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Abstract

The investments made by companies, from various segments of the economy, in information technology (IT) and information systems (IS) have been increasing worldwide. From these investments, companies seek: greater efficiency, agility and security in their operations, their management of knowledge, and so forth. Nevertheless, being able to demonstrate what benefits arise from such investments has been reported as one of the major organizational challenges. Within this context, there are many research studies on the reasons for organizations failing to achieve productivity gains from investments in IS/IT and most of them have concluded that the problem very often lies in the way that productivity is measured. Frequently, traditional financial techniques are used as tools to support decision making in the process of prioritizing IT/IS. However, IT/IS investments are not of the same nature as other capital investments. The decision to invest in IT/IS should not only consider the financial returns, but above all the strategic gains obtained as a result of making the investment.

Within this scenario, this paper proposes a model to evaluate the efficiency of organizations as IT/IS users, by using the model of Data Envelopment Analysis. With the objective of improving the results from this model, the methods of Balanced Scorecard (BSC) and SMARTS are also used. The BSC is used to set the evaluation attributes by aligning them with organizational strategies and the SMARTS procedure is implemented with the aim of establishing restrictions on the weights of the evaluation attributes. The model proposed was used to evaluate the efficiency of Brazilian companies that invest in IT/IS, and reveals a model that is easy to apply, the results of which are consistent with organizational objectives.

Keywords: IT/IS investments, performance evaluation, Data Envelopment Analysis, strategic alignment.

1 INTRODUCTION AND MOTIVATION

The Information Age, in which wealth is produced from innovative ideas and the intelligent use of information, has led organizations to invest more in Information Systems (IS) and Information Technology (IT), with the goal of creating a competitive advantage given that they are faced with a market which is full of challenges.

Companies increasingly focus on business intelligence, the management of knowledge, the speed and security of their operations and increasing their productivity. This fact can be proved by the growth of companies that use systems such as: Business Intelligence (BI), Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), etc.

According to the International Data Corporation (IDC), the global IT market grew by 8% year on year to more than 1.5 trillion US dollars in 2010. The expectation for this market in 2011 is a growth rate of 7% (IDC 2011). Within this context, Brazil has stood out. It is the country in the BRIC block (Brazil, Russia, India and China), which ranks second in investing in this sector (30 billion US dollars in 2010), according to IDC (2010). Although the Brazilian domestic market shows growth potential in investing regarding small, medium and large companies, Brazilian corporations still invest a percentage (2%) of their turnover in technology which is below the global average rate of 4% (Gartner Group 2010).

Measuring the success of investments in systems and technologies remains a top concern for both practitioners and researchers due to the high investments made, the number of IS/IT failures, and the paradox of high investments and low productivity returns (Urbach et al. 2008). This paradox, known as the "productivity paradox" refers to an important issue that has been debated for almost a decade: whether IS/IT investments contribute to productivity growth. Several approaches that seek to achieve and maximize the benefits from IS/IT investments have evolved under what is known as Benefits Management (BM), which is defined as "organizing and managing IS/IT initiatives so that potential benefits arising from the use of IT are actually realized" (Ward et al. 1996). The question thus arises is: how to assess gains in productivity in relation to investments in IT/IS?

Within this context, it becomes important to design models to assess the real contribution of the investments in this sector for organizations and that take into account the operational, strategic and financial aspects.

This paper sets out to put forward a model to evaluate investments in IT/IS based on the efficiency approach. This model consists of several steps, among which the following stand out:

- Setting the evaluation attributes (criteria) by aligning them with organizational strategies. For this step, the BSC (Balanced Scorecard), proposed by Kaplan and Norton (1992), is used.
- Establishing restrictions on the weights of the evaluation attributes, by using the Swing Weights procedure of the SMARTS (Simple Multiattribute Rating Technique using Swing Weights) developed by Edwards and Barron (1994).
- Evaluating the efficiencies of the alternatives, by means of DEA (Data Envelopment Analysis), originally proposed by Charnes et al. (1978), to which Cooper et al. (2000) and Thanassoulis (2001) made later important contributions.

The model proposed offers two important contributions with regard to the study of the use of systems/technologies by different companies: it allows organizations to conduct a benchmarking analysis so as to improve the results obtained from using these technologies and systems; it supports the decision problem of in what system/technology an organization should invest.

The rest of the paper is organized as follows. First, a brief review of the literature on evaluating IT/IS investments is made. The second section discusses the use of DEA in this type of evaluation. Next, the model proposed is presented. An application of this model, in Brazilian companies in the banking sector, is conducted in the subsequent section. Finally, the contributions and conclusions of this paper are set out.

2 BACKGROUND

2.1 Evaluation of IT/IS investments

Ballantine and Stray (1998) argue that there are two main reasons why evaluating IT/IS investments has become important. The first is that organizations have dedicated large amounts of their resources to such investment. The second is that, with increasing levels of spending on IT/IS and the competitive environment faced by companies, assessing the effectiveness of these technologies has increasingly become of greater concern to them.

A review of the literature reveals there is constant use of traditional financial techniques as tools to support decision making in the process of prioritizing IT/IS. Two of the most sophisticated of these techniques are NPV (Net Present Value) and IRR (Internal Rate of Return). However, IT/IS investments are not of the same nature as other capital investments. Traditional financial evaluation techniques do not allow the inclusion of important and intangible costs and benefits of investing in this segment (Ballatine and Stray 1998, Adelakun and Jennex 2002). In the same way, Kohli and Grover (2008) argue it is necessary to seek indirect and intangible paths to economic value influenced by IT/IS-enabled competencies. They further suggest that IT/IS value research should, as a minimum, contain two types of variables: an IT/IS variable or an IT/IS management variable and an endogenous variable with IT/IS economic impact.

Brynjolfsson and Hitt (1998) made great contributions to evaluating IT/IS investment, when addressing the "productivity paradox". This paradox deals with the apparent contradiction between the remarkable advances in computer power and the relatively low growth of productivity in various sectors of the economy. According to these authors, the problem very often lies in the way that productivity is measured. There are two aspects of productivity that are increasingly important if very accurate measurements are to be taken: outputs (results, expected products) and inputs (investment, consumables). Appropriate measures for outputs should include not only the quantity of products manufactured, but especially the value created – in terms of quality, customization, etc – to customers. Likewise, appropriate measures of inputs include not only hours of work, but also the amount and quality of the equipment used, materials and other resources that are consumed, the training of the workforce, besides the amount of organizational capital required. In addition, for these authors, productivity growth is associated with working smarter. This means work that adopts not only new technologies but also new techniques for production.

Brynjolfsson and Hitt (1998) point out that it is important to note that the greatest benefits of IT/IS investments appear to be realized when these investments are linked to other complementary investments, such as: new strategies, new business processes and new organizations. This change is rarely easy since many organizations will require a painful and time-consuming period of reengineering, restructuring and organizational redesign in order to best utilize their IT/IS investments. However, once these investments in change are made, these companies will be positioned to reap the benefits of continuous technological progress in the computer industry, while others may be left farther and farther behind.

Currently, some authors argue that the debate over IT/IS and productivity has shifted to whether the IT/IS economy has led to permanent improvement in the prospects for economic growth, or whether this has been a temporary phenomenon, with much of the acceleration in productivity being driven by the business cycle and concentrated in just a few sectors of the economy (Gordon 2000, Dedrick et al. 2003).

According to Brynjolfsson (1993), productivity is the fundamental measure of the contribution of technology. Therefore, productivity and, consequently efficiency, are important and appropriate performance measures with which to evaluate investments in IT/IS.

Some authors distinguish between the concepts of productivity and efficiency. For them, productivity is the ratio of what was produced and what was spent to produce it, and efficiency is a relative measure since it compares what has been produced with what could have been produced, given the

resources available. Thus, is only possible to say that a company is more efficient than another when their productivities are compared. In this study, however, no difference is made between productivity and efficiency. In the context of IS/IT, productivity gains are only achieved when the company knows how to take advantage of the resources invested, i.e., is seeking to be more efficient in relation to other organizations.

Currently, it has been verified that some companies have spent vast sums on IT/IS with little benefit, while others have spent similar amounts with tremendous success. Thus, the question is no longer whether technology and information processing systems lead to financial and productivity returns for organizations, but rather how can these tools be best used to maximize the benefits.

The studies on the "productivity paradox" lead to three important conclusions regarding evaluating the benefits from IT/IS investments:

- The benefits, in most cases, are only perceived by analyzing the performance of the organization over a reasonable period of time.
- It is useless to invest very large sums of money in new technologies if there is not a corresponding investment in organizational changes (structure, processes, workforce, etc.).
- It is not coherent to assess investments only with respect to financial returns.

2.2 Using the DEA model to evaluate IT/IS investments

Within the context of evaluating investments in IT/IS, DEA has been widely used. Shafer and Byrd (2000), Sowlati et al. (2005) and Bernroider and Stix (2006) make contributions in this context.

The DEA model consists of an LP (Linear Programming) model to assess the relative efficiency of Decision Making Units (DMUs) such as banks, schools, industries, etc. These DMUs have in common the fact that they convert the same set of inputs into the same set of outputs.

The relative efficiency conferred by the DEA model to a given DMU is defined as the ratio of the weighted sum of output levels to the weighted sum of input levels.

A DMU is defined as efficient (efficiency rate equal to 100%) if no other DMU in the data set can produce more outputs with the same inputs, or the same outputs with fewer inputs (Soteriou and Zenios 1999).

Some of the advantages of using DEA, in relation to the traditional models used in evaluating investments in technology and systems, are the facts of being able to consider various aspects in the evaluation, in addition to using the idea of better utilization of the resources (investments made). The evaluation criteria can be strategic, operational, financial, etc.

One of the greatest limitations when using the DEA model is that the results can only be interpreted in relation to the inputs and outputs included in the model. Different inputs and outputs result in different values for the efficiencies of the alternatives under study. Therefore, inputs and outputs aligned with the strategic objectives of the organization should be used in the model.

It is worth noting that traditional DEA models allow total flexibility regarding the selection of the weights of inputs and outputs, thus providing the maximum efficiency value for some DMUs. This flexibility, while important in identifying inefficient DMUs, means that decision makers' value judgments are not taken into account when defining the weights of inputs and outputs. Decision-makers, on perceiving that their preferences are not being considered, judge the results from the model as being incoherent.

Thus, this article proposes the use of the DEA model to evaluate the efficiency of companies that invest in IT/IS, jointly with the use of more structured methodologies in the steps of defining inputs and outputs (evaluation attributes) and of determining weights for them.

Although, the present study focuses on strategic outcomes, the model proposed allows the use of economic and technical outcomes, since evaluating the performance of organizations that use IT/IS would not be complete without these aspects.

3 THE MODEL PROPOSED

The model that this paper puts forward is presented in Figure 1.

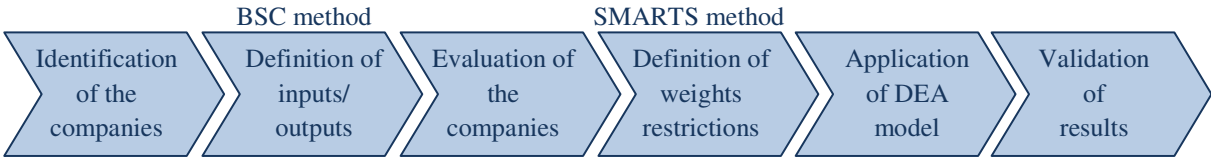

Figure 1. Model proposed for evaluating investments in IT/IS.

The stages of this model are described below:

- Identifying the companies to be evaluated: first, the purpose of evaluating investments in IT/IS should be identified. One of the purposes occurs when a particular company is evaluating the IS or IT available in the market to define which one it will implement. In this case, the investments made by different companies in different IT/IS are compared as are the returns achieved by each of them. The sources of such information will normally be other than the direct competitors themselves. Another possibility is when a certain company already makes use of an IS or an IT and wishes to compare its performance with similar companies that use the same system/technology. This enables companies to identify ways to obtain maximum benefit from these tools, by conducting a benchmarking analysis. In both cases, there is the requirement that the systems and technologies must be used by companies that operate in the same business segment. As already seen previously, the concept of efficiency becomes more appropriate than the concept of productivity when it is associated with the comparison between similar businesses, i.e., those working in the same industry sector, with the same goals, in the same market conditions, using the same resources to produce similar outputs. After having identified the purpose of the evaluation, the companies (users of different systems or of same system) are identified and these are regarded as DMUs in DEA.
- Defining the inputs and outputs: the evaluation attributes are defined at this point. The same inputs and outputs should be considered for evaluating different organizations. The use of BSC is suggested in this stage. More detail will be given below on how the BSC can help this stage.
- Evaluating the companies which are IT/IS users: from the previous stages, each DMU can be evaluated in relation to the attributes considered relevant. This is one of the most complex stages because it is not always easy to quantify the results achieved by virtue of using IT/IS in relation to some attributes that are considered relevant. This step becomes simpler once the metrics, also obtained from the BSC, to evaluate the inputs and outputs have been defined.
- Defining the weights restrictions: in order to define the weights restrictions in the model proposed, the Swing Weights procedure from the SMARTS method is used. This step will also be gone into in greater detail further on.
- Applying the DEA model: the DEA model is applied without taking into account the restrictions defined in the previous step. This stage, although simple, requires, first, choosing the DEA model that best fits the context in which the alternatives are being evaluated. Two models are considered as the classical ones: the CCR or CRS (constant returns to scale) and BCC or VRS (variable returns to scale). The CCR model, originally presented by Charnes et al. (1978), works with constant returns to scale, that is, any variation in the inputs produces a proportional variation in the outputs. The BCC model, due to Banker et al. (1984), considers variable returns to scale. There is also a need to define the type of orientation to be used i.e., if it will be input-oriented or output-oriented. Having obtained the efficiency values, without taking into account the decision maker's value judgments, the values of the weights determined for each input and output will be analyzed, according to the efficiency calculated for each DMU. A DMU will only be considered efficient if in fact it meets the requirements set by the decision maker with respect to the importance of the evaluation attributes.

- Validating the results: the results (efficiency measures), obtained from the DEA model, can be finally validated using traditional statistical techniques such as hypothesis testing and regression analysis. It is also possible to make a comparison with other measures, such as financial measures.

3.1 The use of the BSC for setting the evaluation attributes

To measure the efficiency of companies, who are users of IT/IS, it is necessary to define appropriate evaluation criteria. Criteria that executives find most relevant should be included, and for these, they should provide data or opinions. In this article, the BSC is used to guide the choice of the attributes that will be used to evaluate the efficiencies of each DMU.

The BSC is a method, widely used in the business environment, which includes a collection of measures organized into groups called cards. These groups are related to four major perspectives of management: Financial, Innovation and Learning, Internal Business and the Customer. The measures for these groups are designed to provide executives with information about the performance of their organizations.

This phase of the model can be structured as illustrated in Figure 2.

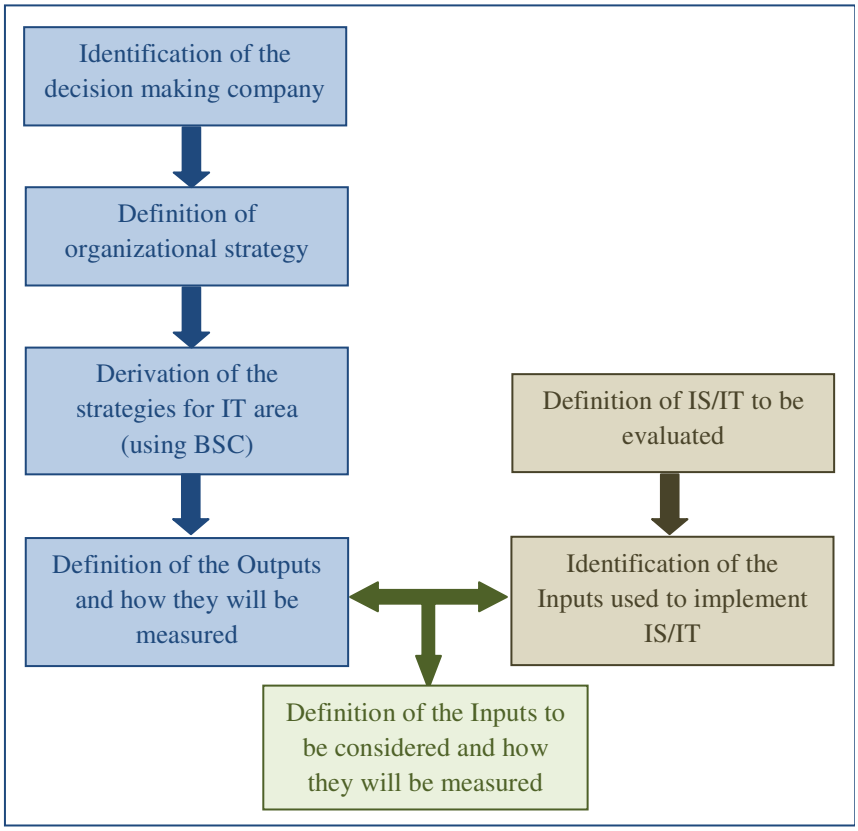

Figure 2. Stage of defining evaluation criteria (inputs and outputs).

The BSC fosters the selection of evaluation criteria aligned with the strategic vision of the organization. In order to do this, companies should present a formal statement of their vision and mission, thus making it easier to derive these by means of a top-down process, for the tactical and operational areas, which make use of IT/IS tools.

In order to apply the BSC, this paper uses as a reference the decision making company – the company interested in evaluating efficiency. The strategic objectives of this company are analyzed in order to obtain measures for the four perspectives with regard to the strategy for the technology area.

When using the BSC, the criteria and measures for evaluating the results obtained from the investments in this sector are defined and interpreted as the outputs of the DEA model. Since these outputs are aligned with the strategies, a more coherent evaluation with management expectations is obtained.

In order to define the inputs to be considered in the model, initially, all resources (material, human, financial, etc.) that have been invested in all organizations to implement technologies and systems, are listed. Then, these inputs are set against the outputs already defined by the BSC in order to assess whether there really is some association between them. For this stage, the statistical technique of regression analysis can be used. There may be cases where the outputs, established by the company decision maker, are not related to inputs used by a company for the implementation of IT/IS. In these situations, the respective inputs are not considered in the model for evaluating efficiency. Thus, the aim is to work with inputs that really influence the company's strategic results.

3.2 Using the Swing Weights procedure of the SMARTS to define the weights restrictions

The SMARTS method is a method of multiattribute utility measurement, which presents a procedure for eliciting weights, known as Swing Weights. The advantage of this procedure is how simple it is a) for the decision maker to respond as required and b) to analyse these responses.

The Swing Weights procedure is divided into two stages. In the first stage, a ranking of the criteria is obtained with regard to their importance to the decision maker, taking into account the evaluations of the alternatives for each criterion. Then, the weights for each criterion are defined.

Based on evaluating the alternatives, in relation to the inputs and outputs, the first step of the Swing Weights procedure may be conducted in order to obtain a ranking of the criteria. That is, a conclusion is reached that a given criterion should have a higher weight than another one. This ranking should be done separately, and take account, on the one hand, of the inputs and on the other, of the outputs.

In the proposed model, only the first step of the Swing Weights procedure will be used. Values for the weights will not be set because, very often, these values, besides being difficult to measure and not entirely capturing the decision makers' preferences, can make the LP problem of the DEA unsolvable. The idea here is to work only with the decision makers' judgments in relation to which evaluation criteria are more important than the other ones. This judgment serves as a reference when evaluating the alternatives.

These judgments are not inserted as direct restrictions on the DEA model. First, the DEA model is applied and then the results are validated considering such requirements as set by the decision making company.

4 APPLICATION AND RESULTS FROM THE DEA MODEL AND THE MODEL PROPOSED

In order to validate the model proposed, this section will be dedicated to an example of applying the model. To do so, information about investments in IT/IS, made by twelve Brazilian banks, will be used. Information regarding this type of investment, made by Brazilian organizations operating in different sectors of the economy, is published annually in a national magazine specializing in computer science – Revista Info Exame. The data published by Revista Info Exame (2003), referring to the year of 2002, included operational, financial and strategic information, which made the data very suitable for the purposes of applying the model.

Banking is the sector that most invests in IT/IS in Brazil. The investments in this sector amounted, in 2002, to around 0.85 billion reais (Info Exame 2003) and, in 2009, to 19.4 billion reais (Febraban 2010). This growth is justified, mainly due the considerable increase in the dependence on bank products and services on such technologies. In order to automate an increasing number of operations and attend to an ever-growing number of customers safely, effectively and in a personalised way, banks have directed many of their resources to purchasing new systems and technologies.

Since the twelve banks (DMUs) invest in different combinations of systems and technologies, such assessment could be motivated by a banking company which is deciding on what system/technology to invest in. Therefore, it may use, as a reference, the assessment of the efficiency of companies that make use of these tools. This company may even be part of the set of the DMUs which are being analyzed and, in this situation, it would be evaluating, depending on the results obtained from the model proposed, the possibility of changing system, technology or supplier, or even improving the advantage these bring, by increasing its investments in IT/IS.

The stage of defining the inputs and outputs moved on to the guidance suggested in Figure 2, which formalizes the process of defining the evaluation attributes, by applying the BSC and some statistical tools.

After having defined the company interested in the evaluation of DMUs, its organizational strategies are identified as are its plans which it sets out for itself for the area of IT/IS. From this standpoint, and in accordance with the four BSC perspectives, four outputs and one input, for example, can be defined. The outputs used were: turnover in 2002 (in millions of US dollars), storage capacity (in terabytes), number of business transactions performed through the internet and percentage of administration conducted through the intranet. As to inputs, only the investment in IT/IS in the year of 2002 (in millions of US dollars) was considered. Other inputs could have been employed, since not only financial resources are required for implementing systems or using new technologies. However, since the main purpose of this paper is to propose a model for evaluating investments in IT/IS, some stages of the application were simplified.

Is important, in this stage, to check whether or not there is a causal relationship between the variables of input and output. To do so, regression analysis can be used. Figures 3 and 4 present the graphs of linear regression analysis for the output of turnover and the output of storage capacity in relation to the input of investment in IT/IS.

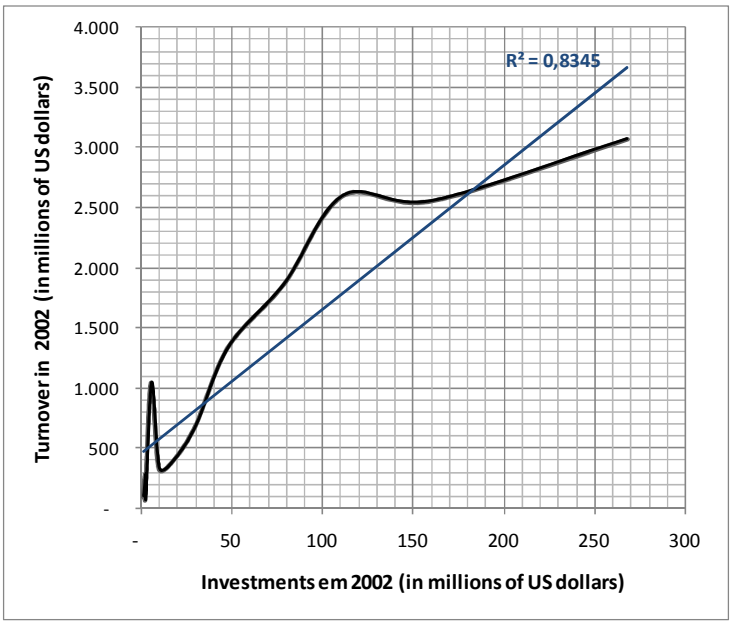

Figure 3. *Graph of regression analysis for the output of turnover and the input of investment in 2002.*

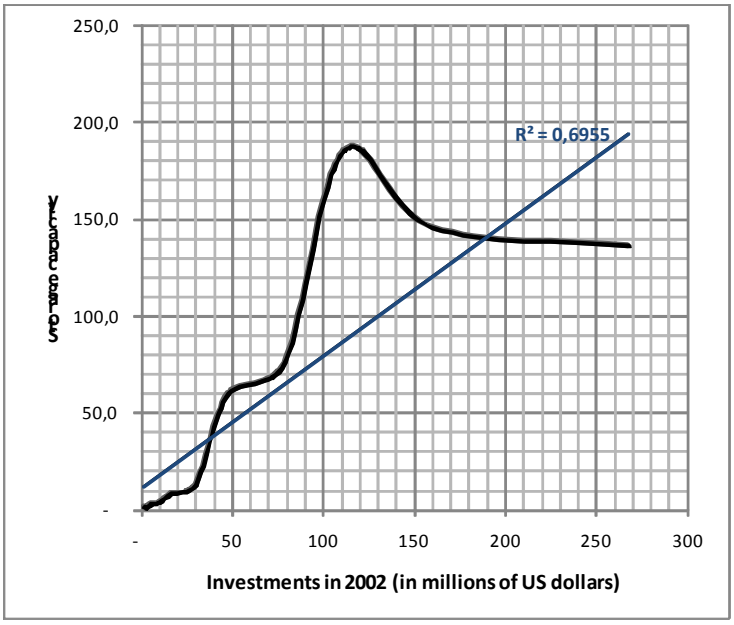

Figure 4. *Graph of regression analysis for the output of storage capacity and the input of investment in 2002.*

It can be concluded, from the coefficients of determination (R^2), calculated for each regression, that there is a significant linear relationship between these outputs and the input. A similar analysis can be carried out for the other outputs.

If, on the one hand, a model with many variables can result in an extremely benevolent assessment with several efficient DMUs (Gomes et al. 2009), on the other, the values of the efficiencies cannot be estimated correctly if the data do not contain a sufficient number of DMUs (Bendoly et al. 2009). Some authors suggest that the number of DMUs should be greater than the product of the number of inputs and outputs (Soteriou and Zenios 1998), or three times the sum of inputs and outputs (Chen and Zhu 2004). For Dyson et al. (2001), the number of DMUs should be at least twice the product of the number of inputs and the number of outputs, in order to reach a reasonable level of discrimination. Therefore, having a set of twelve DMUs, one input and four outputs, meets the rules proposed by these authors.

4.1 Definition of the weights restrictions

At this stage, the decision making company should express its value judgments in relation to the evaluation criteria. A ranking of the outputs considered will therefore be made in relation to their importance. To do so, based on the proposed model, the Swing Weights procedure will be used. Because there is only one input in this analysis, such judgment in relation to this will not be needed.

As a result of applying the Swing Weights procedure, the conclusion can be reached, for example, that the weight of the output of "revenue in 2002" (Output1) is greater than the weight of the output of "number of business transactions performed through the internet" (Output 3), which, in turn, is greater than the weight of the "storage capacity" (Output 2), and greater than the weight of the "percentage of administration conducted through the intranet" (Output 4).

4.2 Results from the DEA model and the model proposed

The BCC DEA model will be used for the application proposed, since in this case there is no evidence that there is proportionality between inputs and outputs. Hollingsworth and Smith (2003) further explain that the BCC formulation is more appropriate when inputs or outputs include ratio variables.

Starting from the assumption that organizations increasingly seek the efficiency of investments made in TI/SI, by achieving benefits which incur the least expenditure of resources, this paper will work with the orientation to inputs.

On applying the BCC DEA model oriented to inputs, without any restriction on the weights of the outputs, the efficiencies for each DMU is obtained, and these are presented in Table 1.

	Efficiency
DMU1	1.0000
DMU2	1.0000
DMU3	0.5161
DMU4	1.0000
DMU5	1.0000
DMU6	0.4726
DMU7	0.3297
DMU8	0.7951
DMU9	1.0000
DMU10	1.0000
DMU11	1.0000
DMU12	1.0000

Table 1. Efficiencies of DMUs.

The weights of the outputs, also obtained from the DEA model, are presented in Table 2.

	Weight of Output 1	Weight of Output 2	Weight of Output 3	Weight of Output 4
DMU1	0.00	0.00	0.65	0.00
DMU2	0.38	0.00	0.18	0.02
DMU3	0.00	0.01	0.00	0.00
DMU4	0.17	0.01	0.09	0.00
DMU5	0.00	0.00	0.00	0.57
DMU6	0.00	0.56	0.04	0.29
DMU7	0.03	0.23	0.00	0.00
DMU8	0.02	0.14	0.04	0.00
DMU9	0.10	0.00	0.00	0.06
DMU10	0.00	0.07	0.00	0.00
DMU11	0.15	0.00	0.00	0.03
DMU12	0.16	0.00	0.00	0.02

Table 2. Weights of the outputs.

On analyzing the weights presented in Table 2 it can be seen that only DMU4 meets the decision maker's value judgments that the weight of output1 > weight of output 3 > weight of output 2 > weight of output 4. Therefore, as a result of applying the proposed model, it can be concluded that only DMU4 is efficient, given the preferences of the company interested in the assessment.

As can be observed, the model proposed is applied using data from organizations that made investments in IT/IS and the results obtained can support organizations in the decision process of prioritizing IT/IS investments for the future. Thus, the benchmark that a Brazilian bank would take in the process of deciding on what systems and technologies to invest in is the organization represented by DMU 4. This organization, when compared to the other organizations evaluated, presented the best results (economic, technical and strategic) given the investments made.

Although this application may well be important for a better understanding of the model proposed, this is not the main contribution of this paper which is to propose a model for evaluating investments in IT/IS by using efficiency measures.

5 CONCLUSIONS AND LIMITATIONS

This paper makes a contribution to the field of IT/IS performance measurement by proposing a model to assess the efficiency of organizations which are users of IT/IS. This model combines the DEA model with the BSC and SMARTS methods, which allows more coherent results to be obtained with respect to organizational objectives and values. It can be used by companies who wish to assess the efficiency of similar companies that invest in IT/IS, in order to decide in what system or technology to invest or to conduct a benchmarking analysis.

The BSC enables an alignment between the evaluation criteria and the organizational strategic goals, in the step of defining the inputs and outputs of the DEA model. Establishing the forms of measurement for the criteria was also possible by means of this method.

By using the Swing Weights procedure of SMARTS, it was possible to consider the preferences, with respect to the importance of the evaluation criteria of the company interested in evaluating efficiency. Therefore, a greater distinction was obtained between the alternatives that are efficient only because of flexibility in choosing the weights of the inputs and outputs, and the alternatives that are efficient in effect, by considering the ranking established for the weights. In the case study, initially eight DMUs were evaluated as efficient. However, only one of them satisfied the value judgment of the decision making company with respect to the weights of the outputs.

The use of this model, in assessing the efficiency of Brazilian banks which use IT/IS, allowed the particularities of some of its stages to be visualized. Its advantages over other models, used for the same purpose, are: simultaneous consideration of both financial, operational and strategic aspects in the evaluation; incorporating into the model the value judgments of the company interested in the evaluation; establishing the evaluation criteria aligned with the business strategy; simplicity of use; it being easy to understand the results obtained; and to support the decision regarding in what system/technology to invest.

One of the limitations of the model proposed is the fact that, in some situations, there is no DMU that is simultaneously efficient and meets the preferences with respect to the ranking of the criteria weights. Thus, for future research, it is suggested a study be made of other ways of setting restrictions on weights, which can be incorporated into the DEA model without, however, making the problem one that can have no solution.

One of the conclusions of the “productivity paradox” is that the benefits, in most cases, are only perceived after analyzing the performance of the organization over a reasonable period of time. So it is also suggested that further research take this into consideration and work with data of different periods.

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