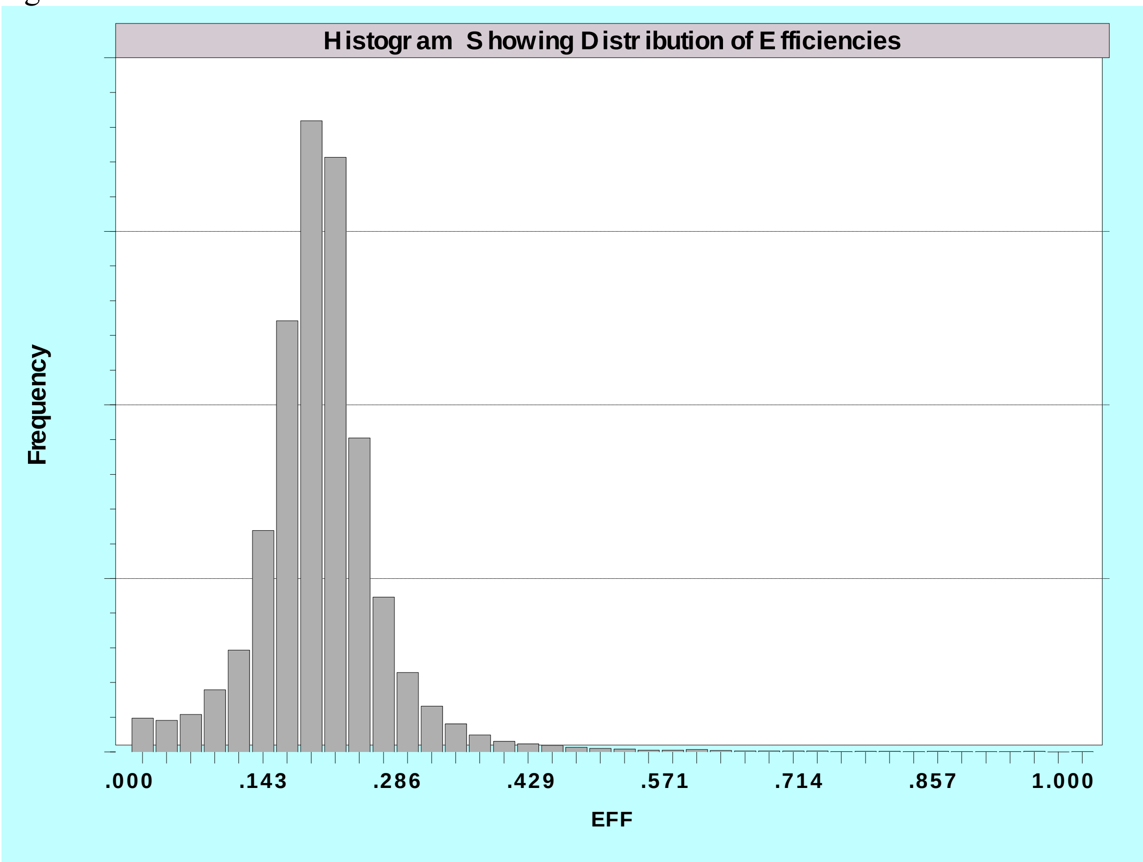

Figure 2

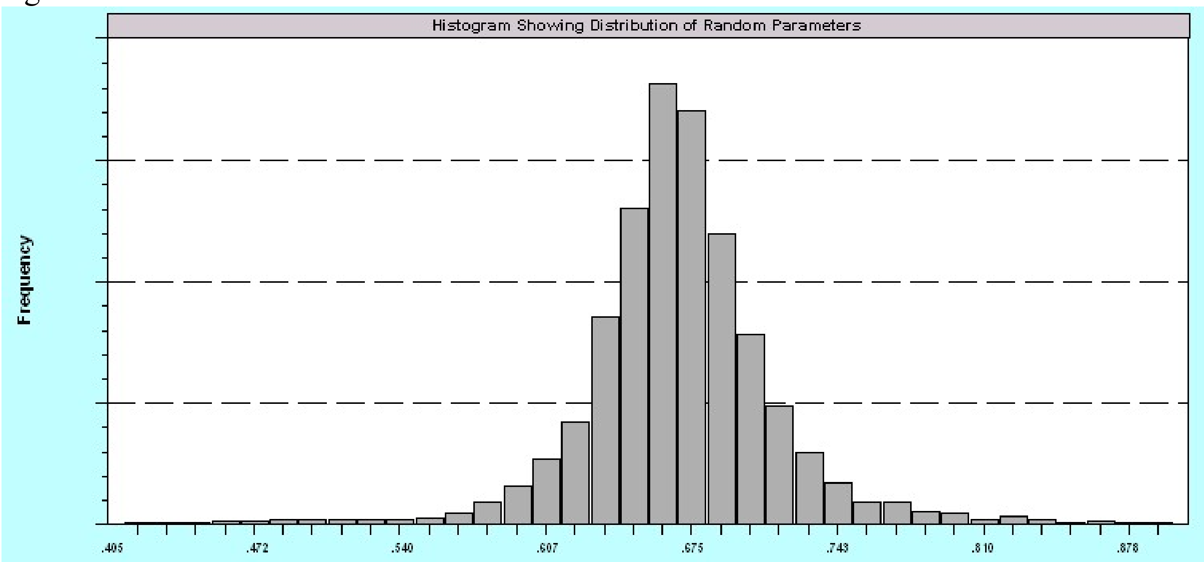

Figure 3

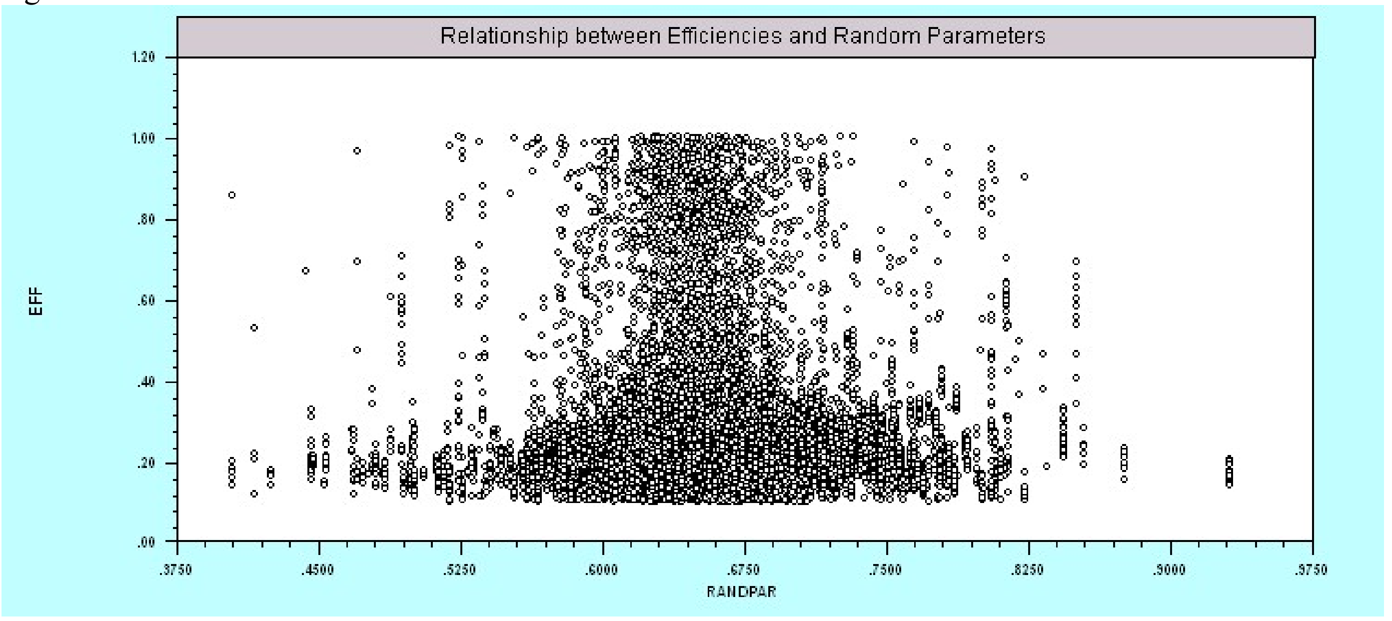

Table 1 Descriptive statistics

Variable	Mean	Standard deviation
Liabilities	367.60	2936.08
Funds	133.50	704.97
Costs	138.16	737.99
Sales	496.98	3776.36

Table 2 Results of a parsimonious random parameter Tobit model

variable	coefficient
Means for random parameters	
constant	0.0645
	(0.0003)
lagged efficiency score	0.6549
	(0.0012)
Scale parameters for distributions of random parameters	
constant	0.0092
	(0.0002)
lagged efficiency score	0.0753
	(0.0004)
Variance parameter	
standard deviation	0.0364
	(0.0000)
log likelihood	70696.14

Note: standard errors in parentheses.

Table 3 Results of a richer random parameter Tobit model

variable	coefficient
non-random parameters	
NAICS211	-0.070 (0.0011)
NAICS212	-0.0196 (0.0011)
NAICS213	-0.0111 (0.0013)
NAICS221	0.0036 (0.0010)
NAICS236	-0.0102 (0.0017)
NAICS237	-0.0061 (0.0013)
NAICS238	-0.0040 (0.0020)
NAICS311	0.0049 (0.0011)
NAICS312	0.0067 (0.0013)
NAICS313	-0.0089 (0.0018)
NAICS314	-0.0016 (0.0032)
NAICS315	0.0045 (0.0017)
NAICS316	0.0063 (0.0024)
NAICS321	-0.0117 (0.0033)
NAICS322	-0.0054 (0.0021)
NAICS323	-0.0023 (0.0031)
NAICS324	-0.0047 (0.0022)
NAICS325	-0.0047 (0.0010)
NAICS326	-0.0027 (0.0019)
NAICS327	-0.0062 (0.0019)
NAICS331	-0.0070 (0.0015)
NAICS332	-0.0038 (0.0012)
NAICS333	-0.0059 (0.0010)

NAICS334	-0.0046
	(0.0008)
NAICS335	-0.0050
	(0.0012)
NAICS336	-0.0039
	(0.0011)
NAICS337	0.0058
	(0.0019)
UK	-0.0001
	(0.0006)
Germany	0.0276
	(0.0009)
France	0.0045
	(0.0009)
Portugal	-0.0099
	(0.0035)
Spain	-0.0048
	(0.0019)
Japan	-0.0064
	(0.0007)
Netherlands	0.0186
	(0.0011)
Italy	-0.0131
	(0.0019)
Greece	-0.0145
	(0.0031)
Australia	0.0060
	(0.0011)
Canada	-0.0071
	(0.0008)
1985	-0.0053
	(0.0018)
1986	-0.0056
	(0.0021)
1987	-0.0048
	(0.0020)
1988	-0.0004
	(0.0023)
1989	-0.0045
	(0.0022)
1990	-0.0042
	(0.0022)
1991	-0.0064
	(0.0021)
1992	-0.0025
	(0.0019)
1993	-0.0046
	(0.0020)
1994	-0.0025
	(0.0018)

1995	-0.0043
	(0.0019)
1996	-0.0067
	(0.0018)
1997	-0.0057
	(0.0018)
1998	-0.0063
	(0.0018)
1999	-0.0074
	(0.0017)
2000	-0.0062
	(0.0018)
2001	-0.0090
	(0.0018)
2002	-0.0082
	(0.0017)
2003	-0.0034
	(0.0017)
Means for random parameters	
constant	0.0785
	(0.0018)
lagged efficiency score	0.6317
	(0.0013)
Scale parameters for distributions of random parameters	
constant	0.0076
	(0.0002)
lagged efficiency score	0.0690
	(0.0005)
Variance parameter	
standard deviation	0.0362
	(0.0000)
log likelihood	71111.01

Note: the excluded industry is NAICS339; the excluded country is the USA; the excluded year is 1984. Standard errors in parentheses.

NAICS codes are as follows:

211 Oil and gas extraction
212 Mining
213 Support activities for mining
221 Utilities
236 Construction of buildings
237 Heavy and civil engineering construction
238 Specialty trade contractors
311 Food manufacturing

312 Beverage and tobacco product manufacturing
313 Textile mills
314 Textile product mills
315 Apparel manufacturing
316 Leather and allied product manufacturing
321 Wood product manufacturing
322 Paper manufacturing
323 Printing and related support activities
324 Petroleum and coal products manufacturing
325 Chemical manufacturing
326 Plastics and rubber products manufacturing
327 Nonmetallic mineral product manufacturing
331 Primary metal manufacturing
332 Fabricated metal product manufacturing
333 Machinery manufacturing
334 Computer and electronic product manufacturing
335 Electrical equipment, appliance and component manufacturing
336 Transportation equipment manufacturing
337 Furniture and related product manufacturing
339 Miscellaneous manufacturing