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Information Technology and Organizational Efficiency: A Study in the Capital Goods Sector

Giuseppe Arpino
University of Sao Paulo, giuseppe@aarmac.com.br

Cesar Alexandre de Souza
University of Sao Paulo, calesou@usp.br

Ronaldo Zwicker
University of Sao Paulo, rzwicker@usp.br

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Ronaldo Zwicker
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rzwicker@usp.br

ABSTRACT

Among the possible measures for Information Technology (IT) success is its impact on companies´ performance. Many researches have been conducted to show the influence of IT on firms´ results, but mainly through studies in large-sized firms. The objective of this work is to analyze the relationships between IT investments and organizational efficiency, focusing on micro, small and medium sized enterprises. For this, critical success factors for industrial firms' performance were identified and a two-stage data envelopment analysis (DEA) model was developed and tested in a sample of firms in the capital goods sector. DEA is especially interesting because it allows comparing and differentiating those firms in the sample which are more efficient in deriving results from IT. Among the results found were the higher capacity of small firms to translate IT investments into operational efficiency and the higher capacity of larger firms to convert critical success factors into profitability.

Keywords

IT impacts; IT and performance; data envelopment analysis.

INTRODUCTION

The correct evaluation of results deriving from IT investments has been a constant concern for firms in different sectors. This is especially important in micro, small and medium firms, which in many cases lack the necessary financial resources and knowledge to properly plan and implement information systems (Zwicker, Vidal and Souza, 2005). The goals of this work are to analyze the relationship between investments in IT and organizational efficiency in firms in the capital goods industry, and to identify aspects that distinguish those able to obtain better results through the use of IT.

This work is structured as follows: initially, a brief literature review is presented; then, the research model is developed and inputs and outputs for the data envelopment analysis - DEA model are defined, based on critical success factors for industrial firms; DEA is then applied in two stages, initially with the goal of relating the application of IT to effects on the operational processes of firms and their critical success factors; next, these effects are related to the financial performance results of the firms; DEA results are used to benchmark and differentiate those firms in the sample which are more efficient in deriving results from IT and this efficiency is related to organizational factors and informatization level of companies; finally, the conclusions are presented.

As contributions, this work presents data a two-stage model relating IT application to efficiency, indicating possible measures for the intermediate effects of IT application connected to critical success factors in manufacturing firms and relates results obtained through the use of IT to informatization factors.

LITERATURE REVIEW

IT and Organizational Performance

Since the late 1980s there has been a suspicion that investments made in IT have not been yielding the expected results. The so-called "productivity paradox", or the inexistence of correlation between investments in IT and a firm´s efficiency, attracted the attention of researchers and market professionals. Seeking indications of these gains, a number of studies have identified IT contributions to firms' results, particularly in large-sized firms (for instance Weill, 1992; Hitt and Brynjolfsson, 1996; Rai, Patnayakuni and Patnayakuni, 1997; Lunardi, Maçada and Becker, 2002; Hu and Quan, 2005).

A smaller number of studies have been conducted in micro, small and medium sized enterprises (MSMEs). Many of these firms consider IT investments too high, ignore the possibilities and difficulties of the use of IT and do not know how to evaluate improvements obtained. Nevertheless, some studies are now showing correlations between investments in IT and specific performance measures. Becchetti (2003), for instance, showed that IT investments in Italian MSMEs positively influenced the creation of new products and processes and the increase in productive capacity, thereby creating a "flexibility option" through which irreversible decisions like building a new factory could be postponed.

DEA and Studies Focusing on IT and Organizational Performance

One of the various methods used in studies relating IT investments to measures of productivity is DEA (Wang, Gopal and Zionts, 1997). DEA is a mathematical programming approach used to measure relative productivity of units of analysis (DMUs, or decision making units) that transform multiple inputs in multiple outputs. This technique uses linear programming to build a hypothetical unit based on all the units of the reference group. The unit being analyzed can be rated as relatively inefficient if the composite unit requires fewer entries to obtain the same outputs from the unit being assessed. Or, it is judged as relatively efficient if the composite unit requires the same entries as the unit being assessed. DEA quantitatively determines the efficiency of each DMU by providing an efficiency index that ranges between 0 and 1.

Among the advantages of this technique in IT context, as pointed out by Wang et al. (1997) are: data on IT investments do not need to be normalized as necessary in econometric approaches; the technique does not require a priori modeling of a function relating outputs to inputs, an advantage in the case of the analysis of IT investments, a field in which little is known about the dynamics of the interaction between inputs and outputs in the process of obtaining value through the use of IT; and DEA allows avoiding the problems of directly analyzing the relationship between investments in IT and company results, once the firm can be investing in systems but not adequately using them (aspects seen as one of the causes of the "paradox"). Hence, the technique allows firms that are efficient in converting IT investments into results to be differentiated from others and, in posterior analyses, allowing the efficiency index to be related to other factors, including degree and quality of the use of IT, quality of IT management and strategic alignment (this possibility is of particular importance regarding the objectives of this paper). More details on the mathematical formulation of DEA and its computational aspects can be obtained in Wang et al. (1997) and Lunardi et al. (2002).

IT and Performance: Use of DEA in Research on Manufacturing Firms

A few studies have applied DEA in the area of manufacturing. Dasgupta, Sarkis and Talluri (1999), for instance, analyzed the impact of IT investments on the results of service and manufacturing firms. They used DEA in various configurations, followed by a statistical test showing that the efficiency index was negatively correlated with values invested in IT. According to the authors, a possible reason for these results is that as firms invest more in IT systems there is more need to coordinate different activities and systems across all the areas of an organization, possibly indicating a decreasing gain of scale in informatization. Petroni and Bevilacqua (2002) applied DEA to identify the MPMEs operating in the efficiency frontier of flexible manufacturing in 89 Italian firms. The model adopted used the following output measures: degree of machinery flexibility, degree of process flexibility, degree of product flexibility, degree of routing flexibility, degree of volume flexibility, degree of expansion flexibility and degree of layout flexibility, all associated with operational efficiency in manufacturing firms. Although not specifically connected to the evaluation of the IT use, their work suggests possibilities of applying the technique in manufacturing because it uses a series of variables concerning aspects of the productive process as outputs of a process of inputs transformation. These concepts will be used in this work.

METHODOLOGY AND RESEARCH MODEL

The Two-Stage Research Model

In their study, Wang et al. (1997) emphasize that the impact of IT on financial results of firms is indirect and must be analyzed based on the impact of IT on the firm's production processes. This aspect led the authors to develop a two-stage model with the goal of mapping the extent to which production processes are affected by investments in IT, and the extent to which such investments affect the efficiency of organizations. Based on these considerations, the proposal of this work is to develop the analysis of DEA in two stages, using the investments in IT as inputs and the various critical success factors for capital goods firms as outputs of the a first intermediary stage (operational efficiency stage), and considering the firms' financial results as the model's final output, in a second stage (organizational efficiency stage). The proposed two-stage efficiency analysis model is presented in Figure 1. The next items describe each of the variables in the model.

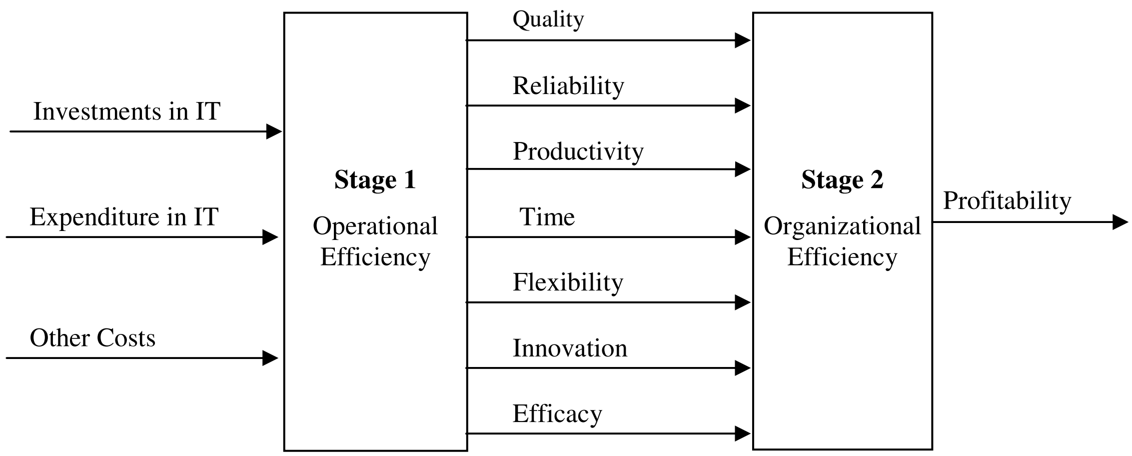

Figure 1—Initial DEA model

First-stage Inputs

The inputs in first stage are variables associated with IT expenditures and IT capital investments. The composition of these variables, recommended by the literature, is shown in Table 1. Note that other costs of the firm are also included in the model (all corporate but IT costs), because IT investments must be combined with other production inputs for the desired results to be achieved (Lunardi et al., 2002).

1st stage inputs	Variable Composition	References
IT Expenditures	maintenance, telecom, IT staff, outsourced services	Rai et al. (1997); Weill (1992)
IT Investments	IT infrastructure, IT applications Hardware, software	Rai et al. (1997); Dasgupta et al. (1999); Hitt and Brynjolfsson (1996)
Other costs of the firm	Labor, raw material and administrative expenses	Lunardi et al. (2002)

Table 1 –First stage inputs

First-Stage Outputs (Second-Stage Inputs)

The first stage has output variables representing firms' performance in a series of categories associated with production processes that are important for success. We identified these categories by analyzing the literature on critical success factors - CSFs in manufacturing. In the literature review, CSFs for manufacturing and indicators for their measurement were identified and are presented in Table 2.

Second-Stage Outputs

The outputs of the second stage are variables representing financial or market results of the firm's operations. Factors more commonly associated with the final results of an organization are profitability and billings. Thus, in the model the profitability variable, measured as profit as a percentage of sales, represents the output of the second stage.

1st stage outputs	Variable Composition	References
Quality	Level of defects, certifications , quality perception	Rosa (2006); Saccani (2006)
Reliability	Percentage of orders delivered with delay, orders average delay time	Rosa (2006)
Productivity	Labor productivity, quantity produced / man hour, inventory turnover	Sink and Tuttle (1989)
Time	Production cycle time, supply cycle time, delivery frequency	Rosa (2006)
Flexibility	Time to change programming, labor flexibility	Rosa (2006)
Innovation	Number of new procedures adopted, number of new products successfully released per period, inventory reduction, number of people in R&D	Sink and Tuttle (1989)
Efficacy	Revenues obtained / expected revenues, real production time /expected production time	Rosa (2006)
Cost	Cost per hour of operation, rate of installations per hour, unitary cost of materials , labor rate per hour	Rosa (2006)

Table 2 – First-Stage Outputs

Factors Associated with the Adequate Use of IT

Characteristics that can influence the conversion of IT investments into organizational results, both in the first and second stages, were identified in the literature and are presented in Table 3. These three factors, herein called informatization factors, will be used in an exploratory analysis comparing them with DEA results to verify possible interactions between these factors and efficiency.

Informatization Factor	Variable Composition	References
Informatization Level (IL)	Degree and extension of IT use, dependence on IT use, technical quality and integration of systems	Zwicker et al. (2005)
Degree of technological and organizational integration (TOI)	Degree of integration of the organization and of the supply chain	Lagacé (2000)
IT Operational conditions (IOC)	IT Planning, workers' and executives' participation in and knowledge of IT planning	Zwicker et al. (2005)

Table 3 – Informatization Factors

Data Collection

A questionnaire was developed based on variables and factors described and sent by e-mail in February 2008 to a list supplied by ABIMAQ (Brazilian Machinery Builders' Association) containing 3,833 Brazilian firms in the capital goods sector. By the end of data collection, in March 2008, 80 firms (2.1%) had filled in all or part of the questionnaire. The questionnaire was pre-tested in three firms. In Brazil, this sector comprises some 4,000 firms, of which 65% are small-sized or micro-sized, 25% are medium-sized and 10% are large-sized firms.

DATA ANALYSIS

Sample Obtained

Of the 80 firms that answered all or part of the questionnaire, 23% were micro-sized firms, 47% were small-sized firms, 20% percent were medium-sized firms and 10% were large-sized firms. The number of employees was used to classify firms by size (micro-sized firms with 1 to 9 employees, small-sized firms with 10 to 99, medium-sized with 100 to 499, and large-sized firms with 500 or more employees). Table 4 shows characteristics of firms in the sample.

Size	n	%	N. Employees (Average)	2007 Revenues (US$) (Average)	2007 Profits (US$) (Average)	Profit (%) (Average)
Micro	18	22.5%	9	1,491,308	111,848	7.5
Small	38	47.5%	50	4,629,798	459,739	9.93
Medium	16	20.0%	148	31,099,288	2,876,684	9.25
Large	8	10.0%	2,325	455,757,591	30,353,456	6.66
All firms	80	100.0%	288	39,232,048	3,472,036	8.85

Table 4 – Characteristics of firms in the sample

IT Expenditures and Investments

Table 5 presents average values for accumulated investments in IT, calculated based on the valuation of equipment and systems the firm owns as informed by respondents, at estimated current market values. Calculated values were divided by the revenues reported in 2007, to enable comparison (note that in the case of IT investments, the value was not invested in 2007, but over time; the relationship only allows making the investments comparable per firm). It can be observed that, although expenses and investments increase with the size of the firm, the relationship with revenues gradually decreases. This shows the higher relative capacity of bigger firms to spend more in IT.

Size	n	Annual Expenses in IT (US$)	n	2007Annual Expenses /Revenues	n	Accumulated Investment in IT (R$)	n	2007 Investments in IT/Revenues
Micros	14	12,785	14	2.8%	17	26,828	14	4.11%
Small	26	28,057	26	1.0%	38	170,058	31	5.38%
Medium	6	68,107	6	0.5%	16	530,177	8	2.50%
Large	3	941,250	3	0.3%	8	4,879,624	4	1.13%
All Firms	**49**	123,950	**49**	**1,4%**	**79**	689,090	**57**	**4,36%**

Table 5 – Expenditure and Investments in IT per size and general

Analysis of Activities Supported by IT

In order to compose the informatization level of firms, companies were asked about business activities conducted with the support of computerized information systems. Table 6 presents the percentage of firms that reported using each of the systems examined. IT in manufacture includes traditional management information systems (Enterprise Resource Planning—ERP, Customer Relationship Management—CRM, and Supply Chain Management—SCM, among others) and systems, technologies and software directly focused on production and product design (Computer Numeric Control—CNC and Computer Aided Manufacturing—CAM, Computer-Aided Design—CAD).

Results showed that large firms use more systems in comparison with other companies. The most significant difference occurred among small and micro firms. These results are in accordance with those previously obtained (Zwicker et al., 2005) and indicate that the growth of informatization level according to size is also verified in the sector studied in this work (mechanical capital goods).

The percentage of firms adopting production and project systems is considerably smaller than that of firms adopting management systems, as expected given results of other studies. It was also observed that firms seem to give more attention to CAD systems than to MRP. This can be explained by the fact that a good portion of the firms in sample manufacture equipment on demand, which results in less need to use optimal management of materials and modern production systems like Just In Time. In the same way, because equipment is made on demand, the use of CAD systems is more intense. Also CAD systems are cheaper to implement. Moreover, CAD can present more immediate and more easily perceived results.

	Application/System	All (n=76)	Micro (n=15)	Small (n=37)	Medium (n=16)	Large (n=8)
Management systems	ERP (one or more modules)	99 %	93 %	100 %	100 %	100 %
	Web Site and Electronic Commerce	82 %	100 %	70 %	94 %	75 %
	CRM	34 %	27 %	30 %	44 %	50 %
	SCM	33 %	40 %	32 %	31 %	25 %
	Electronic data Interchange (EDI)	18 %	13 %	11 %	13 %	75 %
	Business Intelligence (BI)	37 %	20 %	30 %	56 %	63 %
Production systems	Materials Requirement Planning (MRP)	62 %	27 %	70 %	63 %	88 %
	CAD	79 %	47 %	84 %	94 %	88 %
	CAM	36 %	7 %	41 %	38 %	63 %
	Quality Control applications	47 %	7 %	51 %	63 %	75 %
	Advanced Planning Systems (APS)	32 %	7 %	27 %	56 %	50 %
	CNC	53 %	0 %	70 %	56 %	63 %
	Robots	17 %	0 %	19 %	19 %	38 %
Total		**54 %**	**36 %**	**55 %**	**60 %**	**70 %**

Table 6 – Information systems usage (in percentages)

Critical Success Factors (Intermediate Stage Outputs)

The questions related to the intermediary stage of the model (table 2) presented a smaller number of respondents and more inconsistent responses than questions related to other parts of the questionnaire. This was expected because firms usually hesitate to report financial data and many firms, mainly smaller ones, could not answer because of lack of knowledge or unavailability of information. As a result, many performance indicators initially foreseen to compose the model had to be discarded, and the CSFs were composed as shown in Table 7, for 28 companies.

Critical Success Factors	Performance Indicators	Micro (n=8)	Small (n=15)	Medium (n=3)	Large (n=2)	All Firms (n=28)
Quality	Quality Perception	4.18	4.30	4.15	4.71	4.28
Reliability	Rate of orders with delays (%)	12.78	22.53	21.81	9.13	18.9
Productivity	Billings /Employee (2007)	152,652	92,162	206,000	190,278	35,957
Flexibility	Flexibility of labor (%)	40.12	28.14	17.64	47.5	30.89
Innovation	Number of new products	7.14	2.94	3.60	18.00	5.21
Efficacy	Number of extra hours worked	1,183.75	3,282.68	7,453.62	22,412.67	4,465.00

Table 7 – CSFs obtaied and their indicators

EXECUTION OF THE DEA TECHNIQUE

DEA Results

The DEA model was executed using inputs orientation and the BCC model, which takes into consideration the possibility of non-proportional increases in productivity (Wang et al., 1997). As discussed above, not all indicators for CSFs could be obtained from respondents. Also, companies´ costs could not also be reliably derived from responses. In consequence, fewer variables than initially expected could be used, and the model effectively tested is illustrated in Figure 2.

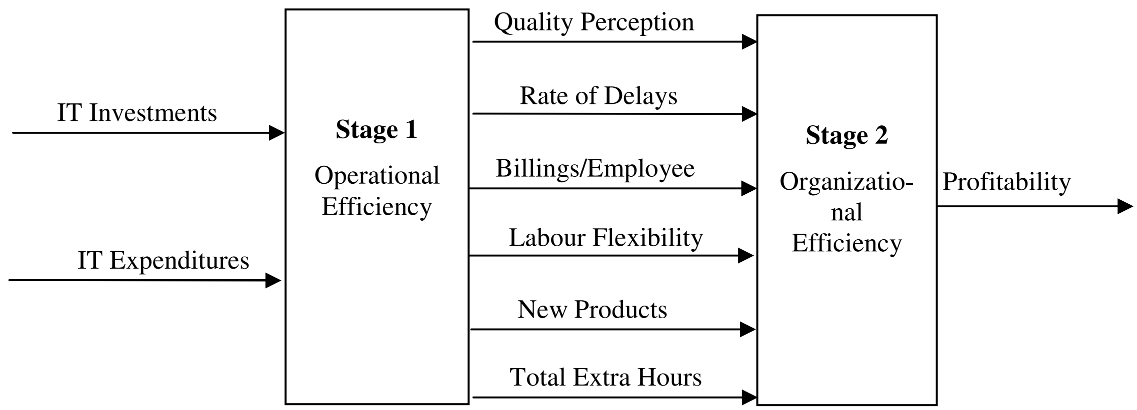

Figure 2 –DEA model tested with variables obtained in the sample

Although only 28 firms (35% of the sample) provided the necessary data for the DEA model, this did not hinder the application of the technique as the number of DMUs may be as small as twice the total number of variables used (inputs plus outputs) (Lins and Meza, 2000). Three analyses were conducted, the results of which are presented in Table 8: the first analysis considered first-stage entries and second-stage outputs ("global"); the second considered first-stage inputs and outputs; and the third considering considered second-stage inputs and outputs. The global model analyzes the firms' capacity to convert IT investments and expenditures directly into profitability, whereas the two models test the conversion in each stage.

In each group of columns in Table 8, the first (Clas.) represents the classification of each firm according to the DEA index (DEA Index) representing the firm's productivity in relation to firms situated on the frontier of efficiency. Firms with the same index value obtained the same classification. The third column (Size) shows firm size, with number 1 used for micro, 2 for small, 3 for medium and 4 for large.

A large variation is noted in the results from various firms in the global model and in the first stage, whereas the efficiency index varies little in the second stage. By and large, firms have shown to be more efficient in the second stage than in the first, because they are more concentrated in the higher levels, mainly in the efficiency frontier (21 firms) of that stage. This result could indicate that the indicators selected for the evaluation of CSFs may be in fact related to profitability of the firms in this specific sector. Nevertheless, due to the size of the sample obtained, this is a statement requiring care and new field work. A smaller quantity of firms was shown as efficient in converting IT investments and expenditures into critical success factors in the first stage, in which there are 13 firms in the efficiency frontier, with more than 13 below the 0.148 index. That could be further indication that in these latter firms, IT has been less focused on direct improvements in companies' critical success factors, and more focused on administrative systems and supports.

GLOBAL MODEL				FIRST STAGE				SECOND STAGE			
Clas.	Firm	Size	DEA Index	Clas.	Firm	Size	DEA Index	Clas.	Firm	Size	DEA Index
1	FIRM2	1	1.000	1	FIRM1	1	1.000	1	FIRM3	1	1.000
1	FIRM6	1	1.000	1	FIRM2	1	1.000	1	FIRM4	1	1.000
1	FIRM9	2	1.000	1	FIRM3	1	1.000	1	FIRM6	1	1.000
1	FIRM10	2	1.000	1	FIRM4	1	1.000	1	FIRM8	1	1.000
1	FIRM16	2	1.000	1	FIRM5	1	1.000	1	FIRM9	2	1.000
1	FIRM20	2	1.000	1	FIRM6	1	1.000	1	FIRM12	2	1.000
1	FIRM21	2	1.000	1	FIRM7	1	1.000	1	FIRM14	2	1.000
1	FIRM23	2	1.000	1	FIRM11	2	1.000	1	FIRM15	2	1.000
1	FIRM24	3	1.000	1	FIRM16	2	1.000	1	FIRM16	2	1.000
1	FIRM27	4	1.000	1	FIRM17	2	1.000	1	FIRM17	2	1.000
1	FIRM28	4	1.000	1	FIRM21	2	1.000	1	FIRM18	2	1.000
12	FIRM8	1	0.938	1	FIRM27	4	1.000	1	FIRM19	2	1.000
13	FIRM7	1	0.756	1	FIRM28	4	1.000	1	FIRM20	2	1.000
14	FIRM3	1	0.702	14	FIRM8	1	0.907	1	FIRM21	2	1.000
15	FIRM5	1	0.626	15	FIRM23	2	0.353	1	FIRM22	2	1.000
16	FIRM26	3	0.484	16	FIRM12	2	0.148	1	FIRM23	2	1.000
17	FIRM22	2	0.336	17	FIRM10	2	0.137	1	FIRM24	3	1.000
18	FIRM25	3	0.294	18	FIRM19	2	0.125	1	FIRM25	3	1.000
19	FIRM19	2	0.257	19	FIRM22	2	0.123	1	FIRM26	3	1.000
20	FIRM1	1	0.250	19	FIRM26	3	0.123	1	FIRM27	4	1.000
21	FIRM4	1	0.243	21	FIRM18	2	0.077	1	FIRM28	4	1.000
22	FIRM12	2	0.196	22	FIRM13	2	0.067	22	FIRM10	2	0.966
23	FIRM11	2	0.184	23	FIRM9	2	0.063	23	FIRM7	1	0.919
24	FIRM15	2	0.162	23	FIRM14	2	0.063	24	FIRM5	1	0.812
25	FIRM17	2	0.156	25	FIRM15	2	0.056	25	FIRM1	1	0.800
26	FIRM18	2	0.118	26	FIRM20	2	0.016	25	FIRM2	1	0.800
27	FIRM13	2	0.104	27	FIRM24	3	0.015	25	FIRM11	2	0.800
28	FIRM14	2	0.069	28	FIRM25	3	0.005	25	FIRM13	2	0.800

Table 8 – DEA Results

Correlations between Efficiency Index and Informatization Factors

In relation to the informatization factors, the survey consisted of Likert-scale questions, which were factor analyzed. Their Pearson correlations with DEA indexes are presented in Table 9, along with Spearman correlations between DEA indexes and firm size. Because of sample size, significance levels of 5% and 10% were considered.

DEA Index	(n=28)	IL	TOI	IOC	SIZE
Global	*correlation*	-,018	-,146	-,104	,076
	sig. (bi-caudal)	,926	,459	,598	,697
First Stage	*correlation*	,345 (*)	,465 (**)	,318 (*)	-,455 (**)
	sig. (bi-caudal)	,073	,013	,099	,014
Second Stage	*correlation*	,036	,046	-,279	,395 (**)
	sig. (bi-caudal)	,854	,816	,150	,037

(*) – significant at 10% level (**) – significant at 5% level

Table 9 – Correlations between DEA Indexes and Informatization Factors

No significant correlations were found between DEA index in global model and informatization factors or firm size. That indicates that aspects associated with the adequate use of IT are not related to a better achievement of firm financial results, which would be a contradiction with a good portion of the literature. However, this absence of correlation can be analyzed by observing the results in the separate stages.

Regarding the first stage, correlations with the three informatization factors were significant to a 10% level and to a 5% level in the case of the organizational integration factor. This result indicate that, as expected, firms with a higher combination of degree of informatization, organizational integration and operation conditions tend to be more efficient in the conversion process established for the first stage, thereby favoring improvement of the CSFs for manufacturing. In other words, IT planning and management contribute to its correct application in firms. The factor most strongly correlated was that of organizational integration, precisely the factor that implies the organization's alignment with the integration provided by IT.

However, in the second stage, the informatization factors were not correlated with the DEA index. This result could indicate that the transformation of the CSFs into profitability depends on factors beyond the correct use of IT, which makes a lot of sense. For instance, aspects like entrepreneurial strategy ad competition and correct positioning, among others, would have a stronger impact on this conversion than IT (which, no doubt, has to be correctly installed and be adequately used to enable or help the critical success factors available to be transformed into results—that is IT's role).

It is worth noting that the correlation between the efficiency level of the first stage and firm size is negative, significant at a 5% level, whereas in the second stage the correlation is positive, also significant at a 5% level. That could mean that smaller firms are more efficient in improving CSFs with IT. A possible explanation could be that smaller firms are quicker to meet Quality, Flexibility, Innovation and Efficacy standards. On the other hand, it may mean that larger firms are more effective in transforming CSFs into Profitability and Billings. That makes sense, because smaller firms generally have a low managerial capacity, despite being more agile. Besides that, size and scale often allow large firms to obtain negotiation advantages, regardless of other CSFs.

CONCLUSIONS

This work analyzed the relationship between IT usage and firms' efficiency in the Brazilian sector of mechanical capital goods, and the role of the informatization factors in this relationship, by means of the DEA technique. The DEA method was applied in two stages to allow observation of the intermediary production processes. Next, efficiency indices were compared with informatization factors.

Although no conclusions were reached concerning the relation between use of IT and profitability, a correlation was observed between the efficiency indexes of the first stage of DEA model and the informatization factors, a result that allows hypothesizing on the influence of the informatization level, IT operational conditions and organizational integration in the CSFs in manufacturing. It was also verified that smaller firms can be more efficient in improving CSFs through IT usage, but larger ones seem to be more efficient in converting CSFs into profitability, possibility because of their better firm management and issues concerning scale.

The greatest difficulty of this research was collecting information from the firms involved, mostly micro and small firms, which resulted in a reduced number of returned questionnaires (80) and a consequent reduced sample for the DEA model (28 firms). Although DEA allows small samples, this reduces the possibility of generalizing results. Another limiting aspect was the impossibility of using the other costs of the firms as input for the model, which eliminated the possibility of discovering whether firms presenting informatization factors are also able to convert IT investments into cost reductions.

Possibilities for further researches should include replication with a bigger sample and improving the instrument for collecting all critical success factors in the model with greater accuracy.

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