PROJECT PORTFOLIO PRIORITIZATION FRAMEWORK - CASE STUDY APPLIED AT A BRAZILIAN SEMICONDUCTOR SUBSIDIARY

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Abstract
Project evaluation problem is a decision-making effort that integrates portfolio management and stakeholder engagement needs. Only feedbacks from project managers are not guarantee of success. The objective of this article is the presentation of an integrated approach that uses Data Envelopment Analysis (DEA) and Balanced Scorecard (BSC) as technique and tool to support firms to solve the problem about the decision of which project is efficient and which is not. The research method was a literature review and a case study of a semiconductor subsidiary developing design projects in Brazil. The inputs and outputs used for the DEA model offered graphic results that can be understood as a proper subset of projects evaluating their relative efficiency. Nineteen projects of integrated circuits were analyzed using DEA Variable Returns to Scale Input Oriented model in the case study. Inputs and outputs were considered as indicators. These indicators were based on project scorecards arising from the headquarter strategy for subsidiaries. The measures used were delivery precision, design revisions, cycle time, development cost, unplanned feature, and schedule conformance. Results showed that twelve projects were efficient and seven were not efficient. In conclusion, evaluation methods of project efficiency make possible to highlight a constructivist logic that appears helpful to develop criteria of decision-making in the portfolio management. To sum up, the communication is another important issue that the framework accomplishes using stakeholder theory and feedback requirements. This analytical structure could be used as a tool for performance management and control.

Keywords
Strategic Project Portfolio Management; Balanced Scorecard; Data Envelopment Analysis; Project Evaluation; Stakeholder.

1. Introduction
This paper’s objective is to supply an approach based on efficiency evaluation, project scorecards, and prioritization of projects using a case study in a semiconductor company in Brazil as analysis unit. Firms developing projects with reduced resources are required to integrate several
perspectives to evaluate their indispensable efforts. Our approach integrates Project Portfolio Management (PPM), Balanced Scorecard (BSC), Data Envelopment Analysis (DEA), and Stakeholder Management.

Portfolio is a component collection of programs, projects or operations managed as a group to achieve strategic objectives (1). Project portfolio management (PPM) is a common technique to align a project portfolio to these goals (2). BSC is a practical framework created by Kaplan and Norton (3) that solved the problem on how to follow up the strategy, monitoring indicators. DEA is a technique taken from operational research area developed by Charnes, Cooper, and Rhodes (4) used to evaluate the efficiency frontier. According with Freeman (5), stakeholder is any group or individual that can affect or be affected by achievements linked to the strategic objectives of the firms. Stakeholder behavior and stakeholder management are key success factors within PPM (6).

The relationship between PPM and the definition of an optimal state for the selection of existing and incoming projects has been studied over the years (6;2). Projects, in most cases, involve deliveries that are directly related to business strategies. The PPM through strategic control plays a crucial role in the management of deliberate and emerging strategies (7).

Even if, the positive results of firms with project-based business model are proportional to the selection of right projects (8), little has been published in the main newspapers of project management on the methods and techniques to accomplish this task. Locatelli et al. (9) discussed the selection, planning and the context of corrupt project. Especially for megaprojects, defined as large single projects (9).

Automation through software makes the criteria for selecting projects within the portfolio more objective. Software based on the DEA method is an interesting option for analyzing projects because it performs sorting based on the production function. Therefore, the metrics that will be used must meet the criteria adopted in the PPM. The analytical techniques employed in making project selection decisions are strictly financial in origin and tend to consider projects as entities separate from organizations (10). In the case of the DEA the indicators can be defined in the strategic planning and will be used to determine which project is efficient and which is not.

Broadly speaking, in the case study of this research, only operational indicators adopted by the project scorecard of the company, linking BSC and PPM, were defined. It is possible to apply the stakeholder theory to the project portfolio context. We researched a semiconductor firm where millions of dollars are spent in production and development of integrated circuits, so the operational indicators were used. The theory of stakeholder supports the need for feedback and reporting to anyone who needs it.

Next section presents the theoretical background and integrated framework proposed as a process. The third and fourth sections shows the case study with data extracted from a semiconductor firm.
company in Brazil. The procedure for collecting data and method employed area is discussed in the fifth section. The sixth section describes the results and formulates conclusions.

2. Theoretical Background and Integrated Framework

Many researches have shown that the need for an integration process between portfolio management, strategy, and tools and techniques to implement this approach. Too and Weaver (11) examine existing research, ideas and concepts of project governance and enterprise project management to supply a framework to build on current theory development and practice. They propose four key elements to improve the performance of projects and hence create value for firms. These four elements are portfolio management, project sponsorship, Project Management Office (PMO), and projects and program support. According with the authors, the framework proposed offers a guidance to firms in the development of effective project governance to optimize the management of projects.

Costantino, Di Gravio, and Nonino (12) showed a project selection in project portfolio management by means of an artificial neural network (ANN) based on critical success factors (CSF). Their research proposed a method to help managers in assessing projects during the selection phase. They used a system to predict project performances based on ANN scalable to any set of CSFs. The result was a kind of ranking of project’s riskiness, extracting the experience of project managers from successful and unsuccessful projects.

Kaiser, El Arbi, and Ahlemann (2) studied the effects of fundamental strategic changes on the project selection and organizational structure. From their three cases analysis in the German construction industry, they develop a substantive theory that integrates strategy implementation, organizational information processing, and structural adaptation.

On the other perspective, quite a lot of method studies have been conducted, trying to offer process, techniques and tools to improves delivery accuracy of projects (e.g. PMBOK, Prince2, SBOK). Another evident factor is the appearance of guidelines to improve project evaluation in firms that bring excellence in their practices on project management. Large organizations have budget to buy software that integrates high-level algorithms. Notwithstanding, our proposal is an integrated framework as an alternative to firms that would like to evaluate their portfolio of projects based, approaching the portfolio management, BSC, DEA and stakeholder management.

To propose an integrated framework, first we use a portfolio management concept that refers to the centralized management of one or more portfolios, which includes identifying, prioritizing, authorizing, managing, and controlling projects, programs, and other related work, to achieve specific strategic business objectives as mentioned in the Project Management Institute (13). Second, as projects compete for limited resources, the BSC proposed by Kaplan and Norton (14), a management tool composed of a collection of measures related to four major managerial
perspectives is important to strategic actions. Third, the popular non-parametric method of DEA will be used to evaluate the efficiency of projects and the integration with BSC (15). Furthermore, when thinking about projects and their management, it is impossible to forget the need for stakeholder evaluation. Freeman (5) argues that events and pressure groups with which we should be familiar become crises because we have not incorporated the idea of their existence into our day-to-day routine. Finally, the stakeholder communication is an important part of the process stipulated by our framework.

2.1. Stakeholder theory
In the past, approaches to understanding the business environment fail to take into consideration a wide range of groups that affect or are affected by corporations. The stakeholder theory provides a way to address new demands from groups having legitimate interests at different levels of the company.

This theoretical approach is linked with a generic and testable orientation for management strategic decision making. However, as stated by Freeman (5), it is also practical because any theory of strategic decisions must be applicable in the real world of firms. Changes occur in the external environment and are needed in the way executives think about their work and their firm. A strategic management approach should be conceptually rigorous in terms of managerial actions.

The 5th PMBok Guide of Project Management Institute (14) included the stakeholder management as a separated concentration area, considering the importance of this theory for firms. The guide provides four processes for managing project stakeholders: stakeholder identification, planning of stakeholder management, management of stakeholder engagement, and control of stakeholder engagement.

Academic works on stakeholder management have focused on the primary stakeholders who are skilled in controlling project resources, while the effect on secondary stakeholders, such as the local community (16), central governments, Non-Governmental Organization (NGO) (17), and media remain little studied. Communities are legitimate stakeholders in projects (18). Current studies tend to focus on achieving the benefits of stakeholder analysis and management in the social context, with a relationship to risk.

Stakeholder attributes are socially constructed variables and have been classified as power, legitimacy and urgency based on stakeholder theory (19). Mok, Shen, and Yang (20) addressed the complexity of managing stakeholders in projects related to cultural construction, mentioning the lack of relevant empirical studies. From the stakeholder perspective, Yu et al. (21) used social networks to investigate social risks related to the demolition of housing. The authors looked at the risks associated with stakeholders and their interrelationships based on literature review and interviews with key stakeholders, identified the critical risks and their corresponding stakeholders through the analysis of a social network. Teo and Loosemore (19) based on collective identity and
social capital theories to present an ethnographic analysis of community action in a controversial large-scale civil construction project in Australia. Beringer et al. (22) points out that measures of PPM maturity affect the nature of the relationship between the intensity of engagement (IoE) of stakeholders and portfolio success.

2.2. Project Portfolio Management

Organizational strategies are formulated to seek increased performance. The way in which knowledge is converted adds value to the strategic theory of firms. This affirmation can be verified in the learning strategy formation as an emergent process (23). In this perspective, strategy formulation is an emerging process. Kopmann et al. (8) suggested that formal strategy processes have been shown to be insufficient in formation of organizational adaptability. the emergent strategies are important for strategic calibration plans which are independent of processes presents in the top-down deliberate strategy.

Figure 1 shows the organizational context in a pyramid format and the relationships between levels according to strategy, project portfolio management and organizational processes.

![Figure 1 - Organizational Context of Portfolio Management.

Source - Project Management Institute (1).](image)

According with the portfolio management approach (1), the organizational strategy is a plan that describes how strengths and core competencies of the firm will effectively manage resources and value for stakeholders. As stated by the Project Management Institute, strategies must capitalize
on opportunities, minimize the impact of threats, respond to market changes, laws and the regulatory environment, and reinforce focus on critical operational activities.

Petro and Gardiner (24) point out that many studies focus on investigation of the organizational structural factors and their influence on project success. Researchers also investigated portfolio success and effectiveness. The authors noted that such constructs are a product of strategy, and if not aligned correctly, a dichotomy will appear between strategy (portfolio) and its translation (structure) with an effect on performance. The findings of the study developed by Padovani and Carvalho (25) indicate that there is a strong relationship between project portfolio management and performance. The author used, in their project portfolio management measurement model, a set of 11 processes described as knowledge of the organizational context; opportunity identification; decision criteria; classification; selection, prioritization, optimization and sequencing; balancing; approval; resource allocation; formation of portfolio; and project portfolio management infrastructure.

Patanakul (26) proposed the understanding of project portfolio management (PPM) effectiveness identifying six attributes based on strategy and operation. The strategic are: strategic alignment, adaptability to internal and external changes, and the expected value of the portfolio. The operational attributes are project visibility, transparency in portfolio decision making, and predictability of project delivery.

It is noted that organizational resources are distributed in the management of on-going operations (recurring activities of organizational processes) producing value and management of authorized projects and programs (project activities), increasing the organizational ability to produce value. In principle, aligning portfolio management with organizational strategy is to establish a balanced and realistic planning that will support and control the acquisition of strategic goals. Portfolio is the set of programs and projects determined in the organizational strategy.

Production of business value for the firms is a unique concept for each one. As proposed by the Project Management Institute (1), the total value of the business is sought, the sum of the tangible and intangible elements. Monetary assets, luminaries, net worth and utility are tangible and goodwill, brand recognition, public benefit and trademark registration are intangible.

Value can be created through effective management of ongoing operations. However, when the perspective is oriented to project management, it is assumed that through the effective use of portfolio management, programs and projects, firms can obtain the ability to employ reliable and established processes to achieve strategic goals and win higher value in business from project investments.

Recently publications in operation management argue in favor of project management to develop and improve operational capabilities. The operations and processes management model (27) shows project management, improvements, quality and risk management and resilience among the
relevant themes for the development and improvement of the production system. The projects have a unique aspect in relation to business operations that require a special management approach (28). The acceptance of the importance of project management for operations and strategy is helpful. Tools like Balanced Scorecard should help firms acquire their goals and put in place the plans for competitive advantage, including in project and portfolio management.

Davies and Brady (29) distinguished between project capabilities at the operational and dynamic capabilities at the strategic levels. Firms depend on identifiable portfolio management techniques that are dynamic capabilities to know how and when to maintain actual project capabilities and when to modify or replace them depending on the environment conditions (29). This dependence leads to special attention to the implementation of the strategy.

Observing the Brazilian scenario, Biscola et al. (30) used PPM as a tool to select projects in which public funds were invested, developing a PPM diagnostic model for public research institutions. It is feasible to integrate the project portfolio with the organizational strategy. The implementation of effective strategic planning for public research institutions is paramount to the success of the project portfolio (30).

2.3. Perspectives of Balanced Scorecard

In today’s turbulent environment, strategy has never been more important. Yet research shows that most firms fail to execute strategy successfully, going further down firms fail in implementing their strategies even though they employ project, programme and portfolio management techniques (31). In this perspective, Kaiser et al. (2) argue that successful project portfolio management - and consequently, effective strategy implementation – depends on structural alignment of the firm with the needs of PPM. The authors developed a substantive theory to explain how the criteria, used by a company to choose and evaluate its projects, influence the company's structure through the information requirements created by such criteria.

In the Brazilian context, Cavalcante and Macedo (32) applied DEA method to BSC indicators of 50 branches of the middle market segment of one of the 10 largest Brazilian banks to defining efficient and inefficient units, comparing them with the scores of BSC defined by the analyzed firm in study. Considering the discussions between bank executives and unit managers, the authors identified a strong alignment of DEA results with the premises proclaimed in these meetings of participatory observation.
Furthermore, Golany, Eilat, and Shtb (16) propose an uncertainty perspective in additional to that presented in the Figure 2, the perspectives of Balanced Scorecard (15).

![Perspectives of Balanced Scorecard (BSC).](image)

The uncertainty perspective includes measures such as the probability of technical success and the probability of commercial success, which are critical measures in evaluating research and development (R&D) projects. Our understanding is that uncertainty is an important perspective not only for evaluation of R&D projects but to evaluate all kind of projects and to build plans and stakeholder focused strategy.

The strategic management processes are vision translation, communicating and linking, business planning and feedback and learning (3). The translation of the vision occurs through the simplification of vision and consensus achievement. The process of communicating and linking occurs through education, setting goals, and linking awards to performance measures. Business planning happens with targeting, linking strategic initiatives and allocating resources. Feedback and learning appears with the articulation of shared vision, providing strategic feedback and facilitating strategy review and learning.
Feedback from the real world can stimulate changes in mental models (33). Learning involves new understandings or reformulation of a situation and leads to new goals and new rules of decision. Therefore, Sterman (33) points out that learning is a signifying occurrence of the ability to move fast in relation to changes in the real world, before transforming existing obsolete knowledge. It turns out that in the real world of social action, these feedbacks often do not work well.

After reviewing the seminal and current studies of stakeholder theory, PPM, and BSC as well as its recent use in project management knowledge area, the following section introduces the DEA. The DEA model that was used to calculate the relative technical efficiency of the projects evaluated in the case study of a semiconductor company in Brazil will be detailed and its mathematical formula will be shown.

2.4. Data Envelopment Analysis (DEA)

Since the original DEA study of Charnes, Cooper, and Rhodes (4), a lot of publications and different field of applications have been continuously growing. Green, Doyle, and Cook (34) worked on the preference voting and project ranking using DEA and cross-evaluation. Linton, Walsh, and Morabito (35) started the analysis, ranking and selection of R&D projects in a portfolio. After these previous researches, Eilat, Golany, and Shhtub (36) published a methodology based on DEA to evaluate balanced portfolios of R&D projects. As mentioned before, Golany, Eilat, and Shhtub (16) identified efficient projects using the key performance indicator (KPI) defined in the strategic maps of BSC.

DEA has opened possibilities for use in cases of complex relations between the multiple inputs and multiple outputs involved in many activities (37). From the viewpoint of DEA, we developed a model that treats data inputs and outputs in accordance with the scorecards definition.

When analyzing this kind of project, a variable return-to-scale model of DEA may be more suitable. This model commonly known as the BCC (Banker, Charnes, and Cooper) or VRS (Variable Returns to Scale) model (38).

The term Decision Making Unit (DMU) represents any business operations, processes, or entities under evaluation. DMU can be any entity that converts multiple inputs into outputs (39). The BCC/VRS model has its production frontiers spanned by the convex hull of existing DMUs (37). This VRS Envelopment Model Input Oriented is represented by the equation (1) (39).
Min $\Theta$

subject to:

\[
\begin{align*}
\sum_{j=1}^{n} \lambda_j x_{ij} & \leq \Theta x_{i0}, & i = 1, \ldots, m \\
\sum_{j=1}^{n} \lambda_j x_{rj} & \geq y_{r0}, & r = 1, \ldots, s \\
\sum_{j=1}^{n} \lambda_j & = 1 \\
\lambda_j & \geq 0, & \forall j
\end{align*}
\]  

Equation (1)

In this equation (1) of DEA proposed by Cook and Zhu (38), $\Theta$ indicates the level of efficiency of the unit under analysis. The vectors of inputs $x$ and outputs $y$ of unit $j$ are represented by $x_{ij}$ and $y_{rj}$. If $\Theta = 1$, the unit $l$ (unit under analysis) is on the frontier of efficiency. On the other hand, if $\Theta < 1$ then the unit can still reduce its inputs, maintaining all the outputs unaltered, and is, therefore, inefficient among the group of units analyzed by the model.

Broadly speaking, DEA consist of a family of models with various assumptions on the input-output relationships that are exhibited by the DMUs under consideration of Charnes et al. (40). To facilitate the understanding of some concepts in this article, projects are defined as DMU (Decision Making Unit). This connotation is important to DEA outputs comprehension. We will adopt metrics that reflect the strategy to choose project under evaluation. These measures are used for a global company that need to make decision on which projects and design houses are meeting stretch and above points required globally.

In the study of Iyer and Banerjee (41), a group of 57 projects was selected and configured as Decision Making Units (DMUs) in a Data Envelopment Analysis (DEA) procedure which is then integrated with Principal Component Analysis (PCA). The authors did suitable modifications in
their model to change the overall and relative performance of DMUs to measure and rank their managerial efficiency.

In another scientific research, the objective of Sudhaman and Thangavel (42) was to analyze the efficiency of ERP projects based on their quality measures (defect counts) using the Data Envelopment Analysis Constant Returns to Scale (DEA CRS) model and identify the most efficient ERP projects.

Shi et al. (43) conducted a case study of risk analysis in China in the context of program management using fuzzy logic and DEA. The authors followed the content analysis of building a delivery risk structure for a construction program as the foundation of risk qualitative and quantitative analysis, creation of risk magnitude and assess the efficiency of delivery methods by using fuzzy logic theory and DEA. Finally, they conducted a case study of the 2010 Guangzhou Asian Games, applying and verifying the mixed delivery risk assessment approach developed.

3. Method

The research was characterized as a case study. A case study is best defined as an intensive study of a single unit of analysis to generalize across a larger set of units (44). It is necessary to define the unit of analysis that can be one or more individuals, groups, firms, events, countries or regions (45). The case study of this research focused on inductive observation of theory (46), this means that contextual conditions are approached considering that they are related to the phenomenon under study (45). However, because it is unique, we are aware of the logical question of generalization (44). The case was carried out within the unit of analysis at an exact moment in time.

The application of techniques and tools present in the integrated framework proposed to the case study was done after a previous immersion of the researcher in the subsidiary under analysis. The data collection was based on documents that were collected before the decision to use them.

The access of this documentation was verified and authorized after by company executives and managers. Basically, these documents were used to prioritize projects portfolio based on scorecards defined in the strategy of the semiconductor firm.

3.1. Case study

The work presented in this paper involves a Design Center based in Brazil of a large semiconductor manufacturer that caters for several markets worldwide.

Their portfolio of power management solutions, microprocessors, microcontrollers, sensors, radio frequency semiconductors, analog and mixed signal circuits and software technologies are embedded in products used around the world.
Essentially, a Design House (DH) is equivalent to the architectural office. DH designs circuits, according to the need of products. Potential customers are the automotive companies, manufacturers of white line, telecommunications area, among others.

As soon as the project is ready, it is sent to a factory. The factory produces a sample component, following the indications of the project. If the sample after tested by DH, is considered appropriate, the factory then begins to provide the component. The intellectual property of the project is entirely with the customer or is split with the DH, depending on the contract.

As pointed by the site CI Brazil (47), this company focused on the development of microcontroller designs, analogical Integrated Circuits (ICs) and digital and analog Intellectual Properties (IPs), some with very high precision and or very low consumption requirements. Originally, this semiconductor company stands out as an international reference in the development and manufacture of digital and analog integrated circuits, in what is the most modern in the world in automotive, consumer, industrial and communication solutions.

Its operations in Brazil began in 1967 as the semiconductor industry, laying the foundations for what would become the Brazil Semiconductor Technology Center (BSTC) in 1997.

The company had more than 100 projects delivered in 2008, including 8- and 32-bit microcontrollers, mainly for the automotive and industrial markets, analog ICs and digital and analog IPs. These products include applications in electronic injection and transmission, serial-parallel interfaces, voltage regulators, automotive network physical layer, integrated power switches, automotive panel drivers, amplifiers, integrated fuses, analog comparators, power management subsystem, A / D converters (SAR) and oscillators, among others.

The main differential was the specialized training that the company offers its clients, to enable them to develop projects that use their devices. One of the results of the interaction between the teams and its clients is the competitive differential presented by the company, in the national market.

Nowadays, this semiconductor manufacturer has been acquired by another player of the marketplace. The acquisition was finished in Dec 2015. The new owner is a world leader in secure connectivity solutions for embedded applications, driving innovation in their connected solutions. The new company has 45,000 employees in more than 35 countries in that moment.

3.2. Data collection

The generation of data load was made extracting measures from the project scorecard spreadsheet present in the documentation of the Brazilian semiconductor design center. The units of analysis were nineteen projects that were being developed at the time of data extraction. The evaluation of these projects involves many performance aspects. However, we took in consideration 2 inputs and 4 outputs. Table 1 shows the inputs and outputs extracted from IC projects scorecard.
Table 1 - Scorecard of integrated circuit projects.

<table>
<thead>
<tr>
<th>Integrated Circuits Projects</th>
<th>INPUTS</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Delivery Precision</td>
<td>Design Revisions</td>
</tr>
<tr>
<td>Digital Intellectual Property 1</td>
<td>1.50</td>
<td>1.00</td>
</tr>
<tr>
<td>Digital Intellectual Property 2</td>
<td>1.22</td>
<td>1.50</td>
</tr>
<tr>
<td>Digital Intellectual Property 3</td>
<td>1.35</td>
<td>1.50</td>
</tr>
<tr>
<td>Digital Intellectual Property 4</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>Analog Intellectual Property 1</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>Analog Intellectual Property 2</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>Analog Intellectual Property 3</td>
<td>1.45</td>
<td>1.50</td>
</tr>
<tr>
<td>8-bit Microcontroller 1</td>
<td>1.50</td>
<td>1.00</td>
</tr>
<tr>
<td>8-bit Microcontroller 2</td>
<td>1.50</td>
<td>1.00</td>
</tr>
<tr>
<td>8-bit Microcontroller 3</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>32-bit Microcontroller 1</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>32-bit Microcontroller 2</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>32-bit Microcontroller 3</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>Memory Module 1</td>
<td>1.32</td>
<td>1.00</td>
</tr>
<tr>
<td>Memory Module 2</td>
<td>1.50</td>
<td>1.00</td>
</tr>
<tr>
<td>Memory Module 3</td>
<td>1.50</td>
<td>1.00</td>
</tr>
<tr>
<td>Memory Module 4</td>
<td>1.50</td>
<td>1.00</td>
</tr>
<tr>
<td>Memory Module 5</td>
<td>1.34</td>
<td>1.00</td>
</tr>
<tr>
<td>Memory Module 6</td>
<td>1.11</td>
<td>1.00</td>
</tr>
</tbody>
</table>

The inputs were Delivery Precision, Design Revision and Cycle Time. The outputs were Unplanned Feature and Schedule Conformance. Delivery precision is an important KPI for a business because it gives an indication of how well the company’s supply chain is performing (48).

In principle, the design is the central process of semiconductor firm. Its productivity for closing the increasing design gap which exists between the ability in manufacturing microchips and the capability to design them are crucial (49;50).

The design revision is the scorecard that determines the number of revisions required to have a tiny wafer of semiconducting material used to make an integrated circuit (51). The period required to complete one cycle of an operation, function, job, or task from start to finish. Cycle time is used in differentiating total duration of a process from its run time (52). The Unplanned feature is a scorecard that complies with characteristics not provided for a microchip that needs to be incorporated into the activities of the design team carrying the inclusion on the project schedule. Schedule conformance is the variance of current production against scheduled production.

The interpretation of this scorecard is how much manufacturing is over or under produces against task plans. Assertive continuous improvement programs should be in place to decrease the variance (53).

According with documental analyze extracted from the design center the outputs was defined in terms of points that were based on measurements of their compliance. The data source for the case study is compounded by indicators of performance developed to supply capacity of decision in terms of which project is on good stand.
4. Findings and Discussions

To measure the projects in terms of output-oriented model the Table 2 below shows the points and classification used for the evaluation.

The model used to find the efficiency of projects was the DEA VRS Envelopment Input Oriented. Data for the case are presented in Table 2 that will be presented in the next topic defined as research method.

Table 2 - Points and measures of the IC Projects.

<table>
<thead>
<tr>
<th>Four Outputs</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low &amp; Below</td>
<td>0</td>
</tr>
<tr>
<td>Low &amp; Commit</td>
<td>0.0 to 1.0</td>
</tr>
<tr>
<td>Commit to Stretch</td>
<td>1.0 to 1.5</td>
</tr>
<tr>
<td>Stretch &amp; Above</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Table 3 presents the results of the implementation of the VRS model for projects as DMUs. The first column presents the DEA efficiency score, whereas the next column presents a ranking. Projects with the same DEA score were assigned the same rank.

The group of projects with the scores 1 in the VRS input oriented results includes 12 projects and the range of scores for other projects is between 0.125 and 1.

Table 3 - Efficiency Score of DMU.

<table>
<thead>
<tr>
<th>Number</th>
<th>DMU</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Digital Intellectual Property 1</td>
<td>1.00</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Digital Intellectual Property 2</td>
<td>0.50</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>Digital Intellectual Property 3</td>
<td>0.33</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>Digital Intellectual Property 4</td>
<td>1.00</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Analog Intellectual Property 1</td>
<td>1.00</td>
<td>1</td>
</tr>
</tbody>
</table>
Efficiency of integrated circuits projects can be showed better using a graph distribution with the limit of frontier set as 1. In the Graphic 1, it is possible to observe that the efficient projects are:

- Memory Module projects 2, 3, 4, and 5;
- Digital Intellectual Property 1 and 4;
- Analog Intellectual Property 1, 2, and 3;
- 8-bit Microcontroller 1 and 2.

Inefficient projects are:

- Memory Module 6;
- Digital Intellectual Property 2 and 3;
- 8-bit Microcontroller 3;
- 32-bit Microcontroller 1, 2 and 3.
The fact that no 32-bit microcontroller project is under the efficient frontier could be explained because of the development and execution complexity of this kind of project.

![Diagram](Image)

**Graphic 1 - Graph of project efficiency based on Table 3.**

**Source** - Developed by the authors as result of DEA Solver Software.

These results could be communicated through the subsidiary, in special to the stakeholders of the project (15). With this approach projects managers receive a clear signal on their success, by using an objective evaluation method.
4.1. Project Portfolio Prioritization Framework

Based on literature review and the case study of a Brazilian semiconductor subsidiary, we proposed the efficient theoretical framework of Project Portfolio Prioritization. The desired result is explained in an integrated structure of project evaluation showed in the Figure 3.

![Figure 3 - Organizational Context of Project Portfolio Management efficient framework.](image)

The flow starts from a group of projects present in the portfolio that will help executives decide whether money is being spent wisely in pursuit of strategic objectives. The Balanced Scorecard support the indicators that drive performance, putting the strategic actions to work in conformance with strategy management system and correct measures that will help project teams properly. The DEA Model will focus exclusively on strategy indicators objectives. The graphics of project efficiency will be delivered to any group or individual that is required to make decision to achieve the organization goals, providing a way to think about project portfolio prioritization.

An important flow of this framework is the feedback. After the utilization of the reports to take better decisions, stakeholders are required to send their insights about the relevance and improvements to be taken by the portfolio management and strategic planning teams in order to improve the scorecards and available projects to be prioritized. Most of the time, this teams are organized in a Project Management Office (PMO).
5. Final Considerations and Implications for the Future

Given the operating constraints like cost and resources that characterize project-oriented firms, we believe that our efficient project portfolio framework can help them in two ways. First, a tool based on Linear Programming like DEA supplies more flexibility and transparency possibilities to communicate project status to stakeholders, including project managers and teams. Second, the results of this work show the way to associate projects evaluation in function of operational productivity, instead of only finance or other performance indicator.

To sum up, a better comprehension of evaluation methods of project efficiency should make it possible to highlight a constructivist logic that appears helpful to develop criteria in the portfolio management. BSC is a tool to follow up the strategic plan. The efficiency or non-efficiency of a DEA model results are based on the scorecards defined in the formulation of the strategy.

The communication is another important issue that the framework accomplishes using stakeholder theory and feedback requirements. This analytical structure could be used as a tool for performance management and control.

The limitations existing in the propositions of this research are found in the fact that a documentary analysis was carried out, relying on only a single case study. New cases must be performed to refine the proposed structure. Besides that, as future work, the inclusion of cost and quality indicators is an interesting enlargement alternative.

6. References


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