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Evolutionary Game Theory and its relation to administrative sciences

Teoría de Juegos Evolutivos y su relación con las Ciencias Administrativa

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Abstract

This documentary research explores the relationship between evolutionary game theory and administrative sciences in commercial companies during the period 2018-2023. Evolutionary game theory, an extension of traditional game theory is used to model and analyze adaptive strategies in changing environments, with applications in business administration. This study analyzes how business firms apply principles of evolutionary game theory to improve strategic decision making, competitiveness, and organizational efficiency. Through a comprehensive review of the literature, several theoretical models were identified that demonstrate the implementation of these principles in administrative practice. The results indicate that companies that integrate concepts from evolutionary game theory tend to show greater adaptability and success in competitive markets. The discussion addresses the practical implications of these findings, as well as limitations and opportunities for future research. The conclusions highlight the importance of evolutionary game theory as a complementary tool in the formulation of administrative strategies, highlighting its relevance in the development of sustainable and efficient business policies. This study contributes to interdisciplinary knowledge by integrating game theory concepts with contemporary administrative practices, offering a robust theoretical framework for innovation in business management.

Keywords: *Evolutionary game theory, administrative sciences, business strategies, sustainability, competitiveness.*

Resumen

Esta investigación documental explora la relación entre la teoría de juegos evolutivos y las ciencias administrativas en empresas comerciales durante el periodo 2018-2023. La teoría de juegos evolutivos, una extensión de la teoría de juegos tradicional se utiliza para modelar y analizar estrategias adaptativas en entornos cambiantes, con aplicaciones en la administración de empresas. Este estudio analiza cómo las empresas comerciales aplican principios de la teoría de juegos evolutivos para mejorar la toma de decisiones estratégicas, la competitividad y la eficiencia organizacional. A través de una revisión exhaustiva de la literatura, se identificaron varios modelos teóricos que demuestran la implementación de estos principios en la práctica administrativa. Los resultados indican que las empresas que integran conceptos de la teoría de juegos evolutivos tienden a mostrar mayor adaptabilidad y éxito en mercados competitivos. La discusión aborda las implicaciones prácticas de estos hallazgos, así como las limitaciones y oportunidades para futuras investigaciones. Las conclusiones subrayan la importancia de la teoría de juegos evolutivos como herramienta complementaria en la formulación de estrategias administrativas, destacan su relevancia en el desarrollo de políticas empresariales sostenibles y eficientes. Este estudio contribuye al conocimiento interdisciplinario al integrar conceptos de la teoría de juegos con prácticas administrativas contemporáneas, ofrece un marco teórico robusto para la innovación en la gestión empresarial.

Palabras clave: *Teoría de juegos evolutivos, ciencias administrativas, estrategias empresariales, sostenibilidad, competitividad.*

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Introduction

Evolutionary game theory emerged as a powerful tool to understand strategic dynamics in competitive environments (Calvo, 2018; Fernández Fernández, 2018). Unlike classical game theory, which focuses on rational and static decisions, evolutionary game theory incorporates the concept of adaptation and the evolution of strategies over time (Ruiz Contreras, 2023; Viera Pereira, 2023). This approach is particularly relevant in the context of administrative sciences, where companies must continuously adapt to changes in the market and the competitive environment (Pérez, 2023; Ruiz Contreras, 2023).

Administrative sciences have undergone a significant transformation in recent decades, integrating approaches and methodologies from various disciplines to improve organizational efficiency and competitiveness (Hernández Vargas, 2023; Pérez et al., 2023). In this context, evolutionary game theory provides an innovative theoretical framework for analyzing and improving business strategies. This article seeks to explore the relationship between evolutionary game theory and administrative sciences, focusing on practical applications in commercial enterprises during the period 2018–2023.

Evolutionary game theory is based on the idea that successful strategies replicate and adapt over time, similar to the principles of natural selection in biology (Gómez Díaz & Figueroa Ortiz, 2022; González Martínez de Aragón, 2022). In the business sphere, this translates into the adaptation and evolution of organizational strategies to maintain competitiveness. Companies that adopt an evolutionary approach are better able to anticipate market changes and respond more effectively to threats and opportunities (Hervada Gallego, 2021; Martín Dorta, 2021). This is crucial in a business environment characterized by rapid and often unpredictable changes driven by factors such as globalization and digitalization.

Between 2018 and 2023, the business environment experienced significant changes due to globalization, digitalization, and the growing importance of sustainability (Pérez et al., 2023; Viera Pereira, 2023). These shifts forced companies to continually revise and adapt their strategies to remain competitive. In this context, evolutionary game theory provides a useful tool for analyzing how firms adapt and evolve in response to such challenges (Gómez Díaz & Figueroa Ortiz, 2022; Quintero Peña, 2021). Globalization intensified competition by opening markets and enabling firms to operate internationally, while digitalization transformed the way businesses interact with customers and manage internal operations.

In addition to global changes, significant knowledge gaps have been observed regarding the application of evolutionary game theory across different countries. In many developing economies, the lack of research and resources limits the capacity of firms to adopt and adapt such advanced theories (Almeida-Guzmán & Díaz-Guevara, 2020; Beltrán Puentes, 2018). For instance, in Latin American countries, research on the integration of evolutionary game theory into business strategies is still incipient. This limits the competitiveness of local firms in a globalized market (Alenza García, 2020; Castro Pérez, 2018). Likewise, in many regions of Asia and Africa, implementation of these principles is hindered by limited training and education in advanced administrative sciences.

This knowledge gap affects the competitiveness of companies and also constrains their capacity to innovate and adapt to changing market dynamics. The lack of access to up-to-date research and theoretical models restricts the development of effective strategies that enhance operational efficiency and business sustainability. In this context, it is crucial to promote research and education in evolutionary game theory and its application to business management in these countries. This would help reduce disparities in global competitiveness and foster more equitable economic development.

Evolutionary game theory has been used to model and analyze a wide variety of phenomena in the social and natural sciences (González-Campo & Zamora Mina, 2020; Pulido Aponte, 2020). In the field of administrative sciences, this theory offers valuable insights into how firms develop adaptive strategies that allow them to survive and thrive in competitive environments (González Martínez de Aragón, 2022; Pulido Aponte, 2020). For example, the replicator dynamic—a central concept in evolutionary game

theory—is applied to understand how successful strategies spread and are adopted within an organization (Luque, 2019; Rodríguez Cartabia, 2019).

In practice, evolutionary game theory assists companies in identifying and replicating successful strategies, optimizing resource allocation, and enhancing their responsiveness to market fluctuations (Hervada Gallego, 2021; Rodríguez Cartabia, 2019). This is especially relevant in sectors where innovation and adaptability are crucial to success. Consequently, firms that quickly adapt to market changes gain a significant competitive advantage. For instance, the ability to adjust prices in response to competition and market demand represents an effective evolutionary strategy that enables firms to maximize revenue and market share (Maqueda, 2023; Silveira Pérez et al., 2022).

Moreover, evolutionary game theory provides a framework for developing more sustainable and responsible corporate policies. Strategies that balance short-term profitability with long-term growth and social responsibility improve firms' sustainability and corporate image (Pérez et al., 2023; Pulido Aponte, 2020). In a business environment where social responsibility and sustainability are increasingly important, companies adopting an evolutionary approach enhance their reputation and attract consumers and employees committed to sustainability (Almeida-Guzmán & Díaz-Guevara, 2020; Beltrán Puentes, 2018).

Another important aspect is firms' ability to adapt to changing market dynamics, as evolutionary game theory provides a theoretical framework that enables companies to anticipate market trends and adjust their strategies accordingly (Fernández de Gatta Sánchez, 2021; Mulder & Albaladejo, 2021). This is crucial for maintaining a competitive advantage in dynamic and constantly evolving markets. Companies that foresee and respond to market shifts more effectively are more likely to achieve long-term success (García García, 2018; Graziani, 2018).

The integration of evolutionary game theory into corporate strategy also enhances organizational resilience. Firms that adopt an evolutionary approach develop strategies that better equip them to face economic crises and other external shocks (Martín Dorta, 2021; Pulido Aponte, 2020). The continuous adjustment and adaptation of organizational strategies in response to environmental changes is essential for long-term survival and success (Rodríguez Cartabia, 2019; Ulate Montero, 2018).

However, despite the potential benefits of evolutionary game theory, its practical implementation faces several challenges. The complexity of theoretical models and the need for accurate data are significant barriers to effective application. The availability of suitable data is crucial for implementing these models, and the lack of accurate data reduces their effectiveness. There is also the possibility of publication bias, where studies with positive results are more likely to be published, thus affecting the generalization of findings (González-Campo & Zamora Mina, 2020; Hervada Gallego, 2021).

Variability in the implementation of evolutionary game theory across firms and sectors also poses a considerable challenge. Differences in organizational culture and industry structure influence the effectiveness of these theoretical models, highlighting the need to adapt strategies to the specific characteristics of each business context.

Resistance to change and inadequate training further limit the adoption of evolutionary approaches. Implementing an evolutionary perspective requires a shift in mindset and organizational culture, which often faces resistance from employees and management. The lack of training and understanding of evolutionary game theory principles hinders its successful application (Gómez Díaz & Figueroa Ortiz, 2022; Quintero Peña, 2021). To overcome these challenges, it is essential that companies invest in information systems and data analysis to facilitate the application of evolutionary strategies. Organizations need to develop policies that promote sustainability and social responsibility while integrating the principles of evolutionary game theory into their corporate strategy.

Managers and executives need training in evolutionary game theory to enhance their strategic decision-making skills. Employees should be encouraged to participate in continuous training

programs that include evolutionary game theory principles, thereby fostering an adaptive organizational culture (Rodríguez Cartabia, 2019; Vila Martínez, 2019).

In this regard, the relevance of this research lies in its capacity to offer a theoretical framework that facilitates the understanding and application of evolutionary game theory in the management of commercial enterprises. Its social relevance is reflected in the improvement of firms' competitiveness and sustainability, which has a positive impact on employment and economic development. The practical implications are significant, as the study provides companies with tools to optimize their strategies and enhance their capacity to adapt to a dynamic business environment. The theoretical value of this research lies in the integration of game theory concepts with administrative practices, contributing to the advancement of interdisciplinary knowledge. Its methodological utility is reflected in the systematic and rigorous approach employed in the review and analysis of the literature, which ensures the validity and reliability of the findings.

This study seeks to address the following overarching research question: *What is the relationship between evolutionary game theory and administrative sciences in commercial enterprises during the period 2018–2023?* More specifically:

1. How do commercial enterprises apply the principles of evolutionary game theory in strategic decision-making?
2. What impact does evolutionary game theory have on the competitiveness and adaptability of commercial enterprises?
3. In what ways does evolutionary game theory influence corporate sustainability and social responsibility?

The general objective of this research is to analyze the relationship between evolutionary game theory and administrative sciences in commercial enterprises during the period 2018–2023. The specific objectives are:

1. To evaluate the application of evolutionary game theory principles in strategic decision-making within commercial enterprises.
2. To determine the impact of evolutionary game theory on the competitiveness and adaptability of commercial enterprises.
3. To examine the influence of evolutionary game theory on corporate sustainability and social responsibility.

Methodology

The methodology of this documentary research is based on an exhaustive review of the existing literature, covering 40 documents including academic articles, business reports, market studies, and other relevant sources. Selection criteria were established to ensure the relevance and quality of the materials. The studies reviewed were published between 2018 and 2023, with priority given to articles from prestigious academic journals and conferences. Reports and market studies providing empirical evidence on the application of evolutionary game theory in commercial enterprises were also considered. In addition, sources from different regions and industrial sectors were included to obtain a comprehensive and diverse perspective.

Data collection was carried out in several stages. First, searches were conducted in academic databases such as Google Scholar, Redalyc, Latindex, Dialnet, JSTOR, and Scopus using keywords such as *"evolutionary game theory"*, *"administrative sciences"*, and *"commercial enterprises."* The initial results were filtered according to the established selection criteria, and abstracts and conclusions were reviewed to determine relevance. Selected studies were analyzed in detail, and relevant information was extracted regarding the application of evolutionary game theory in administrative practice. A comparative analysis of the identified theoretical models was performed, highlighting common patterns and significant differences.

For the documentary analysis, content analysis was used to identify recurring themes and patterns in the reviewed literature, through the coding of references to evolutionary game theory and its application in

strategic decision-making and organizational efficiency. In addition, network analysis was employed to visualize the relationships between different concepts and authors in the literature, which made it possible to identify research communities and predominant theoretical approaches.

Accordingly, the methodology applied in this research was designed to provide a comprehensive and rigorous perspective on the relationship between evolutionary game theory and administrative sciences in commercial enterprises. Through a systematic and multifaceted approach, this study seeks to contribute to interdisciplinary knowledge and offer a robust theoretical framework for innovation in business management.

Results

The exhaustive review of the literature revealed several theoretical models demonstrating the effective application of evolutionary game theory in the administrative practice of commercial enterprises. Table 1 shows that the application of evolutionary game theory in strategic decision-making has proven effective for the development of adaptive strategies and resource optimization.

Table 1. Application of evolutionary game theory in strategic decision-making.

Category	Subcategory
Strategic decision-making	Development of adaptive strategies, resource optimization
Theoretical models	Replicator dynamics, evolution of pricing strategies

Companies employing replicator dynamics adjust their strategies in response to market changes, thereby enhancing their capacity to compete more efficiently (Maqueda, 2023; Silveira Pérez et al., 2022). The evolution of pricing strategies allows firms to adapt quickly to changing market conditions, resulting in an improved competitive position (Suárez Eiroa, 2021; Yáñez, 2021).

These theoretical models provide firms with tools to continuously analyze and adjust their policies, enabling agile and effective responses to environmental changes. Furthermore, the capacity to develop adaptive strategies enhances operational efficiency and also contributes to greater organizational resilience. The integration of these principles into strategic decision-making fosters a proactive approach to market challenges, which is essential for maintaining competitiveness in a dynamic and globalized environment. Thus, evolutionary game theory emerges as a relevant framework for continuous improvement and innovation in business strategies.

As shown in table 2, the results indicate that companies integrating concepts from evolutionary game theory tend to display greater organizational adaptability and competitiveness in the market. Anticipating market trends and adjusting product offerings allow firms to maintain their relevance and appeal to consumers (Fernández de Gatta Sánchez, 2021; Mulder & Albaladejo, 2021). Likewise, these companies achieve greater market share and demonstrate resilience in the face of economic fluctuations, which is crucial for their long-term sustainability (Martínez & Porcelli, 2019; Porcelli & Martínez, 2018).

Table 2. Organizational Adaptability and Competitiveness

Category	Subcategory
Organizational Adaptability	Anticipation of market trends, adjustment of product offerings
Competitiveness	Greater market share, resilience in the face of economic fluctuations

The ability to anticipate market trends enables companies not only to react to changes but also to influence them, thereby creating sustainable competitive advantages. The continuous adaptation of product offerings ensures that companies meet the evolving needs of consumers while strengthening their market position. Moreover, resilience in the face of economic fluctuations allows companies not only to survive during times of crisis but also to thrive by seizing opportunities that arise in uncertain environments. Therefore, the integration of evolutionary game theory into business management enhances both adaptability and competitiveness while ensuring long-term growth and sustainability.

In table 3, several theoretical models are identified that provide a framework for implementing evolutionary strategies in business management. Replicator dynamics and the diffusion of successful strategies are key concepts in these models. Optimizing pricing policies through these strategies leads to revenue maximization (Moscoso Paucarchuco et al., 2019; Porcelli & Martínez, 2018). These theoretical models enable companies to continuously analyze and adjust their policies to better adapt to market conditions, thereby improving financial performance (Martínez & Porcelli, 2019; Porcelli & Martínez, 2018). Replicator dynamics, by focusing on the reproduction of successful strategies, ensures that best practices are disseminated and adapted throughout the organization. This not only optimizes internal processes but also enhances external competitiveness by ensuring that companies maintain practices proven effective in diverse contexts.

Table 3. Theoretical models of evolutionary strategies.

Category	Subcategory
Evolutionary Strategies	Replicator dynamics, diffusion of successful strategies
Business Applications	Pricing optimization, revenue maximization policy

The ability to continuously adjust policies allows for agile and proactive responses to market fluctuations, which is essential in a dynamic business environment. Furthermore, revenue maximization through price optimization ensures that companies remain both competitive and profitable. The integration of these theoretical models into business strategy provides a robust framework for innovation and continuous improvement, ensuring that firms adapt and prosper in competitive markets.

With respect to table 4, another relevant finding is the positive impact of evolutionary game theory on business sustainability. In this regard, companies adopting an evolutionary approach tend to develop more sustainable business policies that focus not only on short-term profitability but also on long-term growth and social responsibility. The adoption of sustainable practices significantly enhances corporate image and operational efficiency (Suárez Eiroa, 2021; Yáñez, 2021).

Table 4. Impact on business sustainability.

Category	Subcategory
Business Sustainability	Development of sustainable policies, balance between short-term profitability and long-term growth
Social Responsibility	Enhanced corporate image, sustainable practices

This, in turn, contributes to more balanced and sustainable long-term development (Ribeiro de Oliveira et al., 2019; Santamaría Arinas, 2019). The adoption of sustainable policies not only addresses increasing regulatory and social demands but also strengthens firms' competitive positions by building a positive and lasting reputation. Integrating sustainable practices into corporate strategy ensures that companies balance profitability with environmental and social responsibility, thereby creating long-term value for all stakeholders.

Moreover, companies that prioritize sustainability tend to attract and retain talent, which is crucial for innovation and growth. Enhancing operational efficiency through sustainable practices also contributes to cost reduction, which is essential in a competitive economic environment. Therefore, evolutionary game theory provides a framework for competitiveness and adaptability while ensuring that companies operate sustainably and responsibly.

In table 5, it becomes clear that despite the identified benefits, the implementation of evolutionary game theory in administrative practice faces several challenges. The complexity of theoretical models and the need for precise data are significant barriers to effective application. The availability of adequate data is critical for the implementation of these models, while the lack of precise data limits their effectiveness (Maqueda, 2023; Silveira Pérez et al., 2022; Yáñez, 2021). Additionally, publication bias may occur, whereby studies with positive results are more likely to be published, thus affecting the generalizability of findings (Fernández de Gatta Sánchez, 2021; Mulder & Albaladejo, 2021; Suárez Eiroa, 2021). Variability in the implementation of evolutionary game theory

across different firms and industries also presents a major challenge. Differences in organizational culture and industry structure influence the effectiveness of these theoretical models, highlighting the need to adapt strategies to the specific characteristics of each business context.

Table 5. Limitations and challenges in implementation.

Category	Subcategory
Challenges	Complexity of theoretical models, need for precise data
Limitations	Data availability, publication bias, variability in implementation

Additionally, resistance to change and lack of adequate training limit the adoption of evolutionary approaches, which requires a comprehensive approach to change management and continuous training. Therefore, while evolutionary game theory offers a relevant framework for improving strategic decision-making and competitiveness, its effective implementation requires a systematic and adaptive approach that accounts for the specific characteristics of each company and sector.

Discussion

The findings of this research highlight the relevance of evolutionary game theory as a powerful tool to enhance strategic decision-making and organizational efficiency in commercial enterprises. The application of evolutionary game theory to strategic decision-making offers several practical advantages for businesses. First, it allows companies to develop adaptive strategies that respond effectively to changes in the competitive environment. This is particularly relevant in a context of globalization and digitalization, where market conditions shift rapidly (Martínez & Porcelli, 2019; Moneva et al., 2018; Porcelli & Martínez, 2018).

In addition, evolutionary game theory provides a framework for optimizing resource allocation and maximizing operational efficiency. Companies that adopt an evolutionary approach identify and replicate successful strategies, thereby improving their competitiveness and resilience. This is especially important in sectors where innovation and adaptability are crucial for success. Another important aspect is the positive impact on business sustainability. The adoption of evolutionary strategies enables companies to develop more sustainable and responsible policies, which not only enhance corporate image but also contribute to long-term growth. This is particularly relevant in a context where social responsibility and sustainability have become key factors for business success.

Despite the benefits identified, this research also faces several limitations that must be considered. First, the complexity of theoretical models in evolutionary game theory complicates their practical application. Effective implementation requires a deep understanding of theoretical principles and the ability to adapt to changing market dynamics (Martínez & Porcelli, 2019; Ribeiro de Oliveira et al., 2019). Furthermore, the availability of accurate and updated data is crucial for applying evolutionary game theory. The lack of adequate data limits the effectiveness of theoretical models and hinders informed decision-making (Acosta-Pérez et al., 2020; Alenza García, 2020). In this sense, companies need to invest in information systems and data analysis to enable the effective implementation of evolutionary strategies (Almeida-Guzmán & Díaz-Guevara, 2020; Da Silva Antunes de Souza & Pasold, 2020).

Another major challenge is resistance to change and differences in organizational culture, since adopting an evolutionary approach requires a shift in mindset and organizational culture that often meets resistance from employees and management. The lack of training and understanding of evolutionary game theory principles further limits effective implementation (Ribeiro de Oliveira et al., 2019; Santamaría Arinas, 2019). Despite these limitations, research on the relationship between evolutionary game theory and administrative sciences offers several opportunities for future studies. First, empirical studies are needed to evaluate the effectiveness of evolutionary strategies in different business contexts (Graziani, 2018; Martínez & Porcelli, 2018). This will allow the validation of theoretical models and provide empirical evidence of their practical applicability.

It is also important to investigate how differences in organizational culture and industry structure affect the implementation of evolutionary game theory. This will

allow the development of adaptive strategies tailored to the specific characteristics of each company and sector, thereby improving their effectiveness (Mulder & Albaladejo, 2021; Suárez Eiroa, 2021; Yáñez, 2021). Another relevant aspect is the integration of evolutionary game theory with other methodologies and approaches in administrative sciences. Combining different approaches provides a more comprehensive and robust framework for strategic decision-making and business management (Perez, 2023; Ruiz Contreras, 2023; Viera Pereira, 2023). In this regard, future research should explore how evolutionary game theory complements other tools and methodologies, such as data analytics and artificial intelligence (González-Campo & Zamora Mina, 2020; Hervada Gallego, 2021; Pulido Aponte, 2020).

Finally, evolutionary game theory offers a pertinent theoretical framework for innovation in business management. Its practical application significantly improves strategic decision-making, competitiveness, and sustainability in commercial enterprises (Luque, 2019; Rodriguez Cartabia, 2019; Vila Martínez, 2019). However, effective implementation requires a deep understanding of theoretical principles, the ability to adapt to changing market dynamics, and an organizational culture that fosters innovation and adaptability (Fernández Fernández, 2018; Muñoz Ramos, 2018). This study contributes to interdisciplinary knowledge by integrating concepts from game theory with contemporary administrative practices (González-Campo & Zamora Mina, 2020; Pulido Aponte, 2020). For this reason, the findings are expected to provide a robust theoretical framework to be used by researchers and professionals for the improvement of business management in a competitive and ever-evolving environment.

Conclusions

This research has demonstrated that evolutionary game theory is a powerful tool for strategic decision-making in commercial enterprises. Companies that integrate these principles show greater adaptability and competitiveness, which enhances their resilience to market changes. In addition, the adoption of evolutionary strategies contributes to business sustainability, allowing a balance between short-term profitability and long-term sustainable development.

With regard to the first specific objective, the application of evolutionary game theory principles in strategic decision-making was evaluated. It was found that these principles facilitate the development of adaptive strategies and the optimization of resources. Companies that adopt an evolutionary approach adjust their strategies in response to market changes, which allows them to compete more efficiently. This proactive approach improves companies' ability to anticipate threats and opportunities in the competitive environment. The integration of these principles into strategic decision-making enables a quick and effective response to market challenges, which is essential to maintaining competitiveness in a dynamic and globalized environment. Evolutionary game theory thus emerges as a relevant framework for continuous improvement and innovation in business strategies.

The second specific objective focused on determining the impact of evolutionary game theory on competitiveness and adaptability in commercial enterprises. The results indicate that companies that integrate evolutionary game theory concepts tend to show greater organizational adaptability and market competitiveness. The ability to anticipate market trends and adjust product offerings enables companies to maintain their relevance and attractiveness to consumers. Likewise, these companies achieve greater market share and demonstrate resilience to economic fluctuations, which is crucial for long-term sustainability. The integration of evolutionary game theory into business management not only improves adaptability and competitiveness but also ensures long-term growth and sustainability.

Regarding the third specific objective, the influence of evolutionary game theory on business sustainability and social responsibility was examined. It is concluded that the adoption of evolutionary strategies has a positive impact on business sustainability. Companies that adopt an evolutionary approach tend to develop more sustainable business policies, focusing not only on short-term profitability but also on

long-term growth and social responsibility. The adoption of sustainable practices significantly enhances corporate image and operational efficiency. This contributes to a more balanced and sustainable development in the long term. The adoption of sustainable policies responds to growing regulatory and social demands and strengthens companies' competitive position by building a positive and lasting reputation.

The integration of sustainable practices into business strategy ensures that companies balance the need for profitability with environmental and social responsibility, creating long-term value for all stakeholders. Moreover, companies that prioritize sustainability tend to attract and retain talent, which is crucial for innovation and growth. Improving operational efficiency through sustainable practices also contributes to cost reduction, which is essential in a competitive economic environment. Therefore, evolutionary game theory provides a framework not only for competitiveness and adaptability but also for ensuring that companies operate sustainably and responsibly.

Despite the benefits identified, the implementation of evolutionary game theory faces several challenges, such as the complexity of theoretical models and the need for accurate data, which are major barriers to effective application. The availability of adequate data is crucial for the implementation of these models, and the lack of accurate data limits their effectiveness. There is also the possibility of publication bias, whereby studies with positive results are more likely to be published, thus affecting the generalization of findings.

Variability in the implementation of evolutionary game theory across different companies and sectors also presents a significant challenge. Differences in organizational culture and industry structure influence the effectiveness of these theoretical models, underscoring the need to adapt strategies to the specific characteristics of each business context. Resistance to change and lack of adequate training also limit the adoption of evolutionary approaches, requiring a comprehensive approach to change management and ongoing training. Although evolutionary game theory offers a relevant framework for improving strategic decision-making and competitiveness, its effective implementation requires a systematic and adaptive approach that considers the particularities of each company and sector.

To address these challenges, it is recommended that companies invest in information systems and data analytics to facilitate the application of evolutionary strategies. Organizations need to develop policies that promote sustainability and social responsibility, integrating the principles of evolutionary game theory into their corporate strategy. Managers and executives need training in evolutionary game theory to strengthen their strategic decision-making skills. Employees should be encouraged to participate in continuous training programs that include evolutionary game theory principles to foster an adaptive organizational culture.

In addition, several opportunities for future research were identified. Empirical studies are needed to evaluate the effectiveness of evolutionary strategies in diverse business contexts. Further research should explore how differences in organizational culture and industry structure affect the implementation of evolutionary game theory. Integrating this theory with other methodologies and approaches in administrative sciences provides a more comprehensive framework for business management. Exploring the combination of evolutionary game theory with tools such as data analytics and artificial intelligence would further enhance the effectiveness of business strategies.

In conclusion, evolutionary game theory offers a pertinent theoretical framework for innovation in business management. Its practical application significantly improves strategic decision-making, competitiveness, and sustainability in commercial enterprises. This study contributes to interdisciplinary knowledge by integrating concepts from game theory with contemporary administrative practices, providing a robust theoretical framework for improving business management in a competitive and ever-evolving environment. Companies that adopt these principles will be better prepared to face future challenges and seize opportunities in a globalized and dynamic

market. Therefore, it is crucial that both researchers and professionals continue to explore and develop this field to maximize its positive impact on business management.

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