

EcoMCS: A Project Management Application Through Management Control Systems for Residential Construction Firms in Colombia

Milton Soto-Ferrari

Scott College of Business,

Indiana State University, Terre Haute, IN, USA

Email: milton.soto-ferrari@indstate.edu (*Corresponding Author*)

Odette Chams-Anturi

Department of Economic Science,

Universidad de la Costa, Colombia

Email: ochams@cuc.edu.co

ABSTRACT

This research article aims to introduce a novel project management application, denominated EcoMCS, based on Management Control Systems (MCS) assessment to improve the performance of residential construction firms in Colombia. The study is grounded in the conceptualization of project management and MCS and builds upon an interview study conducted with managers of residential construction firms in the country. Our findings revealed that the economic dimension is the least developed, indicating a need for improvement. The project's specific objectives include enhancing the MCS's economic dimension, refining evaluation methods for goal fulfillment, implementing incentive programs, fostering decentralized decision-making, and nurturing human potential within residential construction firms. By addressing these objectives, the proposed EcoMCS application seeks to facilitate efficient and effective project management practices in the residential construction industry, ultimately contributing to more sustainable and cost-effective construction projects.

Keywords: *economic dimension, management control systems, project management, residential construction firms*

1. INTRODUCTION

Project management is critical in successfully delivering projects across various industries, and the residential construction sector is no exception (Ahadzie, Proverbs and Olomolaiye, 2008). Project management has gained considerable attention due to its significant role in determining the success of construction projects. In the construction industry, project management is vital in managing the complex interrelationships between multiple stakeholders, resources, and project objectives (Müller, Geraldi and Turner, 2007).

Project management is centered on planning, organizing, and controlling resources to achieve specific goals within a predetermined time, cost, and quality framework (Geraldi and Lechter, 2012). Effective project management contributes to project success by ensuring the fulfillment of client expectations and maintaining control over the project life cycle with the support and commitment

of top management to implement well-documented projects and systems, including identifying qualified personnel, motivation, and communication (Zwikael and Smyrk, 2015; Kumar *et al.*, 2021).

The construction industry, specifically the residential sector, has been facing numerous challenges, such as cost overruns, delays, and issues in quality control, which can have severe economic implications (Ahadzie, Proverbs and Olomolaiye, 2008; Love *et al.*, 2015). In recent years, there has been an increased emphasis on Management Control Systems (MCS) as an effective means to enhance project performance. MCS encompasses various techniques and tools that businesses use to coordinate and control their activities to achieve organizational goals (Nogueira, Hernández and Negrín, 2002; Zwikael and Smyrk, 2015).

In the context of residential construction projects, MCS data can be instrumental in understanding and addressing the challenges associated with these projects. Residential construction projects in developing countries encounter additional unique challenges, such as inadequate resources, complex regulatory environments, and high demand for affordable housing (Ahadzie, Proverbs, and Olomolaiye, 2008). These challenges impose the development of robust MCS that can provide a comprehensive view of project performance and enable timely decision-making to address potential issues.

MCS is essential for guiding, monitoring, and evaluating project performance, thus enhancing decision-making processes and improving overall project outcomes (Simons, 1995). The application of MCS in project management allows organizations to align their strategic objectives with project outcomes and monitor performance more effectively.

MCS facilitates the control of information, resources, and decision-making processes, which in turn contribute to achieving the desired results in project execution. In construction projects, MCS is crucial for identifying and mitigating risks and uncertainties, thus upkeeping the project's successful completion (Caballero, 2016).

In this research, we developed an interview study with managers of residential construction firms in Colombia that

has identified the need to improve the economic dimension of the MCS, which is crucial for ensuring the financial viability and sustainability of construction projects (Memon *et al.*, 2012).

The collected data indicates that the economic dimension of MCS is the weakest among the studied dimensions. In this light, there is a pressing need to develop project management applications that address this shortcoming and improve the overall performance of residential construction projects. The primary objective of this investigation is to develop a project management application using MCS assessment to enhance the economic dimension of the residential construction sector in Colombia.

The project management application will aim to address several specific objectives to achieve the overarching goal of improving the economic dimension of the MCS. First, the application will enhance evaluation methods for goal fulfillment, incorporating best practices from the literature and empirical research (Tukel and Rom, 2001; Chams-Anturi *et al.*, 2022). By doing so, the application will enable residential construction firms to effectively track and evaluate their progress towards defined project goals, providing valuable feedback for decision-making and improvement efforts.

Moreover, the study intends to enhance the evaluation methods for goal fulfillment in residential construction firms. Tukel and Rom (2001) suggest that one possible approach could be analogous to a balanced scorecard framework that can help to establish more effective project evaluation criteria.

The proposed project management application will introduce incentive programs that align the interests of various stakeholders with project objectives (Hwang, Zhao and Goh, 2014). This scheme will foster a collaborative work environment and motivate team members to achieve project goals. The incentive programs will be designed based on the MCS assessment and informed by the best practices identified in the literature (Nogueira, Hernández and Negrín, 2002; Caballero, 2016).

An additional project goal is to promote decentralized decision-making in residential construction firms. Decentralized decision-making empowers project managers and teams to make informed decisions based on localized information, enabling rapid responses to project challenges (Zwikael and Smyrk, 2015). By fostering decentralized decision-making, the application will help firms to effectively address project risks and uncertainties, ultimately improving project outcomes.

The proposed development also includes stages related to the people's potential within residential construction firms (Psychogios *et al.*, 2016). The application will facilitate the identification of skill gaps and training needs in the workforce, enabling firms to invest in targeted capacity-building efforts (Müller, Geraldi and Turner, 2007; Ma *et al.*, 2019). As a result, residential construction firms will be better equipped to meet the demands of their projects and adapt to evolving industry trends and practices.

2. LITERATURE REVIEW

In developing a project management application embedded with MCS assessment from residential construction firms in developing countries such as

Colombia, it is essential to conduct an exhaustive literature review to provide a comprehensive understanding of the existing research and establish the following foundation for the investigation.

Ahadzie, Proverbs and Olomolaiye (2008) discuss critical success criteria for mass house-building projects in developing countries. Their research offers valuable insights into the unique challenges and success factors construction projects face in developing countries like Colombia. This study serves as a crucial starting point for understanding the context and the factors that may impact the proposed project management application in the Colombian residential construction sector.

Zwikael and Smyrk (2015) address project governance by balancing control and trust in risk management. They emphasize the need for an effective risk management process and the importance of balancing control and trust in project governance. This research can guide the development of a project management application in managing risks and fostering a trusting environment among stakeholders.

Psychogios *et al.* (2016) propose a three-fold framework for understanding human resource management (HRM) practices in South-East Asian construction organizations. Their study highlights the importance of HRM practices in construction projects. It provides a framework that can be adapted to the Colombian context.

Geraldi and Lechter (2012) critically analyze Gantt charts and their implications in managing projects today. Their research offers insights into the strengths and limitations of Gantt charts as a project management tool and can enlighten the development of the project management application in Colombia.

Hwang, Zhao and Goh (2014) investigate client-related rework in building projects, focusing on the case of Singapore. Their study identifies various factors contributing to rework and provides valuable information for developing project management applications to minimize rework and improve project outcomes.

Several other studies (Müller, Geraldi and Turner, 2007; Ma *et al.*, 2019; Saunders, Gale and Sherry, 2016) provide valuable insights into various aspects of project management, such as project success factors, risk management, cost and time performance, stakeholder management, and the integration of management control tools. These studies serve as essential resources in understanding the broader context of project management and the factors that may influence the development and implementation of the proposed project management application in Colombia.

Remarkably, studies such as Memon *et al.* (2012) and Rodríguez-Rivero *et al.* (2020) provide a deeper understanding of the dimensions of project success that can be related to the construction industry, emphasizing the importance of time and cost performance as well as risk management. These studies can inform the application's design to ensure it addresses the critical success factors in construction projects.

Müller, Geraldi and Turner (2007) link project managers' complexity and leadership competencies, highlighting the need for practical leadership skills in managing intricate projects. Their review can be valuable in identifying the competencies that should be fostered and supported by the project management application.

Opoku and Fortune (2013) focus on implementing sustainable practices in UK construction organizations, offering insights into how social practice theory can be used to understand and support sustainable practices.

Additionally, studies such as Stanitsas, Kirytopoulos and Leopoulos (2021) explore the integration of sustainability indicators in construction project management practices. They contribute to sustainable project management for construction projects by providing a holistic view of project management indicators in the Triple Constraint (TBL) and display the likelihoods for professionals to choose the right indicators for their projects.

On the other hand, Lalmi, Fernandes and Souad (2021) study that traditional project management is sometimes not the most appropriate approach for complex construction projects since they are constantly changing, and more agile approaches are required. They propose a hybrid project management approach for construction projects, discussing traditional, agile, and lean practices and promoting change and more interaction with the customer to increase the probability of success of construction projects.

Unegbu, Yawas and Dan-Asabe (2022) studied the relationship between project performance measures and construction project management practices for the construction industry in Nigeria. They designed a questionnaire to collect data on 19 project management performance measures and 53 project management practices.

Similarly, Herath and Chong (2021) identify key project components and critical success factors for successful project management in the construction industry. The research proposes five key project components (i.e., project human resources management, project design package, project management efficiency, project stakeholder management, and project budget) that contribute to successful project management for construction projects. Critical success factors, such as top management support and commitment, provide a cultural work environment and friendly environmental factors.

Ghorbani (2023) conducted an in-depth review of the competencies and leadership of construction project managers. The study praised the dynamism of the projects and the risks involved. Concluding that construction-oriented organizations must be trained, competent, leading, and with experienced project managers. A successful project manager must have personal knowledge, skill, leadership, ability, and attitude to complete the project successfully.

Numerous other studies, including Tukul and Rom (2001), Williams and Samset (2010), and Le *et al.* (2014), explore different aspects of project evaluation, safety management, front-end decision-making, and corruption in the construction sector. These studies provide critical insights into the challenges faced by the construction industry. They can inform the development of the project management application to ensure it addresses these challenges.

This brief review offers valuable insights into project management, success factors, risk management, and management control systems in construction projects. By synthesizing the findings from these studies, a solid foundation can be established for developing a project management application using MCS data and assessment from residential construction firms in Colombia, as proposed in this research.

This evaluation will ensure that the application is designed to meet the unique challenges and success factors of the Colombian construction industry and supports effective project management practices.

3. PROPOSED PROJECT MANAGEMENT APPLICATION: ECOMCS

In the quest to improve the project management practices within residential construction firms in Colombia, this research paper presents a novel project management application named EcoMCS (Economic Management Control Systems) that aims to address the challenges these organizations face. The development of EcoMCS is driven by data collected from an interview study with 11 managers of construction firms in the country. These interviews focused on the various dimensions of MCS, particularly the economic dimension, identified as the lowest-performing area.

The EcoMCS application has been strategically segmented into six distinct yet interconnected modules, each designed to target a specific aspect of the construction firms' project management processes. By creating specialized modules, the application ensures a comprehensive and targeted approach to enhance the efficiency and effectiveness of project management practices. These modules are as follows: (a) Financial Assessment Module, (b) Cost Management Module, (c) Performance Measurement Module, (d) Incentive Programs Module, (e) Decentralized Decision-making Module, and (f) People Development Module, as presented in **Figure 1**.

The Financial Assessment Module serves as a crucial component for analyzing residential construction firms' financial health and identifying constraints and opportunities to optimize their economic performance. This module offers a foundation for the other modules, as it sets the stage for understanding the firms' financial capabilities and adjusting strategies accordingly.

The Cost Management Module plays a vital role in streamlining the management of financial resources. This module is instrumental in promoting financial discipline and optimizing resource utilization by focusing on cost estimation, budgeting, procurement, and resource allocation.

The Performance Measurement Module offers a structured approach to setting project objectives and monitoring progress. This module enables construction firms to continuously evaluate and improve their project outcomes by using clear performance indicators and establishing an integrated monitoring system.

The incentive Programs Module addresses the need for motivation and employee engagement within residential construction firms. By designing performance-based reward systems and team-based incentives, this module fosters a culture of excellence and promotes collaboration among the workforce.

The Decentralized Decision-making Module encourages a more agile and responsive management approach within construction firms. By empowering project managers with decision-making autonomy and fostering cross-functional communication, this module allows for

faster and more effective responses to project challenges and opportunities.

Lastly, the People Development Module focuses on nurturing the skills and potential of individuals within residential construction firms. By offering training, mentorship programs, and succession planning, this module ensures continuous growth and development of the workforce.

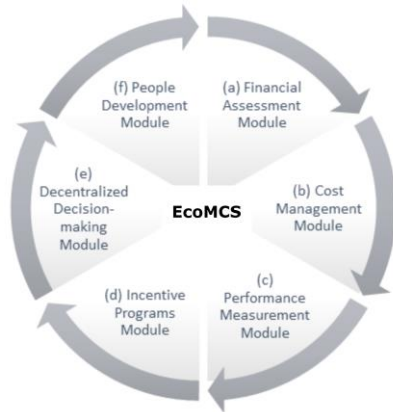


Figure 1 EcoMCS Modules

The EcoMCS application offers a comprehensive and targeted approach to improving project management practices within residential construction firms in Colombia. With its modular design, EcoMCS directly addresses the specific challenges and opportunities identified through the interview study with managers, using the MCS dimensions as the foundation for data collection assessment and analysis.

The implementation of EcoMCS promises to contribute significantly to the advancement of project management processes, ultimately enhancing the performance and success of residential construction firms in the country. In the following sections, we detail the features activities and data collection structure to proceed with the implementation.

3.1 EcoMCS Modules Features

The EcoMCS framework contemplates the subsequent systematic practices and activities in each of its modules:

- a. Financial Assessment Module
 - (i) Conduct a financial assessment of the target residential construction firms: Develop a financial assessment tool that considers crucial financial ratios and indicators to analyze the financial health of residential construction firms (e.g., Balance Scorecard).
 - (ii) Identify financial constraints and adapt strategies accordingly: Create procedures that identify financial constraints and suggest tailored strategies for overcoming them.
 - (iii) Utilize local financial resources and partnerships: Integrate a database of local financial resources and partnerships, allowing companies to find suitable financing options.
- b. Cost Management Module
 - (i) Optimize cost management processes: Implement cost estimation and budgeting tools that consider the specific conditions, as in our case for the residential construction sector in Colombia.
 - (ii) Implement budget tracking and variance analysis: Develop a budget tracking system with real-time updates on actual expenses and variance analysis.
 - (iii) Enhance procurement and supply chain management: Create a

procurement and supply chain management tool that enables users to manage suppliers, contracts, and inventory.

- (iv) Streamline resource allocation and utilization: Implement resource allocation and utilization algorithms that optimize workforce and equipment distribution.

- c. Performance Measurement Module
 - (i) Set clear project objectives and performance indicators: Design a user-friendly interface for setting project objectives and selecting appropriate performance indicators.
 - (ii) Develop an integrated performance monitoring system: Develop an integrated performance monitoring system that consolidates data from various segments to track progress against set objectives.
 - (iii) Establish a continuous improvement process: Implement a continuous improvement process with automated alerts and recommendations for adjustments.
- d. Incentive Programs Module
 - (i) Design performance-based incentive schemes: Design a customizable template for different performance-based reward structures.
 - (ii) Create recognition and reward systems: Create a recognition and reward system allowing users to nominate and celebrate outstanding achievements.
 - (iii) Develop team-based incentives to encourage collaboration: Implement methods for designing team-based incentives that consider individual and collective contributions to project success
- e. Decentralized Decision-making Module
 - (i) Empower project managers with decision-making autonomy: Build an organizational hierarchy management tool that assigns decision-making authority to appropriate levels.
 - (ii) Implement a decision-making framework with delegated authority: Implement a decision-making framework that guides users through a structured process, including data analysis, alternatives evaluation, and final decision recording.
 - (iii) Encourage cross-functional communication and collaboration: Develop collaboration tools that enable cross-functional communication and sharing of best practices.
- f. People Development Module
 - (i) Offer training and development opportunities: Integrate an e-learning platform with training and development resources tailored to the residential construction sector.
 - (ii) Set up mentorship programs for knowledge sharing and skill enhancement: Build a mentorship management tool that matches mentors and mentees based on skill sets and development needs.
 - (iii) Implement succession planning for continuous growth and development: Implement a succession planning system that identifies potential future leaders and outlines their growth and development steps.

These detailed development steps for each module will help ensure that the EcoMCS application effectively addresses the specific objectives of the research project, considering the financial aspects of developing countries and focusing on the residential construction firms in Colombia.

3.2 EcoMCS Application Workflow

An archetypal sequencing workflow to implement EcoMCS consists of the following:

1. Begin by assessing the current financial situation of residential construction firms using MCS as foundational to collect data and identify residential construction firms' setbacks.
2. Use the Financial Assessment and Cost Management Modules to optimize cost management processes and track budget variances.
3. Establish clear objectives and performance indicators in the Performance Measurement Module.
4. Design incentive programs and reward systems within the Incentive Programs Module.
5. Implement decentralized decision-making using the Decentralized Decision-making Module.
6. Develop people's potential through training, mentorship, and succession planning in the People Development Module.
7. Continuously monitor performance and adapt strategies accordingly.

This EcoMCS sequential workflow addresses the specific objectives of the project management application by focusing on the financial aspects of developing countries, improving the economic dimension, evaluation methods, incentive programs, decision-making processes, and people's potential within residential construction firms.

3.3 EcoMCS Data Assessment

Informed by the research of Simons (1995), Nogueira, Hernández and Negrín (2002), and Caballero (2016). We developed a 33-question interview assessment as presented in Appendix A. This evaluation focuses on three key MCS dimensions: (i) strategic, (ii) tactical-operational, and (iii) economic. Through systematic questioning, we aim to obtain a comprehensive rating measure for the overall performance of the MCS dimensions within organizations. We ultimately seek to explore and assess project management practices within residential construction firms in Colombia.

MCS are vital components of organizations that help to align organizational goals, strategic objectives, and the activities and decisions of the employees. In the context of residential construction firms in Colombia, the MCS dimensions are categorized as strategic, tactical-operational, and economic. Although the economic dimension may seem different from the other two, it is an essential aspect of the MCS framework for the following reasons:

1. Holistic approach: The three dimensions together provide a holistic view of construction firms' project management processes and practices. Strategic and tactical-operational dimensions represent the decision-making levels within the organization, while the economic dimension serves as a criterion through which these decisions can be assessed and evaluated.
2. Interdependence: The economic dimension is intertwined with construction firms' strategic and tactical-operational dimensions. The strategic decisions made by the management directly affect the organization's financial performance, and the tactical-operational decisions influence the costs and revenues generated by individual projects. Therefore, it is crucial to consider the economic and other dimensions to provide a complete understanding of the factors that influence the efficiency and effectiveness of project management practices.

3. Financial performance: One of the primary goals of any organization is to achieve financial success. In construction firms, financial performance is closely linked to management's strategic and tactical-operational decisions. By including the economic dimension in the analysis, the research aims to identify the financial challenges faced by the firms and how these challenges can be addressed by implementing the EcoMCS application.
4. Emphasis on the weakest link: The economic dimension has been identified by previous research as the lowest-performing area within MCS for developing countries' construction firms (Ahadzie, Proverbs and Olomolaiye, 2008; Unegbu, Yawas and Dan-Asabe, 2022). Including it in the analysis is essential to understand the underlying issues and propose targeted solutions through the EcoMCS application. By doing so, the research seeks to create a more robust and balanced MCS that supports the growth and development of these firms.

Although the economic dimension appears different from the strategic and tactical-operational dimensions, it is an integral part of the MCS framework. The three dimensions together provide a comprehensive understanding of the project management practices and help identify and address the challenges the construction firms confront.

3.4 EcoMCS Data Collection

This research employed the Colombian Chamber of Construction (Camacol) valuable resources to obtain accurate and dependable information. Camacol, a non-profit association recognized for its comprehensive representation of organizations across the construction value chain in Colombia, offers an accessible directory of affiliates on its website (Camacol, 2022).

Leveraging this resource, we strategically identified and selected verified large residential construction firms as participants, enhancing our data's reliability. Our primary data collection method involved conducting an interview study with 11 high-ranking administrators, including managers and directors, from these large residential construction firms in Colombia. The participants were requested to rate a series of assessment questions on a Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). In order to capture a more nuanced understanding of participants' perspectives, some questions within the survey offered predefined alternatives to the Likert scale.

The interview structure was thoroughly designed to address the critical aspects of MCS sequentially using the 33-questionnaire as the baseline (see Appendix A). The strategic dimension was addressed through questions 1 to 17, followed by the tactical-operational dimension covered in questions 18 to 29, and concluding with the economic dimension in questions 30 to 33.

After completing the interview study, we calculated each firm's overall dimensions ratings. A k-medoid clustering approach was implemented to analyze the data further, using gap statistics to determine the optimal number of clusters (k). This procedure aims to classify firms with similar performance in terms of MCS dimensions; thus, we can focus on solutions on the identified clusters of firms providing valuable insights into the EcoMCS application.

We employed a random sampling strategy, approaching a mix of project managers and operations directors for the interviews. Operations directors generally possess comprehensive knowledge of a firm's projects, finances, and staff, while project managers oversee individual or multiple construction projects on-site. Throughout the interview process, we maintained a professional and structured approach. We began by explaining the study's objectives and obtaining consent from participants.

Each interview was conducted in a private and comfortable setting, with open-ended questions allowing respondents to express their thoughts and experiences freely. We carefully documented responses, ensuring confidentiality, and conducted follow-up interviews as necessary. By adhering to these rigorous standards, we aimed to produce a high-quality, reliable, and valid assessment of project management practices in the Colombian residential construction sector.

4. ECOMCS IMPLEMENTATION IN COLOMBIAN CONSTRUCTION FIRMS

This section describes the EcoMCS application underpinned by data collected from interviews with 11 managers of construction firms in Colombia. These interviews primarily focused on MCS, particularly on the economic dimension, which was identified as the lowest-performing area.

4.1 Interview Study Results

The interviews were conducted utilizing the comprehensive 33-question survey administered to the managers of the participating firms (see Appendix A), and the findings are delineated in **Table 1**. This table encapsulates each firm's mean outcomes and corresponding standard deviations, presented within parentheses, across the various MCS dimensions. Among these dimensions, the strategic exhibits the most considerable mean performance.

With respect to the results within the strategic dimension, six firms (Firms 3, 4, 7, 8, 10, and 11) demonstrate superior average rate values. Firm 9 presents a substantial discrepancy in the mean value compared to its counterparts. The tactical-operational dimension reveals analogous outcomes, with seven firms (Firms 1, 3, 4, 7, 8, 10, and 11) displaying optimal performance within this aspect. Once again, Firm 9 manifests a marked decline in its rating.

Although the economic dimension unveils similar patterns, it displays a significantly diminished score, indicating that merely three firms (Firms 3, 4, and 11) are achieving satisfactory results, while Firm 9 continues to maintain the lowest performance. Notably, the economic

dimension primarily exhibits the least overall performance among the dimensions analyzed.

Considering the observed disparities among the firms, we sought to employ a k-medoid clustering technique to classify the firms systematically. This approach will provide a deeper understanding of the analyzed data's underlying relationships and performance patterns.

We used the gap statistics approach to find the adequate number of clusters, which was a *k* equal to 4 for our case. We subsequently split the firms into clusters and visualized their performance using their ratings across the MCS dimensions. This procedure is illustrated in **Figure 2**, where each cluster is depicted in a two-dimensional plot using the actual ratings from the MCS dimensions. The clusters are color-coded for easy identification, enabling direct differentiation of performance levels relative to the mean scores across the dimensions.

Significantly, each firm represented in **Figure 2** is marked with a 'C#' label, where '#' implies the cluster number to which the firm belongs. This denotation allows for the straightforward identification of each firm's respective cluster. The figure includes two views: one comparing the Economic (y-axis) and Strategic (x-axis) dimensions and another contrasting the Economic (y-axis) and Tactical-Operational (x-axis) dimensions. These graphical representations facilitate a clear understanding of the relative performance of each cluster within the different MCS dimensions.

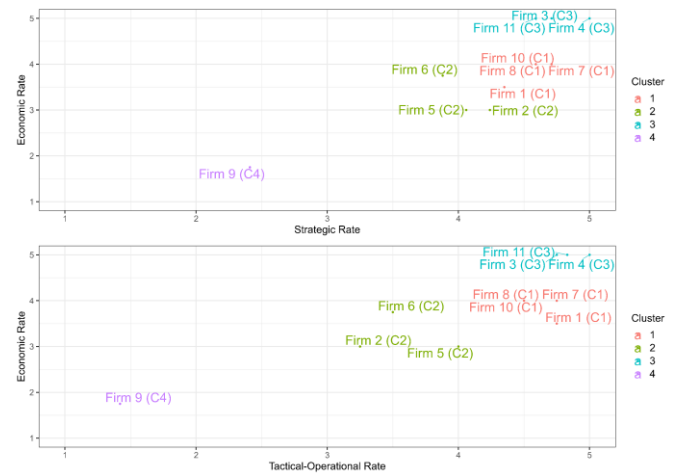


Figure 2 Firms Clustering Classification

The clustering approach produced four clusters: Cluster 1 with Firms 1, 7, 8, and 10; Cluster 2 with Firms 2, 5, 6; Cluster 3 with Firms 3, 4, 11; and Cluster 4 with Firm 9. with Cluster 3 representing high-performing firms, Clusters 1 and 2 representing mid-performing firms, and Cluster 4 representing the low-performing firm. Considering these results, we propose a strategic approach utilizing the EcoMCS application to address the specific needs of the firms within each cluster.

Table 1 MCS Dimensions Overall Results

| No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Overall |
|--------------------|----------------|----------------|----------------|----------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Firm ID | Firm 1 | Firm 2 | Firm 3 | Firm 4 | Firm 5 | Firm 6 | Firm 7 | Firm 8 | Firm 9 | Firm 10 | Firm 11 | |
| Strategic | 4.35 (1.46) | 4.24 (0.66) | 4.71 (0.69) | 5 (0) | 4.06 (0.75) | 3.88 (0.78) | 4.71 (0.77) | 4.59 (0.51) | 2.41 (1.46) | 4.59 (0.51) | 4.59 (0.71) | 4.28 (1.06) |
| Tactical | 4.75 (0.62) | 3.25 (1.06) | 4.75 (0.87) | 5 (0) | 4 (0.6) | 3.5 (0.67) | 4.75 (0.62) | 4.5 (0.67) | 1.42 (0.51) | 4.5 (0.67) | 4.83 (0.39) | 4.11 (1.2) |
| Operational | 3.5 (1) | 3 (1.41) | 5 (0) | 5 (0) | 3 (1.41) | 3.75 (1.5) | 4 (1.15) | 4 (2) | 1.75 (0.96) | 4 (2) | 5 (0) | 3.82 (1.47) |
| Economic | 4.39 (1.2) | 3.73 (1.04) | 4.76 (0.71) | 5 (0) | 3.91 (0.84) | 3.73 (0.84) | 4.64 (0.78) | 4.48 (0.83) | 1.97 (1.21) | 4.48 (0.83) | 4.73 (0.57) | |
| Overall | | | | | | | | | | | | |

4.2 EcoMCS Strategic Approach

The strategic approach to providing solutions based on the interview results and the working modules of EcoMCS can be outlined as follows:

1. Analyze the interview results: Conduct a thorough analysis of the interview results, focusing on the performance ratings across the strategic, tactical-operational, and economic dimensions. Identify the strengths and weaknesses in the management control systems of the construction firms.
2. Prioritize areas for improvement: Based on the analysis, prioritize the areas with the lowest performance ratings for improvement. Give special attention to the economic dimension, as it has been identified as the lowest-performing area among the firms.
3. Tailor the EcoMCS modules: Customize each module within the EcoMCS application to address the specific challenges identified in the interview results. Ensure a targeted approach that addresses each cluster firm’s most pressing issues by adjusting the modules according to the firms’ performance ratings in the three dimensions (see sections 3.1 and 3.2 for detailed information about the modules).
4. Develop and implement action plans: Create action plans for each cluster based on the tailored EcoMCS modules. Outline the steps required to improve performance in the prioritized areas, incorporating best practices from higher-performing firms and industry benchmarks. Implement the action plans using the EcoMCS application as a guide.
5. Monitor progress and adjust as necessary: Use the Performance Measurement Module of EcoMCS to monitor the progress in implementing the action plans. Track improvements, identify areas where additional support is needed, and adjust strategies as necessary.

4.3 EcoMCS for Colombian Firms

Based on the resulting clusters, we propose a definite set of strategies employing the EcoMCS application to provide tailored solutions for the firms within each cluster.

High-performing firms in Cluster 3: The focus should be on continuous improvement and innovation. These firms can further optimize the Financial Assessment and Cost Management Modules for greater accuracy and efficiency. The Performance Measurement Module can be refined to capture innovative practices, driving continuous growth. Lastly, the firms should also consider expanding

collaborative efforts with other high-performing firms to share best practices and maintain a competitive edge.

Mid-performing firms in Cluster 1: These firms should prioritize strengthening their strategic and tactical-operational dimensions. The Incentive Programs and Decentralized Decision-making Modules can be employed to encourage greater employee engagement and empowerment. Additionally, the firms can explore partnerships with suppliers and subcontractors to foster mutually beneficial relationships and streamline the construction process.

Mid-performing firms in Cluster 2: These firms should focus on enhancing their economic dimension performance. Utilizing the Cost Management and People Development Modules can improve resource allocation and workforce competency. Furthermore, these firms should consider investing in training programs that emphasize project management, cost control, and financial planning to develop internal expertise.

Low-performing firms in Cluster 4: A comprehensive overhaul of project management practices is needed. The EcoMCS application can provide an integrated approach to address shortcomings across all dimensions. Emphasis should be placed on the Financial Assessment, Performance Measurement, and Economic Modules to enhance financial management, performance tracking, and overall economic performance. Additionally, the firms in this classification should consider seeking external expertise, such as management consultants, in order to facilitate the implementation of new processes and practices.

Focusing specifically on the only firm in this cluster, Firm 9, we propose detailed business tactics and evaluation measures tailored to the EcoMCS application.

- a. Financial Assessment Module:
 - Tactic: Conduct a comprehensive financial analysis of Firm 9 to diagnose its current financial situation, identify financial risks, and evaluate investment opportunities.
 - Evaluation Measures: Regularly review financial reports, comparing them against industry benchmarks and Firm 9’s historical performance. Track progress in reducing financial risks and improving profitability.
- b. Cost Management Module:
 - Tactic: Implement cost control measures and develop accurate cost estimations by adopting advanced techniques and tools in Firm 9. Optimize resource allocation to improve construction processes and profitability.
 - Evaluation Measures: Monitor cost-saving measures and compare actual costs against estimated costs at

various project stages. Track resource utilization and efficiency improved over time.

- c. Performance Measurement Module:
Tactic: Establish clear performance indicators and targets for Firm 9 in alignment with its strategic goals. Regularly monitor and evaluate progress against these targets to make necessary adjustments.
Evaluation Measures: Assess performance against established key performance indicators (KPIs) on a monthly or quarterly basis. Use trend analysis to determine progress and areas requiring further attention or improvement.
- d. Incentive Programs Module:
Tactic: Design and implement incentive programs to motivate employees, increase productivity, and enhance job satisfaction. These programs may include performance-based bonuses, recognition awards, and non-financial incentives.
Evaluation Measures: Conduct regular employee surveys to assess job satisfaction and engagement levels. Compare productivity and performance metrics before and after the implementation of incentive programs.
- e. Decentralized Decision-making Module:
Tactic: Empower lower-level managers and employees within Firm 9, fostering a culture of decentralized decision-making to allow for faster responses to changes in the construction environment.
Evaluation Measures: Track the number of decisions made at lower management levels and their outcomes. Conduct periodic reviews to assess the effectiveness of decentralized decision-making in improving responsiveness and agility.
- f. People Development Module:
Tactic: Identify skill gaps and provide targeted training programs to address them. Develop leadership capabilities within Firm 9 to foster a culture of continuous improvement and innovation.
Evaluation Measures: Monitor the participation and completion rates of training programs. Assess improvements in skill levels and the impact of leadership development on the firm's performance and culture.
- g. People Development Module:
Tactic: Identify skill gaps and provide targeted training programs to address them. Develop leadership capabilities within Firm 9 to foster a culture of continuous improvement and innovation.
Evaluation Measures: Monitor the participation and completion rates of training programs. Assess improvements in skill levels and the impact of leadership development on the firm's performance and culture.

Firm 9 can significantly improve its project management practices and overall performance across all dimensions by implementing these tailored tactics and evaluation measures. A similar approach can be applied to other firms, using the EcoMCS application to address their unique challenges and drive improvement in their respective MCS performance.

5. DISCUSSION

In this article, we presented the implementation of the novel Project Management Application, EcoMCS, that aims to improve project management practices within residential construction firms in Colombia. The application comprises six interconnected modules designed to address specific aspects of project management processes. By creating specialized modules, EcoMCS ensures a comprehensive and targeted approach to enhance the efficiency and effectiveness of the project management practices within these firms.

Interview studies with 11 managers of construction firms in Colombia were conducted, and the results revealed differences in the approaches taken by the organizations on the strategic, tactical-operational, and economic dimensions. The firms were then clustered using a k-medoid methodology, resulting in four distinct clusters. Clusters 1 and 2 represent mid-performing firms, Cluster 3 represents high-performing firms, and Cluster 4 represents low-performing ones.

A strategic approach utilizing the EcoMCS application is proposed to provide tailored solutions for firms within each cluster. High-performing firms in Cluster 3 should focus on continuous improvement and innovation by optimizing the Financial Assessment and Cost Management Modules, refining the Performance Measurement Module, and expanding collaborative efforts with other high-performing firms.

Mid-performing firms in Cluster 1 should prioritize strengthening their strategic and tactical-operational dimensions using the Incentive Programs and Decentralized Decision-making Modules and exploring partnerships with suppliers and subcontractors. Meanwhile, mid-performing firms in Cluster 2 should focus on enhancing their economic dimension performance by utilizing the Cost Management and People Development Modules and investing in training programs emphasizing project management, cost control, and financial planning.

The low-performing firm in Cluster 4 requires more intensive intervention to address its shortcomings. This firm should concentrate on implementing the full range of EcoMCS modules, starting with the Financial Assessment and Cost Management Modules, which will provide immediate benefits by improving the economic dimension. The Performance Measurement Module will help identify specific areas requiring attention, while the Incentive Programs and Decentralized Decision-making Modules can drive motivation and employee engagement.

To ensure a successful implementation of EcoMCS, all firms should consider the importance of change management. This includes communicating the objectives and benefits of the application to employees, addressing potential resistance, and providing adequate training and support. Firms should also monitor the progress of the application's adoption and adjust their strategies as necessary.

The integration of EcoMCS can also foster a culture of continuous improvement within the firms. By establishing a feedback loop between the application and the firms' management, companies can ensure that the system evolves with their needs, allowing for ongoing refinement and adaptation to changing market conditions. The Financial

Assessment Module will help firms in all clusters by providing a comprehensive financial analysis of their projects, ensuring more accurate budgeting and forecasting. This module will enable firms to identify potential cost savings areas and allocate resources more effectively.

The Cost Management Module can significantly impact the economic dimension for firms in Clusters 1, 2, and 4. This module can help firms identify and address cost overruns by providing real-time cost tracking and analysis, ultimately improving their financial performance and competitiveness.

The Performance Measurement Module, which focuses on KPIs, can help firms monitor and improve their project management processes. By tracking project performance against predetermined goals, companies can quickly identify issues and implement corrective measures. This module is particularly relevant for firms in Clusters 1 and 3, which have demonstrated strength in the strategic and tactical-operational dimensions.

The Incentive Programs Module can enhance employee motivation and performance by creating a link between individual performance and company success. By implementing an effective incentive program, firms in Clusters 1 and 2 can motivate their employees to achieve higher performance levels, ultimately leading to better project outcomes and increased competitiveness.

The Decentralized Decision-making Module is crucial for firms in Clusters 1 and 2 that need to improve their strategic and tactical-operational dimensions. By empowering employees to make decisions and take ownership of their work, firms can foster a more agile and responsive organizational structure, allowing for quicker adaptation to changing project demands and market conditions.

The People Development Module is particularly relevant for firms in Cluster 2 that need to improve their economic dimension performance. By investing in training programs, firms can develop their employees' skills and expertise in project management, cost control, and financial planning. This investment will lead to better project outcomes and a stronger competitive position in the market.

Firms in Cluster 3 should consider leveraging their high performance to mentor and collaborate with other firms in the industry. By sharing best practices and lessons learned, these high-performing firms can contribute to improving project management practices within the residential construction industry in Colombia.

The adoption of EcoMCS across all clusters will benefit individual firms and the residential construction industry in Colombia as a whole. By enhancing the efficiency and effectiveness of project management practices, the industry will become more competitive and better prepared to face the challenges of a rapidly changing global market.

6. CONCLUSIONS

The analysis of the interview study and k-medoid clustering results reveals a clear need for targeted interventions to address the varying performance levels among residential construction firms in Colombia. With its six interconnected modules, the novel Project Management Application, EcoMCS, provides a comprehensive and

targeted approach for addressing each firm's specific challenges based on its cluster classification. By tailoring the implementation of EcoMCS modules to the unique needs of each cluster, firms can effectively address their weaknesses and build on their strengths. The proposed strategic approach enables firms to enhance their project management practices, focusing on continuous improvement, innovation, and collaboration.

Change management and developing a culture of continuous improvement are essential components for the successful implementation of EcoMCS. Firms should communicate the benefits of the application, address potential resistance, and provide adequate training and support to ensure a smooth transition.

The proposed strategic approach based on EcoMCS has the potential to significantly improve the project management practices within residential construction firms in Colombia. By enhancing efficiency and effectiveness in all aspects of project management, these firms can become more competitive and better equipped to meet the challenges of an increasingly complex and dynamic global market.

Implementing EcoMCS across the residential construction industry in Colombia can potentially drive substantial improvements in project management practices. The targeted approach, combined with a focus on change management and continuous improvement, can ultimately lead to a more competitive and resilient industry that is better prepared to face future challenges.

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APPENDIX A: QUESTIONS MCS DIMENSIONS

Questions MCS dimensions

Strategic dimension

Scale: Q1-Q5, Q7-Q17 (1: “Strongly disagree”; 2: “Disagree”; 3: “Neither agree nor disagree”; 4: “Agree”; 5: “Strongly agree”), **Q6** (5: “Yes”; 1: “No.”)

- Q1. The company has a defined mission, describing what it does, how it does it, and why.
 - Q2. The company has described in its vision how it sees itself within the next few years.
 - Q3. The company has a series of established values within its organizational culture.
 - Q4. In developing strategic planning, analytical tools are used to create strategic diagnoses.
 - Q5. The objectives of the company and the strategies to achieve them have been previously defined.
 - Q6. The company has a strategic map or a system similar to a balanced scorecard.
 - Q7. All company levels know the mission, vision, and balanced scorecard, if any.
 - Q8. The management, support, and operational teams generate their action plans according to what is defined in the balanced scorecard or a general indicator.
 - Q9. Periodic follow-ups are developed to review the key performance indicators defined in the strategic planning.
 - Q10. Multiple evaluation methods measure the fulfillment of the goals or objectives (indicators).
 - Q11. Corrective or improvement actions are performed according to the results obtained in reviewing the fulfillment of the goals or objectives.
 - Q12. Management and senior executives promote ownership of strategic planning throughout the organization.
 - Q13. The company has a stimulus or incentive program that promotes the achievement of the objectives.
 - Q14. The company uses analytical tools to identify its critical competitive factors.
 - Q15. Internal regulations and company conduct codes are part of its internal policy.
 - Q16. The company has defined policies for designing and complying with its strategic planning.
 - Q17. There are resource allocation systems for the operation of the company, its functional areas, and the projects to be executed.
-

Tactical – Operational dimension

Scale: Q18-Q29 (1: “Strongly disagree”; 2: “Disagree”; 3: “Neither agree nor disagree”; 4: “Agree”; 5: “Strongly agree”), **Q29** (5: “Select all four stages”; 3: “Select two or three stages”; 1: “Select one or none stages”)

- Q18. The decision-making process is decentralized in the company.
 - Q19. The organization has identified the fundamental processes of its value chain.
 - Q20. Internal processes are constantly evaluated to procure efficiency and effectiveness.
 - Q21. The company works on the potential of people through training, assigning goals, strengthening relationships, and creating an internal leadership culture.
 - Q22. Meetings are scheduled between leaders and their teams to monitor the planning and make joint decisions.
 - Q23. The functional area leaders communicate their overall results to their teams.
 - Q24. Senior management meets with the leaders of the functional areas to review the planning results and define joint strategies to achieve the objectives.
 - Q25. The company defines the annual budget and controls the internal budget for each functional area.
 - Q26. The functional areas define their profitability projections and monitor the results achieved periodically.
 - Q27. There is a system of indicators to monitor the management in developing the projects.
 - Q28. For projects, there are defined activities for supervision and control of processes within a plan or system that guarantee their management or implementation.
 - Q29. The projects developed by the company are based on a measurement system of indicators related to multiple stages (select all that apply): Stage I. Design / Planning, Stage II. Execution / Construction, Stage III. Sale / Delivery, and Stage IV. Customer Satisfaction.
-

Economic dimension

Scale: Q30 (5: “Select between five or seven indicators”; 3: “Select between three and four indicators”; 1: “Select between two and none indicators.”), **Q31** (5: “Select four or five reports”; 3: “Select three reports”; 1: “Select between two and none reports.”), **Q32-Q33** (1: “Strongly disagree”; 2: “Disagree”; 3: “Neither agree nor disagree”; 4: “Agree”; 5: “Strongly agree”)

- Q30. From its financial perspective, the company uses the following indicators (select all that apply): (1) Liquidity index, (2) Debt index, (3) Return on equity, (4) Return on assets, (5) Interest coverage ratio, (6) Working capital, and (7) Total operating assets.
 - Q31. Within its financial perspective, the company uses the following reports (select all that apply): (1) a balance sheet, (2) an income statement, (3) a statement of changes in equity, (4) a statement of changes in financial position, and (5) a statement of cash flows.
 - Q32. The company performs a sensitivity analysis on the results obtained from the financial reports for decision-making.
 - Q33. The company performs risk analysis on the results obtained from the financial reports for decision-making.
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Dr. Milton Soto-Ferrari currently holds a position as an Associate Professor within the Department of Marketing and Operations at Scott College of Business, Indiana State University. With a research focus that encompasses business and healthcare analytics, supply chain management, and logistics, he continues to contribute extensively to these fields. His most recent scholarly pursuits have yielded publications concentrating on a wide range of topics, including strategic management, advanced analytics in healthcare, and forecasting policies.

Dr. Odette Chams-Anturi is an Assistant Professor in the Department of Economic Science at Universidad de la Costa (Colombia). Her research interests are Supply Chain Management, Innovation, and Ambidexterity. She has worked in public and private companies of mass consumption and healthcare entities. She has published numerous journals and conference papers and has participated in several research projects contributing to these fields. Her most recent publications focus on topics such as innovation and strategic management.