Efficiency in the Treatment of Hip Fractures

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Abstract: This study addresses the issue of efficiency in the treatment and rehabilitation of hip fracture patients in Sweden. The treatment and rehabilitation of hip fracture patients is defined in terms of a *hip fracture treatment process* where resources in orthopaedics and after care are used for “producing“ operated patients with a given survival and residence the year after fracture. Each hip fracture treatment process is evaluated in terms of technical and allocative efficiency, using data envelopment analysis (DEA) which is a non-parametric linear programming technique. This method enables identification of inefficient processes and measurement of potential cost savings. It is shown that the annual potential cost savings for the Stockholm area amount to about 40 Million SEK assuming overall efficiency which represents about 11 percent of the total costs related to the hip fracture treatment process.

Keywords: Data Envelopment Analysis; Efficiency; Hip fractures; Potential cost savings.

JEL classification: D61; I10; I12.

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1. Introduction

Hip fractures are associated with the most severe morbidity and mortality of all osteoporotic or age-related fractures (Cummings 1993). The mortality rate within one year of hip fracture is about 20 percent in many countries. In for example England and Wales hip fracture patients utilise about 20 percent of all beds in orthopaedic departments (Barrett-Connor 1995, Lindsay, 1995). In Sweden hip fracture patients occupy about 25 percent of all orthopaedic beds, and this is by far the largest diagnosed group (Borgquist 1991). In 1990 the number of hip fractures in Sweden amounted to about 17,000.

In Sweden, many health care providers are involved in the treatment and rehabilitation of a hip fracture patient. After the initial orthopaedic stay the hip fracture patient is discharged to different types of after care such as geriatrics, nursing homes, homes for the elderly or group residence. Municipal home help and primary health care may also be utilised during the year following a hip fracture. In the city of Stockholm, the resource consumption in orthopaedic departments, geriatrics and nursing homes account for 70 percent of the total costs within one year after a fracture (Zethraeus *et al*. 1997). In treating elderly hip fracture patients, a primary goal for the orthopaedic department is to facilitate an early return to pre-fracture residence (Svensson *et al*. 1996, Zuckerman 1993). Thus for patients admitted from independent residence, a successful hip fracture treatment may be characterised in terms of an early return to independent residence after the fracture.

The treatment and rehabilitation of a hip fracture patient can be viewed in terms of a "*hip fracture treatment process*" which uses resources from the health care providers involved in the treatment and rehabilitation of a hip fracture in order to "produce" output in terms of a number of operated patients. The output may have differences in quality such as survival and return to independent residence after hip fracture. The fact that several health care entities provide the treatment and rehabilitation of hip fracture patients may imply inefficiencies in the hip fracture treatment process due to suboptimisations. In the Stockholm county council (SCC) there have been discussions about the possibility of letting only one health care provider be responsible for the entire treatment process. This means that, for example, the orthopaedic department would be reimbursed for the entire treatment and rehabilitation after the fracture. The risk of suboptimisation might then decrease.

The purpose of the paper is to compare all ten hip fracture treatment processes in the area administered by the SCC in the year of 1990, in terms of technical and allocative efficiency, and to estimate the potential cost savings if all the processes were overall efficient. In the model the hip fracture treatment process, or *unit*, uses resources in orthopaedics and after care in geriatrics and nursing homes to "produce" a number of operated patients with a given survival and residence category, one year after a hip fracture. Each unit is evaluated in terms of technical and allocative efficiency, using a non-parametric linear programming (LP) technique known as data envelopment analysis (DEA). The DEA method enables us to identify inefficient treatment processes and to measure potential cost savings assuming overall efficiency. This is accomplished even for small samples without imposing any functional form.

The paper is organised into six sections. In Section 2 the hip fracture treatment process is presented, and this is followed by Section 3 where the efficiency models are described. Section 4 describes the data while Section 5 presents the results. Section 6 discusses and concludes the paper.

2. A model for the hip fracture treatment process

First it is assumed that the hip fracture treatment process uses resources in orthopaedics and after care, in geriatrics and nursing homes, to “produce“ a number of operated patients with a given survival and residence from one year after a hip fracture. Each treatment process is defined according to the hospital, or equivalently the orthopaedic department, where the patient is admitted, i.e. they uniquely identify the hip fracture treatment processes. Secondly, it is assumed that the stay in the orthopaedics department and the after care determine quality one year after fracture, in terms of survival and return to independent residence. A total of ten units are defined and evaluated in terms of technical and allocative efficiency. The ten units correspond to the 10 orthopaedic departments (hospitals) which provided care for hip fracture patients in the SCC in the year 1990. Thus, all hospitals in the SCC are included in the study. To model the hip fracture treatment processes a two- input, one output and two-quality attribute-production model is used. *Figure 1* presents the production model.

FIGURE 1 IN HERE

The input variables are defined as:

x_1=*Number of days in orthopaedics within one year after a hip fracture*

x_2=*Number of days in after care within one year after a hip fracture*

It is assumed that days in orthopaedics and after care consume the same amount of resources irrespective of the producing unit, i.e. one day in orthopaedics at hospital 1 consumes the same amount of resources in terms of, for example, physician and nursing hours, capital etc. as one day in hospital ten. It is also assumed that one day in geriatrics consumes the same amount of resources as one day in a nursing home. This assumption is made because days in geriatrics can not be separated from days in nursing homes due to the prevailing institutional conditions in Sweden in the year of 1990, i.e., the county councils administered nursing homes and geriatrics. The output variable and the quality attribute variables are defined as:

y_1 = *Number of operated patients*

q_1 = *Number of surviving days within one year after hip fracture*

q_2 = *Number of hip fracture patients returning to independent residence one year after hip fracture*

In a sensitivity analysis, three alternative production models are specified (see Appendix). The sensitivity analysis is performed in order to check that the efficiency scores do not change dramatically as the original model specification is slightly changed. In the first alternative production model the second input variable was defined as days in after care and other acute care. In the second alternative model, days in other acute care was added as a third input variable while the variable number of surviving days was excluded by comparison with the original model. Finally, in the last model days in other acute care was added as a third input variable while return to independent residence was excluded compared to the basic model. In the original model specification the quality attribute variables were also defined as fractions, i.e. the number of surviving days was replaced with the surviving rate, and patients returning to independent residence was replaced with the fraction of patients returning to independent residence within one year after fracture.

3. The efficiency evaluation model

Following the efficiency definition in Farrell (1957), we divide productive efficiency into two components. The first refers to the use of as little input as possible, given the quantity and quality of the outputs. This is a strictly technical notion of efficiency, and is referred to as input-based technical efficiency. It is an input-based measure since we seek minimal feasible inputs given the level of the output and quality attributes. The second component is a price-dependent measure that reflects the extent to which a hospital, department etc. uses a cost minimising input-mix, which is referred to as allocative efficiency. Technical inefficiency occurs if one unit uses a relatively excessive quantity of clinical resources compared with other units practising with a similar size and mix of patients. Allocative inefficiency is present if there is a discrepancy between the marginal rate of technical substitution of two inputs (e.g., capital and labour) and their relative prices, i.e. the unit fails to purchase inputs, given their prices, so as to minimise costs.

Technical efficiency

Let x denote a vector of inputs used in the production of y outputs, with quality attributes q. The vector y refers to quantity data (number of operated patients) and the vector q refers to quality of the outputs (e.g., survival and return to independent residence). In an input-based setting, where output and quality are taken as given, the production technology can be described by the efficiency measure (Farrell 1957):

$$F_i = min\{\lambda \geq 0 : \lambda x \ is \ feasible, \text{ i.e., can produce } y \text{ and } q\} \qquad (1)$$

The inverse of Farrell efficiency measure is equal to the maximal proportional contraction of observed inputs that is feasible relative to the (unobserved) input requirement set[1]. The efficiency measure is independent of unit of measurement and takes on values less than or equal to one for a feasible input bundle. Values equal to one indicate technical efficiency and values less than one indicate technical inefficiency. Technical efficiency is illustrated in *Figure 2.*

FIGURE 2 IN HERE

In *Figure 2*, the observed input combination for process A is the filled square in the north-east region. The technical efficiency measure is equal to $F_i = 0A^t / 0A < 1$, where A^t represents the transformed, efficient, vector of inputs. An interpretation is that $100 \cdot (1 - F_i)$ represents the maximal percentage reduction of inputs that is possible given that the original output can be produced.

Allocative efficiency

To analyse allocative efficiency we have to solve a cost minimisation problem. This necessitates information on the input prices for each treatment process. The cost minimisation problem is specified as:

$$C = \min_{\tilde{x}} \left\{ \sum_{n=1}^{N} w_n \tilde{x}_n : \tilde{x} \text{ is feasible} \right\} \tag{2}$$

Using (2) and observed inputs (x_n) and input prices (w_n), we define $O_i = C / \sum_n w_n x_n$ A, as a cost efficiency measure. This measure can in turn be used to define the allocative component of productive efficiency as (Färe, Grosskopf and Lovell 1994):

$$A_i = \frac{O_i}{F_i} \tag{3}$$

As the technical efficiency measure, the allocative measure is bounded by zero and one and is independent of unit of measurement. By a simple rearrangement of (3) we see that the input cost efficiency measure, or overall efficiency, is equal to the product of technical and allocative efficiency, i.e., $O_i = F_i \cdot A_i$. In *Figure 2*, the allocative efficiency measure for process A is equal to $A_i = 0A^a / 0A^t$. Note that the input combination A^a is not feasible. The input combination, which is both technically and allocatively efficient, is represented by A^o. The overall efficiency measure, which is the product of the technical and the allocative components, is then equal to $O_i = 0A^a / 0A$. Note that a unit can be *either* technically or allocatively inefficient or *both*.

Estimation of efficiency

Since the input requirement set, which each unit is compared to, is unobservable, we have to estimate this reference technology. We use a piecewise linear representation of the reference technology to analyse differences in technical efficiency for a set of hip fracture treatment processes. This is essentially a DEA-model (see, e.g., Charnes *et al.* 1994). Some of the virtues of the DEA method are that no functional form has to be imposed and technical efficiency can be estimated without price- or cost-data, even for a small sample. Consider then K observations employing N inputs in the production of M outputs with J quality attributes. The Farrell efficiency measures can be estimated by solving K linear programming problems, one for each process. The Farrell efficiency measure for observation k' when constant returns to scale (CRS) is assumed is obtained from the solution to the LP problem (Färe, Grosskopf and Roos 1995):

$$\begin{aligned}
&\hat{F}_i = \min_z \theta \quad \textit{subject to} \\
&\theta x_{nk'} \geq \sum_{k=1}^{K} z_k x_{nk} \quad \textit{for all } n \\
&y_{mk'} \leq \sum_{k=1}^{K} z_k y_{mk} \quad \textit{for all } m \\
&q_{jk'} \leq \sum_{k=1}^{K} z_k q_{jk} \quad \textit{for all } j \\
&z_k \geq 0 \quad \textit{for all } k
\end{aligned} \tag{4}$$

where z is a vector of intensity variables. CRS can be relaxed by restricting the intensity variables to sum to one. This gives an efficiency estimate under variable returns to scale (VRS).

The cost minimisation problem in (2) can be analysed in a DEA setting by solving the following linear programming problem (Färe, Grosskopf and Lovell 1994):

$$\hat{C} = \min_{z,\tilde{x}} \sum_{n=1}^{N} w_{nk'} \tilde{x}_n \quad subject\ to$$

$$\begin{aligned}
&\tilde{x}_n \geq \sum_{k=1}^{K} z_k x_{nk} \quad for\ all\ n \\
&y_{mk'} \leq \sum_{k=1}^{K} z_k y_{mk} \quad for\ all\ m \\
&q_{jk'} \leq \sum_{k=1}^{K} z_k q_{jk} \quad for\ all\ j \\
&x_n \geq 0 \quad for\ all\ n \\
&z_k \geq 0 \quad or\ all\ k,
\end{aligned} \tag{5}$$

where x_{nk} denotes observed values and $\tilde{x}_n$ represents the choice variables.

4. Description of data

The subjects for this study were all patients admitted for primary hip fracture surgery during the year of 1990 in the area administered by the SCC; data were collected for 1,987 hip fracture patients admitted from an independent residence and aged 65 years or older. The patients were admitted to one of ten hospitals representing all the available health care providers during the year 1990 in the SCC[2]. *Table 1* shows that the hospitals are relatively homogenous with respect to the patient characteristics age and gender.

TABLE 1 IN HERE

Table 2 summarises the data for the hospitals on input, output and quality attribute variables, which are used when defining the hip fracture treatment process.

TABLE 2 IN HERE

Input variables in the original model were the number of hospital days in orthopaedics and after care, while the quality attribute variables were the number of patients who had returned to independent residence one year after fracture and the number of surviving days during the year after hip fracture. The output variable was defined as the number of operated patients. Each patient was followed during one year after the admission for hip fracture surgery. Thus all consumption in orthopaedics and after care within one year after the fracture was included. The data have been extracted from the inpatient database of the SCC.

The input prices used were the average unit costs. The average costs included both fixed and variable costs. With a long-term perspective it is important to include also the fixed costs when estimating the costs because in the long run, if the treatment process is made more efficient, for example, it may be possible to decrease the number of hospital beds in orthopaedics and geriatrics and eventually to build smaller hospitals. All input prices are in SEK[3] and refer to the prices of 1994. The average unit costs per orthopaedic care hospital day and other acute hospital care days were extracted from the Huddinge University Hospital patient-related accounting system, while the average unit cost per geriatric care day was calculated by the geriatric department at the Huddinge hospital. The average unit cost for a day in a nursing home was obtained from the social welfare authority. The input price for a day in after care was calculated as an average of the average unit costs in nursing homes and geriatrics[4].

It was not possible to obtain input prices for each health care provider conditioned on the hip fracture treatment process. Instead the same input prices for all the different orthopaedic departments were used. The same input prices are also used for the after care irrespective of the initial hospital. The reason for not using cost estimates from each department was the lack of data, plus the fact that Huddinge hospital was the only hospital with a patient-related accounting system in 1994. Thus the same average unit cost was used for all ten processes, which implies that the allocative efficiency scores must be interpreted with some caution. However, this becomes a problem, when estimating allocative efficiency, if the different orthopaedic and after care departments differ substantially with respect to input prices. This is perhaps not so problematic as it can appear at first sight. Firstly, in the ten processes the same long-term care home can host patients from all the ten orthopaedic departments. Secondly, there are reasons to believe that the cost for one bed-day at the orthopaedic departments is not so different between the departments. For example, there is no, or at least very little, regional variation in the factor markets since all orthopaedic departments are situated in the same county. It may be argued that orthopaedic and after care departments do not differ strongly with respect to input prices because the health care providers are a homogeneous group in a limited catchment area in the Stockholm region, using the same kinds of labour, technology etc.

5. Results

Using the data described in *Table 2*, we calculated Farrell input-based efficiency scores for each of the ten hip fracture treatment processes. Three types of efficiency scores were estimated. The first is the Farrell technical efficiency score. The second is the overall efficiency score, which is needed in order to obtain the third measure, allocative efficiency.

The results show that six of the ten hip fracture treatment processes are estimated as technically efficient using the original model (*Table 3*).

TABLE 3 IN HERE

The interpretation is that for the six departments with a score equal to one, it is not possible to decrease the use of resources without producing less in terms of quantity or quality. According to *Table 3*, treatment process ten is the most inefficient unit with a score equal to 0.74. However, this result is not so stable if we look at the results using the alternative model specifications. For the remaining three inefficient processes (nos. 2, 5 and 8) the results seem to be more robust. Further, four processes are consistently technically efficient (nos. 1, 3, 7 and 9) in all the four models.

Turning to the allocative efficiency score, we see that process number nine is efficient in all the tested model specifications (*Table 4*).

TABLE 4 IN HERE

On the other hand, we have processes four and ten as most inefficient allocatively in the original model. The latter result can be explained by the fact that these two processes are the ones that have the highest ratio of orthopaedic days to long term care bed-days. Since orthopaedic bed-days are almost twice as expensive as the long term care bed-days, processes four and ten use more orthopaedic days by contrast with long term days, which in turn makes them allocatively inefficient. The opposite relation holds for process 1, which uses twice as many long-term bed-days compared to orthopaedic bed-days. This specialisation goes too far in the other direction, which makes process 1 allocatively inefficient as well. Only process nine is allocatively efficient in the original model (and in all other specifications as well). Note, however, that unit five is very close to being fully allocatively efficient in the original model.

Multiplying the technical and allocative components, we get the overall efficiency score, which are presented in Table 5.

TABLE 5 IN HERE

The results show that process nine is overall efficient in all the tested models. That is, it is only for process nine that no potential cost savings are possible. Process ten is again the most inefficient unit with an overall efficiency score equal to 0.66. This can then be interpreted as a potential cost saving of about 34 percent if process ten were to achieve full efficiency, i.e., choosing the cost saving input-mix and being technically efficient. For the sample, the average overall efficiency score is equal to 0.89. This can be interpreted as a potential cost saving for the SCC of approximately 11 percent, which is equal to SEK 38 Million using the same cost data as before. The efficiency scores did not change when the quality attribute variables were instead defined as fractions.

6. Discussion

This paper evaluated ten hip fracture treatment processes, in the area administered by the SCC, in terms of technical and allocative efficiency, using the DEA method. It is demonstrated that the potential cost savings amounted to 11 percent of the total treatment and rehabilitation costs in the SCC, which is equivalent to about SEK 40 Million each year, assuming overall efficiency. The result is insensitive to changes in the model specification and the potential cost savings always exceeded SEK 35 Million or 9 percent of the total treatment and rehabilitation cost in all efficiency estimates.

The hip fracture treatment process used resources in orthopaedics and after care to "produce" a number of operated patients with a given survival and residence the year after a hip fracture. Ideally, all the health care provision during the year after fracture should be included on the input side and all the relevant case- and patient-mix variables should be included on the outcome side. However, it is well known that the number of input/outcome variables that can be included depends on the number of observations (Charnes *et al*. 1994). That is, given a small number of observations, an increased number of input/outcome dimensions implies a larger number of efficient units. Thus since only ten hospitals are situated in the area of this study, only up to about five input/outcome variables could be included. Moreover, in DEA it is essential to define the input and outcome variables in a meaningful way. It has been common in hospital efficiency studies to use hospital days as outputs and physician hours etc. as inputs (Charnes *et al.* 1994). We argue that the number of days in orthopaedics etc. can instead be viewed as a measure of resource use (SPRI 1992). Further, it could be argued that the aim of health care is to ”produce” health in terms of survival and quality of life and not hospital days per se. We used the number of surviving days and patients returning to independent residence as a way to take into account survival and quality of life in the outcome measure. An alternative outcome measure could be quality adjusted life years (QALYs), which in one measure captures changes in survival and quality of life.

Differences in overall efficiency between the units can be explained by looking at the differences in technical and allocative efficiency, respectively. Given the number of operations and the level of the quality attributes, how is it that some of the units use more resources compared to the other units? Although, there are relatively small variations in age among the departments it may be argued, for example, that unit ten is technically inefficient compared to the other units because of the higher mean age associated with unit ten. But this is already partially accounted for in the estimation of overall efficiency because of the included quality attribute variable surviving days, which is negatively correlated with age. Furthermore, it has been indicated that women have higher hip fracture costs than men, which is not accounted for in the estimation of efficiency (Borgquist *et al*. 1993). We note that units nine and ten differ substantially in technical efficiency although they have the same gender structure, which indicates that this problem may be of minor importance in this case. It has also been indicated that trochanteric fractures are associated with higher costs by comparison with cervical fractures (Borgquist *et al*. 1993, Zethraeus and Gerdtham 1998). Despite this, unit nine is more technically efficient than unit ten, which contradicts this hypothesis. It may also be argued, for example, that hip fracture patients with severe fractures will be admitted to a specific orthopaedic department that specialises in severe fractures. However, in the area administered by the SCC, the admission destination for hip fracture patients is determined according to where the patient is situated and not according to severity. Another factor that may explain differences in resource utilisation is the differences in health status among the patients. Some hospitals are located in regions where the hip fracture patients are healthier and have a well-developed social network. This implies that, conditional on survival and residence one year after fracture, such hospitals may use less resources compared to hospitals with more unhealthy patients. Whether these kind of differences exist in the SCC is uncertain but must be considered as a further factor.

Irrespective of technical efficiency, allocative inefficiency may still be present for the hip fracture treatment processes. Allocative inefficiency for a unit is present if the unit does not minimise its costs, in terms of choosing the least costly mix of inputs. Because each health care provider, for example the orthopaedic department, is responsible for only its own resource use, the risk of suboptimisation for the unit is apparent. Even if each health care provider is allocatively efficient, this will not necessarily imply that the *unit* is allocatively efficient. The “production “ of an operated hip fracture patient conditional on the level of the quality attributes may be accomplished in different ways, i.e. it may be possible to substitute for example days in geriatrics for days in orthopaedics or to substitute days in nursing homes for hours in municipal home help. If these substitutions are available it is possible to choose production techniques based on the relatively cheaper input. If one health care provider is in charge for the entire treatment and rehabilitation programme, these substitutions may be facilitated. In the SCC, “Case management systems“ are discussed, which means that the orthopaedic department will be responsible for the whole rehabilitation and treatment process for a hip fracture patient. These kinds of system may improve the conditions for allocative efficiency in that substitutions between inputs are facilitated. On the other hand, if each health care provider is responsible for its part of the process it may instead be possible to design an appropriate reimbursement system in order to obtain a more efficient resource allocation.

Finally, there seem to be some differences in efficiency that can not be explained by patient- or case mix variables. Thus, there may be other factors that explain differences in efficiency, such as how the treatment and after care is organised at different units and to what extent the orthopaedic department is responsible for the rehabilitation of the patient. These aspects of explaining differences in efficiency should be a subject for future research.

Notes

[1]The input requirement set is defined as $L(y,q) = \{x: x \text{ can produce } y \text{ and } q\}$.

[2]The patients were mainly operated on using osteosynthesis; this involves either a sliding screw-plate or screws.

[3]27 September 1996: £1=10.36 SEK; $1=6.63 SEK. The reason for not using 1990 as base year is that accurate cost data was not available before 1994.

[4]The weight is calculated using the fraction of days in nursing homes to days in geriatrics, based on the ratio in the city of Stockholm for 1992 (Zethraeus *et al*. 1997).

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Appendix

Model specifications:

Original model:

x_1= *Number of days in orthopaedics within one year after a hip fracture*
x_2= *Number of days in after care within one year after a hip fracture*
y_1= *Number of operated patients*
q_1= *Number of surviving days within one year after hip fracture*
q_2= *Number of hip fracture patients returning to independent residence one year after hip fracture*

Alternative model 1 (Alt. dat. 1):

x_1 = *Number of days in orthopaedics within one year after a hip fracture*
x_2 = *Number of days in after care and in other acute care within one year after a hip fracture*
y_1 = *Number of operated patients*
q_1 = *Number of surviving days within one year after hip fracture*
q_2 = *Number of hip fracture patients returning to independent residence one year after hip fracture*

Alternative model 2 (Alt. dat. 2):

x_1 = *Number of days in orthopaedics within one year after a hip fracture*
x_2 = *Number of days in after care within one year after a hip fracture*
x_3 = *Number of days in other acute care within one year after a hip fracture*
y_1 = *Number of operated patients*
q_1 = *Number of hip fracture patients returning to independent residence one year after hip fracture*

Alternative model 3 (Alt. dat. 3):

x_1 =*Number of days in orthopaedics within one year after a hip fracture*
x_2 =*Number of days in after care within one year after a hip fracture*
x_3 =*Number of days in other acute care within one year after a hip fracture*
y_1 =*Number of operated patients*
q_1 =*Number of surviving days within one year after hip fracture*

Tables

Table 1: Characteristics of the ten hospitals defining the *hip fracture treatment processes*.

				Mean number of days:		One year after hip fracture (%):					
		Fracture type (%):							Gender (%):		Mean
Hosp.	**Patients**	*Trochanteric*	*Cervical*	*Orthopaedic department*	*After care*	*Dead*	*Independent residence*	*Institutional residence*	*Men*	*Women*	**age**
1	322	47	53	19	57	22	64	14	21	79	81
2	227	40	60	22	56	21	61	18	22	78	80
3	155	44	56	24	40	21	61	17	18	82	79
4	66	41	59	31	33	26	64	11	32	68	81
5	104	45	55	27	59	26	61	13	25	75	80
6	57	33	67	29	38	11	70	19	23	77	78
7	471	49	51	25	37	22	66	11	20	80	80
8	270	49	51	25	47	22	69	9	20	80	82
9	220	47	53	20	47	19	70	11	18	82	81
10	95	37	63	40	45	32	55	14	18	82	82
Total	1 987	46	54	24	46	22	65	13	21	79	81

Table 2: Description of variables used for defining the *hip fracture treatment process* (*n*=10).

VARIABLES		1990
Hospital days in Orthopaedics	*Max*	11,816
	Mean	4,831
	Min	1,642
	Std dev	2,961
Days in after care	*Max*	18,329
	Mean	9,234
	Min	2,145
	Std dev	5,964
Days in other acute care	*Max*	2,982
	Mean	1,149
	Min	468
	Std dev	754
Number of operated patients	*Max*	471
	Mean	199
	Min	57
	Std dev	131
Surviving days	*Max*	146,157
	Mean	61,877
	Min	18,608
	Std dev	41,022
Patients returning to Independent residence	*Max*	313
	Mean	129
	Min	40
	Std dev	89

Table 3: Farrell-technical efficiency

	Original	**Alt dat 1**	**Alt dat 2**	**Alt dat 3**
1	1.000	1.000	1.000	1.000
2	0.898	0.893	0.898	0.898
3	1.000	1.000	1.000	1.000
4	1.000	0.937	1.000	1.000
5	0.780	0.784	0.836	0.836
6	1.000	0.963	1.000	0.987
7	1.000	1.000	1.000	1.000
8	0.919	0.928	0.950	0.938
9	1.000	1.000	1.000	1.000
10	0.742	0.877	0.956	0.956
Average	0.934	0.938	0.964	0.961

Table 4: Allocative efficiency

	Original	**Alt dat 1**	**Alt dat 2**	**Alt dat 3**
1	0.931	0.843	0.921	0.921
2	0.979	0.917	0.939	0.939
3	0.978	0.998	0.953	0.953
4	0.882	0.950	0.730	0.730
5	0.997	0.964	0.936	0.936
6	0.903	0.982	0.793	0.820
7	0.972	1.000	0.923	0.923
8	0.979	0.998	0.938	0.950
9	1.000	1.000	1.000	1.000
10	0.894	0.870	0.706	0.706
Average	0.952	0.952	0.884	0.888

Table 5: Cost-efficiency, i.e., overall efficiency

	Original	**Alt dat 1**	**Alt dat 2**	**Alt dat 3**
1	0.931	0.843	0.921	0.921
2	0.879	0.819	0.843	0.843
3	0.978	0.998	0.953	0.953
4	0.882	0.891	0.730	0.730
5	0.777	0.756	0.783	0.783
6	0.903	0.946	0.793	0.809
7	0.972	1.000	0.923	0.923
8	0.900	0.926	0.891	0.891
9	1.000	1.000	1.000	1.000
10	0.663	0.763	0.675	0.675
Average	0.888	0.894	0.851	0.853

FIGURE LEGENDS

Figure 1: Production model to evaluate the "*hip fracture treatment process*".

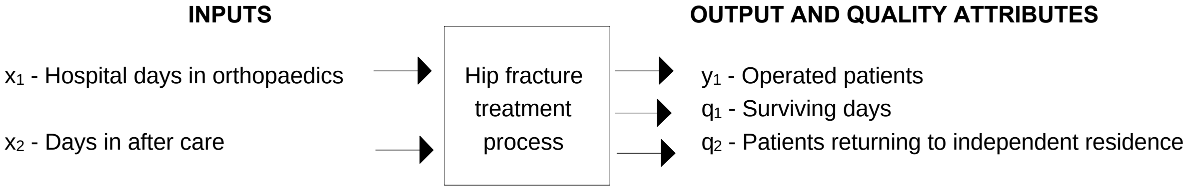

Figure 2: Technical and allocative efficiency