*Sánchez, Marisa Analía*

# INTEGRATING SUSTAINABILITY ISSUES INTO PROJECT MANAGEMENT

Journal of Cleaner Production

Año 2015, no. 96, pp. 319-330

Journal of Cleaner Production 96 (2015) 319–330

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

# Integrating sustainability issues into project management

Marisa Analía Sánchez*

*Departamento de Ciencias de la Administración, Universidad Nacional del Sur, 12 de octubre 1198, Bahía Blanca, Argentina*

ARTICLE INFO

*Article history:*
Received 21 July 2013
Received in revised form
30 December 2013
Accepted 30 December 2013
Available online 17 January 2014

*Keywords:*
Sustainability management
Project management
Stakeholder analysis
Strategy Map
Data Envelopment Analysis

ABSTRACT

Sustainability was adopted by many companies through their mission statement and strategy. However, social and environmental dimensions of sustainability are difficult to incorporate in programs and projects. The purpose of this work is to develop a framework to help ensure that an organization is working on the right projects to attain its business strategy and stakeholders demands. The proposal addresses both the portfolio selection problem and the project tracking phase. The portfolio selection allows selecting the better mix of projects based on the simultaneous analysis of eco-impacts and contribution to organizational goals. Once a portfolio is selected, monitoring aims to control project realization and decide on adjustments arisen from deviations from initial estimations. Both selection and monitoring are modeled as an optimization problem. The authors believe that this conceptual framework has a good potential for integrating sustainability and project management in operational terms.



## 1. Introduction

Sustainable development, as defined by the Brundtland Commission's Report, is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (United Nations, 1987). Elkington developed the concept of Triple Bottom Line which proposed that business goals were inseparable from the societies and environments within which they operate (Elkington, 1997). Sustainability was adopted by many companies through their mission statement and strategy. However, the social and environmental dimensions of sustainability are difficult to incorporate in programs and projects – the vehicles for executing the organization's strategy. In order to assess projects with respect to goals defined within an organization, it is necessary to consider (a) goals and related measures, and (b) economic, social and environmental criteria.

The Guide to the Project Management Body of Knowledge defines a project as a temporary endeavor undertaken to create a unique product, service, or result (Project Management Institute, 2008). In addition, projects or deliverables of a project can have social, economic and environmental impacts that far outlast the projects themselves. Then, aligning portfolio selection and monitoring with the principles of sustainable development requires evaluating and comparing several alternatives and ranking them based on their immediate costs, long-term costs and contribution to organizational goals. Sometimes, these costs and contributions are difficult to quantify or express in monetary terms. In addition, another of the hard tasks are tracking if projects are contributing to goals as planned and re-prioritizing them when organizational goals change.

There are several references and instruments that are regarded as relevant to environmental, economic and social sustainability evaluations of particular processes, products or activities: International Policy Frameworks, Codes of Conduct and Principles, Sustainability Reporting Frameworks, Social Responsibility Implementation Guidelines, Auditing and Monitoring Frameworks and Financial Indices (Kolk, 2005). In order to address sustainable issues into Project Management a clear understanding of the various life cycles involved in a project and their interactions is required. Labuschagne and Brent (2005) propose to consider the project life cycle, the asset/process life cycle, and the product life cycle while assessing sustainability issues in the manufacturing sector. In fact, many authors have proposed methods like Life Cycle Assessment (LCA), an analytical tool that implements life cycle thinking, which has been standardized by the International Organization for Standardization (International Organization for Standardization, 1997), for analyzing the environmental impacts of products or services. Hence, LCA may be used to derive economic, environmental and social impact indicators. From the management field, the Balanced Scorecard (BSC) tool translates mission and vision statements into a comprehensive set of objectives and performance measures that can be quantified and appraised. Thus it helps in implementation, monitoring, and evaluation of organizational strategy. The adaptability and the integration capability of the BSC structure when compared with other management tools make it a stronger tool (Contrada, 2000), and thus it is amenable

* Tel.: +54 291 4595132x2511; fax: +54 291 4595133.
*E-mail address:* mas@uns.edu.ar.

0959-6526/$ – see front matter © 2014 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jclepro.2013.12.087

to include sustainability aspects. However, with the intention of aligning Project Management decisions with sustainability concerns stated in a BSC, it is necessary to consider different methodologies.

The aim of this paper is to address this need to integrate sustainability in Project Management by presenting a theoretical framework to evaluate projects that takes into account profits and economic, environmental, and social impacts. Given a set of projects, in order to perform a simultaneous analysis of multiple costs, environmental and social impacts to multiple organizational goals supported by projects, a multi-factor productivity approach is necessary. We propose to use indicators derived from sustainability analysis and key performance indicators included in the BSC and formulate a decision problem using Data Envelopment Analysis (DEA). DEA uses all the available data to construct a best practice empirical frontier to which each inefficient unit of analysis is compared. DEA is attractive because it does not require the specification of any functional form but available data are those who determine the efficiency frontier. Additionally, it allows working with variables expressed using different units. All these characteristics are relevant in sustainability problems since ideal production functions are unknown and data belong from different sources.

The author believes that this work can provide a foundation on how to jointly use management and sustainability evaluation methodologies to assist decision-makers who are required to assess and monitor projects in terms of monetary and socio-environmental criteria. The framework will help ensure that an organization is working on the right projects to attain its business strategy and stakeholders demands. Conclusions are supported by results from a case study. The rest of this paper is structured as follows: in Sections 2 and 3 background concepts and related research are reviewed. Section 4 presents the proposed framework. Section 5 contains a demonstrative example illustrating how such a framework could be used. Finally, Section 6 provides some conclusions and plans for future work.

## 2. Background concepts

In what follows, the terminology and concepts used to elaborate our framework, stakeholder analysis, the BSC and DEA, are reviewed.

### 2.1. Stakeholder analysis

Stakeholders may be defined as individuals, groups and organizations that are affected by or can affect a decision or action. Corporate sustainability, that is the capacity of a firm to continue operating over a long period of time, depends on the sustainability of its stakeholder relationships (Perrini and Tencati, 2006). Stakeholder theory recognizes that organizations have obligations not only to shareholders but also to other interest groups such as customers, employees, suppliers and the wider community; amongst many others (Asif et al., 2013). The authors argue that the development of business-specific indicators requires a systematic stakeholder analysis approach whereby the organizations interact with stakeholders to identify their key expectations and areas of concern. However, stakeholder analysis is often done on an ad hoc basis.

The tasks involved in managing within a network of stakeholders include identifying stakeholders and their interests, categorize stakeholders, and investigate relationships between stakeholders. Reed et al. (2009) discuss methods for stakeholder analysis that are common within research on natural resource management. The author suggests that stakeholders' identification can be done using expert opinion, focus groups, semi-structured interviews, snow-ball sampling, or a combination of these. The level of participation of stakeholders in analysis can vary considerably from passive consultation to active engagement where there is a two-way exchange of information between stakeholders and analysts. Categorization methods follow either top-down analytical categorizations, or bottom-up reconstructive methods. Finally, there are some methods that have been developed to investigate the relationships that exist between stakeholders in the context of the issue of interest. Examples include actor-linkage matrices and social network analysis.

### 2.2. The balanced scorecard

More than a decade ago, Kaplan and Norton (1996) introduced the BSC, a strategy-based measurement system that allows translating a strategy to operational terms. The BSC organizes its measurement system in four perspectives. In each perspective we define goals for all concerns that should be monitored. For each goal, key performance indicators (KPIs), appropriate targets, and projects are defined. The financial perspective includes traditional accounting measures; the customer perspective groups measures relating to the identification of target groups for the company's products in addition to marketing-focused measures of customer satisfaction, retention, etc. The internal business process perspective includes all the processes relating to the realization of products and services. Finally, the learning and growth perspective includes all metrics relating to employees and systems available to facilitate learning and knowledge diffusion. The causal relationships between different domains of management are represented by the so-called Strategy Map. The Strategy Map links together several domains and elements of the strategy in the four key perspectives. These linkages visualize hypothesis for cause-and effect relationships.

Many authors have discussed the use of BSC to consider nonfinancial issues which characterize many sustainability aspects and strongly recommend the use of the BSC to help establish and ensure a proactive environmental strategy (Kaplan and Norton, 2004; Hsu and Liu, 2010; Epstein and Wisner, 2001; Figge et al., 2002; Cheng et al., 2010; Länsiluoto and Järvenpää, 2010).

Kaplan and Norton (2004) discuss how to report regulatory and social performance processes along several dimensions (environment, safety and health, employment practices and community investment) and provide examples of measurements. By means of a case study they show how to integrate sustainable concerns into the Strategy Map. The top of the Strategy Map shows commitment to triple bottom-line performance (create economic value sustainably in the long run, generate value through a system of corporate social responsibility, and generate value through environmental management) and there is a fifth dimension named "environmental and social".

Epstein and Wisner (2001) describe some examples of companies that have used the BSC approach for implementing sustainability strategies. They also discuss whether to include a fifth perspective to capture social and environmental indicators, or to include sustainability indicators in each of the four perspectives, concluding that the choice is dependent upon the challenges facing the organization.

According to Figge et al. (2002) environmental and social aspects can be integrated in the BSC in three ways: they can be integrated in the existing four standard perspectives; an additional perspective can be added to take environmental and social aspects into account; or a specific environmental and/or social scorecard can be formulated. The necessity for an additional non-market perspective arises when environmental or social aspects significantly influence the firm's success from outside the market system which at the same time cannot be reflected according to their strategic relevance within the four standard BSC perspectives. The third approach ensues developing a derived environmental and social scorecard that is dependent upon an existing BSC. This variant allows coordinated control of all sustainable aspects which are spread in the BSC.

Cheng et al. (2010) conceptualize a BSC approach using six logically linked perspectives including environmental and societal perspectives. It encompasses the environmental and societal perspectives in addition to financial, customer, internal process, learning and growth perspectives that were introduced by Kaplan and Norton (1996).

Länsiluoto and Järvenpää (2010) investigate by means of a case study how Performance Measuring Systems are changed to reflect environmental issues. They found that the BSC provided structure and well-known reporting approach for the implementation of the environment measures. The BSC enabled the environmental measures as part of the everyday managerial measures. Finally, the company used as a case study was able to embark on a process of organizational environmental improvement after highlighting the causal linkage between the improvement of environmental issues and cost savings.

Hsu and Liu (2010) conducted a survey of performance measures for automobile industry in Taiwan. They used statistical methods to identify and verify some relationships among the measures proposed by Kaplan and Norton (1996). The results of this study suggest that the BSC can be a management tool for environmental performance evaluation and environmental strategy control.

### 2.3. DEA

DEA, first proposed by Charnes et al. (1978), is a non-parametric technique used to measure the efficiency of Decision Making Units (DMUs). Each DMU is seen as being engaged in a transformation process, in which, some inputs (resources) are used to try to produce some outputs (goods or services). DEA uses all the available data to construct a best practice empirical frontier to which each inefficient DMU is compared. This data-driven approach, which is implemented with mathematical programming algorithms, requires no specification of assumed functional forms of relations between inputs and outputs. In management contexts, DEA serves as a tool for control and evaluation of past accomplishments as well as a tool to aid in planning future activities (Banker et al., 1984). DEA models are comprehensively treated by Cook and Seiford (2009) and Cooper and Seiford (2004).

DEA has been used with LCA for efficiency analysis in many industrial sectors. The reader is referred to Zhou et al. (2008) which presents a literature survey on the application of DEA to energy and environmental studies. Recently, Egilmez et al. (2013) used the Economic Input-Output Life Cycle Assessment (EIO-LCA) and DEA to assess the eco-efficiency of U.S. manufacturing sector. The eco-efficiency is defined as the ratio of total economic output to the overall environmental impact. The EIO-LCA model tool is used to quantify greenhouse gas emissions, energy use, water withdrawals, hazardous waste generation, and toxic releases, and these results are used as inputs for the DEA model. The output represents economic value added by each sector. In this work, companies are the unit of analysis.

## 3. Related work

There are proposals that explore the relationships between project management and sustainability. Most works focus in defining a process or sustainable project management methodology. Gareis et al. (2009) develop a model to discuss relationships between sustainable development and project management. The model includes sustainable development principles (holistic approach, long-term orientation, large spatial and institutional scale, risk and uncertainty reduction, values and ethical consideration and participation) and project management objects (for example, project objectives, scope, schedule, resources, organization, context and design of the project management). As a result, challenges and future research lines for a sustainable project management are defined. Note that the focus is project management according to sustainable principles. A Maturity Model for integrating sustainability in project management is developed by Silvius and Schipper (2010). The model assesses the level (*i.e.* resources, business process, business model and product and services delivered by the project) on which different aspects of sustainability are considered in the project.

Labuschagne and Brent (2003) propose a comprehensive sustainability evaluation framework to assess projects during the early life cycle phases in terms of sustainability consequences of the future implemented assets and products. The framework shows the high level criteria that must be considered and possible indicators. Labuschagne and Brent (2008) conclude that the three most important life cycle phases of which impacts should be assessed are the construct phase of the asset; the operational phase, under which all impacts of the product life cycle are also grouped and the decommissioning phase of the asset, and hence they consider these phases to verify adequacy and completeness of indicators proposed in earlier research.

The problem of selecting the best portfolio with respect to the organizational strategy that includes sustainable goals was considered by Vandaele and Decouttere (2013). The authors develop a DEA model with the aim of supporting strategic Research and Development portfolio management. By means of two case studies the authors propose to use development costs, investment costs, and technical risks as inputs for DEA; and performance indicators such as market size, competition, sales potential, profitability or technical probability of success as outputs for DEA.

Sánchez et al. (2014) define a theoretical framework on how to assess the strategy value contribution of Information Technology (IT) investments so as to deliver maximum business value. To see if IT projects fit strategy the Strategy Map provides a framework for defining the portfolio value and DEA is used to measure the efficiency of project portfolios. By explicitly linking IT investments with organizational goals, this approach provides a strategy-based approach to Project Portfolio Management. The work considers the portfolio selection and project tracking phase. The portfolio selection is formulated as a DEA problem where DMUs represent portfolios; inputs represent development and operational costs; outputs represent the contribution of portfolios to each goal. Project monitoring is also formulated as a DEA problem. However, this work does not describe how to proceed when sustainability issues are relevant, *e.g.* how to integrate environmental or social impact information into project assessment. The work provides a baseline for the research introduced in this paper, and should be extended to describe how to include stakeholders' concerns and project impacts and combine this information into the selection and monitoring tasks.

## 4. Methodology

This section presents a methodology to help ensure that an organization is working on the right projects to attain its business strategy and stakeholders demands. The methodology comprises four steps: (1) cover stakeholders' concerns by means of stakeholder analysis; (2) define a Strategy Map; (3) conduct sustainability analysis; and (4) perform a global optimization of projects.

In carrying out steps 1–3, we rely on key methodological steps that have been discussed elsewhere. Our focus is on how to combine approaches to enhance project management. On the other hand, we give attention to phase 4 that is essential in combining the models and information produced in previous steps.

### 4.1. Stakeholder analysis

The tasks involved in stakeholder analysis include identifying stakeholders and their interests, categorize stakeholders, and investigate relationships between stakeholders.

As a result of the analysis, we should be able to translate stakeholders' interests into goals to be achieved in each stakeholder relationship, and a Strategy Map is drawn, defining objectives in different perspectives. We shall now discuss how to structure the Strategy Map.

### 4.2. Strategy Map

Based on the analysis of previous research (see Section 2) that discusses how to structure a BSC to include aspects of sustainability, in this paper we suggest using the following perspectives: Triple Bottom Line, Stakeholders, and the traditional Internal Process and Learning and Growth. The Triple Bottom Line perspective was first proposed by Kaplan and Norton (2004) and includes economic, environmental and social value goals. The traditional Customer perspective is replaced by a Stakeholder perspective balancing the interests of all stakeholders. Depending on the objective set, others derive from them. To meet stakeholders' expectations, the Internal Process perspective may include themes such as organizational efficiency and effectiveness, conformance to industry standards, and reduction of mitigation of negative impacts. Finally, the Learning and Growth perspective includes goals related with the skills, culture and technology necessary for its employees to do the work required.

Standard goals and measures (*i.e.* common across all BSC) are not introduced. The development of the BSC depends on the organization's needs.

In order to satisfy goals, project proposals are defined. Then, economic, environmental and social impacts of projects should be assessed.

### 4.3. Sustainability analysis

The goal of this step is to provide a combined environmental and social sustainability assessment for project proposals. LCA is defined (based on ISO 14040) as the compilation and evaluation of the material and energy flows of the potential environmental impact of the life cycle of physical product or service.

In this section, we limit to describe the synergies that result from the use of LCA within the framework proposed in this paper. LCA studies comprise four phases:

#### 4.3.1. The goal and scope definition

Stakeholder analysis and the BSC can be used to collect and structure ideas and views from stakeholders. Hence, they provide information to state some of the reasons for carrying out the study, the intended audience, and some of the classes representing environmental issues of concern.

#### 4.3.2. Inventory analysis

Inventory analysis involves data collection and calculation procedures to quantify relevant inputs and outputs of a product system.

#### 4.3.3. Life cycle impact assessment

The collection of indicator results provides information on the environmental issues associated with the flows of the product system.

#### 4.3.4. Interpretation

The findings from the inventory analysis and the impact assessment are considered together to provide conclusions or recommendations to decision-makers. Some of the findings may take the form of inputs for the optimization problem defined in Section 4.4.

### 4.4. Global optimization of portfolios and projects

In order to implement strategies, organizations define some alternative projects. Each project contributes to the realization of different goals, and some projects may contribute better than others. At the same time, each project has one-time implementation costs, future operational and maintenance expenditures, and environmental and social impacts. The purpose of this section is twofold. First, it is described how to select the better mix of projects based on the simultaneous assessment of economic, environmental and social impacts to goals depicted in a Strategy Map. Second, it is explained how to proceed to perform monitoring in order to control project realization and decide on adjustments arisen from deviations in impact or budget estimations, or updates in organizational goals.

Sánchez et al. (2014) defined a framework on how to assess the strategic value contribution of IT investments (see Section 3). In this study, we extend the approach to include sustainability issues.

The framework considers a medium or long-term period of analysis $t_b - t_e$ for which managers define goals and targets to be met. At time $t_b$ (initial instant of time) the portfolio which will deliver more value at the time point $t_e$ (end of the interval) should be defined. In addition, environmental and social issues may have impact in the long run.

#### 4.4.1. Portfolio selection

There are two main pieces of information that should be gathered (see Fig. 1): (a) the initial investments and impacts arising from financial and sustainability analysis (see 1 in Fig. 1); (b) for each goal (from the Strategy Map), the contribution that each portfolio can provide to it at time point $t_e$ (see 2 in Fig. 1). The portfolio selection may be formulated as a DEA problem where DMUs represent portfolios; inputs represent initial investments, development, operational and disposal costs, and socio-environmental impacts derived from sustainability analysis; outputs represent the estimated contribution of portfolios to each goal. In this way, DEA results provide a ranking of portfolios based on business value that takes into account the incurred and future spending (see 3 in Fig. 1). An "efficient" portfolio should be interpreted as supporting strategic goals with the minimal environmental impact.

At this step sensitivity analysis allows knowing what may happen to a specific DMU's efficiency if data variation occurs. From the management perspective, decision-makers would like to assess different scenarios. Since an increase of any output or a decrease of any input cannot worsen the efficiency of a given DMU, the analysis should consider a decrease in outputs and increase in inputs for the DMU under consideration.

#### 4.4.2. Project monitoring

Projects are monitored in order to track their development (updating costs and benefit estimates to detect deviations) and re-prioritize them when strategic goals (or their target values) change, new initiatives appear, or projects are finished. Let $t_d$, $t_b < t_d < t_e$, be a checking point. At time $t_d$ we need to assess management's capacity to re-prioritize projects and decide whether to continue, cancel, postpone or add projects. Also, the Strategy Map is in constant update as new goals are set or existing goals are dismissed as a result of changes in organizational strategy. Hence, some projects may become obsolete; or newly defined goals may not be supported by any project.

The DEA problem is formulated as follows. Each project defines two DMUs: one DMU represents the ongoing projects and input and output data are given by incurred eco-impacts and by realized contribution to organizational goals, or updated cost forecasts and value if the project is not closed; the other DMU represents the planned project and input and output data are given by initial estimated eco-impacts and planned value. Also, there may be additional DMUs representing projects that started before selecting the portfolio. Ideally, DMUs representing planned projects would define the efficient frontier and would be the reference set for ongoing projects. Inputs represent operational expenditures, switching costs (if the project is abandoned), development costs (converted to time $t_d$

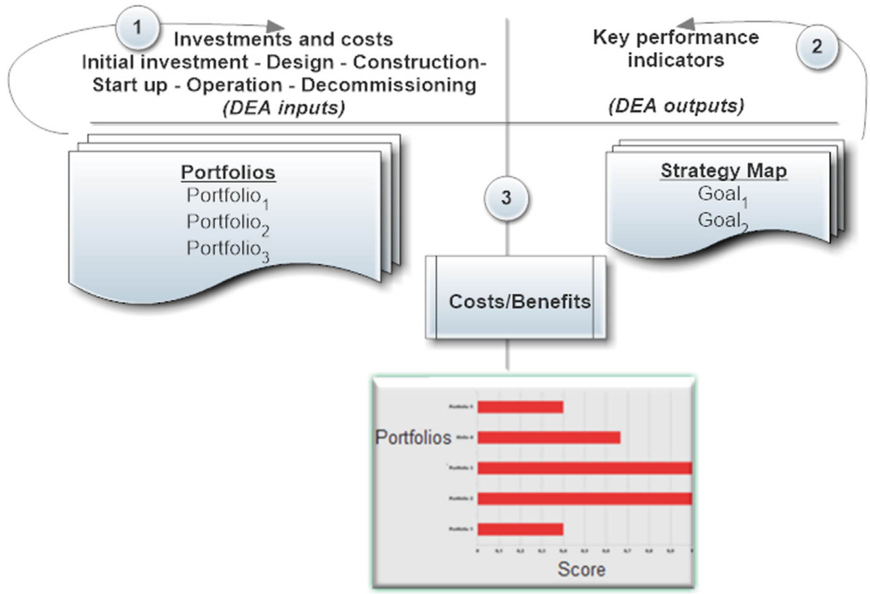


**Fig. 1.** Portfolio selection. Portfolios' investments, costs, impacts and contribution to each goal in the Strategy Map feed an optimization problem that gives a ranked list of portfolios.

value equivalent) (see 2 in Fig. 2), and eco-impacts; outputs relate the contribution of projects to each goal (see 1 in Fig. 2).

The formulation of the DEA problem is as proposed by Tone (2001). The model assumes an output orientation and is computed using Super-efficiency Slack-Based Measure. Details about the mathematical formulation of the problem are included in Appendixes A and B.

In most DEA models, the best performers share the full efficient status denoted by the score unity (1). In practice, multiple DMUs usually have this "efficient" status. The Super-efficiency model discriminates between these efficient DMUs. The super-efficient methodology can give "specialized" DMUs an excessively high ranking. Another problem lies with the infeasibility issue, which if it occurs, means that the super-efficient technique cannot provide a complete ranking of all DMUs. Some authors developed super-efficient models that avoid these problems (Adler et al., 2002; Mehrabian et al., 1999), the implementation of these algorithms is beyond the scope of the presentation of this paper.

Although a linear programming problem is theoretically polynomial-time solvable, in practice, solution times increases significantly for large cases (Chen and Cho, 2009).

## 5. Illustrative example

In order to illustrate the application of the approach consider the following example adapted from an ongoing work at an information technology company (Alas Ingenieria). The company provides advanced solutions for engineering and information management for industrial plants. They also provide support to develop, implement and integrate applications. The organization

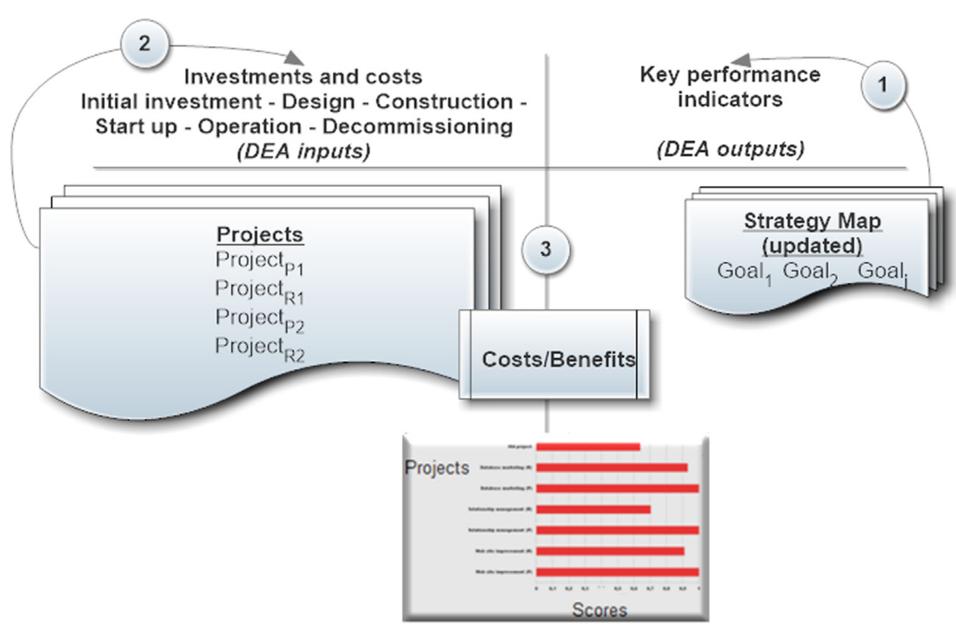


**Fig. 2.** Projects monitoring. An optimization problem is defined in which the units of analysis denote planned projects and ongoing projects. The solution gives a ranked list of projects based on achievement of updated strategic goals.

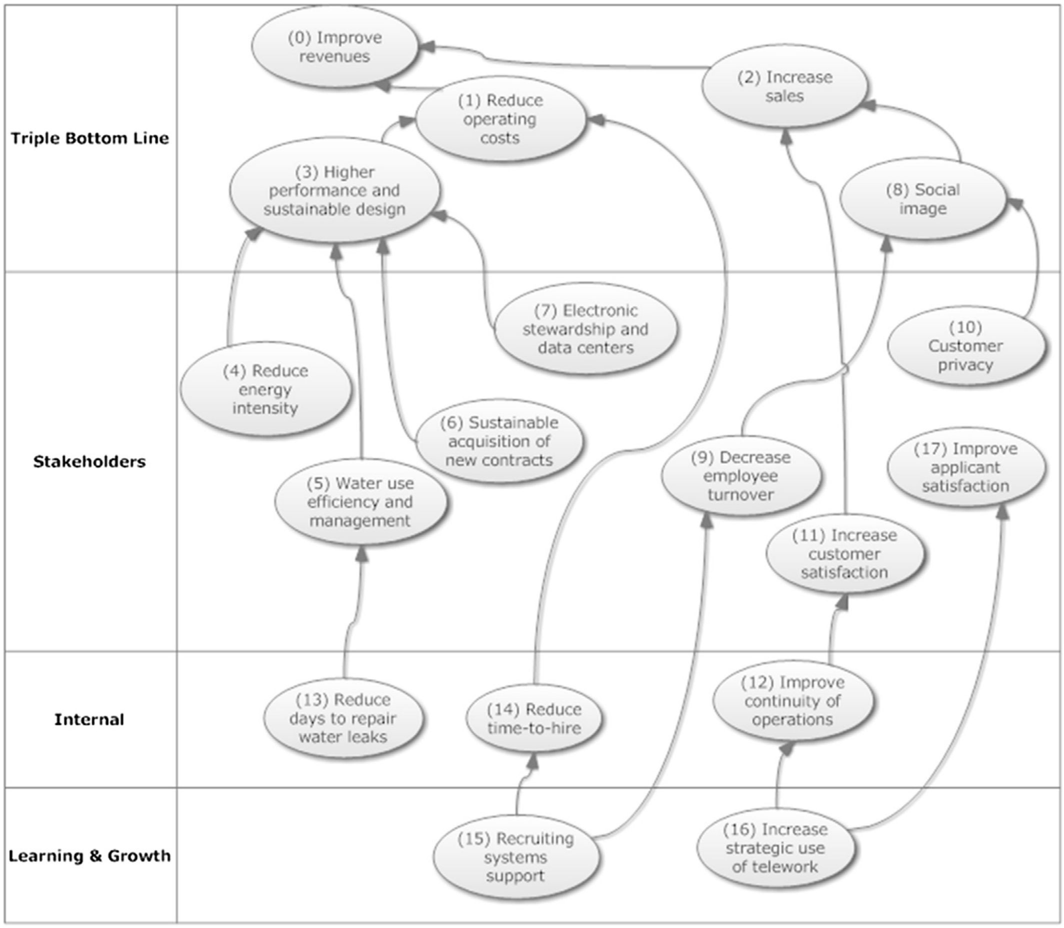


**Fig. 3.** Example of a Strategy Map using four perspectives that relate stakeholders' concerns to organizational strategy.

recognizes sustainability as an opportunity to make its operations more efficient and robust. Alas Ingenieria has not yet implemented all the projects. However, efforts toward sustainability issues have been made related to many of the goals outlined in what follows.

### 5.1. Stakeholder analysis

We began by identifying relevant stakeholders and the goals to be achieved in each stakeholder relationship using semi-structured interviews (see Fig. 5). Shareowners represent the sources of capital and are concerned with high operating costs and decreasing sales. The company anticipates a significant portion of cost reductions to come from efficient use of energy and water, and environmentally preferable (EP) products. Also, the company has a strong commitment to recruit and retain top talent.

Both the company and customers are dependent on the efficient functioning of the data center. Additionally, some customers (plant operators) are concerned with continuity of operations.

Employees are mainly concerned with work–life-balance (using telework would allow to better manage their work and family obligations).

The local community is quite concerned about efficient energy and water management.

### 5.2. Strategy Map

From stakeholders' concerns, organizational goals are derived. As an illustration consider Figs. 3 and 4 which show how initiatives combine to create a financial payoff from the strategy based on the templates provided by Kaplan and Norton (2004).

We assume there are three portfolios consisting of a number of projects and that there are sufficient funds available for any of these portfolios. Portfolio 1 (see Fig. 6) includes projects that support all strategic goals. Two projects ("Replace aging outdated equipment with new energy efficient equipment" and "Install an automated computer program to request and track work orders for system maintenance") combine to improve goals related with energy consumption and days to repair water leaks. Another sustainable design concerns are supported by projects 2 and 4. Projects 5 and 6 allow to increase the strategic use of telework, and hence both customer and employee satisfaction. Projects 7 and 8 are aimed at supporting the employee hiring process. Projects 9 and 10 focus on electronic stewardship concerns. Finally, Project 11 allows fulfilling customer privacy requirements.

Portfolio 2 does not support all goals. Portfolio 3 is similar to Portfolio 1 except that it includes Project 12 (an alternative to Project 3 which does not automate the whole process to request and track work orders, and hence while it has lower implementation costs, it requires more paper).

### 5.3. Sustainability analysis

Depending on the industrial sector and type of project development, the appropriate sustainability approach should be used. The information used for this paper is used for illustrative purposes only. The impact categories which are particularly significant for this study are energy consumption, paper use and economic (initial costs and total cost of ownership).

### 5.4. Portfolio selection

The inputs are "Initial costs" (one-time implementation costs), paper and energy expenditures; and "Total cost of ownership" (operating and other long-term expenses). The output data will be estimates of project contribution to goals as described in Fig. 7. Table C.1 exhibits the data. It is desirable that the number of DMUs exceeds the number of inputs and outputs several times (Cooper et al., 2006). However, since the focus of this example is on describing how to apply DEA we used a small number of portfolios in order to keep the explanation as simple as possible.

The DEA model was run following the Super-efficiency formulation, with output orientation, in order to obtain relative performance scores for the three portfolios considered. As can be seen from Table 1, results may be considered as an appropriate representation of the portfolios. It can be observed that all portfolios are efficient. Portfolio 1 is the best performer (although it has large input values, output values are equal or greater compared with the other portfolios).

To determine robustness of the efficiency scores obtained by DEA for the situation where input variable "Initial costs" may be

| Internal Stakeholders | Organizational goals |
|---|---|
| Shareowners | 0, 1, 2, 3, 4, 5, 6, 7, 9 |
| Employees | 9, 16 |
| External Stakeholders | |
| Customers | 7,10,11 |
| Community | 4, 5 |

**Fig. 5.** Organizational goals are derived from stakeholders' concerns.

| Portfolio | Projects |
|---|---|
| 1 | 1 to 11 |
| 2 | 1, 2, 3, 4, 5, 6, 7, 8, 11 |
| 3 | 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12 |

**Fig. 6.** Detail of projects in each portfolio.

| Strategy Map. Theme: TBL | | |
|---|---|---|
| | **Goals** | **Measure** |
| Triple Bottom Line | Improve returns | - Market value |
| | Reduce operating costs | - Amount reduced ($) |
| | Increase sales | - Number of new customers<br>- Percentage of customers placing repeated orders |
| | Higher performance and sustainable design | |
| | Social image | |
| Stakeholders | Reduce energy intensity by 3% per year through FY 2018, relative to FY 2012 baseline | - % energy reduction |
| | Water use efficiency and management | - % water efficient equipment |
| | Sustainable acquisition of new contracts | - 95% contracts use EP products (actual 40%) |
| | Electronic stewardship and data centers | - % electronic assets covered by sound dispositions practices.<br>- % of cloud activity |
| | Increase customer satisfaction | |
| | Decrease employee turnover | - Average working years of leaving employees |
| | Customer privacy | - Number of substantiated complaints regarding breaches of customer privacy. |
| Internal Processes | Reduce days to repair water leaks | - Days to repair |
| | Reduce time-to-hire | - Reduce time-to-hire by 10% per year |
| | Improve continuity of operations | |
| Learning & Growth | Recruiting systems support | - % of system development per month |
| | Increase strategic use of telework | - % of tasks supported by telework (actual 10%, target 40%) |
| | Improve applicant satisfaction | - Improve applicant satisfaction by 1% per quarter |

**Fig. 4.** Detail of goals and their KPIs.

increased we performed a sensitivity analysis. Portfolio 1 remains efficient even if "Initial costs" is increased up to 280% and the data for remaining DMUs are assumed fixed (see Fig. 8).

## 5.5. Project monitoring

Assume that Portfolio 1 is selected. The DEA efficiency scores allow comparing realized projects with their planned counterparts and they identify low performers. Also, DEA models yield performance information indicating by how much outputs have to increase (or inputs to decrease) to achieve efficiency. From the management perspective, the approach provides support to decide if corrective actions are necessary.

Table C.2 shows the data and Fig. 9 summarizes the results: in this example, DMUs that represent planned projects define the efficiency frontier; DMUs that represent the current realization of projects have lower scores than their planned counterparts. For example, ongoing projects R5, R6 and R11 are "inefficient" compared with initial plans denoted by projects P5, P6 and P11, respectively. For the case of projects 5 and 6, the percentage of tasks supported by telework is less than planned (Table 2 exhibits the projected points for DMU R6). For the case of Project 11, it has not reduced the number of complaints regarding breaches of customer privacy as planned. This may be due because of planning errors, projects are not closed, or benefits have not been realized yet. DMU R9 is inefficient. It uses more input (initial costs) than P9 and produces less output (percentage of cloud activity hosted in data center and percentage of eligible products with EP features implemented and in use).

**Table 1**
Portfolio selection: DEA efficiency scores measure relative efficiency across portfolios based on investments, costs, eco-impacts and contribution to goals.

| DMU | Score | Rank |
|---|---|---|
| Portfolio 1 | 1.16 | 1 |
| Portfolio 2 | 1 | 3 |
| Portfolio 3 | 1.05 | 2 |

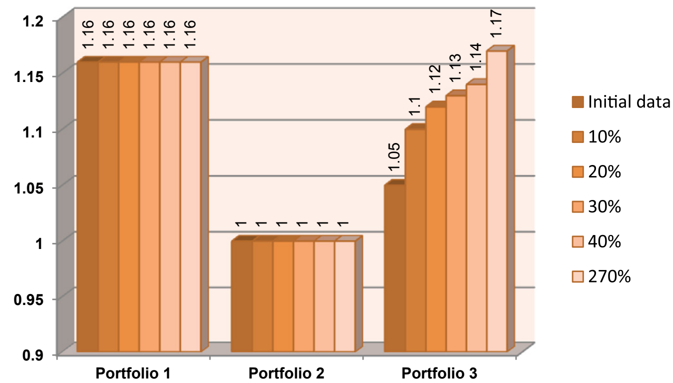


**Fig. 8.** Sensitivity analysis results where input variable "Initial costs" is increased for Portfolio 1 and the data for remaining portfolios are assumed fixed.

| Projects | | Strategy Map Goals |
|---|---|---|
| Number | Description | |
| 1 | Replace aging outdated equipment with new energy efficient equipment | 4 |
| 2 | Replace aging outdated equipment with new water efficient equipment | 5 |
| 3 | Install an automated computer program to request and track work orders for system maintenance | 4-13 |
| 4 | Develop a tool to track EP purchases (should include justifications for not purchasing EP products when they are available) | 6 |
| 5 | Establish a telework policy | 16 |
| 6 | Telework training | 16 |
| 7 | Website which improves information, tools,and guidance on all things related to recruiting | 9-14-17 |
| 8 | Website targeted to human resources professionals and hiring managers, offers training modules on key areas accross related hiring | 9-14-17 |
| 9 | Establish a policy to ensure use of power management, duplex printing and other environmentally preferred options | 7 |
| 10 | Update policies as needed, but no less than annually, to ensure implementation of best management practices for energy efficient management of servers and data servers. | 7 |
| 11 | Implement database security program | 10 |
| 12 | Install an automated computer program to request work orders for system maintenance (similar to project 3 but requires paper-based foms for tracking) | 4-13 |

**Fig. 7.** Description of projects and the organizational goals that they support.

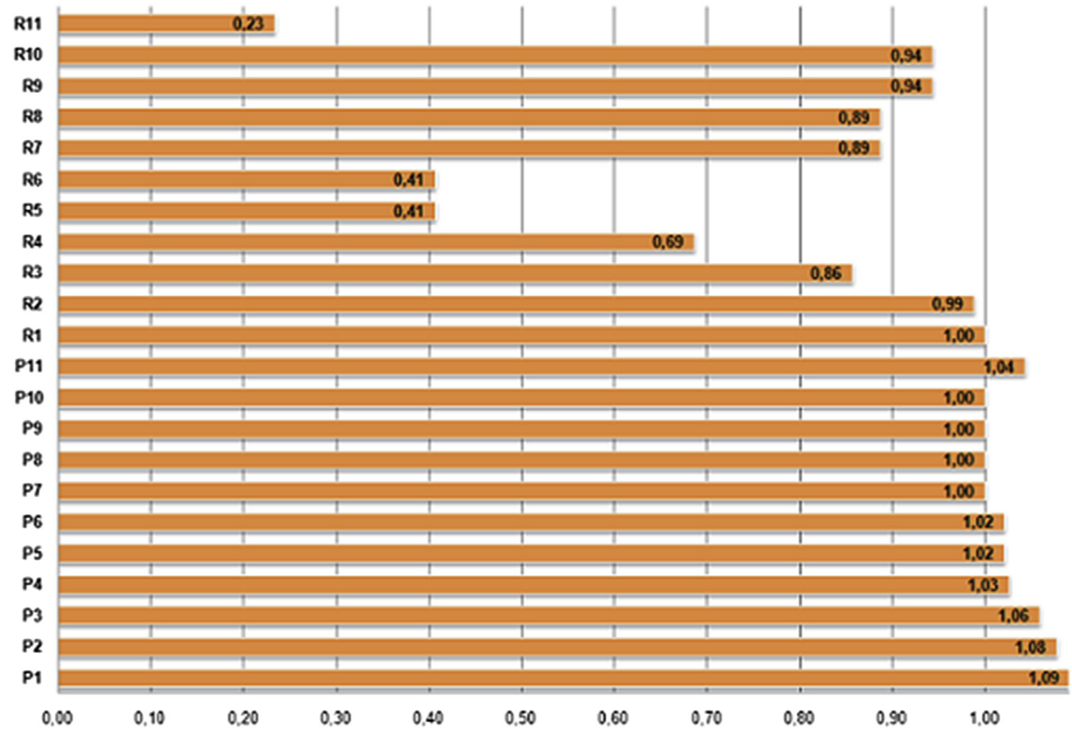


**Fig. 9.** Project monitoring: DEA efficiency scores measure progress. Initial plans denoted by projects $\boldsymbol{P}_i$ ($1 \le i \le 11$) may be seen as a benchmark.

## 6. Conclusions and future work

This work defines a framework to evaluate projects that takes into account profits and economic, environmental, and social impacts. The methodology comprises four steps. Stakeholder analysis allows identifying key stakeholders and their concerns. Then a Strategy Map is drawn defining goals structured in four perspectives: Triple Bottom Line, Stakeholders, Internal Process and Learning and Growth. For each goal, KPIs, appropriate targets and projects are defined. The Strategy Map may be used as a source of information for sustainability analysis since it highlights relevant stakeholders' demands. The portfolio selection allows selecting the better mix of projects based on the simultaneous analysis of eco-impacts and contribution to organizational goals. Project monitoring aims to control project realization and decide on adjustments arisen from deviations from initial estimations. The framework provides the means to integrate Sustainability Analysis and Project Management in operational terms since sustainability results are used to solve a decision problem to support the selection and monitoring tasks.

The use of an optimization technique goes a step further from performance evaluation systems. In general, project managers or any other decision maker uses KPIs to monitor progress. However, this work proposes to also use these data to feed an optimization problem and derive a ranked list based on the achievement of goals.

The proposed approach extends previous research by introducing a systematic and formal approach to rank portfolios based on sustainability criteria. This proposal differs from the work of Vandaele and Decouttere (2013) because they use a pre-defined list of measures (costs and benefits). Goals depend on the organization's needs and sustainability criteria are also dependent on organizational, geographical and socio-economic factors. Our work describes how to systematically formulate the portfolio selection and project monitoring problems, and also gives insight about how to derive the necessary information. All steps are based on the use of widely used and accepted management tools such as stakeholder analysis and the BSC. The use of DEA is attractive since DEA does not require the specification of a functional form because available data define the efficiency frontier. In addition, it allows working with data expressed in different units of measurement what is quite relevant when working with variables of diverse nature.

When defining goals in the Strategy Map, targets for their related measures are defined. In the approach we do not punish projects that exceed targets (this situation may give raise to a waste of resources). Future research aims to define how to handle this problem.

## Appendix A. DEA model of portfolio selection

Let $\boldsymbol{P} = \{P_t, 1 \le t \le n\}$ be a set of portfolios. Let $P_t = \{p_k^t, 1 \le k \le v_t\}$ denote the projects in portfolio $P_t$ where $v_t$ is the number of projects and $1 \le t \le n$. Assume projects in $P_t$ deriving $m_t$ costs (initial investment and impacts derived from sustainability analysis) and let $X_t = \{x_{ij}^t : 1 \le i \le m_t,\ 1 \le j \le v_t\}$ be the set of all costs; and producing $s_t$ outputs and let $Y_t = \{y_{ij}^t : 1 \le i \le s_t,\ 1 \le j \le v_t\}$ be the set of all outputs (forecasted contribution to goals and measured by KPIs).

In portfolio selection, since portfolios in $\boldsymbol{P}$ may have different costs, consider $\boldsymbol{P}' = \{P_t',\ 1 \le t \le n\}$ deriving $m' = |X'|$ costs where $X' = \cup_{t=1}^{n} X_t$ is the set of all costs. In other words, $X' = \{x_{gh}: 1 \le g \le m', 1 \le h \le n\}$. Furthermore, let $Y' = \cup_{t=1}^{n} Y_t$, $s' = |.Y'|$. where $Y' = \{y_{gh}: 1 \le g \le s', 1 \le h \le n\}$ is the set of all outputs. Note that each portfolio $P_t'$, $1 \le t \le n$, is the same as $P_t$ except that it has all the expenditures in $X'$ (this is necessary to satisfy the DEA assumption that units consume the same type of resources). If a portfolio does not require spending $X_t$ then assume $X_t$ assumes a value close to zero.

The model assumes an output orientation and is computed using Super-efficiency Slack-Based Measure. The formulation of the DEA problem as proposed by Tone (2001) is as follows. We assume that the data set is positive, i.e. $X' > 0$ and $Y' > 0$. The production possibility set is $P = \{(\boldsymbol{x}, \boldsymbol{y}) \cdot \boldsymbol{x} \ge X'\lambda, \boldsymbol{y} \le Y'\lambda, \lambda \ge 0\}$, where $\lambda$ is a non-negative vector in $R^n$. Consider an expression for describing a certain DMU $(\boldsymbol{x}_0 \boldsymbol{y}_0)$ as

$$\boldsymbol{x}_0 = X'\lambda + \boldsymbol{s}^-$$

**Table 2**
The projection of a super-efficient DMU R6 designates the nearest point on the production possibility set excluding the DMU. Reference set is P5 and P6.

| DMU input/output | Score data | Projection | Difference |
|---|---|---|---|
| Initial costs | 10,000 | 8222.22 | −17.78% |
| Paper | 5 | 5 | 0.00% |
| Energy | 50 | 50 | 0.00% |
| Total cost of ownership | 4945 | 3280 | −33.67% |
| # of Substantiated complaints regarding breaches of customer | 0.33 | 0.33 | 0 |
| Avg working years of leaving employees | 3 | 3 | 0.00% |
| Applicant satisfaction | 1 | 1 | 0.00% |
| % of Tasks supported by telework | 30 | 30 | 0.00% |
| % of System development per month | 0 | 1.29E−14 | 0.00% |
| Reduce time-to-hire by 10% per year | 0 | 1.29E−15 | 0.00% |
| Days to repair water leaks | 0.2 | 0.2 | 0.00% |
| % of Cloud activity hosted in data center | 1 | 17.33 | 999.90% |
| % of Eligible products with EP features implemented and in use | 20 | 43.33 | 116.67% |
| % Energy reduction | 0 | 0 | 0.00% |
| % Contracts using EP products (target 95%) | 40 | 40 | 0.00% |
| % Water efficient equipment | 10 | 10 | 0.00% |

$$\boldsymbol{y}_0 = Y'\boldsymbol{\lambda} + \boldsymbol{s}^+$$

with $\lambda \geq 0$, $\boldsymbol{s}^- \geq 0$ and $\boldsymbol{s}^+ \geq 0$. The vectors $\boldsymbol{s}^- \in R^{m'}$ and $\boldsymbol{s}^+ \in R^{m'}$ indicate the input excess and output shortfall of this expression, respectively, and are called slacks. Let us define a production set $P/(\boldsymbol{x}_0, \boldsymbol{y}_0)$ spanned by $(X', Y'$ excluding $(\boldsymbol{x}_0 \boldsymbol{y}_0)$, i.e.,

$$P/(\boldsymbol{x}_0, \boldsymbol{y}_0) = \left\{ (\overline{\boldsymbol{x}}, \overline{\boldsymbol{y}}) \middle| \overline{\boldsymbol{x}} \geq \sum\nolimits_{i=1,\neq 0}^{n} \lambda_i \boldsymbol{x}_i, \quad \overline{\boldsymbol{y}} \leq \sum\nolimits_{i=1,\neq 0}^{n} \lambda_i \boldsymbol{y}_i, \overline{\boldsymbol{y}} \geq 0, \quad \lambda \geq 0 \right\}$$

The super-efficiency score $(\delta_0^*)$ is evaluated by solving the following program:

$$\delta_0^* = \min \delta = \frac{1}{\frac{1}{s}\sum_{r=1}^{s} \overline{y}_r / y_{r0}} \tag{A.1}$$

subject to:

$$\overline{\boldsymbol{x}} \geq \sum\nolimits_{j=1,\neq 0}^{n} \lambda_j \boldsymbol{x}_j$$

$$\overline{\boldsymbol{y}} \geq \sum\nolimits_{j=1,\neq 0}^{n} \lambda_j \boldsymbol{y}_j$$

$$\overline{\boldsymbol{x}} = \boldsymbol{x}_0, \quad 0 \leq \overline{\boldsymbol{y}} \leq \boldsymbol{y}_0, \quad \lambda \geq 0$$

Let $Y_{r0}$ be the amount of output $r$ generated by unit 0 and $\lambda_h$ be the intensity variable for DMU $h$. The score $\delta$ obtained from the solution to this linear programming problem measures the maximum output surpluses that are achieved by a specific efficient DMU compared with the remaining DMUs. By solving model (Eq. (A.1)) $n$ times (each time evaluating a different DMU at the objective function) we get the relative efficiency scores for all the DMUs.

## Appendix B. DEA model of project monitoring

The DEA problem is similar to that defined previously. Let assume portfolio $P_t' = \{p_k^t, \ 1 \leq k \leq v_t\}$ has been selected. Each project in $P_t'$ defines two DMUs, and there may be additional DMUs representing projects that started before selecting portfolio $P_t'$, as explained in Section 4.4. Hence, assume that there are $u$ DMUs, where $u \geq 2^* v_t$ DMUs. The set of outputs for DEA is given by $M$. $M = \{m_i, 1 \leq i \leq s\}$ where $m_i$ represents a KPI related with a current goal in the Strategy Map and $s$ is the number of KPIs.

## Appendix C

**Table C.1**
Portfolio selection. DEA input variables (investments, costs and eco-impacts) and output variables (portfolios' contribution to KPIs).

| Portfolios | Inputs | | | | Outputs | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initial costs | Paper | Energy | Total cost of ownership | # of Substantiated complaints regarding breaches of customer privacy | Avg working years of leaving employees | Applicant satisfaction | % of Tasks supported by telework | % of System development per month | Reduce time-to-hire by 10% per year | 1/Days to repair water leaks (1) | % of Cloud activity hosted in data center | % of Eligible products with EP features implemented and in use | % Energy reduction | % Contracts using EP products (target 95%) | % Water efficient equipment |
| 1 | 89,000 | 85 | 1860 | 48,060 | 1 | 5 | 3 | 40 | 100 | 10 | 1 | 50 | 90 | 3 | 90 | 70 |
| 2 | 79,000 | 75 | 1860 | 43,065 | 1 | 5 | 3 | 40 | 100 | 10 | 1 | 1 | 20 | 3 | 90 | 70 |
| 3 | 86,000 | 235 | 1860 | 48,060 | 1 | 5 | 3 | 40 | 100 | 10 | 0.333 | 50 | 90 | 3 | 90 | 70 |

Note (1): the inverse is used since the goal is to minimize the days to repair water leaks.

**Table C.2**
Project monitoring. DEA data derived from initial forecasts (P: planned projects) and ongoing projects (R: realized projects).

| Projects | Inputs | | | | Outputs | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initial costs | Paper | Energy | Total cost of ownership | # of Substantiated complaints regarding breaches of customer privacy | Avg working years of leaving employees | Applicant satisfaction | % of Tasks supported by telework | % of System development per month | Reduce time-to-hire by 10% per year | 1/Days to repair water leaks | % of Cloud activity hosted in data center | % of Eligible products with EP features implemented and in use | % Energy reduction | % Contracts using EP products (target 95%) | % Water efficient equipment |
| P1 | 7000 | 0 | 0 | 5000 | 0.333 | 3 | 1 | 10 | 0 | 0 | 0.2 | 1 | 20 | 3 | 40 | 10 |
| P2 | 7000 | 0 | 0 | 5000 | 0.333 | 3 | 1 | 10 | 0 | 0 | 0.2 | 1 | 20 | 0 | 40 | 70 |
| P3 | 5000 | 50 | 200 | 4750 | 0.333 | 3 | 1 | 10 | 0 | 0 | 1 | 1 | 20 | 1 | 40 | 10 |
| P4 | 5000 | 10 | 400 | 4590 | 0.333 | 3 | 1 | 40 | 0 | 0 | 0.2 | 1 | 20 | 0 | 90 | 10 |
| P5 | 5000 | 5 | 800 | 4195 | 0.333 | 3 | 1 | 40 | 0 | 0 | 0.2 | 1 | 20 | 0 | 40 | 10 |
| P6 | 10,000 | 5 | 50 | 4945 | 0.333 | 3 | 1 | 40 | 0 | 0 | 0.2 | 1 | 20 | 0 | 40 | 10 |
| P7 | 15,000 | 0 | 200 | 4800 | 0.333 | 5 | 3 | 10 | 100 | 10 | 0.2 | 1 | 20 | 0 | 40 | 10 |
| P8 | 15,000 | 0 | 200 | 4800 | 0.333 | 5 | 3 | 10 | 100 | 10 | 0.2 | 1 | 20 | 0 | 40 | 10 |
| P9 | 5000 | 5 | 0 | 0 | 0.333 | 3 | 1 | 10 | 0 | 0 | 0.2 | 50 | 90 | 0 | 40 | 10 |
| P10 | 5000 | 5 | 0 | 4995 | 0.333 | 3 | 1 | 10 | 0 | 0 | 0.2 | 50 | 90 | 0 | 40 | 10 |
| P11 | 10,000 | 5 | 10 | 4985 | 1 | 3 | 1 | 10 | 0 | 0 | 0.2 | 1 | 20 | 0 | 40 | 10 |
| R1 | 8000 | 0 | 0 | 5000 | 0.333 | 3 | 1 | 10 | 0 | 0 | 0.2 | 1 | 20 | 3 | 40 | 10 |
| R2 | 9000 | 0 | 0 | 5000 | 0.333 | 3 | 1 | 10 | 0 | 0 | 0.2 | 1 | 20 | 0 | 40 | 68 |
| R3 | 5000 | 50 | 200 | 4750 | 0.333 | 3 | 1 | 10 | 0 | 0 | 0.333 | 1 | 20 | 1 | 40 | 10 |
| R4 | 5000 | 10 | 400 | 4590 | 0.333 | 3 | 1 | 30 | 0 | 0 | 0.2 | 1 | 20 | 0 | 85 | 10 |
| R5 | 5000 | 5 | 800 | 4195 | 0.333 | 3 | 1 | 30 | 0 | 0 | 0.2 | 1 | 20 | 0 | 40 | 10 |
| R6 | 10,000 | 5 | 50 | 4945 | 0.333 | 3 | 1 | 30 | 0 | 0 | 0.2 | 1 | 20 | 0 | 40 | 10 |
| R7 | 15,000 | 0 | 200 | 4800 | 0.333 | 3 | 2 | 10 | 90 | 8 | 0.2 | 1 | 20 | 0 | 40 | 10 |
| R8 | 15,000 | 0 | 200 | 4800 | 0.333 | 3 | 2 | 10 | 90 | 8 | 0.2 | 1 | 20 | 0 | 40 | 10 |
| R9 | 6000 | 5 | 0 | 0 | 0.333 | 3 | 1 | 10 | 0 | 0 | 0.2 | 30 | 85 | 0 | 40 | 10 |
| R10 | 5000 | 5 | 0 | 4995 | 0.333 | 3 | 1 | 10 | 0 | 0 | 0.2 | 30 | 85 | 0 | 40 | 10 |
| R11 | 10,000 | 5 | 10 | 4985 | 0.5 | 3 | 1 | 10 | 0 | 0 | 0.2 | 1 | 20 | 0 | 40 | 10 |

## References


Adler, N., Friedman, L., Sinuany-Stern, Z., 2002. Review of ranking methods in the data envelopment analysis context. Eur. J. Oper. Res. 140, 249–265.

Asif, M., Searcy, C., Zutshi, A., Fischer, O., 2013. An integrated management systems approach to corporate social responsibility. J. Clean. Prod. 56, 7–17.

Banker, R., Charnes, A., Cooper, W., 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. Manag. Sci. 30, 1078–1092.

Contrada, M., 2000. Using the Balanced Scorecard to Manage Value in Your Business. Harvard Business Publishing Newsletters.

Cook, W., Seiford, L., 2009. Data envelopment analysis (DEA) – thirty years on. Eur. J. Oper. Res. 192, 1–17.

Cooper, W., Seiford, L., 2004. Handbook on Data Envelopment Analysis. Kluwer Academic Publishers, New York.

Cooper, W., Seiford, L., Tone, K., 2006. Introduction to Data Envelopment Analysis and Its Uses. Springer Science+Business Media, New York.

Charnes, A., Cooper, W., Rhodes, E., 1978. Measuring the efficiency of decision making units. Eur. J. Oper. Res. 2, 428–444.

Chen, W., Cho, W., 2009. A procedure for large-scale DEA computations. Comput. Oper. Res. 36, 1813–1824.

Cheng, C., Fet, A., Holmen, E., 2010. Using a hexagonal balanced scorecard approach to integrate corporate sustainability into strategy. In: International Sustainable Development Research Conference. Hong Kong.

Egilmez, G., Kucukvar, M., Tatari, O., 2013. Sustainability assessment of U.S. manufacturing sectors: an economic input output-based frontier approach. J. Clean. Prod. 53, 91–102.

Elkington, J., 1997. Cannibals with Forks: the Triple Bottom Line of 21st Century Business. Capstone Publishing, Ltd, Oxford.

Epstein, M., Wisner, P., 2001. Using a balanced scorecard to implement sustainability. Environ. Qual. Manag. 11, 1–10.

Figge, F., Hahn, T., Schaltegger, S., Wagner, M., 2002. The sustainability balanced scorecard: linking sustainability management to business strategy. Bus. Strategy Environ. 11, 269–284.

Gareis, R., Heumann, M., Martinuzzi, A., 2009. Relating Sustainable Development and Project Management. IRNOP IX, Berlin.

Hsu, Y., Liu, C., 2010. Environmental performance evaluation and strategy management using balanced scorecard. Environ. Monit. Assess. 170, 599–607.

International Organization for Standardization, 1997. Environmental Management. Life Cycle Assessment. Principles and Framework. International Standard ISO 14040, Geneva.

Kaplan, R., Norton, D., 1996. The Balanced Scorecard: Translating Strategy into Action. Harvard Business Press Books.

Kaplan, R., Norton, R., 2004. Strategy Maps. Converting Intangible Assets into Tangible Outcomes. Harvard Business School Press, Boston.

Kolk, A., 2005. Sustainability reporting. VBA J. 21, 34–42.

Labuschagne, C., Brent, A., 2003. A proposed lifecycle impact assessment framework for South Africa from available environmental data. S. Afr. J. Sci. 99, 115–122.

Labuschagne, C., Brent, A., 2005. Sustainable project life cycle management: the need to integrate life cycles in the manufacturing sector. Int. J. Proj. Manag. 23, 159–168.

Labuschagne, C., Brent, A., 2008. An industry perspective of the completeness and relevance of a social assessment framework for project and technology management in the manufacturing sector. J. Clean. Prod. 16, 253–262.

Länsiluoto, A., Järvenpää, M., 2010. Greening the balanced scorecard. Bus. Horiz. 53, 385–395.

Mehrabian, S., Alirezaee, M., Jahanshahloo, G., 1999. A complete efficiency ranking of decision making units in data envelopment analysis. Comput. Optim. Appl. 14, 261–266.

Perrini, F., Tencati, A., 2006. Sustainability and stakeholder management: the need for new corporate performance evaluation and reporting systems. Bus. Strategy Environ. 15, 296–308.

Project Management Institute, 2008. A Guide to the Project Management Body of Knowledge (PMBOK Guide), forth ed. PMI Publications, Newtown Square.

Reed, M., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. J. Environ. Manag. 90, 1933–1949.

Sánchez, M.A., Maçada, A.G., Sagardoy, M.d.V., 2014. Development of a strategy-oriented information technology investments assessment method. Int. J. Manag. Proj. Bus. Adm. 7, 43–60.

Silvius, G., Schipper, R., 2010. A maturity model for integrating sustainability in projects and project management. In: 24th World Congress of the International Project Management Association. IPMA, Istanbul.

Tone, K., 2001. A slacks-based measure of efficiency in data envelopment analysis. Eur. J. Oper. Res. 130, 498–509.

United Nations, 1987. Report of the World Commission on Environment and Development: Our Common Future.

Vandaele, N., Decouttere, C., 2013. Sustainable R&D portfolio assessment. Decis. Support Syst. 54, 1521–1532.

Zhou, P., Ang, B., Poh, K., 2008. A survey of data envelopment analysis in energy and environmental studies. Eur. J. Oper. Res. 189, 1–18.