African Journal of Business Management Vol.6 (5), pp. 1872-1882,8 February, 2012
Available online at http://www.academicjournals.org/AJBM
DOI: 10.5897/AJBM11.1474
ISSN 1993-8233 ©2012 Academic Journals

Full Length Research Paper

Performance evaluation in research and development, intellectual capital, and firm infrastructure projects as intangible assets

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Accepted 26 August, 2011

The purpose of this study is to measure the performance of software development teams with the data envelopment analysis. In the measurement process, multiple input and output from research and development, intellectual capital and firm infrastructure projects as intangible assets with many different aspects were taken into consideration and performance was evaluated. The data were obtained from an application development center, year 2009 human resources database. For the evaluation, year 2009 Application Development Annual Report, demands met with services and customer satisfaction survey results were used. Administrative staff, customer satisfaction, actualized demand, programming errors and omissions were determined in relation to team costs and important conclusions were reached.

Key words: Research and development, intellectual capital, infrastructure, performance, performance evaluation, data envelopment analysis.

INTRODUCTION

Advances in science and technology have brought the use of information concept in companies to the foreground (Ghalayini et al., 1996). Increasing science and technology prominence has accelerated competition among companies. For this reason, survival of companies in a competitive environment will directly be proportional to the importance they place on science and technology. This situation forces companies to invest not only on financial assets but also on non-financial assets such as intellectual capital.

Competitive advantage in an information economy depends on companies' intellectual capital and infrastructural assets and how these are governed besides financial assets. It is obvious that today, intangible assets such as technical information, customer loyalty, ability and innovation are used in institutions to provide competitive advantage rather than firms using resources such as raw materials, capital and machines as they did in the past. Especially in technology based enterprises, employers are evaluated by the intellectual capital they add/bring to the company.

The main duty of intellectual capital in companies is to conduct company objectives, tasks and responsibilities in the best possible and most successful way. The deterministic factor on the subject of what is best and most successful is the result of a company's performance. Evaluations used until today are based on only financial indicators and it has been realized that these are insufficient in properly measuring a company's performance. With the increasing importance of research and development each passing day, companies should expand their effective management conceptions to include non-financial assets together with high-valued, possessed intellectual capital and infrastructural assets. Therefore, in information society, it became unavoidable to use infrastructural assets and managerial abilities in performance evaluations.

Moreover, for work performance and performance

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evaluation, performance management is of great importance in the evaluating research and development, intellectual capital and firm infrastructure projects as intangible assets.

This study is significant in emphasizing and attracting care on performance evaluation in software development teams. To show the significance of the study, comparative performance evaluation in software teams was actualized by using data envelopment analysis.

LITERATURE OVERVIEW

In literature, there are various studies and researches related to the subjects of work performance, performance evaluation, performance management, research and development, intellectual capital and firm infrastructure concepts as intangible assets. Performance can be defined as a measure of output determinant on achieving objectives with resources used in the production of outputs, level of reaching a certain target, productivity and effectiveness of an activity intended for a goal (Ağca, 2005).

The concept of performance is uttered together with the concepts of efficiency, effectiveness and productivity. Efficiency is the expression of how resources are used to produce beneficial output. It is the value found by the comparison of inputs to standards. Effectiveness is defined as the level of achieving objectives and is calculated by the proportion of realized outputs to the planned output (Eren, 2003). Productivity is the relation between output that a production or service system generates and input used to produce this output. Therefore, productivity is the effective use of resources in the production of goods and services. Effectiveness is a concept related with output however, efficiency is a concept related with the usage of resources. Efficiency is the obtainment of the best output. On the otherhand, efficiency is to do the right thing at the right time. Efficiency and effectiveness create productivity (Eren, 2003).

Gulliyes (1997), and Louis and Bestor (2000) pointed out that performance is not absolute as it carries different meanings from different points of processes and performance is a multidimensional concept that cannot be summed up with only one index as there are relations between performance parameters that are not independent.

Performance evaluation is defined as the process of determining efficiency and productivity of the methods applied to achieve set objectives. Performance evaluation system can also be expressed as all the indicators that measure productivity and efficiency activities in a company. A properly designed performance evaluation system is the basis for an effective performance management system that will be used as a managerial tool at strategic, tactical and operational levels. For the measurement of performance, objectives, proper performance indicators and standards should be seen to give opportunity to comparative and fair valuation; and after data from these criteria are collected, the measurement process should be operated with these data (Ağca, 2005).

An accurate performance evaluation method provides the chance to form a basis for determination and application of effective strategies in institutions, for guiding worker behaviors and for valuation of managerial efficiency (Bakioğlu, 2001).

Early studies on performance evaluation were actualized by Chatfield (1971) and Johnson (1972, 1975, 1978, 1981). These authors chose to explain performance evaluation parallel to improvements in cost and scope of operation. In recent researches, it is stated that traditional performance evaluation methods have been insufficient and companies should search for new techniques (Walker, 1996; Garret and Macdonald, 2001; Stone, 1996; Otley, 1999). In these studies, it is embodied that institutions use financial indicators excessively in performance evaluation (Kabatepe, 2006).

With the aim of eliminating constraints resulting from the use of financial indicators and evaluating a company's performance more accurately, Kaplan and Norton in the year 1992 provided an interactive application that lasted one year and to which managers had attended and as a result, produced a new method called Balanced Scorecard in which non-financial criteria are used besides financial criteria (Tekeli, 2003). The Balanced Scorecard method has been accepted as a crucial revolutionary advance in performance evaluation literature by many academicians (Frigo and Krumwiede, 2000; Malmi, 2001; Pineno, 2002; Zelman et al., 2003; De Eaal, 2003).

Until recently, studies related to performance evaluation were generally focused on commercial enterprises. On the other hand, in the past, a considerable rise was observed in the number of researches and publications on performance evaluation in non-profit organizations such as non-governmental organizations and public bodies (Tekeli, 2003).

RESEARCH AND DEVELOPMENT, INTELLECTUAL CAPITAL AND INFRASTRUCTURE

Thoughts and approaches to performance evaluation in firms proceed as dynamic growth continuously changes and improves from past to present. Throughout this process, it is seen that new performance mentalities had emanated and come into prominence. This improvement process is explained as passing notions that give weight to new and various performance dimensions such as customer satisfaction, employee satisfaction, quality and innovation besides low cost, maximum production and high profit (Akal, 2005: 5). In this new process, firms

place special importance on intellectual capital, research and development.

Research and development (R&D)

R&D is a systematic and creative work oriented to discover new products and production processes in institutions/companies. R&D involves regular works performed for gathering new information to improve science and technology, for producing new materials, products and tools with existing knowledge, for constructing new systems, processes and services including software production, and for improving existing ones (TOBB, 2004). It is possible to define R&D as endeavors organized for product and process innovation and increasing scientific knowledge.

Research can be divided into two groups: basic and applied. The important thing in research is to make concrete contributions to the improvement of existing applications (Eren, 2003). Development function in institutions entails the usage of basic and applied research results with the aim of discovering all kinds of beneficial materials, tools, products, systems, production processes and improving existing ones (Tuncer, 1974).

R&D in software development

In naming software development activities as R&D, it must be dependent on a scientific and/or technological improvement to be concluded and the aim of the project must be to provide a systematic solution to any scientific and/or technological uncertainty (Frascati Guide, 2002).

The structure of software development process makes R&D components more difficult to define even if it is not impossible. If software development components of projects lead to an improvement in the area of computer software, they can be classified as R&D. Examples presented thus display R&D concept in the software area (Frascati Guide, 2002):

i. R&D studies developing new theorems and algorithms in the area of theoretical computer sciences.
ii. Improving information technology by operating systems, programming languages, data management, communication software and software development tools.
iii. Improvements in internet technology.
iv. Researches related to software design, development, setting and protection.
v. Software development efforts that achieve improvements by generic approaches in data research, transfer, storage, return, manipulation and display
vi. Experimental development works that aim at filling the gaps in information technology which is necessary to develop a software program or system
vii. R&D image processing, geographical data presentation, character definition, artificial intelligence etc. developed on software tools and technology; one of the computer software expertise branches

Performance indicators of R&D

Performance indicators of research and development activities can be classified under these titles (Kabatepe, 2006):

i. Structural elements oriented
ii. Process factors oriented
iii. Output factors oriented

Another way of classifying performance indicators of research and development is grouping them by their business factors:

i. Strategic management based
ii. Production management based
iii. Marketing management based
iv. Financial management based

Intellectual capital

While intellectual is defined as ‘belonging to or performed by rational and cleverly thinking’ in dictionaries, capital is expressed as ‘defined good stock’. Hence, intellectual capital can be defined as ‘consideration and accumulation capacity’ in spoken language (Arıkboğa, 2003).

In the improving information economy, it is accepted that intellectual capital in the organizational sense firstly came into question from an article ‘Brain Power’ written by Thomas Stewart in June 1991. In this article, intellectual capital is defined as ‘total knowledge of a company’s employers that supplies the company competitive advantage in the market’. Other definitions of intellectual capital by Stewart can be summarized as ‘accumulation of knowledge and know-how as the source of invention and innovation’ and ‘abilities, skills and expertise embedded in human brains’. In his book, Intellectual Capital: The New Wealth of Organizations’ published in 1997, Stewart defined intellectual capital in its broadest sense as ‘obtained useful knowledge’ and denoted that it includes organization’s processes, technologies, patents, management skills, information about customers, suppliers and other interested parties.
Another comprehensive definition is made by Annie Brooking. According to Brooking, as it is also affirmed in her article published in year 2000, intellectual capital is the ‘total of the nonfinancial assets that supply maintenance of the organizational activities’. From the point of accounting, it is the difference between book value and market value.

Fundamental to intellectual capital management is direct

Table 1. Components of structural capital.

Intellectual property element	Infrastructure element
Patent	Management philosophy
Copyright	Business culture
Design right	Management processes
Trade secret	Information systems
Trade mark	Network information systems
Service mark	Financial relations

Source: Yalama (2005). Entellektüel Sermayenin Entellektüel Katma Değer Katsayısı ile Ölçülmesi ve Veri Zarflama Analizi Yöntemi Kullanılarak Karlılığa Etkisinin Sınanması. p. 52.

convergence of knowledge (raw material) into something valuable (information product) for the company. Knowledge and abilities of an individual can possibly create an inward value for him without 'convergence' or 'reinforcement', but in this wise, it will remain as a disused hidden organizational source. Once the knowledge of an individual is started to be used and shared for creating an organizational value, this value added 'product' now becomes one part of intellectual capital (Demirkol, 2006).

Intellectual capital is more than a static asset; it is a dynamic factor that creates value when it is applied for company needs. This includes organization's processes, technologies, patents, management skills and information about customers, suppliers and other interested parties. The thing just remains in files, databases or on papers as neither data nor information. Intellectual capital consists of ideas put into practice and necessary for determining what is supported to be protected for the design and maintenance of a company's activities (Demirkol, 2006). A company's better functioning displays its performance and competitive advantage.

Components of intellectual capital

Components that constitute intellectual capital can be considered in many different aspects such as human capital, structural capital, relationship capital, customer capital, competitive capital, social capital, supply source capital, society capital, regulatory capital, and contract capital. The main reason for this variety is the difference in the point of view and in the approaches of people who make classification.

A model was constructed by Edvinsson (Skandia), Onge (The Mutual Group) and Petrash (Dow Chemical), and it was named Value Platform (Demirkol, 2006). This model explains the relation between three main kinds of intellectual capital. The aim of Vale Platform is to intensify the relation between assets for maximizing value area, that is, the intersection of intellectual assets. For this model, intellectual capital is composed of three main elements: human capital, structural capital and customer capital.

Human capital is the value of knowledge, abilities and experiences of company employees and it is the main sources of organizational innovation and renewal process. According to Luthy, human capital is the human himself. For this reason, organizations cannot own human capital, can just rent it. So when employees quit the company, human capital, too, quits the company.

American Nobel prized Economist, Theodore W. Schultz, defined human capital as workforce, land, capital, action of increasing welfare and life quality of poor people; improving knowledge. Human capital is the total human ability that was brought together to solve business problems (Yalama, 2005). Know-how, education, job-oriented features, business related information, business evaluation, business related competition, entrepreneurship strength, innovation, pre-process and post-process comprehension ability; changeability can be counted as the assortments of intellectual capital (Yalama, 2005).

Structural capital

Structural capital can be defined as 'what employees leave back to the organization when they go home at night' (Yalama, 2005). Structural capital totally belongs to the company. It can be reproduced and shared (Table 1).

Customer capital

Customer capital is the information channels, customer choices and tendencies, and competitive intelligence. It contains relations with existed customers, customer loyalty to the company and moreover organization's outside ties such as supplier relations. Customer capital may not be limited with organizational capital (TOBB, 2004).

Every company that has customers also has customer capital. Hubert Saint- Onge defined customer capital as the worth of a company's name, worth of company's ongoing relations with other organizations and customers with whom it actualizes its sales. Among the three elements of intellectual capital, the one with the most definite value is customers (Table 2). Customer capital is evaluated by the indicators such as market share that reflects it, ratios of keeping and losing customers, profitability per customer (TOBB, 2004).

Intellectual capital and infrastructural assets

Supportive infrastructure forms, directs, and capacitates human capital, constructs an organization's structural capital with all its prospects and dimensions. This situation can also be named as corporate organizational abilities. Even if some kind of differences can be

Table 2. Components of customer capital.

Component
Marks
Customers
Customer loyalty
License agreements
Useful agreements
Franchising agreements

Source: Yalama (2005).

observed in organizations' characteristics, an organization's structural capital is compounded of these infrastructural assets (Kanibir, 2004):

1. Management philosophy
2. Business culture
3. Management processes
4. Information systems
5. Network systems
6. Financial relations

Effects of intellectual capital on organizational performance

Structural capital is the mechanism that on one side inspires the potential lying in human capital and on the other side, transforms knowledge that was gathered as a result of relational capital to the values (Kanibir, 2004).

Intellectual capital, that is, the result of analysis made on factors that will push organizational performance to the highest level, emphasizes that instead of 'brain power of the management echelon' that is a product of traditional view, 'brain power of all organization members' should be taken as the basis and all structures and processes should be redesigned in this frame. Organizations can reveal their members' mental abilities together with their professional skills and not only encouraging and strengthening them (Kanibir, 2004).

DATA ENVELOPMENT ANALYSIS (DEA)

Performance evaluation application in software development teams

Service/product companies invest in their research and development activities, intellectual capital and infrastructural assets in order to increase their competitive strength. They need to evaluate performance of these properties to see the results of their investments. The objective of this study is to evaluate investments made on software development teams and to evaluate performance actualized by the assets as a response to investments.

This research was carried out at Fintek Co., a firm that operates in the information technology industry. Fintek Co. was founded in year 2001 as a subsidiary of T.R. Ziraat Bank. Its headquarters is located in Ankara and it has a branch in Istanbul. Fintek Co. supplies information technology management and consulting services for Ziraat Bank.

Fintek Co. provides software development services for Ziraat Bank through Application Development Center (ADC) which belongs to its structure. The organizational structure of ADC was designed to be parallel to the organizational structure of the bank's business units. Demand is derived from the 'service' units founded as a counter to the bank's business units. ADC consists of 16 service units.

For the performance evaluation of the software development team in Fintek Co., a model was formulated and the comparative performances of teams were put forward starting from team needs. Inefficient teams were determined and suggestions were offered for their betterment.

Assumptions

1. Demand, software desires made to Fintek Co. through ADC from Ziraat Bank are certain.
2. Arriving demands are served by windows-based, web-based or database application.
3. It is assumed that software necessities are homogeneous in DEA application.

With DEA application, inefficient decision units are determined and objectives are set for them to increase their performances. It is accepted that these units can reach other comparatively efficient units' efficiency level by applying other methods.

Data collection

Team and employee data were obtained from the 2009 Human Resource Database of Fintek Co. ADC. In addition, the 2009 Application Development Activity Report and demand for services were taken into consideration. In the same report, defects emerged on applications and programming insufficiency percentages were determined. Customer Satisfaction Survey results of Ziraat Bank for year 2009 were also used.

APPLICATION OF DATA ENVELOPMENT ANALYSIS

DEA is a linear programming based technique that measures comparative performance of decision units in the situations that comparisons become more difficult because of inputs and outputs measured by different and more than one scales or in different measurement units. In DEA, comparative efficiency of a decision unit is defined as the ratio of total weighted outputs to total weighted inputs and can also be called 'technical efficiency'.

The most important problem encountered in the calculation of technical efficiency is how to give weight to inputs and outputs where there are more than one input and/or output. DEA provides every decision unit the chance of giving weight to inputs and outputs as wished under the constraints of no negative valued weight and no decision unit efficiency below one when it is applied to other decision units included in the analysis. DEA assumes that every decision unit chooses its inputs and outputs as maximizing its efficiency level (Onaran, 2006; p. 20).

DEA can be divided into two models; 'input oriented' and 'output oriented'. Input and output oriented DEA models are very similar however, while input oriented DEA models search how the most appropriate input composition must be to produce a determined output composition in the most efficient way, output oriented DEA models search how much output composition can be produced at most with a determined input synthesis (Onaran, 2006; p. 22).

In this study, output oriented DEA model was used. The general formulation of this model is given thus:

$$Ek = Maks\beta + (\varepsilon \sum_{i=1}^{m} Si) + (\varepsilon \sum_{r=1}^{t} Sr) \quad (1)$$

$$\sum_{j=0}^{n} Xij\lambda j + Si - Xik = 0 \quad (2)$$

$$\sum_{j=1}^{n} Yrj\lambda j + Sj - (\beta Yrk) = 0 \quad (3)$$

$\lambda j, Si, Sj \geq 0 \quad i = 1, \ldots, m ; r = 1,\ldots,t$

where; E_k, Efficiency of decision unit k; β, expansion coefficient of the output; ε , sufficiently small positive number; S_i, residual value belonging to i^{th} input of decision unit k; S_r, residual value belonging to r^{th} output of decision unit k; X_{ij}, quantity of input i used by j^{th} decision unit; λ_j, intensity value of j^{th} decision unit; Y_{rj}, quantity of output r produced by j^{th} decision unit; n , number of decision units; t, Quantity of output; m, quantity of input.

To solve DEA problems, DEA Solver Program Version 1.0 was used. DEA Solver is a macro application that works by integration with Microsoft Excel program. For the application of DEA the following steps should be completed respectively:

1. Selection of decision units
2. Determination of inputs and outputs
3. Ascertainment of efficiency levels
4. Obtainment of potential improvement values for inefficient decision units
5. Evaluation of results

Selection of decision units

As the first process of DEA, similar decision units in which same decisions are taken were chosen for the ease of comparison.

In the linear programming model and for the validity of research, it is accepted as a constraint that there must be at least m+p+1 decision units for m input and p output. The number of decision units involved in the research was limited to be at least two times the total number of variables.

In the second process of the constructed model, because 4 inputs and 3 outputs were used, the number of decision units was decided to be at least 8 (number of inputs + number of outputs + 1 that is, 4 + 3 + 1 = 8). In this research, 16 Software Development Teams were used as decision units (Table 3).

Determination of inputs and outputs

Inputs and outputs in the research formed the basis for the comparison of decision units. Inputs and outputs were determined depending on the production process. Every input and output in the model is a proportion belonging to one software development team.

Inputs of the model (I) are: (PN), Proportion of personnel number in ADC; (ITC), percentage of personnel possessing information technology certificate in the team; (TC), percentage of team cost in ADC costs; (AP), percentage of administrative personnel in the team.

Outputs of the model (O): (CS), Customer satisfaction percentage; (ST), ratio of demand made by the team to ADC demand; (EI), programmatic error or insufficiency ratio on demand responses.

Input and output values determined for each software development team are calculated and presented in Table 4.

Ascertainment of efficiency levels

Efficiency levels are summarized in Table 5. These were obtained by solving for values in Table 4 with the DEA Solver Program. Teams with an efficiency coefficient of '1' were considered efficient. According to the efficiency table, it was seen that internet banking, card payment systems, KMH and TOKI housing loans and CCB applications, risk management, core banking and investment teams are efficient units. Teams with an efficiency coefficient of '<1' were considered as inefficient. Comments should be interpreted thus:

When Corporate Loans Software Development Team (SDT) was examined, it was realized that its efficiency degree is 0.950001. This value reveals that this team is inefficient compared with other teams and to make it efficient, its output should be increased by 5.2634% (1 – 0.950001) / 0, 950001 = 0.0526304) not by changing its input level.

Obtainment of potential improvement values

Potential improvement values were calculated for each of the 9 SDT whose inefficiencies were detected in the

Table 3. Decision units: ADC software development teams.

S/No.	Software development team
1	Analytical banking
2	Unit applications
3	Applications of foreign exchange transactions
4	Foreign trade and treasury
5	Internet banking
6	Card payment systems
7	KMH and TOKI housing loans and CCB applications
8	Enterprise content management
9	Corporate loans
10	Cash management payments
11	Cash management collections
12	Reporting intranet applications
13	Risk management
14	Telephone banking
15	Core banking
16	Investment

Table 4. SDT (software development teams) input and output values.

Decision unit / Input and output	(I)PS	(I)BS	(I)TM	(I)YP	(O)MM	(O)PT	(O)HA
Analytical banking	0.0497	0.2222	0.0504	0.3333	0.82	0.0419	-0.0673
Unit applications	0.0718	0.3077	0.0687	0.2308	0.77	0.0351	-0.0772
Applications of foreign exchange transactions	0.0608	0.2727	0.0593	0.2727	0.79	0.04	-0.0481
Foreign trade and treasury	0.0442	0.25	0.0516	0.375	0.86	0.053	-0.0783
Internet banking	0.0442	0.25	0.0464	0.375	0.87	0.032	-0.0275
Card payment systems	0.116	0.1905	0.1028	0.1905	0.83	0.1188	-0.0373
KMH and TOKI housing loans and CCB applications	0.0718	0.1538	0.0698	0.2308	0.93	0.0677	-0.0673
Enterprise content management	0.0497	0.1111	0.0434	0.2222	0.81	0.0394	-0.0573
Corporate loans	0.0829	0.2	0.0882	0.3333	0.7	0.1022	-0.1172
Cash management payments	0.0552	0.2	0.0606	0.3	0.81	0.0548	-0.0441
Cash management collections	0.0608	0.2727	0.0577	0.2727	0.69	0.0653	-0.0941
Reporting intranet applications	0.0608	0.1818	0.0591	0.2727	0.86	0.0493	-0.0543
Risk management	0.0331	0.1667	0.0379	0.5	0.87	0.04	-0.0355
Telephone banking	0.0497	0.2222	0.0528	0.3333	0.8	0.0517	-0.0713
Core banking	0.0884	0.1875	0.0863	0.1875	0.81	0.1115	-0.0438
Investment	0.0608	0.2727	0.065	0.2727	0.9	0.0973	-0.0794

research and is shown in Table 6. The most significant benefit of applying DEA is that it sets reachable objectives for the improvement of inefficient decision units. It is assumed that inefficient decision units can reach the same efficiency level of comparatively efficient units by applying other methods.

Evaluation of results

Appendix 1 shows the differences in existing and expected values, and potential improvement values. By examining these ratios, it is possible to make an evaluation on the value of improvement ratio needed by which efficiency of inefficient decision units can be increased. If (TC): 7.13% decrease in team costs, (AP): 37.62% decrease in the administrative personnel ratio, (CS): 17.88% increase in the customer satisfaction ratio, (ST): 5.26% increase in supplied demand ratio and (EI): 58.16% decrease in programmatic error or insufficiency ratio: are provided, corporate loans team can be efficient.

Especially in institutions that are knowledge-based, R&D activities, intellectual capital, infrastructure assets are strategic assets that should be included among priority issues. These assets play an important role in the

Table 5. SDT efficiency levels.

SDT	Level
Analytical banking	0.938911
Unit applications	0.832309
Applications of foreign exchange transactions	0.881638
Foreign trade and treasury	0.995835
Internet banking	1
Card payment systems	1
KMH and TOKI housing loans and CCB applications	1
Enterprise content management	1
Corporate loans	0.950001
Cash management payments	0.948636
Cash management collections	0.829967
Reporting intranet applications	0.960466
Risk management	1
Telephone banking	0.915973
Core banking	1
Investment	1

realization of enterprises' long-term goals. For this reason, interest should be shown in intangible assets in addition to a company's financial and physical management.

Performance evaluation of intellectual capital assets has become critically important in companies. The goal of performance evaluation systems in organizations is to facilitate fulfillment of strategies, encourage managers and employees to achieve organizational goals and objectives, determine the level of reaching objectives and ensure taking corrective precautions.

Intense rivalry experienced recently has forced institutions to utilize resources in the most efficient way and to comparatively evaluate their performances in a competitive environment so as to determine institutions/ groups that they should take as references within the boundaries of efficiency. At this point, DEA, a method supplying an opportunity of examining too many variables interacting with each others can be used as a decision tool.

The results of the analysis show that more than half of the teams cannot reach efficiency frontiers and potential improvement ratios were obtained thus forming references for these teams to be efficient. These results can be helpful for managerial decision taking.

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APPENDIX

Appendix 1. SDT potential improvement values.

SDT Input (I) / Output (O)	Existing efficiency degree	Expected efficiency degree	Difference	%
Analytical banking	0.938911			
PN	0.049724	0.049724	0	0.00
ITC	0.222222	0.207808	-0.014414	-6.49
TC	0.050386	0.050386	0	0.00
AP	0.333333	0.333333	0	0.00
CS	0.82	0.873352	0.053352	6.51
ST	0.041872	0.044596	0	0.00
EI	-0.0673	-0.043007	0.024293	36.10
Unit applications	0.832309			
PN	0.071823	0.070889	0	0.00
ITC	0.307692	0.152389	-0.155304	-50.47
TC	0.068718	0.068718	0	0.00
AP	0.230769	0.230769	0	0.00
CS	0.77	0.925137	0.155137	20.15
ST	0.035099	0.066536	0.031437	89.57
EI	-0.0772	-0.066814	0.010386	13.45
Applications of foreign exchange transactions	0.881638			
PN	0.060773	0.06062	0	0.00
ITC	0.272727	0.176876	-0.095851	-35.15
TC	0.059294	0.059294	0	0.00
AP	0.272727	0.272727	0	0.00
CS	0.79	0.896059	0.106059	13.43
ST	0.040025	0.053283	0.013258	33.12
EI	-0.0481	-0.054073	-0.005973	-12.42
Foreign trade and treasury	0.995835			
PN	0.044199	0.044199	0	0.00
ITC	0.25	0.184454	-0.065546	-26.22
TC	0.051599	0.046153	-0.005446	-10.55
AP	0.375	0.375	0	0.00
CS	0.86	0.863597	0	0.00
ST	0.052956	0.053177	0	0.00
EI	-0.0783	-0.050526	0.027774	35.47
Internet banking	1			
PN	0.044199	0.044199	0	0.00
ITC	0.25	0.25	0	0.00
TC	0.046397	0.046397	0	0.00
AP	0.375	0.375	0	0.00
CS	0.87	0.87	0	0.00
ST	0.03202	0.03202	0	0.00
EI	-0.0275	-0.0275	0	0.00

Appendix 1. Contd.

Card payment systems	1			
PN	0.116022	0.116022	0	0.00
ITC	0.190476	0.190476	0	0.00
TC	0.102765	0.102765	0	0.00
AP	0.190476	0.190476	0	0.00
CS	0.83	0.83	0	0.00
ST	0.118842	0.118842	0	0.00
EI	-0.0373	-0.0373	0	0.00
KMH and TOKI housing loans and CCB applications	1			
PN	0.071823	0.071823	0	0.00
ITC	0.153846	0.153846	0	0.00
TC	0.069811	0.069811	0	0.00
AP	0.230769	0.230769	0	0.00
CS	0.93	0.93	0	0.00
ST	0.067734	0.067734	0	0.00
EI	-0.0673	-0.0673	0	0.00
Enterprise content management	1			
PN	0.049724	0.049724	0	0.00
ITC	0.111111	0.111111	0	0.00
TC	0.043424	0.043424	0	0.00
AP	0.222222	0.222222	0	0.00
CS	0.81	0.81	0	0.00
ST	0.039409	0.039409	0	0.00
EI	-0.0573	-0.0573	0	0.00
Corporate loans	0.950001			
PN	0.082873	0.082873	0	0.00
ITC	0.2	0.2	0	0.00
TC	0.088197	0.081911	-0.006286	-7.13
AP	0.333333	0.207921	-0.125413	-37.62
CS	0.7	0.825149	0.125149	17.88
ST	0.102217	0.107596	0.00538	5.26
EI	-0.1172	-0.049031	0.068169	58.16
Cash management payments	0.948636			
PN	0.055249	0.055249	0	0.00
ITC	0.2	0.2	0	0.00
TC	0.060612	0.055124	-0.005488	-9.05
AP	0.3	0.3	0	0.00
CS	0.81	0.853857	0.043857	5.41
ST	0.054803	0.05777	0	0.00
EI	-0.0441	-0.046488	0	0.00
Cash management collections	0.829967			
PN	0.060773	0.056234	0	0.00
ITC	0.272727	0.223819	-0.048908	-17.93
TC	0.057696	0.057696	0	0.00
AP	0.272727	0.272727	0	0.00
CS	0.69	0.87447	0.18447	26.73
ST	0.065271	0.078643	0.013372	20.49
EI	-0.0941	-0.070987	0.023113	24.56

Appendix 1. Contd.

Reporting intranet applications	0.960466			
PN	0.060773	0.060493	0	0.00
ITC	0.181818	0.176678	-0.00514	-2.83
TC	0.059145	0.059145	0	0.00
AP	0.272727	0.272727	0	0.00
CS	0.86	0.895398	0.035398	4.12
ST	0.049261	0.05312	0	0.00
EI	-0.0543	-0.054007	0	0.00
Risk management	1			
PN	0.033149	0.033149	0	0.00
ITC	0.166667	0.166667	0	0.00
TC	0.037882	0.037882	0	0.00
AP	0.5	0.5	0	0.00
CS	0.87	0.87	0	0.00
ST	0.040025	0.040025	0	0.00
EI	-0.0355	-0.0355	0	0.00
Telephone Banking	0.915973			
PN	0.049724	0.049724	0	0.00
ITC	0.222222	0.222222	0	0.00
TC	0.052778	0.051579	0	0.00
AP	0.333333	0.333333	0	0.00
CS	0.8	0.873389	0.073389	9.17
ST	0.051724	0.056469	0	0.00
EI	-0.0713	-0.050964	0.020336	28.52
Core banking	1			
PN	0.088398	0.088398	0	0.00
ITC	0.1875	0.1875	0	0.00
TC	0.086315	0.086315	0	0.00
AP	0.1875	0.1875	0	0.00
CS	0.81	0.81	0	0.00
ST	0.111453	0.111453	0	0.00
EI	-0.0438	-0.0438	0	0.00
Investment	1			
PN	0.060773	0.060773	0	0.00
ITC	0.272727	0.272727	0	0.00
TC	0.06498	0.06498	0	0.00
AP	0.272727	0.272727	0	0.00
CS	0.9	0.9	0	0.00
ST	0.097291	0.097291	0	0.00
EI	-0.0794	-0.0794	0	0.00