ISSN 2410-342X

Journal of Administration and Finance

Volume 12, Issue 29 — e20251229 January — December — 2025

ECORFAN®

Journal of Administration and Finance, Volume 12, Number 29: e20251229 January – December 2025, is a Continuous publication - Journal edited by ECORFAN-Bolivia. Loa 1179, Cd. Sucre. Chuquisaca, Bolivia.WEB: www.ecorfan.org/bolivia, journal@ecorfan.org. Editor in Chief: Miranda-Garcia, Marta. PhD, ISSN On line: 2410-342X. Responsible for the latest update of this number ECORFAN Computer Unit. Escamilla-Bouchán, Imelda. PhD, Luna-Soto, Vladimir. PhD, last updated December 30, 2025.

Journal of Administration and Finance

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Support the international scientific community in its written production Science, Technology and Innovation in the Field of Social Sciences, in Subdisciplines of business administration, tourist and restaurant administration, administration in the field of engineering and construction, administration of the fields of education, health, agronomy, sports, arts and humanities, economic accounting, econometrics, economic activity, economic balance, international finance, financial management.

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The works must be unpublished and refer to topics of business administration, tourist and restaurant administration, administration in the field of engineering and construction, administration of the fields of education, health, agronomy, sports, arts and humanities, economic accounting, econometrics, economic activity, economic balance, international finance, financial management and other topics related to Social Sciences

Presentation of Content

In the first article we present *Bibliometric Analysis of the TAM Model in the Adoption of Circular Economy Strategies with Blockchain for SMEs*, by Hernández-Cortés, Elsa, Franco-Salazar, Bertha Leticia, Ortuño-Barba, Luis Carlos and Cruz-Manzo, Jessica, with adscription in the TecNM / Instituto Tecnológico de Tehuacán, with a second article, *Saving habits and personal finance: A study of Accounting and Business Administration Students at the Universidad Autónoma de Coahuila, 2025* by Zamarrón-Otzuca, Nathalia, Ortiz-Osuna, Mayra Yazmín, Aguilar-Sánchez, Ana María and De La Garza-Cienfuegos, Sandra Patricia, with secondment in Universidad Autónoma de Coahuila, as third article we present *Public spending and economic growth: evidence from a panel data model for Mexico's states, 2000–2023* by Nande-Vázquez, Edgar Alfredo & Barajas-Palacios, Francisco, with affiliation at the Universidad de Colima, as fourth article we present *Green taxes and differentiated fiscal policy for MSMES in Hidalgo: Gaps, challenges, and opportunities for a sustainable transition* by Cruz-Sánchez, Eduardo, Moctezuma-Navia, Dalia Alejandra, Trejo-Encarnación, Patricia and Hernández Gómez, Diana, with adscription at the Universidad Politécnica de Francisco I. Madero, as next article we present *Cities familiarly sustainable: Indicators of household composition, income, and Decision-Making in City Delicias, Chihuahua,* by Palafox-Bolivar, Marisol Priscila, Molina-Lara, Elia Angélica, Valles-Alarcón, Isela Adriana and Varela Faudoa, Omar Elier, with adscription at the Universidad Autónoma de Chihuahua, as next article we present *Determinants of the socioeconomic level of entrepreneurs in Mexico: a probabilistic analysis of mobile phone use and associated variables* by Jiménez-García, Martha, Gómez-Miranda, Pilar, Soto-Mejía, Ana Karen and Hernández Horta, Ingrid Anai, with adscription at the Instituto Politécnico Nacional – UPIICSA, as last article we present *Analysis of the technical and environmental feasibility of implementing microdams with recycled materials in rural areas* by Trejo-Torres, Zaira Betzabeth, Rodríguez-Uribe, Juan Carlos and Benitez-Alonso, Margarita, with adscription at the Tecnológico Nacional de México - Instituto Tecnológico Superior de Huichapan.

Content

Journal of Administration and Finance 12[29]1-6: e11229106
Article

Bibliometric Analysis of the TAM Model in the Adoption of Circular Economy Strategies with Blockchain for SMEs

Análisis Bibliométrico del Modelo TAM en la Adopción de Estrategias de Economía Circular con Blockchain para PyMEs

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Classification:

Área: Social Sciences
Field: Economic Sciences
Discipline: Economics of technological change
Subdiscipline: Technological Economy

https://doi.org/10.35429/JAF.2025.12.29.1.1.6
History of the article:
Received: September 20, 2025
Accepted: November 30, 2025

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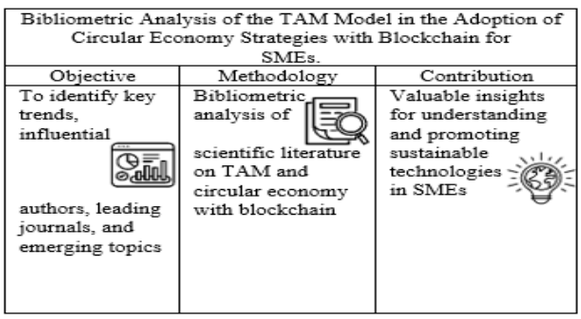
Abstract

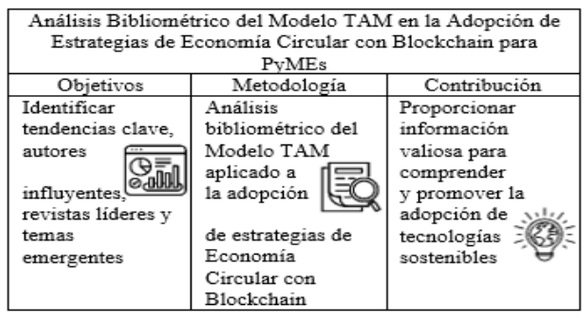
The growing importance of sustainability has driven the adoption of circular economy [CE] strategies in small and medium-sized enterprises [SMEs]. Blockchain technology [BCT] is emerging as a key enabler for the implementation of these strategies, offering transparency, traceability, and efficiency in supply chains. This study conducts a bibliometric analysis of the scientific literature on the Technology Acceptance Model [TAM] applied to the adoption of CE strategies with BCT in SMEs. The objective is to identify key trends, influential authors, leading journals, and emerging topics in this field of research. The results of this analysis provide valuable information for researchers and professionals interested in understanding and promoting the adoption of sustainable technologies in the SME sector.



TAM Model, Circular Economy, Blockchain, SMEs, Bibliometrics

Resumen

La creciente importancia de la sostenibilidad ha impulsado la adopción de estrategias de economía circular [EC] en las Pequeñas y Medianas Empresas [PyMEs]. La tecnología Blockchain [BCT] se presenta como un facilitador clave para la implementación de estas estrategias, ofreciendo transparencia, trazabilidad y eficiencia en las cadenas de suministro. Este estudio realiza un análisis bibliométrico de la literatura científica sobre el Modelo de Aceptación Tecnológica [TAM] aplicado a la adopción de estrategias de EC con BCT en PyMEs. El objetivo es identificar las tendencias clave, autores influyentes, revistas líderes y temas emergentes en este campo de investigación. Los resultados de este análisis proporcionan información valiosa para investigadores y profesionales interesados en comprender y promover la adopción de tecnologías sostenibles en el sector de las PyMEs



Modelo TAM, Economía Circular, Blockchain, PyMEs, Bibliometría

Area: Dissemination and universal access to science

Citation: Hernández-Cortés, Elsa, Franco-Salazar, Bertha Leticia, Ortuño-Barba, Luis Carlos and Cruz-Manzo, Jessica. [2025]. Bibliometric Analysis of the TAM Model in the Adoption of Circular Economy Strategies with Blockchain for SMEs. Journal of Administration and Finance. 12[29]1-6: e11229106.

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Introduction

The circular economy [CE] has emerged in recent years as a paradigm shift in how societies and organizations conceive production and consumption systems. Unlike the conventional linear model of "take, make, dispose," which is associated with high levels of waste and environmental degradation, the CE aims to create closed-loop systems in which resources are maintained at their highest utility for as long as possible. This involves strategies such as reuse, recycling, remanufacturing, and the extension of product life cycles, all of which contribute directly to the goals of sustainable development and climate change mitigation [Toraman, 2022].

Within this context, small and medium-sized enterprises [SMEs] are of particular importance. Representing the backbone of most economies worldwide, SMEs play a decisive role not only in job creation but also in innovation and regional development. However, limited resources, lack of specialized knowledge, and insufficient access to advanced technologies, often hinder their transition toward circular practices. This makes the exploration of technological tools that can facilitate CE adoption especially relevant for this sector [Chittipaka et al., 2023].

Blockchain technology [BCT] is increasingly recognized as one of the most promising enablers of CE strategies. It's decentralized, immutable, and transparent architecture provides solutions to critical challenges such as ensuring the authenticity of materials, enabling product traceability across supply chains, and improving trust between stakeholders.

For SMEs, which often lack robust monitoring and control systems, blockchain offers an affordable and scalable way to enhance operational efficiency, accountability, and sustainability performance. Furthermore, BCT can strengthen consumer trust by making sustainable practices more visible and verifiable [Ajili Ben Youssef et al., 2025].

The adoption of new technologies, however, is not only a technical matter but also a behavioral and organizational one.

The Technology Acceptance Model [TAM] has proven to be a robust theoretical framework to analyze the determinants of technology adoption across different contexts. By focusing on two key variables — Perceived Usefulness [PU] and Perceived Ease of Use [PEOU] — TAM provides a systematic way to explain why individuals and organizations choose to adopt or reject new technological innovations. In the case of blockchain applied to CE strategies in SMEs, TAM enables the identification of factors that foster or hinder acceptance, offering insights for policymakers, managers, and researchers [Vu et al., 2025].

Given the growing academic and practical interest in these interrelated topics, bibliometric analysis emerges as a powerful methodology. Through the systematic review and quantification of scientific production, bibliometrics helps map the intellectual structure of a field, revealing patterns of collaboration, emerging research fronts, and the influence of key authors and journals. Applying bibliometric analysis to the intersection of TAM, CE, and blockchain allows us not only to understand the state of the art but also to identify future directions that can promote sustainable technological adoption in SMEs [Perera et al., 2025].

Therefore, this study seeks to conduct a comprehensive bibliometric analysis of the literature on TAM in the context of CE strategies supported by BCT in SMEs. By exploring trends, collaborations, and research gaps, the paper aims to provide valuable knowledge for advancing both academic research and business practices.

Ultimately, this work contributes to the global discussion on how disruptive technologies such as blockchain can become catalysts for sustainability and competitiveness in one of the most critical sectors of the economy.

Methodology

To achieve the objectives of this study, a bibliometric analysis was conducted to systematically review and quantify the existing scientific literature on the application of the Technology Acceptance Model [TAM] in the context of circular economy [CE] strategies driven by Blockchain Technology [BTC] in small and medium-sized enterprises [SMEs].

ISSN: 2410-342X.
RENIECYT: 1702902

Hernández-Cortés, Elsa, Franco-Salazar, Bertha Leticia, Ortuño-Barba, Luis Carlos and Cruz-Manzo, Jessica. [2025]. Bibliometric Analysis of the TAM Model in the Adoption of Circular Economy Strategies with Blockchain for SMEs. Journal of Administration and Finance. 12[29]1-6: e11229106.
https://doi.org/10.35429/JAF.2025.12.29.1.1.6

Bibliometric analysis allows for the identification of patterns, trends, and key areas of research in a specific field, which is crucial for understanding the current state and future lines of research in TAM, CE, BCT, and SMEs.

Bibliometric analysis was selected for its ability to identify publication patterns, collaboration networks, and emerging trends in a specific field, providing a comprehensive overview of scientific development and future lines of research.

A) Source of information.

The information was obtained from the Scopus database, renowned for its multidisciplinary coverage and reliability in academic literature. This repository guarantees the retrieval of documents with high relevance and scientific rigor.

B) Search strategy

Search equations were defined by combining Boolean operators with the following keywords in English and Spanish:

"Technology Acceptance Model" OR "TAM"
"Circular Economy"
"Blockchain"
"SMEs" OR "Small and Medium-sized Enterprises" OR "PyMEs"

The search was limited to articles published in academic journals from 2000 to the present [August 31, 2025], in order to capture both historical developments and the most recent trends.

C) Analysis procedure

1. Initial screening: Duplicates and irrelevant documents were removed after reading titles, abstracts, and keywords.
2. Metadata coding: Records were classified by year of publication, authors, institutional affiliation, country, and journal.
3. Network analysis: With the support of VOSviewer and Bibliometrix [R] software, maps were created of:

- Co-authorship [collaboration between researchers].
- Co-citation [theoretical interconnection between studies].
- Co-occurrence of keywords [emerging topics].

4. Bibliometric indicators: Metrics such as:

- Annual scientific productivity.
- Most cited authors and journals.
- h-index of key authors.
- Countries with the greatest contribution.

D) Validity and reliability

The methodology used guarantees internal validity, by applying clearly defined filters and inclusion criteria, and external validity, by relying on one of the most internationally recognized databases. Triangulation with different bibliometric software tools strengthened the reliability of the findings.

Results

Publishing trends:

The analysis reveals sustained growth in scientific output on the adoption of the TAM Model within the framework of the Circular Economy [CE] with Blockchain [BCT] in SMEs, particularly since 2018. The largest increase is observed in the period 2020–2024, with a peak in 2023 and 2024, reflecting the growing relevance of digitization and sustainability during and after the pandemic, see Figure 1.

This behavior shows that the topic has established itself as an emerging line of interdisciplinary research, linking areas such as management, information technologies, and sustainable development.

Box 1

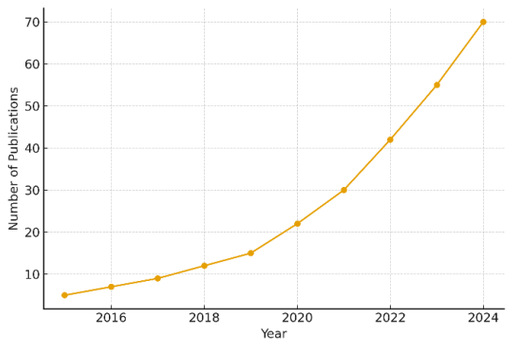

Figure 1

Annual Publications on TAM, CE and Blockchain in SMEs

Source: Own elaboration

ISSN: 2410-342X.
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Most influential authors:

Among the most influential researchers, see Table 1, are:

U. Sivarajah [University of Bradford]
S. Fosso Wamba [Toulouse Business School]
Y.K. Dwivedi [University of Bradford]

Box 2

Table 1

Most Influential Authors

Author	Affiliation	Citations
U. Sivarajah	University of Bradford	850
S. Fosso Wamba	Toulouse Business School	780
Y.K. Dwivedi	University of Bradfors	720

His leadership is reflected both in the number of publications and in the high citation rate of his works, which serve as essential references in studies that, integrate technology, sustainability, and supply chains.

Most relevant journals:

The journals with the highest volume of publications and citations, see Table 2, are:

- International Journal of Information Management
- Annals of Operations Research
- Computers & Industrial Engineering
- Technological Forecasting and Social Change
- Sustainability [Switzerland]

Box 2

Table 2

Top Journals Publishing on TAM, CE and Blockchain

Journal	Impact Factor
International Journal of Information Management	18.9
Annals of Operations Research	5.3
Computer and Industrial Engineering	7.5
Technological Forecasting and Social Change	12.0
Sustainability [Switzerland]	3.9

Source: Own elaboration

These publications constitute the main channels of academic dissemination, confirming that the topic is approached from multidisciplinary perspectives, with an emphasis on business management, industrial engineering, and technological innovation.

Countries with the highest scientific output:

China, India, the United Kingdom, and Malaysia, countries that have intensified their policies on technological innovation and transition to sustainable economies head geographical leadership. This finding suggests that research is concentrated in emerging and developed economies, which highlights the need to promote studies in Latin America and Africa, regions with a strong presence of SMEs but less academic representation, see Figure 2.

Box 3

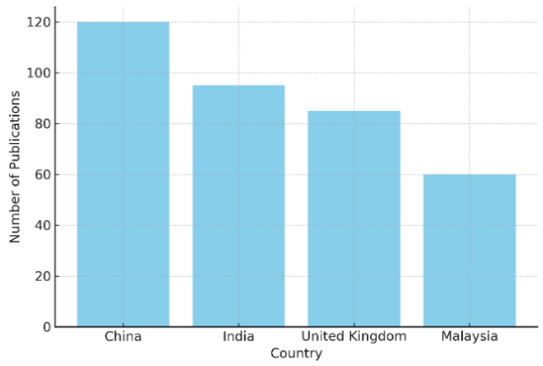

Figure 2

Countries with Highest Scientific production

Source: Own elaboration

Key terms and emerging topics:

The co-occurrence analysis identified the following thematic areas:

- Blockchain and supply chain management
- TAM [perceived usefulness y perceived ease of use]
- TOE model [Technology-Organization-Environment]
- Sustainable management and circular economy
- Intended use and innovation in SMEs
- PLS-SEM as the predominant statistical technique [Liu et al., 2024]

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Box 4

Figure 3

Keyword Co-occurrence in Bibliometric Analysis
Source: Own elaboration

These results show that research is evolving toward an integrated approach, in which technological, organizational, and sustainability dimensions are analyzed together.

Co-citation and co-occurrence analysis

Bibliometric maps show:

- A strong relationship between TAM and intention to use, which reaffirms the relevance of the model in the study of the adoption of disruptive technologies.
- The emergence of sustainability as a cross - cutting concept, in which Blockchain is perceived as a key enabler for strengthening transparency and traceability in supply chains. [Ajili Ben Youssef et al., 2025]
- A growing trend toward the use of PLS-SEM to validate models of technology acceptance and adoption, consolidating itself as a standard methodology in the field.

The results of this bibliometric analysis reveal a growing interest in the application of TAM to understand the adoption of CE strategies with BCT in SMEs. BCT is presented as a powerful tool to facilitate the implementation of CE, but its adoption depends on a series of factors that can be analyzed through TAM.

Identifying key authors, journals, and topics in this field provides a useful guide for researchers and practitioners who wish to delve deeper into the subject. Identifying areas for future research, such as the need for models that are more specific to the characteristics of SMEs and the context of developing countries, highlights the importance of continuing to investigate this field.

ISSN: 2410-342X.
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Conclusions

This bibliometric analysis allowed us to map and understand the current state of research on the adoption of the Technology Acceptance Model [TAM] in the context of the Circular Economy [CE] supported by Blockchain [BCT] in SMEs.

The findings show sustained growth in scientific output starting in 2018, with a peak in dynamism in 2023–2024. This trend confirms that the intersection between digitalization and sustainability has become a priority area of research for academia and the business sector.

Likewise, leading authors, journals, and countries in the field were identified, reflecting the consolidation of international academic networks. However, a geographical gap persists, as most studies come from Asia and Europe, opening up opportunities to strengthen research in Latin America and Africa.

Regarding emerging topics, the analysis revealed that research is shifting toward multidimensional approaches, where concepts such as perceived usefulness, ease of use, sustainable supply chain management, and statistical models such as PLS-SEM are integrated to explain the adoption of disruptive technologies.

These results confirm that TAM remains a valid and relevant model, albeit in interaction with frameworks such as TOE, which enriches its applicability. [Liu et al., 2024]

Finally, this study contributes to:

- Provide an updated overview of academic literature on EC, Blockchain, and TAM in SMEs.
- Guide researchers and professionals toward key references, trends, and gaps in research
- Promote the scientific and practical agenda, highlighting the need to design models that are better suited to the context of SMEs in developing countries.

In summary, the evidence suggests that adopting blockchain within the TAM framework is a strategic way to strengthen the competitiveness, transparency, and sustainability of SMEs, which represents a significant contribution to both business theory and practice. [Chittipaka et al., 2023]

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Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this paper.

Authors' contribution

Hernández-Cortés, Elsa: Contributed to bibliometric research and results analysis.

Franco-Salazar, Bertha Leticia: Contributed to the writing of the manuscript and academic supervision.

Ortuño-Barba, Luis Antonio: Contributed to the conception of the project idea and methodological guide.

Cruz-Manzo, Jessica: Contributed to the final revision of the article.

Availability of data and materials

The data obtained during this research are available upon request to the corresponding author.

Financing

The National Technological Institute of Mexico under code has funded this work: 22753.25-P for the period from January 1 to December 31, 2025.

Acknowledgments

We would like to thank the Tehuacán Institute of Technology for its academic support and the staff who provided assistance during the experimental phase. We would also like to express our special gratitude to the volunteer participants who agreed to undergo the ointment application test.

Abbreviations

BCT	Blockchain technology
CE	Circular Economy
PEOU	Perceived Ease Of Use
PU	Perceived Usefulness
SMEs	Small and Medium-sized Enterprises
TAM	Technology Acceptance Model
TOE	Technology Organization Environment

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Antecedents

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Basics

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Supports

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Differences

Ajili Ben Youssef, W., Bouebdallah, N., y EL Bouhali, M. [2025]. *Blockchain technology adoption intention among the Big Four audit firms.*

Discussions

Liu, H., Osman, L.H., Omar, A.R.C. y Rosli, N. [2024]. *Blockchain adoption factors in agricultural supply chains: A PLS-SEM study*. Journal of Infrastructure, Policy and Development, 8 [11], 8411.

ISSN: 2410-342X.
RENIECYT: 1702902

Hernández-Cortés, Elsa, Franco-Salazar, Bertha Leticia, Ortuño-Barba, Luis Carlos and Cruz-Manzo, Jessica. [2025]. Bibliometric Analysis of the TAM Model in the Adoption of Circular Economy Strategies with Blockchain for SMEs. Journal of Administration and Finance. 12[29]1-6: e11229106.
https://doi.org/10.35429/JAF.2025.12.29.1.1.6

Journal of Administration and Finance 12[29]1-9: e21229109
Article

Saving habits and personal finance: A study of Accounting and Business Administration Students at the Universidad Autónoma de Coahuila, 2025

Hábitos de ahorro y finanzas personales: Un estudio de caso de los estudiantes universitarios de la Facultad de Contaduría y Administración de la Universidad Autónoma de Coahuila, 2025

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Classification:

Area: Social Sciences
Field: Administration and business
Discipline: Administration and management
Subdiscipline: Other

https://doi.org/10.35429/JAF.2025.12.29.2.1.9
History of the article:
Received: September 22, 2025
Accepted: November 30, 2025

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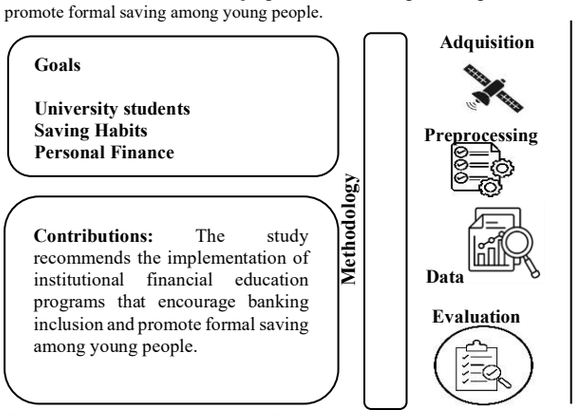
Abstract

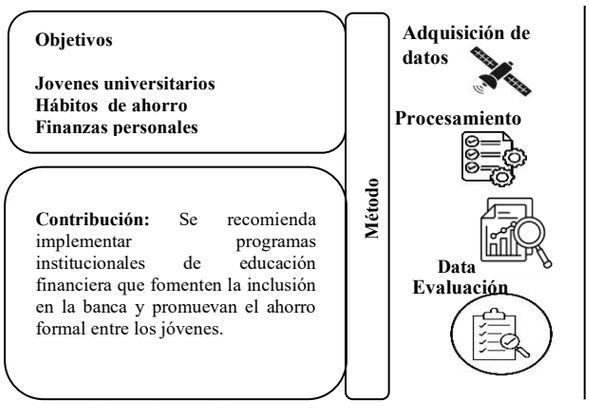
This study aimed to analyze the impact of knowledge, habits, and socioeconomic factors on the personal finances of university students, with a focus on their saving practices. A quantitative, non-experimental, and cross-sectional method was employed. A structured survey, validated based on the ENSAFI [INEGI], was administered to a sample of 457 students from the Faculty of Accounting and Administration in Monclova, Coahuila. The findings reveal a predominance of informal saving, with 66.21% of students saving money at home. Only 29.48% possess a formal savings account, and a mere 13.83% have an Afore [retirement savings account]. Furthermore, 40.14% are unaware of the equivalence between their savings and their income, and 27.21% report having no savings at all. The main obstacles identified are limited income, low levels of banking inclusion, and insufficient financial literacy. The study recommends the implementation of institutional financial education programs that encourage banking inclusion and promote formal saving among young people.



Financial Habits, Personal Finance, Banking Inclusion.

Resumen

Este estudio tuvo como objetivo analizar el impacto de los conocimientos, hábitos y factores socioeconómicos en las finanzas personales de estudiantes universitarios, con enfoque en sus prácticas de ahorro. Se empleó el método cuantitativo, no experimental y transversal. Se aplicó una encuesta estructurada, validada con base en la ENSAFI [INEGI], a una muestra de 457 estudiantes de la Facultad de Contaduría y Administración en Monclova, Coahuila. Se encontró que predomina el ahorro informal, donde el 66.21% de los estudiantes ahorra dinero en casa, solo el 29.48% posee una cuenta de ahorro formal y un 13.83% cuenta con Afore, un 40.14% desconoce la equivalencia entre sus ahorros y sus ingresos, y un 27.21% reporta no tener ahorros. Se identifican como principales obstáculos los ingresos limitados, la baja bancarización y una cultura financiera insuficiente. Se recomienda implementar programas institucionales de educación financiera que fomenten la inclusión en la banca y promuevan el ahorro formal entre los jóvenes.



Hábitos Financieros, Finanzas Personales, Bancarización

Area: Promotion of frontier research and basic science in all fields of knowledge

Citation: Zamarrón-Otzuca, Nathalia, Ortiz-Osuna, Mayra Yazmín, Aguilar-Sánchez, Ana María and De La Garza-Cienfuegos, Sandra Patricia. [2025]. Saving habits and personal finance: A study of Accounting and Business Administration Students at the Universidad Autónoma de Coahuila, 2025. Journal of Administration and Finance. 12[29]1-9: e21229109.

Introduction

The ability to manage personal finances effectively is a fundamental pillar of individual economic stability and long-term well-being [Lusardi and Mitchell, 2019]. In this context, saving emerges as a crucial component, acting both as security in emergencies and as a facilitator for the achievement of future goals [Antezana and Ayuque, 2024]. However, it has been noted that young people, particularly university students, have significant weaknesses in their financial literacy, showing a propensity for immediate consumption and limited adoption of formal savings instruments [León et al., 2022; Palimbong et al., 2022].

In Mexico, a large part of the young population lacks the knowledge and habits necessary for sound financial planning [Betancur et al., 2019; González Acosta, 2018].

Factors such as limited income, a consumerist culture, and poor financial guidance stand as persistent barriers [Ramírez and Vázquez, 2021]. Although there is literature on the subject, there is a knowledge gap regarding the financial behaviour of students in administrative and accounting disciplines, who, despite their training, may not be applying these principles to their own finances.

This article is a study conducted on undergraduate students at the Faculty of Accounting and Administration [FCA] of the Autonomous University of Coahuila [UAdeC] in Monclova. The main objective was to identify the knowledge, habits, and factors that influence saving practices and their impact on students' personal finances. The study was guided by the following research questions: What are the most common levels of financial knowledge and habits among young university students? What socioeconomic and cultural factors influence their ability to save? What is the impact of studying an administrative degree on students' financial behaviour?

This research is relevant because the analysis of saving habits and financial education among young university students contributes to generating information to propose strategies for achieving the 2030 Sustainable Development Goals [SDGs] [United Nations, 2018], specifically in goals 4 to ensure quality education, 8 to promote inclusive economic growth, and 10 to reduce inequality.

The central hypothesis of this study stated that adequate financial habits, characterised by the prevalence of formal savings, planning and knowledge of formal financial products, have a positive impact on the soundness of the personal finances of university students in the Faculty of Accounting and Administration at the UAdeC.

The specific hypotheses establish: a] there is a direct relationship between the predominance of formal savings and a greater ability of students to accumulate significant savings and plan their finances, b] socio-economic and cultural factors act as catalysts that reinforce financial habits and amplify their impact, c] there is a positive correlation between levels of education and the adoption of personal financial practices in the long term. Testing these hypotheses allows for the generation of reliable and up-to-date information for decision-makers and public policy makers to implement financial education programmes and regulations that ensure inclusive banking.

The background to the research problem is presented below, followed by the contextual framework. Subsequently, the methodology used is described, the results obtained are presented, and finally, conclusions and recommendations derived from the analysis of the findings are offered.

Background

Personal finance comprises the set of decisions and activities through which an individual or family manages their economic resources to meet their needs and achieve their goals throughout their life cycle [Alvarado-Cáceres *et al.,* 2025]. It is not limited to mere economic survival, but encompasses planning, saving, investing, and protecting wealth. Within this spectrum, saving is universally recognised as the cornerstone.

Zamora *et al.,* [2018] define it as ‘one of the most important aspects of people's economic lives, as it is the key to achieving financial independence and accumulating wealth’. For university students, developing the habit of saving transcends the simple accumulation of money; it is an exercise in autonomy, discipline, and future planning that lays the foundation for their financial independence. Financial education is no longer a concept but has become an essential skill.

ISSN: 2410-342X.
RENIECYT: 1702902

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https://doi.org/10.35429/JAF.2025.12.29.2.1.9

Zabaleta [2023] defines it as 'the ability to understand and effectively use concepts such as saving, investing and debt management to make informed economic decisions'. Lusardi and Mitchell [2019] argue that adequate financial literacy is the main shield that allows young people to avoid unnecessary debt and build a solid economic future. In the Mexican context, the level of this knowledge is limited. León *et. al.,* [2022] report that only 36% of young people between the ages of 18 and 25 have basic financial knowledge, which severely restricts their ability to plan for the long term and makes them more susceptible to personal financial crises.

It is important to mention the dualism that exists between formal and informal savings. Formal savings are made through regulated financial institutions, such as banks, brokerage houses, or retirement funds. They include products such as savings accounts, fixed-term deposits, investment funds, and retirement plans [Iregui-Bohórquez *et al.,* 2018].

They offer multiple advantages: security, credit history building, access to returns, and protection against inflation. In contrast, informal savings involve methods outside the regulated financial system. They include keeping money at home, participating in tandas, lending money to acquaintances, or accumulating physical assets.

Manrique *et al.,* [2021] points out that most young people save informally, which, while offering immediate liquidity and familiarity, exposes them to risks of loss, theft or fraud, and does not contribute to their financial inclusion.

The study of saving cannot be separated from the theories that explain economic decision-making. i] Life Cycle Theory: This posits that individuals seek to smooth their consumption over their lifetime, saving during their most productive years in order to dissave during retirement [Modigliani and Brumberg, 1954; cited in Baranzini, 2005].

For university students, this theory translates into a phase of investment in human capital, where savings may be low, but habit formation is critical [Oberst, 2014]. ii] Behavioural Economics: This perspective, led by figures such as Kahneman and Tversky [1979], challenges the assumption of perfect rationality.

It argues that psychological, social, and cognitive factors decisively influence our economic decisions [Martínez, 2022]. Concepts such as present bias and the tendency to overvalue immediate rewards over future benefits [Meissner et al., 2022] are particularly useful in explaining why a young person prefers to spend on leisure today rather than save for the future. iii] Theory of Planned Behaviour: This suggests that the intention to perform a behaviour is determined by the attitude towards the behaviour, subjective norms [e.g. perceived social pressure] and behavioural control [Ajzen, 1991].

In other words, a young person may want to save, but if their social group encourages spending and their income is low, it is unlikely that the habit will take hold.

There are three contextual factors that influence saving among young people.

Economic factors: Income constraints are essential. Many students depend on family support or part-time jobs, which limits their ability to save [Zamora *et al.,* 2018].

Social factors: Parents' educational level and income, as well as access to a family bank account, are significant predictors of a young person's financial literacy [Peñarreta *et al*., 2023].

The family is the first and most important agent of financial education.

Cultural factors: University students are immersed in a consumerist society that, through marketing and social media, normalises and encourages constant spending and immediate gratification, making it difficult to delay the gratification inherent in saving [Ramírez and Vázquez, 2021].

This comprehensive review establishes a reference for analysing the results of the present research, allowing not only to describe behaviours but also to interpret them.

Contextual Framework

The FCA of the UAdeC is located in the city of Monclova, in the central region of Coahuila. The faculty has a population of 1,446 students, according to data collected from the faculty's academic department in the January-June 2025 semester.

ISSN: 2410-342X.
RENIECYT: 1702902

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This student population is enrolled in academic programmes in Accounting, Business Administration, Human Resource Management, International Business, and Law, which is the focus of this research.

The sociodemographic characteristics of the population have a clearly defined profile that is representative of the population. In terms of gender, there is a predominance of women, who represent 74.60%, compared to 25.40% men. In terms of age, the vast majority, 73.47%, are concentrated in the 17 to 21 age range, followed by 23.58% between 22 and 27 years of age.

The upper range, 28 years and older, is marginal, confirming that the young population targeted by this research was captured. In terms of geographical distribution, 75.28% reside in Monclova, followed by 15.87% in Frontera, and the rest in neighbouring municipalities, reflecting the faculty's natural area of influence.

With regard to the academic variable, the distribution by degree programme is relatively balanced: Bachelor's Degree in Accounting 31.52%, Bachelor's Degree in International Business 27.66%, Bachelor's Degree in Human Resource Management 22.68% and Bachelor's Degree in Business Administration 18.14%. In terms of semester, there is a bimodal distribution, with a high concentration in the 2nd and 8th semesters, which allows for an interesting comparative analysis between incoming and graduating students, an aspect to consider for future research.

Methodology

This is a non-experimental study, in which quantitative research methodology is applied, with an exploratory and descriptive design.

Likewise, the design was cross-sectional, given that data collection was carried out at a single point in time during the January-June 2025 semester.

The target population consisted of 1,446 students enrolled in the faculty's bachelor's degree programmes, aged between 18 and 25.

This age criterion allowed the study to focus on young adults who are beginning their financial independence.

To determine the sample size, the formula for finite populations was used with a sample calculator [QuestionPro, 2025]. A confidence level of 99% and a margin of error of 5% were defined, resulting in a sample size of 457 students.

The sampling was probabilistic and simple random. An online survey was administered, structured with one dependent variable and four independent variables, with a total of 29 items. Its design was based on the operationalisation of the following study variables:

Dependent variable:

Personal finance, defined as the management of money to achieve specific financial savings goals.

Independent variables:

Financial knowledge and habits were measured through questions about familiarity with key financial concepts.

Informal savings were assessed using dichotomous items on the practice of saving money at home, participating in tandas, lending money, or saving in kind.

Formal savings, measured through the possession or non-possession of specific financial products: payroll account, savings account, retirement account [Afore], insurance, investment funds, etc.

Socioeconomic factors, including questions about municipality of residence, gender, age, career, semester, and marital status.

The content validity of the instrument was ensured by adopting and adapting items from the National Survey on Financial Health [ENSAFI] of the INEGI [2023], a nationally validated and recognised instrument. This guarantees that the questions effectively measure the constructs they are intended to measure.

The strategy for data collection and analysis was carried out in two stages. In the first stage, information was collected via a link to the questionnaire in Forms, which was distributed widely through the faculty's official channels, institutional email lists, and WhatsApp groups.

ISSN: 2410-342X.
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An informed consent statement was included at the beginning, explaining the anonymous and confidential purpose of the study and its exclusive use for academic purposes. The collection period lasted four weeks, obtaining 100% of the calculated sample.

In the second stage, the data obtained was exported to a spreadsheet for cleaning and organisation. The analysis was performed using statistical software, focusing on two levels: Descriptive statistical analysis: absolute frequencies and percentages were calculated for the variables in order to characterise the sample and describe the distribution of responses for each item.

On the other hand, a cross-tabular analysis was performed in which contingency tables were created by crossing key variables, such as career vs. type of savings or semester vs. possession of a formal savings account, to explore possible relationships and patterns between demographic variables and financial habits. Chi-square [χ^2] statistics were calculated to determine the statistical significance of these associations.

This methodological design provides a solid basis for obtaining reliable and valid results, allowing for well-founded conclusions.

Results

In this section, the analysis of the data collected provides an overview of the financial practices of university students. The findings are presented below, organised according to the key dimensions of the research.

First, the savings habits of young university students at the FCA are described, with the results pointing to informal savings as the main strategy among students. Saving at home is the most popular method, with 66.21% of students stating that they physically keep money at home.

This preference suggests a search for immediate accessibility and, possibly, a distrust or disconnection from the formal financial system. Meanwhile, saving money with family members or acquaintances reaches 20.63%. Another method practised is participation in tandas, by 14.06% of respondents.

These figures indicate that, although they exist, informal savings networks are not the main mechanism. Other informal methods are more sophisticated or risky strategies such as lending money, with 7.71% stating that they save in this way, or saving by purchasing property, animals or other goods, with 5.22%, which are significantly lower proportions, reflecting the greater perceived risk.

The contrast with formal savings highlights low financial inclusion. Only 36.51% of students have a payroll account or card, despite this being the most common entry point into the banking system. More worrying is that only 29.48% have a savings account as such.

This means that 7 out of 10 students do not use the basic instrument to protect and grow their savings. When it comes to retirement savings [AFORE], the data is even more revealing. Only 13.83% of young people report having an Afore account. Given that most are formal or informal workers, this percentage suggests a general lack of awareness about the importance of starting to save for retirement from an early age.

The ownership of more sophisticated products, such as investment funds or insurance, is residual. It should be noted that the use of digital accounts was not specifically consulted, which could be an area for future research.

One of the most critical findings of the study concerns self-perception and knowledge about one's own financial situation. When asked, ‘Currently, is the money you save equal to what you earn or receive...?’ the responses were interesting: 40.14% of respondents selected the option ‘Don't know.’

This lack of clarity about a basic indicator of financial health is symptomatic of a lack of budgetary control and planning. On the other hand, 27.21% stated directly, ‘I have no savings.’ Only 11% considered their savings to be equivalent to up to half a month's income, and 10.66% to up to a month's income.

A cross-tabulation analysis between the semester variable and the possession of a formal savings account yielded an interesting result. No statistically significant correlation [$p > 0.05$] was found to indicate that students in their final semesters were more likely to have a savings account than those in their initial semesters.

ISSN: 2410-342X.
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This finding supports the premise that there is a disconnect between the theoretical training received in the classroom and its application in personal finance management. Knowledge does not automatically translate into forward-looking financial behaviour.

Based on the analysis of the results of this research, a financial profile of university students is outlined that is both expected and concerning. This behaviour can be interpreted through the Theory of Planned Behaviour; students perceive this method as the one with the greatest behavioural control, i.e., it is immediate, does not require paperwork, and avoids the perceived complexity of the banking system.

However, this practice keeps them in a cycle of vulnerability, depriving them of the benefits of security, performance, and credit history offered by formalisation [Iregui-Bohórquez *et al.,* 2018].

The low rate of savings account and AFORE ownership is perhaps the clearest indicator of self-imposed or contextual financial exclusion. This result validates the observations of León *et. al*., [2022] on the limited financial knowledge of young people.

The situation of the Afore is particularly critical, where retirement is perceived as such a distant event that it does not deserve immediate attention.

This has serious implications for the sustainability of the pension system and for the quality of life of these future professionals.

The most worrying finding, without a doubt, is that 4 out of 10 students are unaware of the basic relationship between their savings and their income. This data is a barometer of a profound lack of applied financial education. It is not just a matter of not knowing what an interest rate is, but of not keeping even minimal control over personal cash flow.

This lack of financial awareness places them in a highly vulnerable position, unable to gauge their own resilience in the face of an emergency or to plan medium-term goals. Here, behavioural economics offers an explanation: the absence of clear monitoring makes saving a concept, while spending is tangible and immediate, reinforcing present bias.

The lack of correlation between the academic semester and improvement in formal saving habits is challenging. It is assumed that students of financial careers automatically improve their personal financial health.

This suggests that the curriculum, as it is structured, may be failing to bridge the gap between theory and everyday practice in personal finance. Students are taught how to manage a company's finances, but not necessarily their own. This points to the need for a specific programme or subject that explicitly and practically addresses personal financial planning, investment, and saving for retirement.

Taken together, these results provide strong support for the main research hypothesis. Impulsive spending facilitated by immediate access to money at home, lack of planning evidenced by ignorance of one's own finances, a culture that normalises informal saving, and ignorance of formal products combine to negatively affect students' personal finances.

Economic factors, such as limited income, and social factors, such as low banking penetration, act as the main elements of this vulnerable scenario, which current academic training is failing to resolve.

Conclusions

Based on the discussion of the theoretical framework and the analysis of the data, the general objective has been achieved, from which the knowledge, habits, and factors that influence saving practices and their impact on the personal finances of university students have been identified, and the following conclusions can be drawn:

The predominance of financial informality is confirmed. University students at the Faculty of Accounting and Administration in Monclova have a markedly informal savings profile. The practice of keeping money at home is the main method, reflecting a preference for immediate accessibility but exposing them to unnecessary risks and limiting their opportunities for financial growth.

ISSN: 2410-342X.
RENIECYT: 1702902

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Furthermore, it can be argued that there is exclusion from the formal financial system due to low financial inclusion, manifested in the low ownership of basic products such as savings accounts and, more critically, Afore retirement accounts. This indicates a disconnect from formal protection mechanisms that may have long-term negative consequences for their economic security.

Another point to note is that the fact that 40.14% of students are unaware of the equivalence between their savings and income is a symptom of a lack of personal financial control and planning. This finding indicates that the problem is not only a lack of theoretical knowledge, but also a lack of practical skills to manage finances on a daily basis.

Furthermore, there is no significant correlation between career advancement and the adoption of better formal financial habits. This evidence points to a failure in the transfer of specialised knowledge, suggesting that current curricula are insufficient to equip students with the skills necessary to manage their own wealth optimally.

Based on the above conclusions, the following recommendations are proposed:

Higher education institutions are recommended to integrate a compulsory subject on personal finance or a practical workshop into all faculty programmes, focusing on budgeting, formal savings, basic investment, responsible borrowing and retirement planning. This module should be applied, with real exercises in tracking expenses and investment simulation.

Strategic alliances should be established with the financial sector to negotiate agreements with banks and AFOREs to facilitate the opening of savings accounts and AFOREs for students, with preferential conditions and information sessions on campus.

For public policy decision-makers, it is recommended to strengthen national campaigns for youth financial inclusion by designing mass communication campaigns using digital channels and social networks that demystify formal financial products and highlight the importance of long-term savings, especially those related to retirement.

Similarly, they should work with education ministries to incorporate robust financial education content into upper secondary school curricula, creating a knowledge base before students enter university.

In terms of future lines of research, it is recommended that the geographical and disciplinary scope be expanded, i.e., that the study be replicated in other faculties and universities in the country to compare behaviours and identify whether the problem is widespread or specific to a certain profile or location.

Methodologically, a longitudinal study should be conducted that follows a sample of students from their entry to their graduation, in order to accurately measure the evolution of their financial habits and the impact of educational interventions.

The implementation of these recommendations can contribute significantly to closing the gap between financial knowledge and behaviour, empowering young university students to not only be excellent business managers, but also successful in their own economic future.

Declarations

Conflict of interest

The authors declare that they have no conflict of interest.

They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Contribution of the authors

Zamarrón-Otzuca, Nathalia: Contributed to raising the social problem and linking the research variables with the selected items from ENSAFI.

Ortiz-Osuna, Mayra Jazmín: Collaborated in reviewing the state of the art of the phenomenon under study.

Aguilar-Sánchez, Ana María: Captured the surveys, sorted and cleaned the information collected from each variable.

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De La Garza-Cienfuegos, Sandra Patricia: Performed the analysis of the topic and proposed future lines of research.

It should be noted that all the authors participated in the application of the research instrument.

Availability of data and materials

There were no problems in collecting the information. The survey was administered using a form sent to the respondent's WhatsApp and was answered anonymously.

Funding

The project was funded with the authors' own resources.

Acknowledgements

Special thanks to the students of the Faculty of Accounting and Administration in Monclova, who were part of the sample and helped to respond to the survey.

Abbreviations

AFORE	Retirement Fund Administrator
BBVA	Banco Bilbao Vizcaya Argentaria
ENSAFI	National Survey on Financial Health
FCA	Faculty of Accounting and Administration
INEGI	National Institute of Statistics and Geography
UAdeC	Autonomous University of Coahuila

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ISSN: 2410-342X.
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Journal of Administration and Finance 12[29]1-12: e31229112
Article

Public spending and economic growth: evidence from a panel data model for Mexico's states, 2000–2023

Gasto público y crecimiento económico: evidencia desde un modelo de datos de panel para las entidades federativas de México, 2000–2023

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Classification:

Area: Social Sciences
Field: Public expenditure and human rights
Discipline: Government Accounting
Subdiscipline: Econometrics

https://doi.org/10.35429/JAF.2025.12.29.3.1.12
History of the article:
Received: September 20, 2025
Accepted: November 30, 2025

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Abstract

This article analyzes the relationship between public spending and economic growth in Mexico at the state level during the period 2000–2023. Based on a balanced panel of 31 states, an econometric model is estimated that incorporates cultural spending, current spending, and public investment per capita as explanatory variables of state gross domestic product per capita. The methodological strategy combines fixed and random effects estimates, diagnostic tests, and corrections using Panel Corrected Standard Errors [PCSE] to address problems of heteroscedasticity and autocorrelation. The results show that current expenditure has a positive effect on state economic growth, while public investment does not have a robust impact and cultural expenditure has a negative impact in the short term. These findings are the key determinants of economic performance, with relevant implications for budget planning and fiscal sustainability in Mexico.

Objective	Methodology	Contribution
To examine how cultural, current, and investment spending affect state GDP per capita in Mexico [2000–2023]	Balanced panel of 31 states using Fixed Effects and PCSE models.	Current spending promotes growth, investment is not significant, and cultural spending shows short-term negative effects. Spending efficiency and composition are key to development.

Public spending, Economic growth, Panel data

Resumen

Este artículo analiza la relación entre el gasto público y el crecimiento económico en México a nivel estatal durante el periodo 2000–2023. A partir de un panel balanceado de 31 entidades federativas, se estima un modelo econométrico que incorpora el gasto cultural, el gasto corriente y la inversión pública per cápita como variables explicativas del Producto Interno Bruto per cápita estatal. La estrategia metodológica combina estimaciones de efectos fijos y aleatorios, pruebas de diagnóstico y correcciones mediante Panel Corrected Standard Errors [PCSE] para atender problemas de heterocedasticidad y autocorrelación. Los resultados muestran que el gasto corriente tiene un efecto positivo sobre el crecimiento económico estatal, mientras que la inversión pública no presenta impactos robustos y el gasto cultural refleja una incidencia negativa en el corto plazo. Estos hallazgos constituyen el determinante clave del desempeño económico, planteando implicaciones relevantes para la planeación presupuestaria y la sostenibilidad fiscal en México.

Objetivo	Metodología	Contribución
Analizar cómo el gasto cultural, corriente y de inversión afecta el PIB per cápita estatal en México [2000–2023].	Panel balanceado de 31 estados con modelos de efectos fijos y PCSE.	El gasto corriente impulsa el crecimiento, la inversión no es significativa y el gasto cultural tiene efectos negativos de corto plazo. La eficiencia y composición del gasto son clave para el desarrollo.

Gasto público, Crecimiento económico, Datos de panel

Area: Strengthening the scientific community

Citation: Nande-Vázquez, Edgar Alfredo & Barajas-Palacios, Francisco. [2025]. Public spending and economic growth: evidence from a panel data model for Mexico's states, 2000–2023. Journal of Administration and Finance. 12[29]1-12: e31229112.

Introduction

The impact of public spending on economic growth is a persistent debate in economic literature. Since the seminal work of Devarajan, Swaroop and Zou [1996], attention has shifted from the total volume of spending to its composition, highlighting the need to distinguish between components with productive effects and those that generate distortions. Subsequent research has confirmed that the results are mixed: while public investment and social spending tend to be associated with sustained growth [Bose, Haque y Osborn, 2007; Gnangoin, Edjoukou, & Kassi, 2019], current expenditure tends to have ambivalent effects that depend on institutional efficiency [Wu, Tang, & Lin, 2010; Okunlola et al., 2024].

In this context, cultural spending emerges as an under-explored area, but one with the potential to influence social cohesion and long-term economic development [Acerenza y Gandelman, 2019; Jalles y Pessino, 2025].

For Mexico, the discussion takes on special relevance given the need to evaluate the effectiveness of fiscal policy in a scenario marked by budgetary decentralisation and the financial constraints of state governments. Recent studies suggest that, although the magnitude of public spending is considerable, its allocation does not always translate into positive impacts on economic growth [Levy Orlik, 2016; Salazar, 2020]. Regional heterogeneity, institutional differences, and variability in spending efficiency highlight the importance of a disaggregated analysis at the state level.

This article aims to evaluate the relationship between public spending and economic growth in Mexico, considering three specific components: cultural spending, current spending, and public investment. To this end, a balanced panel of state data for the period 2000–2023 is used, and robust econometric estimates are applied to correct for heteroscedasticity and autocorrelation problems.

The study contributes to the literature by providing updated empirical evidence for an emerging country and by putting into perspective the differentiated role of expenditure components in subnational economic performance.

The results offer key elements for the fiscal policy discussion, particularly regarding the sustainability of current expenditure, the efficiency of public investment, and the relevance of recognising cultural expenditure as a long-term social investment.

Previous literature

The link between public spending and economic growth is one of the most persistent debates in contemporary economic literature, bringing together theoretical approaches, empirical controversies and diverse methodological approaches.

The general consensus is that the composition of spending is decisive, but there is still widespread debate about which components are most effective and in what contexts. From an endogenous growth perspective, public spending can generate positive externalities that boost productivity, provided that it is allocated efficiently and targeted at strategic areas [Devarajan, Swaroop, y Zou, 1996].

The seminal work of Devarajan et al. [1996], based on a panel of developing countries, used cross-sectional and time-series data models to show that the orientation of spending toward current expenditure could have negative effects on growth, while public investment was associated with positive returns.

Subsequently, Bose, Haque, and Osborn [2007] conducted a disaggregated analysis using data from developing countries for the period 1970–1990, applying ordinary least squares [OLS] techniques and panel estimates, finding that spending on education and health has significant positive impacts on economic growth. These studies marked the beginning of a trend that emphasises the importance of differentiating the effect of different components of public spending.

The sensitivity of public spending to the level of development was analysed by Wu, Tang and Lin [2010], who used a large panel of 182 countries in the period 1950–2004, estimating dynamic panel data models. Their results indicate that the effects of spending are heterogeneous: in low-income countries, public spending can be a driver of growth, while in high-income countries the effects tend to be marginal or even negative if spending is inefficient.

ISSN: 2410-342X.
RENIECYT: 1702902

Nande-Vázquez, Edgar Alfredo & Barajas-Palacios, Francisco. [2025]. Public spending and economic growth: evidence from a panel data model for Mexico's states, 2000–2023. Journal of Administration and Finance. 12[29]1-12: e31229112.
https://doi.org/10.35429/JAF.2025.12.29.3.1.12

These findings were revisited in more recent European contexts by Sosvilla-Rivero, Ramos-Herrera and Rubio-Guerrero [2025], who applied panel cointegration models and long-term estimates for European Union countries, showing that the composition of public spending is a relevant explanatory factor for growth differences among Member States.

Within the literature on current expenditure, the results have been particularly controversial. Navarro [2019], through a time series analysis for Spain in the period 1980–2016 and based on the Armey curve, concludes that excessive public expenditure—particularly current expenditure—compromises macroeconomic efficiency. Herrero-Alcalde, Martín-Román, Tránchez-Martín and Moral-Arce [2024], using a general equilibrium model applied to Spain and tested with cointegration techniques, demonstrate that the fiscal rules implemented in the last decade have aimed to contain excessive growth in current expenditure and ensure fiscal sustainability.

Lago Peñas and Martínez-Vázquez [2016] conduct a comparative analysis using budgetary indicators and stochastic frontier models, concluding that Spain has expenditure levels below the European average, but with significant deficiencies in allocative efficiency. Kutasi and Bodi [2020], in the context of Eastern Europe, applied ARDL [Autoregressive Distributed Lag] models and cointegration analysis to show that current expenditure can boost GDP in the short term, but generates fiscal pressures in the medium term. Similar results are found in West Africa, where Okunlola, Sanni, Ayetigbo and Oyeyipo [2024], using a dynamic panel GMM [Generalised Method of Moments] model for ECOWAS countries, conclude that current expenditure promotes growth only in institutional environments with low corruption and no conflict, highlighting the importance of the institutional framework in the effectiveness of expenditure.

In Latin America, Afonso and Baquero Fraga [2024] applied spending efficiency techniques using stochastic frontier models and Data Envelopment Analysis [DEA], demonstrating that current spending efficiency is strongly conditioned by institutional quality.

Complementarily, Pessino, Altinok and Chagalj [2022], in an IDB study, applied an allocative efficiency approach based on panel models for more than a decade of data, concluding that even with high levels of spending, the effects on economic growth are limited if policies to improve resource allocation are not implemented. Huber [2008], from a more political angle, showed through case studies and comparative models of social spending that in Latin America, current expenditure is mediated by distributional tensions and institutional pressures that affect its sustainability.

In contrast to the controversy over current expenditure, there is broader consensus on public investment as an engine of economic growth. De la Fuente [2017], using a panel cointegration model for Spanish regions, concluded that regional public investment has positive and sustained impacts on growth and territorial convergence. Gnangoin, Edjoukou and Kassi [2019], using fixed-effects models applied to a panel of Latin American countries, show that public investment promotes growth, but warn that its magnitude depends on macroeconomic stability.

In the case of Mexico, Rodríguez Benavides, Mendoza González and Climent Hernández [2021], using state data and panel models, show that public investment was fundamental to the post-COVID-19 economic recovery. Reyes-Hernández and Mejía-Reyes [2023], using a VAR model applied to data from 1980–2021, demonstrate that public investment is linked to long-term economic cycles. Salazar [2020], applying cointegration techniques, warns that without proper allocation, public investment may be insufficient to generate structural impacts. Tavera Cortés, Torres Sandoval, and Sandoval Gómez [2024] confirm, through budget efficiency models, that the effectiveness of investment depends largely on efficient budget allocation.

An emerging, though less explored, field is that of cultural spending. Acerenza and Gandelman [2019], through an empirical analysis for Latin American countries using surveys and aggregate expenditure data, argue that cultural spending is often considered a luxury in contexts of budgetary constraints.

ISSN: 2410-342X.
RENIECYT: 1702902

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https://doi.org/10.35429/JAF.2025.12.29.3.1.12

However, the authors highlight that such spending can generate positive externalities in the medium and long term, such as strengthening social cohesion and indirect improvements in productivity. Along these lines, Jalles and Pessino [2025], using fiscal consolidation models applied to developing countries, conclude that the effectiveness of different components of spending—including cultural spending—depends on institutional factors such as informality and inequality. Levy Orlik [2016], in the Mexican context, reinforces this view by arguing that the composition of public spending has been a central factor in long-term macroeconomic imbalances.

Recent literature also includes contributions from postgraduate academic work which, although less widely disseminated, reinforce the discussion on the composition of expenditure. Awuh [2018], in a master's thesis, uses OLS models to analyse the composition of expenditure in African countries, showing that the orientation towards non-productive sectors limits growth. Ahamed [2022], in his master's thesis in the United States, uses dynamic panel models for developing countries and confirms that both public and private investment have positive effects, but with different impacts depending on the institutional context.

In summary, the literature shows that the effects of public spending on economic growth are heterogeneous and depend on three fundamental factors: the composition of spending, institutional quality, and the level of economic development. While public investment is consistently associated with positive long-term effects, current and cultural spending show ambiguous results that are conditioned by allocative efficiency and fiscal sustainability.

For Latin America and Mexico, the evidence suggests that the magnitude of spending does not guarantee results, with its composition and efficiency being the determining factors. These findings form the basis for this study, which seeks to analyse the relationship between public expenditure—with an emphasis on cultural expenditure, current expenditure, and public investment—and state economic growth in Mexico during the period 2000–2023, providing empirical evidence using panel data techniques with robust estimates for problems of heteroscedasticity and autocorrelation.

Theoretical framework

The debate on the impact of public spending on economic growth is part of the main currents of economic theory and has evolved from a view focused on the size of the state to more complex approaches that emphasise the composition and efficiency of spending. In neoclassical growth models, such as those of Solow and Swan, the role of the public sector was conceived as exogenous, with an indirect impact on physical capital accumulation. Subsequently, Barro [1990] explicitly incorporated public spending into an economic growth model, arguing that certain types of spending—particularly those on productive public goods—can stimulate growth, while others, such as excessive current spending, can generate distortions and reduce aggregate productivity. This approach laid the foundation for the hypothesis that it is not the aggregate level of spending that matters, but its composition.

The theory of **endogenous growth** represented a fundamental change by highlighting that public investments in human capital, infrastructure, and technology can generate increasing returns and spillover effects on private productivity [Romer, 1986; Lucas, 1988]. From this perspective, public spending on investment and strategic social sectors not only has immediate effects on aggregate demand, but also long-term structural impacts by raising the productive capacity of the economy. In this logic, cultural spending can be interpreted as an investment in human and social capital that, although with less visible returns in the short term, strengthens the foundations for sustained growth.

The **hypothesis of allocative efficiency of spending**, linked to the tradition of public finance [Musgrave, 1959; Tanzi and Zee, 1997], complements this debate by arguing that the effect of public spending depends on the quality of its allocation and the consistency between the destination of resources and the structural needs of the economy. Thus, the same level of spending can generate divergent results depending on whether it is directed toward productive investment or diluted in unproductive current spending. This hypothesis is particularly relevant in contexts such as Latin America and Mexico, where fiscal constraints and institutional weakness pose additional challenges to spending efficiency.

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RENIECYT: 1702902

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In this context, current expenditure appears to be an ambivalent component: it can sustain macroeconomic stability and the provision of basic services in the short term, but it can also lead to budgetary rigidities, structural deficits and adverse effects on private investment if it expands excessively. In contrast, public investment spending is seen as a structural driver of economic growth, generating physical and social infrastructure that expands productive capacities and promotes regional convergence.

An emerging, though less explored, area is that of **cultural spending**, which can be theoretically grounded in social and institutional capital approaches. Putnam [1993] argues that cultural practices strengthen networks of trust and cooperation, creating a more favourable environment for economic development.

North [1990], from an institutional economics perspective, emphasises that institutions and cultural values shape economic incentives and, therefore, growth trajectories. From these perspectives, cultural spending transcends its symbolic dimension to become an indirect determinant of economic dynamism by fostering social cohesion, creativity, and innovation.

In short, the theoretical framework guiding this study articulates three complementary approaches. First, endogenous growth, which explains how public investment and certain social items enhance growth through positive externalities. Second, the allocative efficiency hypothesis, which warns that the results of spending do not depend on its absolute volume, but on its structure and institutional quality.

And third, the human and social capital approaches, which allow cultural spending to be integrated into economic analysis as a relevant variable for sustainable development. Under these premises, it is expected that public investment spending will be positively and robustly associated with state economic growth, that current spending will have heterogeneous effects dependent on institutional efficiency, and that cultural spending, although smaller in magnitude, will indirectly contribute to economic growth through social and cultural externalities.

General objective

To analyse the impact of public spending on culture, current expenditure and public investment per capita on the gross domestic product per capita of Mexico's federal entities in the period 2000–2023, in order to assess the relevance and sign of each component of expenditure on state economic growth.

Specific objectives

1. Estimate the relationship between per capita public spending on culture and per capita GDP to identify whether its effect is expansive or restrictive on economic growth.

2. Determine the influence of per capita current expenditure on state per capita GDP, evaluating its role in the economic dynamics of the states.

3. Examine the impact of per capita public investment on economic growth, verifying whether this component generates a positive and significant effect.

4. Apply robust econometric techniques [fixed effects, diagnostic tests and Panel Corrected Standard Errors] to ensure the statistical validity of the results.

Methodology

This study adopts a quantitative longitudinal approach, using panel data corresponding to 31 federal entities in Mexico during the period 2000–2023. The unit of analysis is the state-year, which allows us to capture both the structural differences between entities and the temporal dynamics of the selected economic and governance variables.

Model specification

This study is developed with a longitudinal quantitative approach, using a balanced panel of data for the 31 federal entities of Mexico during the period 2000–2023. The unit of observation corresponds to the state-year, which allows us to simultaneously capture the structural differences between entities and the temporal evolution of the selected economic and fiscal variables.

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Model specification

The dependent variable is the **state gross domestic product per capita** in natural logarithms [lnGDP_pc], deflated at constant prices.

The main explanatory variables included:

i] **per capita cultural expenditure** [lnGcultura],
ii] **per capita current expenditure** [lnGcorr], and
iii] **per capita public investment** [lnGinv].

The general model is expressed as:

$$ln\,[PIB\_pc_{it}] = \beta_0 + \beta 1 ln\,[\text{Gasto\_cultura}_{it}] + \beta 2 ln[\text{Gasto\_corriente}_{it}] + \beta 3 ln[\text{Inversion\_publica}_{it}] + \mu_i + \tau_t + \varepsilon_{it}$$

where i denotes the federal entity, t the year, represents unobservable effects that are invariant over time, captures shocks common to all states, and corresponds to the idiosyncratic error term.

Estimation strategy

The estimation process was carried out in different stages in order to ensure the statistical validity and robustness of the results. First, fixed effects [FE] **and** random effects [RE] **models were estimated,** which allow for controlling unobservable heterogeneity between federal entities.

The choice between the two was made using the **Hausman test**, which contrasts the efficiency of random effects estimators with the consistency of fixed effects estimators. The results of this test supported the use of the fixed effects model, showing that unobservable differences are correlated with the explanatory variables.

In a second stage, the **classical assumptions of panel models were evaluated.** The **modified Wald test** confirmed the presence of contemporary heteroscedasticity between panels, while the **Wooldridge test** revealed first-order serial autocorrelation in the residuals.

These conditions invalidate the standard errors of conventional models, compromising statistical inference.

To address these limitations, in the third stage, the **Panel Corrected Standard Errors [PCSE]** methodology was implemented under the **Prais–Winsten estimator with AR[1] correction**. This approach, recommended by Beck and Katz [1995] for panels with heteroscedasticity and autocorrelation, robustly adjusts standard errors, preserving the consistency of coefficients and ensuring the validity of significance tests.

In this way, the estimation strategy combines the theoretical robustness of fixed-effects models with the statistical correction of standard errors, guaranteeing reliable results suitable for comparative analysis in social and economic sciences.

Data and variables

The analysis is based on a balanced panel of data corresponding to 31 federal entities in Mexico for the period 2000–2023. The information comes from official sources, mainly the National Institute of Statistics and Geography [INEGI], through the State National Accounts, and the Ministry of Finance and Public Credit [SHCP] through state budget records. These sources offer homogeneous and comparable series that allow for analysis of the relationship between gross domestic product [GDP] per capita and the components of public expenditure.

The dependent variable is state GDP per capita [deflated and expressed in natural logarithms]. The main explanatory variables include: per capita cultural expenditure, per capita current expenditure and per capita public investment, all of which are transformed into natural logarithms after being deflated to constant prices. In this way, the model coefficients are interpreted as elasticities, which facilitates comparison between items with different scales and units of measurement.

The estimation of the first-order autocorrelation common to all panels is also included, captured by the parameter ρ\rhoρ, corrected using the Prais–Winsten method.

Table 1 presents the definition, transformation and characteristics of each variable used in the econometric model.

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Box 1

Table 1

Definition and characteristics of the variables used in the econometric model

Type	Variable in Stata	Definition	Applied Transfor	Unit / Scale	Expected sign
Dependent	log_pib_b	State GDP per capita [deflated]	Natural logarithm	Thousands of constant pounds per capita	
Principal 1	ln_gcultura	Public expenditure on culture per capita [deflated]	Natural logarithm of per capita expenditure	Constant pounds per inhabitant	[+]
Principal 2	ln_gcorr	Proxy indicator of current expenditure per capita	Natural logarithm	Index/value per capita	[–]
Principal 3	ln_ginv	Public investment per capita [deflated]	Natural logarithm of per capita expenditure	Constant pounds per inhabitant	[+]
Constant	_cons	Independent term	—	—	
Error structure	rho	Common AR[1] autocorrelation in panel	Estimated by Prais–Winsten	—	

Source: Prepared internally based on INEGI [State National Accounts], Ministry of Finance and Public Credit [SHCP], and state budget data

Analysis of results

Based on the methodological strategy proposed, the analysis of results begins with the estimation of a **fixed effects [FE] model**, which allows for the control of unobservable heterogeneity among federal entities, assuming that such differences may be correlated with the explanatory variables.

This model constitutes a first approach to evaluating the relationship between the different components of public expenditure—cultural, current, and investment—and economic performance measured through GDP per capita.

The use of the fixed effects model responds to the need to ensure that the structural characteristics of each state, which remain constant over time, do not distort the estimation of the parameters. In this way, the coefficients obtained reflect intra-state variation, i.e., changes that occur within each entity over the study period.

The results of the fixed effects model are presented below [Table 2], followed by the analysis of the random effects models and the robustness tests that allow the validity of the estimators to be verified.

Box 2

Table 2

Results of the fixed effects model [2000–2023]

Variable	Coef.	t	p	sig
Per capita cultural expenditure	-1.322	-0.24	0.813	
Per capita current expenditure	27.149	6.92	0.000	***
Per capita public investment	9.101	1.45	0.153	
Constant	5.403	146.49	0.000	***
Observations: 713 | Entities: 31 | R^2 [within]: 0.3277 | F[3,30]=7.21, p=0.000				
Robust standard errors grouped by entity [cluster id].				
*** p<0.01, ** p<0.05, * p<0.10				

Source: own elaboration based on INEGI [State National Accounts] and SHCP [state budget]

As we can see, the initial results of the **fixed effects model** [Table 2] show that, within the federal entities, current expenditure per capita is positively associated with GDP per capita and is statistically significant at 1%. In contrast, neither per capita cultural expenditure nor public investment are significant, suggesting that, in this specification, their impact on economic growth is not robust.

The within R^2 of 0.33 indicates a moderate explanatory power of the model, while the overall F-test is significant, confirming the relevance of using fixed effects as a starting point. However, the presence of possible heteroscedasticity and autocorrelation problems—identified in subsequent tests—requires these results to be verified using other more robust estimators.

In this sense, the fixed effects model constitutes a **first exploratory approach** that allows preliminary patterns to be identified, but does not represent the final estimate on which the conclusions of the article are based.

Although the fixed effects model constitutes a first approach to analysing the relationship between public spending and state economic growth, it is relevant to contrast its results with the estimation of a random effects model. The latter allows for the incorporation of both intra-state and inter-state variation under the assumption that unobservable effects are not correlated with the explanatory variables.

ISSN: 2410-342X.
RENIECYT: 1702902

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The comparison between the two models, presented in Table 3, is a necessary step before applying the diagnostic tests that will determine the most appropriate specification for this study.

Box 3

Table 3

Results of the random effects model [2000–2023]

Variable	Coef.	z	p	IC 95% lower	IC 95% superior
Per capita cultural expenditure	–2.313	–0.42	0.675	–13.123	8.497
Per capita current expenditure	27.318***	4.10	0.000	14.261	40.374
Per capita public investment	9.289	1.50	0.134	–2.865	21.443
Constant	5.407***	73.22	0.000	5.262	5.551
Observations: 713					
Number of groups [states]: 31					
R^2 [within]: 0.3277					
R^2 [between]: 0.1721					
R^2 [overall]: 0.1466					
Wald $chi^2[3] = 23.61$, p = 0.000					

Source: Prepared internally based on INEGI [State National Accounts] and SHCP [State Budget]].

The results of the random effects model [Table 3] show that current expenditure per capita has a positive and statistically significant impact on GDP per capita, confirming the evidence obtained in the fixed effects model.

In contrast, both cultural expenditure and public investment per capita are not statistically significant, which limits their ability to explain state economic growth in the period analysed.

The Wald test confirms the joint significance of the model. However, to determine the most appropriate specification between fixed and random effects, it is necessary to apply the Hausman test shown in Table 4.

Box 4

Table 4

Results of the Hausman test [2000–2023]

Variable	Coef. FE	Coef. RE	Diference [FE–RE]	Standard error
Expenditure on culture per capita	–1.322	–2.313	0.991	0.718
Current expenditure per capita	27.149	27.318	–0.169	0.093
Public investment per capita	9.101	9.289	–0.187	0.244
$chi^2[3] = 4.33$				
Prob > chi^2 = 0.2279				

Source: Prepared internally based on INEGI [State National Accounts] and SHCP [State Budget]].

As we can see, the Hausman test demonstrates the validity of the fixed effects and random effects models. The statistic obtained was chi^2 [3] = 4.33, with a p-value = 0.2279. Given that this result is not significant, the null hypothesis proposing the absence of systematic differences between both models is not rejected. Consequently, random effects estimators can be considered efficient and consistent for analysing the impact of public spending on state GDP per capita. However, the choice of the final model cannot be based solely on this contrast. As will be evident in the diagnostic tests, the presence of heteroscedasticity and autocorrelation requires the use of more robust techniques, so estimation using **Panel Corrected Standard Errors [PCSE]** is established as the most appropriate strategy to ensure the validity of the results.

The Hausman test indicated that random effects estimators can be considered efficient as no systematic differences were found compared to fixed effects estimators. However, before defining the final estimation, it is essential to apply diagnostic tests to assess the validity of the statistical assumptions of the panel model. In this regard, tests for heteroscedasticity, autocorrelation and multicollinearity were performed, the results of which are presented in Table 5.

Box 5

Table 5

Diagnostic tests of the panel model [2000–2023]

Test	Null hypothesis [H_0]	Statistician	Value p	Decision
Modified Wald [xttest3]	There is no heteroscedasticity between groups.	$chi^2[31]$ = 7993.90	0.000	H_0 rejected → Heteroscedasticity exists
Wooldridge [xtserial]	There is no first-order autocorrelation.	F[1,30] = 93.524	0.000	H_0 rejected → Autocorrelation exists
Variance inflation factor [VIF]	There is no multicollinearity.	VIF medio = 1.04	—	H_0 not rejected → No multicollinearity

Source: Prepared internally based on statistical tests performed in Stata 16.

The results of the diagnostic tests show the presence of heteroscedasticity and first-order autocorrelation in the panel model residuals, which invalidates the assumptions of homoscedasticity and serial independence necessary for reliable statistical inference. In contrast, the values of the **variance inflation factor [VIF]** show an average close to 1, confirming the absence of multicollinearity problems among the explanatory variables.

ISSN: 2410-342X.
RENIECYT: 1702902

These conditions justify the need to use a robust estimator such as the **PCSE [Panel Corrected Standard Errors]** model to ensure the validity of the results.

PCSE model: final estimate corrected for heteroscedasticity and autocorrelation

The PCSE model, presented in Table 6, constitutes the final estimate of the study by correcting the heteroscedasticity and autocorrelation problems identified in the diagnostics.

The results robustly show that the different components of public expenditure have differentiated effects on the GDP per capita of Mexico's federal entities in the period 2000–2023.

Box 6

Table 6

Results of the PCSE model for state GDP per capita [2000–2023]

Variable	Coef.	Standard error	z	p	IC 95% lower	IC 95% superior
ln_gcultura	–0.1107***	0.0156	–7.10	0.000	–0.1413	–0.0801
ln_gcorr	0.0534***	0.0068	7.83	0.000	0.0410	0.0669
ln_ginv	0.0013	0.0022	0.60	0.547	–0.0029	0.0066
Constante	5.2075***	0.0959	54.27	0.000	5.0194	5.3956
Observations: 713						
Number of groups [states]: 31						
R^2 = 0.9879						
Wald chi²[3] = 106.67, p = 0.000						
Common autocorrelation AR[1], rho = 0.9360						

Source: Prepared internally based on INEGI [State National Accounts] and SHCP [State Budget].

Firstly, per capita spending on culture has a negative coefficient [–0.1107] with high statistical significance [$p < 0.01$]. This result indicates that, in the short term, an increase in this type of expenditure does not translate into a direct boost to economic growth, but could be associated with deferred and intangible returns related to human capital formation, social cohesion and the generation of cultural externalities.

Empirical evidence therefore suggests that the relationship between culture and economic growth is not immediate, which raises the need to interpret this item more as a long-term social investment than as a short-term determinant of GDP.

In contrast, **current expenditure per capita** shows a positive and statistically significant effect [0.0534; $p < 0.01$], consolidating itself as the variable with the greatest impact on state economic growth. This finding reveals that the resources allocated to cover operating and administrative expenses have a direct impact on the economic activity of entities, by stimulating the circulation of resources and sustaining the government apparatus.

However, from the perspective of budgetary law and fiscal sustainability, this result raises a debate about the efficiency and rationality of current expenditure, given that its expansion may compromise investment in long-term strategic projects.

For its part, **public investment per capita** does not have a statistically significant effect on GDP per capita [coef. = 0.0013; $p = 0.547$]. This result is consistent with the hypothesis that the effects of public investment tend to manifest themselves over longer periods or depend on the quality, timing and specific destination of the projects financed.

The lack of statistical significance may also reflect problems of efficiency in the allocation of investment resources at the state level, as well as asymmetries in their execution. The model shows high explanatory power, with an **R^2 of 0.9879**, and the Wald test [$\chi^2 = 106.67$; $p < 0.01$] confirms the joint significance of the explanatory variables. Furthermore, the corrected AR[1] autocorrelation [rho = 0.9360] ensures that the estimated coefficients are consistent and adequate for the analysis.

Overall, the results of the PCSE model show that current expenditure is the main driver of state economic growth in the period analysed, while public investment does not show a robust effect and expenditure on culture reflects indirect or long-term impacts.

These findings have important implications for fiscal policy and budget planning in Mexico, as they highlight the need to review the structure of spending and its differentiated effects on economic development.

ISSN: 2410-342X.
RENIECYT: 1702902

Nande-Vázquez, Edgar Alfredo & Barajas-Palacios, Francisco. [2025]. Public spending and economic growth: evidence from a panel data model for Mexico's states, 2000–2023. Journal of Administration and Finance. 12[29]1-12: e31229112.
https://doi.org/10.35429/JAF.2025.12.29.3.1.12

Discussion of results

The results obtained in the PCSE model show differentiated effects of public expenditure components on state economic growth in Mexico during the period 2000–2023. First, the finding that **current expenditure per capita** has a positive and statistically significant effect on GDP per capita is partially consistent with the international literature.

Bose, Haque, and Osborn [2007] documented that social spending on education and health promotes growth in developing countries, which may be related to the dynamics of current expenditure in Mexico, where this item supports the provision of public services and the administrative apparatus. Similarly, Wu, Tang, and Lin [2010] found that public spending can be an engine of growth in middle-income economies, although its effectiveness declines as the level of development increases.

Our results confirm that current expenditure is a short-term stimulus, but they also raise the risk of fiscal sustainability pointed out by Navarro [2019] and Herrero-Alcalde et al. [2024], who warn that excessive current expenditure can compromise macroeconomic efficiency and generate budgetary rigidities.

In contrast, **public investment per capita** did not have a statistically significant impact on state economic growth. This result diverges from the evidence reported in international contexts, where public investment is consistently associated with positive long-term effects [De la Fuente, 2017; Gnangoin, Edjoukou and Kassi, 2019].

In the case of Mexico, previous studies such as those by Rodríguez Benavides, Mendoza González and Climent Hernández [2021] and Reyes-Hernández and Mejía-Reyes [2023] highlight the central role of public investment in economic recovery and long-term cycles. The discrepancy with our findings can be explained by problems of efficiency in the allocation and execution of state projects, which coincides with the warning of Salazar [2020] and Tavera Cortés, Torres Sandoval and Sandoval Gómez [2024], who argue that the effectiveness of investment depends on its strategic orientation and the institutional framework.

Regarding **per capita cultural expenditure**, the results show a negative effect in the short term, albeit with high statistical significance. This evidence is consistent with the idea of Acerenza and Gandelman [2019] that cultural expenditure is often considered a luxury in contexts of budgetary constraints and that its returns tend to be deferred over time. However, from the perspective of social capital [Putnam, 1993] and institutional economics [North, 1990], this finding can be interpreted as the manifestation of indirect and long-term benefits that are not reflected in immediate economic growth. Jalles and Pessino [2025] reinforce this view by demonstrating that the effectiveness of different components of spending depends on institutional factors such as inequality and informality. Thus, the negative result should not be taken as evidence of ineffectiveness, but rather as a call to reconsider how the impact of cultural spending on public policy is measured and valued.

Taken together, the findings of this study reaffirm the hypothesis that the composition of public spending, rather than its total volume, is the central determinant of economic growth [Devarajan, Swaroop and Zou, 1996; Barro, 1990].

While current expenditure is the main driver of growth in Mexico, the lack of significance of public investment and the deferred effects of cultural spending suggest that fiscal policy should be geared not only towards expanding expenditure but also towards ensuring its allocative efficiency, as proposed by Tanzi and Zee [1997] and Afonso and Baquero Fraga [2024]. These conclusions point to the need to review state budget planning and strengthen institutional frameworks to ensure that public investment and cultural spending translate into sustained impacts on economic development.

Conclusions

The study shows that the composition of public spending is more relevant than its aggregate volume in explaining state economic growth in Mexico during 2000–2023. The robust results of the PCSE model show that current per capita expenditure significantly drives state GDP, confirming previous findings in developing countries [Bose et al., 2007; Wu et al., 2010], but also warning of fiscal sustainability dilemmas [Navarro, 2019; Herrero-Alcalde et al., 2024].

ISSN: 2410-342X.
RENIECYT: 1702902

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https://doi.org/10.35429/JAF.2025.12.29.3.1.12

Per capita public investment did not show significant effects, which contrasts with studies that highlight its positive long-term role [De la Fuente, 2017; Rodríguez Benavides et al., 2021], suggesting problems of efficiency in budget allocation [Salazar, 2020; Tavera Cortés et al., 2024]. For its part, per capita cultural expenditure had a negative impact in the short term, although this is consistent with the literature that conceives it as an investment with deferred returns in social and institutional capital [Acerenza and Gandelman, 2019; Putnam, 1993; North, 1990].

These results support the hypothesis that it is not the size of the state, but the efficiency and composition of public spending that determines economic growth [Devarajan et al., 1996; Barro, 1990]. For Mexico, fiscal policy thus faces the challenge of containing the expansion of unproductive current expenditure, improving the quality of public investment, and recognising cultural expenditure as a strategic asset for sustainable development.

This work contributes to the international literature by offering updated evidence from an emerging country with a state panel of more than two decades, applying econometric techniques that are robust to heteroscedasticity and autocorrelation.

However, limitations are recognised: the absence of institutional indicators and the lack of intertemporal dynamics in the model. Future research should integrate measures of governance and transparency [Okunlola et al., 2024], explore the deferred effects of public investment using GMM-Sys [Reyes-Hernández and Mejía-Reyes, 2023], and extend the analysis to international comparisons [Afonso and Baquero Fraga, 2024].

In short, this study provides empirical evidence that reinforces the need to move towards a Mexican fiscal policy based on allocative efficiency and strategic spending. Only through institutional and budgetary redesign that balances current expenditure, public investment, and cultural spending will it be possible to consolidate sustainable, inclusive, and regionally balanced economic growth.

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https://doi.org/10.35429/JAF.2025.12.29.3.1.12

Journal of Administration and Finance 12[29]1-12: e41229112
Article

Green taxes and differentiated fiscal policy for MSMES in Hidalgo: Gaps, challenges, and opportunities for a sustainable transition

Impuestos verdes y política fiscal diferenciada para las MIPYMES en Hidalgo: Brechas, desafíos y oportunidades para una transición sostenible

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Classification:

Area: Social Sciences
Field: Economic Sciences
Discipline: Fiscal Policy and national public finance
Subdiscipline: Public Treasury [budget]

https://doi.org/10.35429/JAF.2025.12.29.4.1.12
History of the article:
Received: September 25, 2025
Accepted: November 30, 2025

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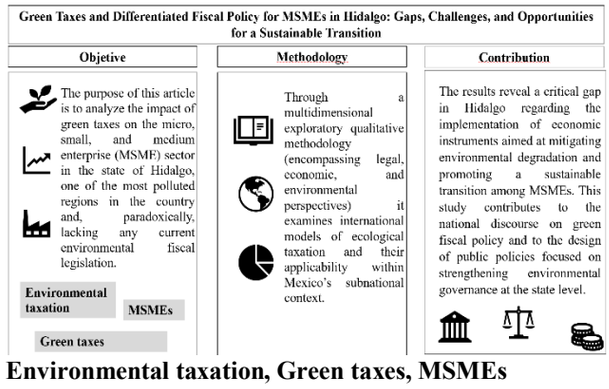
Resumen

El presente artículo tiene como objetivo analizar el impacto de los impuestos verdes en el sector de las micro, pequeñas y medianas empresas [MIPYMES] del estado de Hidalgo, una de las regiones más contaminadas del país y, paradójicamente, sin legislación fiscal ambiental vigente. A través de una metodología cualitativa exploratoria multidimensional [jurídico, económico y ambiental] se examinan modelos internacionales de fiscalidad ecológica y su aplicabilidad al contexto subnacional mexicano. Los resultados evidencian una brecha crítica en Hidalgo respecto a instrumentos económicos para mitigar el deterioro ambiental y fomentar la transición sostenible en las MIPYMES. Este estudio contribuye al debate nacional sobre fiscalidad verde y al diseño de políticas públicas orientadas a fortalecer la gobernanza ambiental desde el ámbito estatal.

Fiscalidad ambiental, Impuestos verdes, MIPYMES

Abstract

The purpose of this article is to analyze the impact of green taxes on the micro, small, and medium enterprise [MSME] sector in the state of Hidalgo, one of the most polluted regions in the country and, paradoxically, lacking any current environmental fiscal legislation. Through a multidimensional exploratory qualitative methodology [encompassing legal, economic, and environmental perspectives] it examines international models of ecological taxation and their applicability within Mexico's subnational context. The results reveal a critical gap in Hidalgo regarding the implementation of economic instruments aimed at mitigating environmental degradation and promoting a sustainable transition among MSMEs. This study contributes to the national discourse on green fiscal policy and to the design of public policies focused on strengthening environmental governance at the state level.



Environmental taxation, Green taxes, MSMEs

Area: Advocacy and attention to national problems

Citation: Cruz-Sánchez, Eduardo, Moctezuma-Navia, Dalia Alejandra, Trejo-Encarnación, Patricia and Hernández Gómez, Diana. [2025]. Green taxes and differentiated fiscal policy for MSMES in Hidalgo: Gaps, challenges, and opportunities for a sustainable transition. Journal of Administration and Finance. 12[29]1-12: e41229112.

Introduction

Public revenue, particularly tax revenue, is the cornerstone that enables the State to fulfil its essential functions, including the provision of public goods and services, institutional strengthening and the promotion of social welfare. In this regard, tax revenues are a key tool in any nation's economic development plans, enabling it to improve its position in tax collection indices compared to member countries of the Organisation for Economic Co-operation and Development [OECD], as well as in Europe and Latin America.

Mexico has shown remarkable growth in tax revenues in recent years. However, achieving optimal collection levels remains a challenge, requiring the constant development of innovative, equitable, and sustainable fiscal policies. The current Mexican tax structure includes various tax figures aimed at taxing economic activities in a differentiated manner, with the objective of sustaining public spending without neglecting efficiency and equity.

Among these alternatives, an environmentally oriented tax modality has gained momentum in recent years: so-called green taxes. Green taxes represent a strategic alternative to respond to the global environmental crisis, as they allow two major public policy challenges to be addressed simultaneously: on the one hand, discouraging polluting activities through corrective fiscal mechanisms; on the other, generating additional revenue for the public treasury.

This approach has been called the 'double dividend,'[Méndez, 2005] and its application is directly linked to the objectives of sustainable development and the transition to low-carbon economies.

Air pollution, intensive use of fossil fuels, and limited adoption of clean energy are real problems that require a decisive response from the fiscal and environmental spheres. In this context, green taxes emerge as a key public policy tool for linking economic development strategies with environmental preservation.

European countries, particularly the Nordic countries and members of the European Union, have successfully promoted environmental tax reforms that encourage the use of renewable energy and reduce polluting emissions, as recognised by the.

In the specific case of Mexico, the main environmentally-oriented fiscal instrument is the Special Tax on Production and Services [IEPS] applied to petrol and diesel. However, questions remain about its effectiveness as an environmental mechanism, given that its design and application are primarily for revenue-raising purposes, without a specific allocation of resources for climate action. It is therefore necessary to analyse the behaviour, impact and reform potential of this tax, particularly from an energy transition perspective.

This paper provides an in-depth analysis of the origin and evolution of green taxes at the global level, comparing them with successful European models and their application in the Mexican context. In addition, it presents a proposal for a differentiated environmental fiscal policy for micro, small and medium-sized enterprises [MSMEs], with an emphasis on the state of Hidalgo, in order to strengthen fiscal equity and promote sustainable business practices without compromising competitiveness or revenue collection.

Background

The concept of green taxes is based on the "polluter pays" principle, established in 1972 by the Organisation for Economic Co-operation and Development [OECD]. In the early days, countries such as Sweden [1991] and Denmark implemented taxes on carbon dioxide [CO_2] and other pollutants. Over time, these instruments gained ground in the field of environmental taxation [OCDE, 2021]. In Europe, progress has been characterised by a coherent eco-taxation policy, integrating taxes on carbon, energy, waste and transport.

In Sweden, the carbon tax introduced in 1991 has been one of the most successful tools. With an initial rate of €29/tonne of CO_2, it currently stands at over €114/tonne [Anderson, 2019].

This tax has helped to reduce emissions by more than 27% since its implementation, without compromising economic growth.

Germany implemented a progressive ecological tax reform starting in 1999, incorporating taxes on electricity, fossil fuels and other sources of polluting emissions.

ISSN: 2410-342X.
RENIECYT: 1702902

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This policy was part of a broader energy transition approach [Energiewende] that sought both to reduce greenhouse gas emissions and improve energy efficiency. Although these taxes did not reach high proportions of GDP, they represented approximately 1.9% of GDP in 2016, and their revenues were partially used to finance the social security system, including reductions in pension insurance contributions as part of the tax redesign [Green Fiscal Policy Network].

This case is internationally recognised as one of the most solid experiences of green taxation applied with social and environmental objectives.

In the United Kingdom, the Climate Change Levy [CCL] has been levied on industrial energy consumption since 2001 and is complemented by emissions trading schemes [Speck, 2013].

Asia is positioning itself as an emerging benchmark in the implementation of green taxes, integrating fiscal instruments with industrial policies to accelerate its ecological transition [Comisión de Hacianda, 2025].

China, the world's largest emitter, adopted an environmental tax on pollutants such as SO_2, NOx, wastewater and solid waste in 2018, raising $4.3 billion in its first year, although at rates that are still low compared to Western standards. Since 2012, Japan has applied a carbon tax of $2.90 per tonne of CO_2, with the revenue going to renewable energy; Tokyo supplements this with taxes on inefficient buildings, achieving a 23% reduction in emissions since 2010.

Singapore leads the way in green vehicle taxation, with a 100–200% tax on combustion cars and exemptions for electric vehicles, resulting in 40% of its fleet being hybrid or electric. South Korea combines its carbon market with sectoral taxes for heavy industries, reducing its emissions by 6.5% since 2015, although it faces criticism for exemptions for conglomerates [chaebols].

India applies a carbon tax of US$6 per tonne and levies on single-use plastics, with Maharashtra standing out for reducing its plastic waste by 50%.

The main challenges in the region include regulatory inequality—with progress in cities such as Hong Kong, but lagging behind in countries such as Indonesia and Vietnam—and a focus on megacities, leaving rural areas behind [Comisión de Hacienda, 2025].

Unlike Europe, where environmental taxes have been integrated in a structured manner since the 1990s as part of broad ecological tax reforms, Latin America and the Caribbean face structural barriers that have limited the systematic adoption of such fiscal instruments. Factors such as socioeconomic inequality, high poverty rates, and rapid urbanisation have forced governments in the region to design fiscal policies with a redistributive, gradual, and politically viable approach. In many cases, green taxes have been applied in a fragmented manner, lacking integration with national sustainability agendas, which reduces their scope and environmental impact [Alatorre, 2018].

Although the region has abundant natural resources, environmental sustainability has not been structurally integrated into tax systems.

Some countries have implemented specific taxes on fossil fuels, plastic bags or emissions; however, these efforts do not constitute comprehensive environmental tax reforms. An adapted approach is required that combines progressivity, administrative simplicity, intersectoral coherence and measurable objectives.

Notable advances include: Chile, a pioneer with its carbon tax [2014] and fixed source tax [2017], which raised US$289 million in 2017; Colombia, with taxes on carbon [2016], plastics and polluting vehicles; Brazil and Uruguay, with incipient progress through regulatory fees; while the United States has opted for market-based schemes [cap-and-trade] instead of taxes, such as its system for controlling SO_2.

Despite the potential, the development of an environmental fiscal policy in the region requires political will, institutional strengthening and greater technical coordination [Comisión de Hacienda, 2025].

ISSN: 2410-342X.
RENIECYT: 1702902

Cruz-Sánchez, Eduardo, Moctezuma-Navia, Dalia Alejandra, Trejo-Encarnación, Patricia and Hernández Gómez, Diana. [2025]. Green taxes and differentiated fiscal policy for MSMES in Hidalgo: Gaps, challenges, and opportunities for a sustainable transition. Journal of Administration and Finance. 12[29]1-12: e41229112.
https://doi.org/10.35429/JAF.2025.12.29.4.1.12

Application in Mexico

The growing environmental damage that Mexico—like other regions of the world—has experienced in recent years has led the Mexican government to implement various actions aimed at preventing and mitigating ecological deterioration. Among these measures is the creation of taxes, both at the federal and local levels, which not only generate revenue for the nation but also seek to discourage practices that are harmful to the environment.

In this scenario, phenomena such as pollution, overexploitation of natural resources [minerals, water] and widespread environmental damage have been recognised as negative externalities. According to the theoretical approach developed by the economist and Nobel Prize winner [Stiglits,1986], these are defined as 'a situation in which the actions of one individual generate a cost for others'.

Faced with this reality, various states, in their role as guarantors of the care of the natural environment, began to establish taxes on products and activities that are clearly harmful to the environment. In this way, the ecological impacts of economic activities legitimised state intervention in fiscal matters, using it as a mechanism to correct market failures.

Box 1

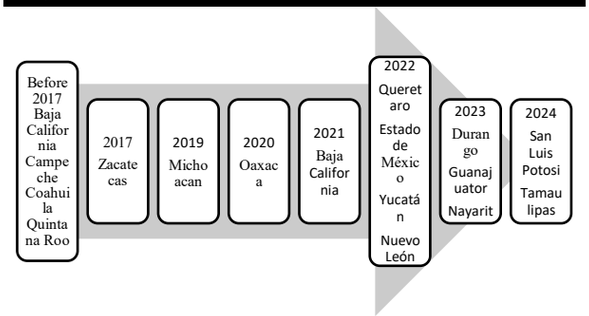

Figure 1

Federal entities that have incorporated some type of environmental tax

Source: Prepared internally based on information contained in Finance Laws, Tax Codes and Revenue Codes of the federal entities.

In Mexico, the legal basis for collecting taxes related to environmental protection is found in Article 4 of the Political Constitution of the United Mexican States [CPEUM], which recognises the right of every person to enjoy a healthy environment, obliging the State to guarantee this and to hold those who damage it accountable.

This principle has been reinforced by the SCJN [Suprema Corte de la Nación, 2020], which has established through case law that pollution constitutes a negative market externality.

In this context, environmental costs are not borne by producers, who obtain economic benefits without considering the damage they cause, thus transferring the costs of repair to the community. In other words, it is society, through public spending, that bears the economic and ecological consequences of environmental damage.

Accordingly, Article 33, section IV, of the CPEUM [Political Constitution of the United Mexican States] imposes on citizens the obligation to contribute to public expenditure in accordance with the provisions of the law. Hence, in fiscal matters, the 'polluter pays' principle is applied, requiring a contribution proportional to the damage caused or its prevention. In addition, the Organisation for Economic Co-operation and Development [OCDE,2022] has pointed out that ecological taxes should be understood primarily as preventive instruments in state environmental policy, and only as a last resort as corrective mechanisms.

Types of environmental taxes in Mexico

The Ministry of the Environment and Natural Resources [SEMARNAT, 2022] defines environmental taxes [also known in the literature as green taxes or eco-taxes] as economic tools designed to incorporate into the prices of goods the negative costs they generate on the environment, either through their production or consumption [Figure 2].

Box 2

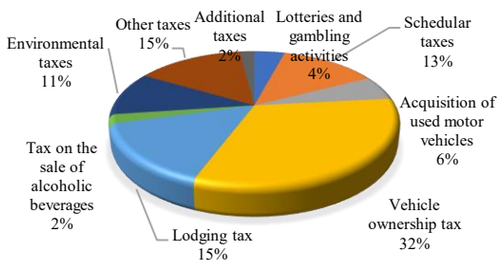

Figure 2

Most representative taxes in the federal entities in fiscal year 2024

Source: Prepared internally based on the revenue laws of the federal entities for fiscal year 2024.

ISSN: 2410-342X.
RENIECYT: 1702902

Cruz-Sánchez, Eduardo, Moctezuma-Navia, Dalia Alejandra, Trejo-Encarnación, Patricia and Hernández Gómez, Diana. [2025]. Green taxes and differentiated fiscal policy for MSMES in Hidalgo: Gaps, challenges, and opportunities for a sustainable transition. Journal of Administration and Finance. 12[29]1-12: e41229112.
https://doi.org/10.35429/JAF.2025.12.29.4.1.12

In Mexico, these taxes are divided into two categories: federal and state. At the federal level, Article 73, section XXIX of the CPEUM grants the Congress of the Union the power to establish specific taxes related to the use and exploitation of natural resources.

It also allows it to legislate on special taxes on various activities, including: electricity generation, tobacco production and consumption, the use of petrol and petroleum derivatives, and forestry exploitation.

This legal framework constitutes the basis for the existence and application of federal ecological taxes in the country.

Federal and state ecological taxes can be consulted in Table 1, which describes some of their main characteristics and the legal basis behind them.

Box 3

Table 1

Federal and State Green Taxes in Mexico.

Level of Government	Green Taxes	Legal Basis / Observations
Federal	- IEPS on fossil fuels - Contributions on the use of natural resources - There is no specific category of "green taxes" - Tax on car ownership or use	Political Constitution of the United Mexican States [Art. 73, fr. XXIX]. Indirect fiscal instrument with environmental and revenue-raising objectives. Administered by the Congress of the Union.
Estatal	- Taxes on atmospheric emissions [Mexico City, Durango, State of Mexico] - Tax on material extraction [Baja California, Durango] - Taxes on water, soil or solid waste pollution - Vehicle environmental tax [several states]	Based on the fiscal autonomy of the federal entities. Examples in: Mexico City, Durango, Baja California, State of Mexico, San Luis Potosí. Design, application and variable rates according to state legislation.

Source: Prepared internally based on GT Law [2025], México2 [2023] y SEMARNAT [2022].

In Mexico, the constitutional framework grants federal entities tax autonomy to establish their own taxes, which has allowed some states to begin implementing green taxes as instruments to discourage polluting activities, strengthen local tax collection, and promote more active environmental policies at the subnational level.

These taxes vary in design, tax base, and objectives according to the environmental, economic, and political conditions of each federal entity [Salazar, 2023].

Below is a detailed and comparative analysis of the main green taxes applied in Mexican states.

Baja California: Environmental Tax on the Extraction and Use of Stone Materials, Environmental Tax on the Emission of Gases into the Atmosphere.

Campeche: Tax on the Extraction of Soil and Subsoil Materials.

Coahuila: Tax on Environmental Remediation in the Extraction of Stone Materials.

Durango: Tax for Ecological Preservation and Restoration in the Extraction of Materials, Tax on the Emission of Gases into the Atmosphere, Tax on the Emission of Pollutants into the Soil, Subsoil and Water, Tax on the Deposit or Storage of Waste.

State of Mexico: Tax on the Emission of Polluting Gases into the Atmosphere, Ecological Tax on the Disposal, Confinement and Storage of Waste, Tax on the Emission of Pollutants into Water.

Guanajuato: Tax for Environmental Remediation for the Emission of Polluting Gases, Tax for Environmental Remediation for the Emission of Pollutants into the Soil, Subsoil and Water, Tax for Environmental Remediation for the Deposit of Waste.

Nayarit: Tax on the Stone Extraction Industry for Transport by Vehicles or Dump Trucks.

Nuevo León: Environmental Tax for Pollution in the Extraction of Stone Materials, Tax for the Emission of Pollutants into the Atmosphere, Tax for the Emission of Pollutants into Water, Tax for the Emission of Pollutants into the Subsoil and/or Soil.

Oaxaca: Tax on the Extraction of Materials for Environmental Remediation.

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Querétaro: Tax on the Emission of Gases into the Atmosphere, Tax on Environmental Remediation Caused by Soil Erosion, Tax on the Final Disposal of Special and Hazardous Waste.

Quintana Roo: Tax on the Extraction of Materials from the Soil and Subsoil.

San Luis Potosí: Tax on the Emission of Polluting Gases into the Atmosphere.

Tamaulipas: Tax on the Emission of Greenhouse Gases and Compounds into the Atmosphere. Yucatán: Tax on the Emission of Gases into the Atmosphere, Tax on the Emission of Pollutants into the Soil, Subsoil and Water. Zacatecas: Tax on Environmental Remediation in the Extraction of Materials, Tax on the Emission of Gases into the Atmosphere, Tax on the Emission of Pollutants into the Soil, Subsoil and Water, Tax on Waste Deposit or Storage [State Finance Laws and Tax Codes of the federal entities in force for the 2024 fiscal year, 2024].

Box 4

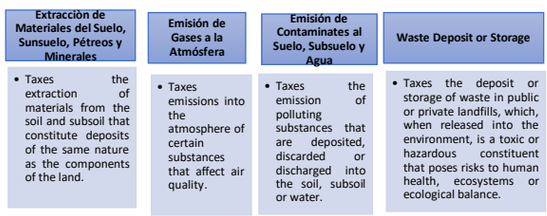

Figure 3

Source: Current environmental tax variables in the federal entities

Source: Tax Bulletin INDITEC.

Future Initiatives

According to the Official Gazette of the Federation 2024, for the period 2026–2027, the implementation of new environmental taxes is contemplated in various federal entities: Coahuila plans a tax on atmospheric emissions; Guanajuato, taxes on soil, subsoil and water pollution; Puebla, a similar tax on emissions; and Tabasco, five new taxes related to materials, emissions, soil and water pollution, and waste disposal.

The Mexico City Megalopolis region, comprising the federal entities of Mexico City, the State of Mexico, Hidalgo, Puebla, Morelos, Tlaxcala and Querétaro, is one of the most densely populated, industrialised and polluted urban areas in the country. Its rapid growth [derived from the centralised model of national economic development] has placed severe pressure on the environment, especially with regard to air quality.

The concentration of population and economic activities has intensified pollutant emissions, mainly from vehicular transport and the industrial sector. Motor vehicle traffic releases large amounts of carbon monoxide [CO], volatile organic compounds [VOCs], tropospheric ozone [O_3], and suspended particulate matter [PM10 and PM2.5]. In turn, the energy and industrial corridor of Tula, in Hidalgo, emits highly dangerous pollutants such as nitrogen dioxide [NO_2] and sulphur oxides [SO_2], generating synergistic effects on the atmosphere and human health. These environmental externalities entail health and economic costs that are not absorbed by the emitters, but by society as a whole.

According to data from the Environmental Commission of the Megalopolis [CAMe, 2022], in 2022 most monitoring stations exceeded the regulatory health protection limits established for PM10 and PM2.5 particles, while ozone and nitrogen dioxide concentrations also exceeded permissible values, especially in the areas of the Valley of Mexico, Puebla and Hidalgo. Despite the existence of programmes such as ‘Hoy No Circula’ [No Driving Today], mandatory vehicle inspections and stricter environmental standards, the results have not been sufficient to reverse the trend of persistent non-compliance in terms of air quality.

This situation highlights the urgent need to incorporate complementary economic instruments, such as green taxes, to internalise the social costs of pollution and encourage the transition to cleaner and more sustainable technologies. However, the complexity and metropolitan scale of the problem requires an effort of inter-state fiscal coordination to harmonise criteria, avoid double counting of emissions and reduce evasion through the territorial displacement of pollution sources.

ISSN: 2410-342X.
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In this context, mechanisms such as a regional tax on vehicle emissions, fixed industrial sources or carbon-intensive energy consumption could be effective tools with high revenue and environmental potential. This would turn the problem of air pollution not only into an environmental challenge, but also into an opportunity to strengthen environmental fiscal policy from a technical, socially legitimate and institutionally coordinated perspective.

Some entities in the Megalopolis have begun to explore these avenues. The State of Mexico has implemented a comprehensive environmental taxation model through four green taxes on atmospheric emissions, water pollution, solid waste and polluting gases, complemented by incentive schemes for companies with sustainable practices. Querétaro has opted for a corrective approach, standing out for imposing the highest rate in the country per tonne of CO_2 emitted and for its technical transparency in environmental fiscal management.

In 2025, Morelos introduced its ecological tax based on rigorous technical studies, targeting mobile and industrial sources.

In contrast, entities such as Hidalgo, despite recording high levels of pollutant emissions, have not yet adopted ecological fiscal mechanisms, which represents a critical gap in the region. Puebla and Tlaxcala have also not legislated on this matter, despite facing acute environmental problems and having legal frameworks that would allow for the development of these instruments.

This diversity of approaches and levels of progress shows both significant achievements and substantial challenges for the construction of a coordinated environmental fiscal policy in the Megalopolis. If this regional strategy can be consolidated, it could become a structuring axis for national climate action and a replicable model for other metropolitan areas in the country.

Despite being part of the Mexico City Megalopolis—one of the most polluted and densely urbanised regions in the country—the state of Hidalgo has not yet developed environmental tax legislation that includes ecological taxes, which represents a critical omission in its legal framework.

This absence is particularly worrying considering that Hidalgo is home to one of the country's main industrial hubs, such as the Tula energy-industrial corridor, identified as a significant source of emissions of pollutants such as SO_2, NO_2 and fine particles.

While other entities in the region have made progress in the design and implementation of green fiscal instruments to address environmental degradation, Hidalgo lags behind in terms of regulations, which limits its capacity to respond to the challenges of climate change and air quality. This lack of legislation not only weakens regional cohesion on environmental issues, but also creates negative incentives by becoming a potential tax haven for polluting activities, affecting both public health and the sustainable development of the state.

Methodology

This research is based on a qualitative, exploratory and multidimensional approach, focusing on the analysis of green taxation from three key perspectives: legal, economic and environmental. The methodology includes a review of federal and state laws to identify the existence of green taxes, as well as their design and framework for application.

Fiscal and environmental data from official sources such as the SHCP, SAT, SEMARNAT, INEGI and CAMe are incorporated, as well as reports from international organisations such as the OECD and UNEP.

Particular emphasis is placed on the state of Hidalgo, an entity that, despite being part of the Megalopolis and one of the regions with the highest pollution load in the country—especially due to the Tula industrial corridor—has not implemented environmental tax legislation, creating a critical gap in the regional strategy against ecological deterioration. This omission represents both a regulatory challenge and an opportunity for innovation in public policy at the state level.

It also examines the role of micro, small and medium-sized enterprises [MSMEs] in Hidalgo, analysing how the possible incorporation of green taxes could affect their cost structure, incentives to adopt clean technologies and access to tax incentives.

ISSN: 2410-342X.
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The methodology is complemented by a review of academic literature and international case studies, allowing for the identification of best practices and risks in the application of ecological taxes at the subnational level, with the aim of proposing a differentiated environmental tax policy model for MSMEs in Hidalgo.

Results

The multidimensional analysis of green taxation in Mexico revealed a series of key findings that show both significant progress and significant delays in the implementation of green taxes. Firstly, the case of the state of Hidalgo stands out. Despite being part of the Mexico City Megalopolis [one of the most polluted regions in the country] and home to important industrial hubs such as the Tula energy corridor, it currently has no environmental tax legislation.

This omission represents a critical gap in terms of environmental justice and regional coordination, especially when compared to neighbouring entities such as the State of Mexico, Querétaro and Morelos, which have developed ecological tax models with varying levels of sophistication.

The State of Mexico has implemented a comprehensive scheme with four differentiated green taxes; Querétaro has established high rates linked to CO_2 emissions[1] with a solid technical basis; and Morelos has recently legislated on the basis of specific diagnoses.

This regulatory heterogeneity highlights the lack of a coordinated environmental fiscal policy in the region, which creates risks of evasion, territorial disincentives, and weakening of the environmental impact of the taxes.

From a business perspective, it was identified that the application of green taxes can be a challenge for micro, small, and medium-sized enterprises [MSMEs], especially those with lower technological capabilities or limited access to green financing.

However, substantial opportunities are also recognised if a differentiated environmental fiscal policy is promoted, including progressive taxation scales, incentives for clean innovation, and government-supported technological transition shemes.

In this sense, the intelligent design of green taxes can function not only as a revenue-raising instrument, but also as a lever for the productive transformation of the local business fabric, especially in entities such as Hidalgo, where manufacturing and agro-industrial MSMEs predominate.

On the other hand, the study confirmed that environmental pollution generates economic and social costs that are not borne by the emitters, but by society as a whole, through the deterioration of public health, health expenditure, loss of productivity and degradation of ecosystems. The incorporation of green taxes would allow these negative externalities to be internalised, promoting greater fiscal equity and environmental sustainability.

The international evidence reviewed [with successful cases in countries such as Sweden, Japan, Singapore and South Korea] supports the technical and political viability of these instruments, especially when accompanied by transparency in their application and reinvestment of resources in environmental actions.

Finally, the study reveals that green taxes in Mexico have high potential both in terms of revenue collection and their ability to induce positive changes in business and citizen behaviour.

However, their effectiveness will depend on overcoming institutional obstacles, harmonising legal frameworks between levels of government, and developing monitoring and evaluation mechanisms. In particular, the state of Hidalgo faces a strategic opportunity to become a national benchmark if it succeeds in designing and implementing a green taxation model adapted to its productive and environmental characteristics, with a differentiated approach for MSMEs and based on principles of climate justice and economic efficiency [Table 2].

[1] Quota: 5.9 UMAs per tCO_2e.

ISSN: 2410-342X.
RENIECYT: 1702902

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Box 5

Table 2

Estimated revenue from environmental taxes in the federal entities, fiscal year 2024

Federative entity	Total estimated revenue from environmental taxes for 2024 [$]	% representing of total taxes
Tamaulipas	1, 511,531,143	21.26
Zacatecas	300,000,000	14.78
Nuevo León	1,526,289,000	8.61
Yucatán	214,033,199	4.97
Querétaro	317,146,519	4.62
Durango	112,000,000	3.36
Campeche	53,620,344	2.83
Quintana Roo	128,454,187	1.52
Oaxaca	20,968,066	1.13
Estado de México	252,186,318	0.93
Coahuila	48,785,684.43	0.76
San Luis Potosí	19,538,541	0.59
Guanajuato	33,685,664	0.32
Baja California	16,47,125	0.12
Nayarit	800,000	0.05
Total	**4,444,404,790**	

Source: Prepared using information from the revenue laws of the federal entities. 2024.

Conclusions

In light of global challenges and successful experiences with green taxation in different parts of the world, the case of the state of Hidalgo represents a critical paradox within the national and regional context. Although it is part of the Mexico City Megalopolis [one of the areas with the highest levels of air pollution and environmental pressure in the country], Hidalgo lags behind in the adoption of green fiscal instruments, with no state legislation providing for environmental taxes or compensatory, regulatory or incentive mechanisms linked to sustainability.

This regulatory gap is particularly worrying given that, according to recent data, the industrial corridor of Tula and its surroundings are home to highly polluting fixed sources that have a negative impact on air quality, local ecosystems and public health. In response to this, international best practices show that well-designed environmental taxes [with progressive rates, reinvestment in green infrastructure, and a redistributive approach] can generate not only ecological benefits, but also social and fiscal benefits, promoting the development of clean economies, energy transition, and environmental equity.

In this scenario, micro, small and medium-sized enterprises [MSMEs] in Hidalgo play a central role. These economic units [which constitute more than 95% of the state's business fabric] are not only generators of employment and local dynamism, but also represent a key opportunity for the successful implementation of green fiscal policies.

A differentiated environmental fiscal policy, adapted to the operational and financial profile of MSMEs, would allow these companies to transition to more sustainable practices without sacrificing their economic viability, promoting efficient use of resources, progressive regulatory compliance and productive innovation with less environmental impact.

Hidalgo has the opportunity [and the urgency] to align itself with a modern environmental fiscal model that responds both to the country's climate commitments and to local financing needs to address the ecological crisis.

The current lag not only implies a potential loss of revenue, but also the omission of tools that could discourage highly polluting activities, support MSMEs in technological conversion processes, and strengthen the state's environmental resilience.

The absence of local green taxation, in contrast to other federal entities such as Querétaro, the State of Mexico or Mexico City, weakens the possibility of coordinated regional environmental governance, which is essential for addressing cross-cutting issues such as air quality, waste management and efficient use of resources.

Consequently, we recommend the creation and implementation of a state ecological tax with a differentiated approach for MSMEs, based on criteria of fiscal progressivity, social compensation, and environmental reinvestment.

This instrument should be accompanied by incentives for technological innovation, transparent monitoring schemes, and citizen participation. This public policy proposal is not only viable but also urgent, and represents an effective route towards an ecological transition with social justice in the state of Hidalgo.

ISSN: 2410-342X.
RENIECYT: 1702902

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Declarations

Conflict of interest

The authors declare that they have no conflict of interest. They have no competing financial interests, known personal relationships or other relationships that could have influenced the development of the information disclosed in this article.

Contribution of the authors

Cruz Sánchez Eduardo, did most of the work, including the main research, data analysis, initial writing of the manuscript and the organisation of the content. Assumes the main responsibility in the direction and execution of the research project.

The first co-author, Moctezuma Navia Dalia Alejandra, contributed significantly in complementary aspects, such as data collection, the implementation of metrics, or in the review and editing of the manuscript, playing a crucial role in ensuring the accuracy and soundness of the research. The second co-author, Trejo Encarnación Patricia, provided technical assistance, analysis of secondary data, support in the discussion of the results and critical review of the text, helping to refine the clarity and cohesion of the final document. Finally, the third co-author Hernández Gómez Diana provided technical assistance, analysis of secondary data, support in the discussion of the results and critical review of the text, helping to refine the clarity and cohesion of the final document.

Availability of data and materials

The data used in this research comes from official, public, and verifiable secondary sources. These include statistical reports from the Ministry of Finance and Public Credit [SHCP], the National Institute of Statistics and Geography [INEGI], the Environmental Commission of the Megalopolis [CAMe], as well as publications from international organisations such as the United Nations Environment Programme [UNEP], the OECD and ECLAC. State laws, tax codes and regulatory documents available on local congress websites and in the Official Gazette of the Federation were also reviewed. All information is publicly available in their respective institutional repositories.

No private databases or confidential information were used. Additional analysis materials, document review files, or comparative tables may be shared by the author upon reasonable request for academic purposes and to replicate the study.

Funding

The research presented here did not receive any funding from public or private institutions or international organisations. All analysis, writing, and review were carried out independently by the authors, without external influences that could affect the objectivity of the results or conclusions presented.

Abbreviations

CAMe	Environmental Commission of the Megalopolis
CCL	Climate Change Levy
CEPAL	Economic Commission for Latin America and the Caribbean
CIEP	Centre for Economic and Budgetary Research
CPEUM	Political Constitution of the United Mexican States
IEPS	Special Tax on Production and Services
INEGI	National Institute of Statistics and Geography
MIPYMES	Micro, Small and Medium-sized Enterprises
OCDE	Organisation for Economic Co-operation and Development
PNUMA	United Nations Environment Programme
SAT	Tax Administration System
SCJN	Supreme Court of Justice of the Nation
SEMARNAT	Ministry of the Environment and Natural Resources
SHCP	Ministry of Finance and Public Credit
UNEP	United Nations Environment Programme

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Journal of Administration and Finance 12[29]1-10: e51229110
Article

Cities familiarly sustainable: Indicators of household composition, income, and Decision-Making in City Delicias, Chihuahua

Ciudades familiarmente sostenibles: indicadores de composición del hogar, ingreso y toma de decisiones en cd. Delicias, Chihuahua

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Classification

Area: Social Sciences
Field: Administration and Business
Discipline: Administration and Management
Subdiscipline: Business Administration

https://doi.org/10.35429/JAF.2025.12.29.5.1.10
History of the article:
Received: September 20, 2025
Accepted: December 30, 2025

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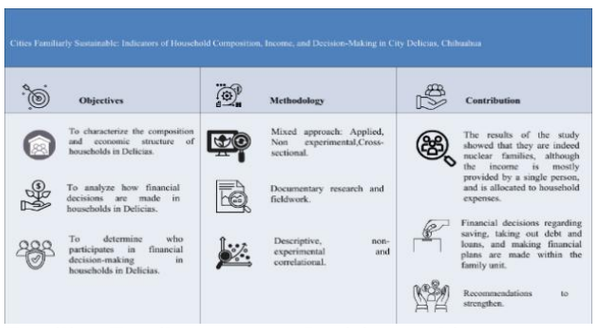
Abstract

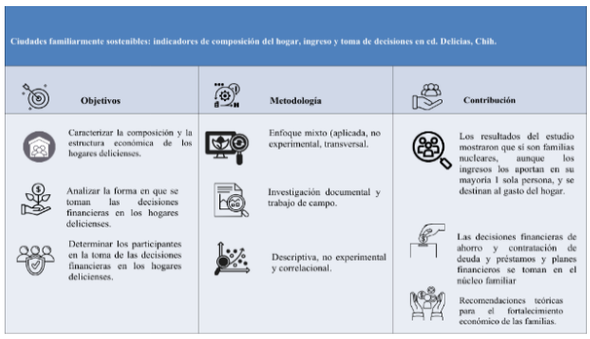
Social projects aimed at strengthening families require indicators that enable them to direct their efforts efficiently. For this reason, research was conducted with the aim of identifying the characteristics of families in Delicias. This research was mixed, applied, descriptive, non-experimental, bibliographic, and field-based. The research was carried out in the city of Delicias, Chihuahua, from March to June 2025. The population of interest was families in Delicias, Chihuahua. The sample frame consisted of families selected from 29 neighborhoods and subdivisions in the city of Delicias, Chihuahua. The sampling type was non-probabilistic. It was found that the families of Delicias are mostly composed of people under 30 years of age, which was the case in 259 instances. In more than 60% of the cases, the father was considered the head of the family, followed by the mother.



Families, Family structure, Decision-making.

Resumen

Los proyectos sociales, dirigidos al fortalecimiento de las familias, requieren indicadores que les permitan dirigir sus esfuerzos eficientemente. Por ello se realizó una investigación con el objetivo de identificar las características de las familias deliciences. Esta investigación fue mixta, de tipo aplicada, descriptiva, no experimental, de modo bibliográfico y a la vez de campo. La Investigación se llevó a cabo en la ciudad de Delicias Chihuahua, durante los meses de marzo a junio del año 2025. La población de interés fueron las familias de Delicias, Chihuahua. El marco muestral fueron familias elegidas en 29 colonias y fraccionamientos de la ciudad de Delicias, Chihuahua. El tipo de muestreo fue no probabilístico. Encontrándose que Las familias delicienses se componen, en su mayoría por menores de 30 años, esto se dio en 259 casos. En más del 60% de los casos el padre de familia era considerado como jefe de la misma, seguido por la madre de familia.



Familias, Estructura familiar, Toma de decisiones.

Area: Promotion of frontier research and basic science in all fields of knowledge

Citation: Palafox-Bolivar, Marisol Priscila, Molina-Lara, Elia Angélica, Valles-Alarcón, Isela Adriana and Varela Faudoa, Omar Elier. [2025]. Cities Familiarly Sustainable: Indicators of household composition, income, and Decision-Making in City Delicias, Chihuahua. Journal of Administration and Finance. 12[29]1-10: e51229110.

Introduction

The Institute for Family Policy Analysis [IAPF] is a civil society organisation dedicated to creating better conditions for the well-being of Mexican families through four areas of action: designing, implementing, promoting, linking and training public and private policies aimed at generating better conditions for the well-being of families. Based in Mexico City, it has been dedicated to organising outreach events in different cities throughout Mexico. One of its programmes is called Family-Sustainable Cities [CFS] and is a comprehensive social intervention programme created with the aim of offering a concrete and solid path that leads cities to become family-sustainable, taking into account international recommendations and global best practices.

The IAPF proposes that a family-sustainable city is one that has set out to generate tools and capacities that allow the family perspective to be mainstreamed in all relevant government agencies through the actions of the Family Diagnostic Survey [EDIFAM], the Municipal Family Strengthening Programme, the Family Perspective Advisory Council and Family Perspective Training [PERFAM].

The CFS programme was presented as a firm and visionary commitment to Mexico's elected mayors, with the aim of placing the family at the heart of public policy. It hopes to offer the strategies necessary to ensure that families are protected and strengthened.

This organisation remains focused on achieving the sustainability of families in cities that decide to adopt this programme because they consider that the role of local governments is fundamental when it comes to the family, as they are the first point of contact and the closest cell to the social fabric, and are also the ones most likely to influence it.

The Declaration of the Organisation of American States [OAS] [1948] recognises that families are considered the basic and natural unit of societies and that it is the obligation of governments to care for and protect them. In December 1948, the United Nations issued the Universal Declaration of Human Rights, in which Article 16.3 recognised the family as the natural and fundamental element of society and established the obligation of society and the State to ensure its right to protection.

In Mexico, the Political Constitution of the United Mexican States [Constitution] establishes the legal obligation to protect the organisation and development of families.

The Population and Housing Census conducted in 2020 indicated that the state of Chihuahua had a population of 3,741,869 inhabitants, who were concentrated in the main cities, starting with Juárez with 40%, the city of Chihuahua with 25%, Cuauhtémoc with 5% and Delicias with 4%, representing a population of 150,506 inhabitants. In 2022, the state of Chihuahua ranked third among the federal entities with the highest growth in Gross Domestic Product [GDP], with 8.1%, advancing 12 places compared to 2021, when it ranked 15th. This percentage can also be interpreted to mean that the state's GDP represented 3.8 per cent of the national GDP during that year.

Ciudad Delicias is the youngest city in the state of Chihuahua, founded in 1933 following the construction of Irrigation District 05. Its location is considered strategic within the state due to its geographical position between the municipalities of Jiménez, Camargo, Saucillo, Chihuahua, and Juárez, thus forming an important commercial and industrial corridor.

According to the Municipal Development Plan [IMPLAN] for the period 2024 to 2027, the municipality of Delicias is divided into 325 localities, with 85% of the population concentrated in the municipal capital and the rest in the rural area of the municipality. The total ageing index is 51.3%, being higher among women [56.10%] than men [48.64%], and the dependency ratio is 37.49% for children and 12.92% for older adults. Forty-nine per cent of its inhabitants are men and 51% are women. The average age is 30 years and the dependency ratio is 50.4%, indicating that there are 50 people of dependency age per 100,000 inhabitants and a density of 281.89 inhabitants per square kilometre.

Theoretical framework

Types of families in Mexico

The classification of family composition mentioned by Rosario [2023] indicates that it has evolved over time. Although the traditional image of father, mother and children remains, the reality is that the family can be formed by a much wider diversity. Some types of families are as follows:

ISSN: 2410-342X.
RENIECYT: 1702902

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https://doi.org/10.35429/JAF.2025.12.29.5.1.10

Nuclear family: Composed of father, mother and children.

Single-parent family: Headed by a single father or mother with their children.

Adoptive family: Composed of parents and children who have been legally adopted.

Blended family: Formed by an adult couple in which at least one of the spouses has a child from a previous relationship.

Same-sex family: A same-sex family is one in which a same-sex couple are parents to one or more children.

Extended family: Includes relatives beyond the nuclear unit, such as grandparents, uncles, aunts and cousins, all living together or in close proximity.

Childless families: These are families in which two couples cannot have children or do not wish to have them.

Grandparent family: A grandparent family is one in which one or more grandparents are raising their grandchild or grandchildren.

Decision-making

Information provided by INEGI on how Mexicans make decisions that impact families shows that, in 2023.

- -in 10.4 million households where the woman was the head of the household, she was the one who made the decision about major expenses: 70.3% for groceries or food, 62.2% for furniture, appliances or electronics, and 58.4% for saving or investing money.

- in 22.6 million households in the country where a man is the head of the household. Most of the decisions were made by him. 51.7% decided to apply it to health expenses, 50.2% to buy or sell property or goods, and 50.1% to buy groceries or food.

INEGI's Self-Reported Well-Being Module [BIARE] aims to generate information on the subjective well-being of the population aged 12 and over in Mexico.

It has been considered a reliable source for understanding quality of life from the perspective of individuals. Its guidelines include the perception of subjective well-being, which includes satisfaction with life in general and satisfaction with specific areas, showing an average life satisfaction score of 8.6, with the average for men being 8.7 and for women 8.6.

Four out of ten people [42.5%] considered that they would have difficulties covering their expenses at the end of the month, 20.7% perceived great difficulty and 21.8% perceived little difficulty. 22.8% of people perceived that they would not be able to or did not know if they would be able to cover their usual household expenses next month.

UN Sustainable Development Goal 11: Make cities more inclusive, safe, resilient and sustainable

Among the Sustainable Development Goals, Goal 11: Make cities more inclusive, safe, resilient and sustainable highlights that many cities are not prepared for rapid growth, making it impossible for them to meet the demands for housing, infrastructure and services necessary to provide a decent life for their inhabitants, which leads to the growth of slums or similar conditions.

Uncontrolled urban growth, air pollution and a shortage of open public spaces persist in cities. The cost of promoting sustainable cities is high, but the benefits are great, which is why it proposes active participation in city administration and management.

Conceptual Framework

Family-friendly sustainable cities

In Mexico, the term is used by the IAPF, which defines it as a city that places the family at the centre of its decisions.

This is achieved by creating an environment that not only provides security and economic resources, but also fosters family cohesion and the emotional well-being of its inhabitants, allowing them to thrive in three dimensions: economically, socially and emotionally. They also recognise the value of the family as a public good in order to achieve sustainability and fulfil the Sustainable Development Goals of the 2030 Agenda.

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Sustainability

In 1987, the UN Brundtland Commission defined sustainability as that which allows the needs of the present to be met without compromising the ability of future generations to meet their own needs.

Family

According to the World Health Organisation [WHO], the family is the group of people living under the same roof, organised into fixed roles such as father, mother and siblings, united by blood or affinity ties, who share a common economic and social existence and express affectionate feelings that bind them together.

Family structure

The invisible set of functional demands that organise the ways in which family members interact.

Methodology

Research approach

The research approach was mixed, quantitative because it was possible to assign quantities to the requested variables through numerical values, and qualitative because their characteristics were analysed.

Form of research

Applied, because the questionnaire provided by the company was used, it was administered to the volunteers who agreed to participate, the results obtained were analysed, and the results and recommendations were presented and provided.

Type of research

Descriptive, non-experimental, because it was limited to describing the results obtained in the surveys; none of the variables were manipulated.

Research method

It was bibliographic and field-based because the results of research by different authors and experts in the field were consulted, and it was field-based because a survey was administered to 384 volunteers who answered more than 190 indicators in the questions.

Method

The method was analytical-synthetic.

Research techniques

The research techniques used bibliographic files, managed through Word, and a questionnaire was also administered to the volunteers. The information collected was processed in the SPSS 25 programme and the tables were generated in Excel.

Research design

Location. The research was carried out in the city of Delicias, Chihuahua, during the months of March to June 2025.

The population of interest was the families of Delicias, Chihuahua.

The sample frame was families chosen from 29 neighbourhoods and subdivisions in the city of Delicias, Chihuahua.

The sampling type was non-probabilistic; however, given people's reluctance to respond, the survey was administered to volunteers.

The sample size was 384 surveys. The sample was selected from volunteers, all of whom were adults who agreed to respond to the survey through the Google Forms application.

The sampling frame

was calculated based on the estimate of 39,093 from the Statistical Diagnosis of the Municipality of Delicias and the Secretariat of Human Development and Common Good [SDHyBC], which corresponds to the total number of inhabited dwellings for residential use in the municipality. It should be noted that this number differs from the 47,700 dwellings reported by INEGI, as these also include dwellings under construction or uninhabited dwellings.

Based on the 39,093 occupied dwellings, the statistically representative sample size was determined by assigning a confidence level of 95% and a margin of error of 5%, resulting in 381 dwellings; 384 surveys were administered to ensure coverage.

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The unit of analysis will be all occupied dwellings in the Municipality of Delicias, Chihuahua.The sampling type was non-probabilistic. With volunteer subjects, because at the beginning of the questionnaire application, several people declined to answer the questions, some considering them to be personal information and others considering that they were investing too much time in answering.The sample size. It was determined by applying the following formula:Finite populations

$$n' = \frac{1}{[1/N] + [1/n]}$$

Where:
n' = sample adjusted according to population
N = population
n = sample obtained from the infinite population

A 95% confidence level will be used, with a margin of error of 5%, and the p and q values will be the maximum for each one:

$$n = \frac{[1.96]^2 * [.5]\,[.5]}{[.05]^2} = 39{,}093$$

The sample is adjusted if the population is known [point 9]:

$$n' = \frac{1}{[1/80] + [1/39{,}093]} = 30$$

This means that 384 of the 39,093 dwellings that meet the characteristics mentioned in the unit of analysis will be included in the study. The sample was selected from among volunteers.

Delimitation of the research

This research was carried out in the city of Delicias, Chihuahua, during the months of March to July 2025.

Results

With regard to the ages of those who completed the instrument, 126 were under 20 years of age, 133 were between 21 and 30 years of age, 16 were between 31 and 40 years of age, 8 were between 41 and 50 years of age, and 17 were over 50 years of age. The percentages are shown in Figure 1.

Box 1

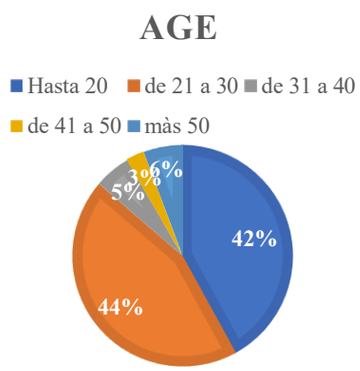

Figure 1
Age of respondents
Source Information obtained from questionnaires

With regard to family composition, it was found that in 101 households the head of the family was the father, in 88 it was the mother, and in 25 households the head of the family was someone else. 5.4% had not completed primary school and 5.9% had not completed secondary school. Article 6 of the Constitution establishes that basic education comprises preschool through secondary school and, together with high school, constitutes education. 9.5% had incomplete secondary education and 24.4% had completed secondary education.

Of those with a bachelor's degree, 5.8% had incomplete studies and 19% had completed their bachelor's degree. 4.07% had a postgraduate degree. This is shown in Table 1.

Box 2

Table 1
Level of education of head of household.

		Head of household	Dad	Mom	Other	No context	Total
Head of household's education	Primary	incomplete	7	2	3	0	12
		complete	6	6	2	0	14
	Secondary school	incomplete	6	7	0	0	13
		complete	17	19	5	2	43
	High school	incomplete	9	11	0	1	21
		complete	24	22	6	2	54
	Bachelor's degree	incomplete	6	5	2	0	13
		complete	21	13	6	2	42
	Postgraduate		5	3	1	0	9
		Total	101	88	25	7	221

Source Information obtained from questionnaires

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The most common occupation was employee, with 104 responses, representing 46.84%, followed by merchant with 29 responses [13.06%], other unidentified with 19 responses, followed by farmer with 15 responses and domestic worker with 14 responses. As shown in Table 2 below.

Box 3

Table 2

Occupation of head of household

	Head of household	Dad	Mom	Other	No context	Total
Occupation of the head of household	Employee	40	52	9	3	104
	Merchant	18	8	3	0	29
	Other	12	3	3	1	19
	Farmer	11	1	2	1	15
	Domestic worker	1	10	2	1	14
	Retired	5	4	4	0	13
	Entrepreneur	8	1	0	1	10
	Teacher	2	5	1	1	9
	Labourer	4	3	0	0	7
	Craftsman	0	0	0	1	1
	Nurse	0	1	0	0	1
	Total	101	88	24	9	222

Source Information obtained from questionnaires

The number of inhabitants in 12 households was 1 person, in 35 households there were 2 people, in 81 households there were 3 inhabitants, in 96 households there were 4 people, in 55 households there were 5 people and in 25 households there were more than 6 people.

In the same number of households, questions were asked about whether any family members were under three years of age, between three and 17 years of age, or over 60 years of age. The responses are shown in Table 3. It is noteworthy that 93.1% had no children under the age of 3, 55.9% had no children between the ages of 3 and 17, and 81.9% had no persons over the age of 60.

Box 4

Table 3

Family members in vulnerable age groups.

	Nùm.	Frecuency	Porcentage
Children under 3 years of age	0	283	93.1
	1	12	3.9
	2	6	2
	3	1	0.3
	4	1	0.3
	Total	303	99.7
Ages 3 to 17	0	170	55.9
	1	87	28.6
	2	35	11.5
	3	11	3.6
	Total	303	99.7
Over 60 years old	0	249	81.9
	1	37	12.2
	2	16	5.3
	3	1	0.3
	4	1	0.3
	Total	304	100

He highlighted that in 55.93% of cases, children attended private school.

Continuing with the analysis of household composition, 264 respondents said they lived in single-family homes, representing 86.8%, and 25 in multi-family homes, representing 6.6%. In the case of multi-family households, they were asked whether everyone contributed to the maintenance of the house, to which 29 answered affirmatively, 64 answered no, and 211 refused to answer. Ten people responded that non-family members lived in the house, 11 responded that they had minor children living elsewhere, and 37 responded that one or both of their parents did not live in the same household. This can be seen in Table 4 below:

Box 5

Table 4

Various characteristics of families

	Yes	No	No context	Total
Contribute to expenses	29	64	211	304
Live with non-family members	10	152	142	304
Minors live in another household	11	142	151	304
Parents live in another household	37	125	138	300

Source Information obtained from questionnaires

Regarding the services available to households, 303 responded that they had drinking water, 302 had electricity, 295 had internet service, and 284 had mobile phones. This is shown in Table 5.

Box 6

Table 5

Basic services in households.

Services	Yes	No	No context	Total
Drinking water available	303	1	0	304
Electricity available	302	0	2	304
Internet available	295	8	1	304
Mobile phone available	284	20	0	304

Source Information obtained from questionnaires

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All households had a bathroom inside the house, of which 207 had 1 bathroom, 80 had 2 bathrooms, and 16 had 3 bathrooms. The number of cars owned by families varied from 119 households with one car, 96 with two, 64 with three, and 25 without a car. The number of bedrooms was 17 households with one bedroom, 91 with two bedrooms, and 196 with three bedrooms. As shown in Table 6.

Box 7

Table 6

Number of bathrooms, bedrooms and cars

	0	1	2	3	Total
Number of bathrooms	0	207	80	16	303
Number of cars	25	119	96	64	304
Number of bedrooms		17	91	196	304

Source Information obtained from questionnaires

Some family decisions are related to financial management, so the following questions were proposed to ascertain respondents' perceptions of their financial situation, all of which addressed the issue of debt and savings. The results are shown in Table 7. Of the 297 responses, 84 did not answer the questions, leaving a base of 213 responses. With debts out of control, 4.23%; with debts under control, 45.07%; without debts, but with a shortage of resources at the end of the month, 6.1%; without debts, but without savings, 12.68%; and with savings, 19.25%.

Box 8

Table 7

State of family finances.

	Head of household				
State of family finances	**Dad**	**Mon**	**Other**	**No context**	**Total**
With debts out of control	0	8	1	1	10
With debts under control	41	44	11	37	133
I have no debts, but I run out of money at the end of the month	8	4	1	3	16
I have no debts, but no savings either	13	10	4	11	38
I have savings, insurance and/or assets	19	16	6	16	57
Total	101	87	25	84	297

Source: Information obtained from questionnaires.

Regarding whether the head of the household has a financial plan, 84 people did not answer, and of the remaining 211, 50.71% answered affirmatively. This can be analysed in Table 8.

Box 9

Table 8

Existence of a family financial plan.

There is a financial plan.			
Head of household	Yes	No	Total
Father	61	40	101
Mother	37	49	86
Other	9	15	24
No response	45	39	84
Total	152	143	295

Source Information obtained from questionnaires

Conclusions

Most Delicias families are composed of individuals under the age of 30, which was the case in 259 instances. In over 60% of cases, the father was considered the head of the family, followed by the mother. 24.4% of the population had completed compulsory education and 9.5% had not completed it.

Of those with a bachelor's degree, 5.8% had not completed their studies and 19% had completed their degree. The most common professions were employees with 104 responses, representing 46.84%, followed by merchants with 29 responses.

It was found that 12 households had 1 person living in them, 35 households had 2 people living in them, and 81 households had 3 people living in them. In these households, 93.1% had no children under the age of 3, 55.9% had no children between the ages of 3 and 17, and 81.9% had no persons over the age of 60 living in them. Of the children under 16 years of age, 55.93% attended private school. In 264 cases, the households were single-family, representing 86.8%, and 25 were multi-family households, representing 6.6%.

Ten households had non-family members living in them, 11 responded that they had minor children living elsewhere, and 37 responded that one or both of their parents did not live in the same household.

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The physical characteristics of the homes were as follows: 303 reported having drinking water, 302 had electricity, 295 had internet service, and 284 had mobile phones. In 207 homes, there was one bathroom, 80 had two bathrooms, and 16 had three bathrooms.

The number of cars owned by families varied from 119 households with one car, 96 with two, 64 with three, and 25 without a car. The number of bedrooms was 17 households with one bedroom, 91 with two bedrooms, and 196 with three bedrooms. These are single-family households, with a father as head of the family and, in his absence, the mother takes his place. They have completed basic education, are employed or self-employed, and have no children under the age of 17 or adults over the age of 60. In cases of households with children, they attended private schools.

The composition of families in Delicias is nuclear, single-parent, with parents and children living in the same household. It is worth noting the level of satisfaction of Delicias families regarding their ability to meet their needs. Regarding food expenses, 17% felt somewhat satisfied and 70.33% felt satisfied or very satisfied. Regarding medication expenses, 21.52% felt somewhat satisfied and 65.89% felt satisfied or very satisfied. Finally, the percentages of satisfaction with the ability to cover education expenses were 18.12% somewhat satisfied and 73.52% satisfied or very satisfied. On 293 occasions, they responded that they were financially able to purchase healthy food, which was 96.38%. The number of meals consumed daily was 214 who consumed 3 meals a day, 60 who consumed more than 3 meals a day, and 29 who consumed 2 meals a day. In relation to medical services, 252 respondents said they were affiliated with a medical service, 27 were not, and 21 did not know. Regarding the habit of going to the doctor for preventive care, 223 respondents said they did not, and 77 said they did.

The monthly family income ranged from less than the minimum wage of $7,468.00 to more than $37,341.00. The results obtained are shown in Figure 3. Forty-eight families received an income below the minimum wage, 101 families, or 34.12%. Owners of their own homes in 263 cases. Fifty-seven families did not spend on medicines, 94 spent less than $500.00, 74 spent less than $1,000.00, and 37 spent less than $2,000.00.

Table 7: Satisfaction with the ability to pay expenses shows a high degree of satisfaction among heads of households with their ability to pay for food, health, and education expenses for their families.

The level of satisfaction of Delicias families regarding their ability to meet their needs is satisfactory at an average level.

Recognise the decision-making processes in Delicias households, according to the parameters established in the CFS survey.

Regarding the person who makes decisions in the family, the response was that when the head of the household is the father, on 9 occasions he answered that one person imposes their will, on 4 occasions one person decides, on 67 occasions decisions are made among adults, and on 22 occasions the opinion of all members involved is sought.

When the mother is the head of the household, 13 respondents said that one family member imposes their will, 53 said that decisions are made among adults, and 18 said that everyone's opinion is sought. Of these, 70.7% responded that they consulted with other members of the household, 15.35% consulted with other family members, and 10.7% did not ask anyone for advice.

Regarding their perception of their financial situation in terms of debt and savings, 4.23% had uncontrolled debt, 45.07% had controlled debt, 6.1% had no debt but lacked resources at the end of the month, 12.68% had no debt but no savings, and 19.25% had savings. However, 211 of them considered that they had a financial plan.

Concern about the family's financial situation and its relationship with the head of the family: 19.52% of them felt no concern, 35.02% felt a little concern. Decisions are made within the family unit, led by the head of the family, and expert advice or government entities are rarely consulted. According to the parameters established in the CFS survey, decision-making in Delicias households is done by a single person, who may be the head of the family. The survey results show that the head of the household makes decisions involving other family members.

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RENIECYT: 1702902

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https://doi.org/10.35429/JAF.2025.12.29.5.1.10

According to the parameters established in the CFS survey, decision-making in Delicias households is carried out by a single person, who may be the head of the household.

Declarations

Conflict of interest

The authors declare that they have no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Contribution of the authors

Palafox-Bolivar, Marisol Priscila: Contributed to the conception of the project, the methodological design, the writing of the manuscript, and the overall coordination of the research. Participated in the critical review of the content and the final integration of the article.
Molina-Lara, Elia Angélica: Collaborated in the application of the data collection instrument, the statistical processing of the information, and the preparation of tables and figures of results.

Valles-Alarcón, Isela Adriana: Participated in the theoretical foundation and writing of the conceptual framework and background sections, as well as in the discussion of the results obtained.

Varela-Faudoa, Omar Elier: Contributed to the literature review, the systematisation of qualitative data, and the drafting of conclusions and recommendations aimed at strengthening the research.

Availability of data and materials

The data used and generated during the course of this research are available upon reasonable request to the corresponding author. The primary information comes from questionnaires administered to households in the municipality of Delicias, Chihuahua, as well as from field observations and records systematised in spreadsheets and SPSS. All materials were safeguarded for academic purposes and are archived in digital format, ensuring the confidentiality of participants and exclusive use for scientific and educational purposes.

Funding

This research did not receive external funding from any public, private, or institutional body. The authors conducted the study with their own resources and for strictly academic and scientific purposes, without the intervention of funding sources that could influence the development or results of the work.

Abbreviations

BIARE	The Self-Reported Well-Being Module
CFS	Family-Sustainable Cities
CIDH	Inter-American Commission on Human Rights
EDIFAM	Family Diagnostic Survey
IAPF	Institute for Family Policy Analysis
INEGI	National Institute of Statistics and Geography
IMPLAN	Municipal Planning Institute of Delicias
OEA	Organisation of American States
ONU	United Nations
PIB	Gross Domestic Product
SDHyBC	Secretariat for Human Development and Common Good

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Background

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ISSN: 2410-342X.
RENIECYT: 1702902

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ISSN: 2410-342X.
RENIECYT: 1702902

Palafox-Bolivar, Marisol Priscila, Molina-Lara, Elia Angélica, Valles-Alarcón, Isela Adriana and Varela Faudoa, Omar Elier. [2025]. Cities Familiarly Sustainable: Indicators of household composition, income, and Decision-Making in City Delicias, Chihuahua. Journal of Administration and Finance. 12[29]1-10: e51229110.
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Journal of Administration and Finance 12[29]1-9: e61229109
Article

Determinants of the socioeconomic level of entrepreneurs in Mexico: a probabilistic analysis of mobile phone use and associated variables

Determinantes del nivel socioeconómico de los empresarios en México: un análisis probabilístico sobre el uso del teléfono móvil y variables asociadas

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Classification:

Area: Social Sciences
Field: Economic Sciences
Discipline: Economics of technological change
Subdiscipline: Technology and social change

https://doi.org/10.35429/JAF.2025.12.29.6.1.9
History of the article:
Received: September 20, 2025
Accepted: December 30, 2025

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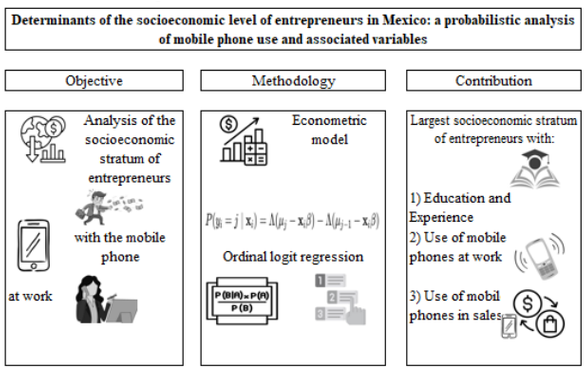
Abstract

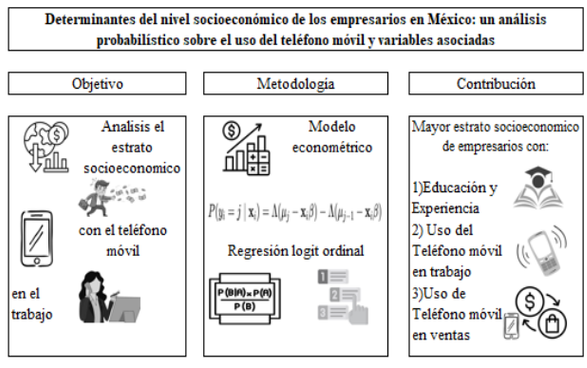
Various economic growth theories have demonstrated the economic growth associated with the use of digital technology. The objective of this study was to analyze the socioeconomic status of business owners in relation to their use of mobile phones for work activities and sales of their products or services, including educational level, experience, and area of residence. The research was quantitative with a probabilistic approach, using data from the 2024 National Survey on the Availability and Use of Information Technologies in Households. An econometric model was developed using ordinal logistic regression. The study found that socioeconomic status is influenced by education, experience, urban location, and the interaction of mobile phone use with work activities and sales. It concludes that business owners should know how to use mobile phones for work activities.



Socioeconomic level, business owners, mobile phone

Resumen

Diversas teorías de crecimiento economico han comprobado el crecimiento economico con el uso de la tecnología digital. El objetivo fue realizar un análisis el estrato socioeconomico de empresarios con el uso del telefono móvil en actividades laborales y en las ventas de sus productos o servicios, incluyendo el nivel educativo, la experiencia, y el área de residencia. La investigación fue cuantitativa con enfoque probabilístico con datos de la Encuesta Nacional sobre Disponibilidad y Uso de las Tecnologías de la Información en los Hogares 2024, y se realizó un modelo econométrico mediante una regresión logística ordinal. Se encontró que en el estrato socioeconomico influyen la educación, la experiencia, el area urbana, así como la interacción del telefono celular con su uso, con actividades laborales y con el uso destinado a las ventas. Se concluye que los empresarios deben saber usar el telefono movil para actividades laborales.



Nivel socioeconómico, empresarios, teléfono móvil

Area: Development of strategic leading-edge technologies and open innovation for social transformation

Citation: Jiménez-García, Martha, Gómez-Miranda, Pilar, Soto-Mejía, Ana Karen and Hernández Horta, Ingrid Anai. [2025]. Determinants of the socioeconomic level of entrepreneurs in Mexico: a probabilistic analysis of mobile phone use and associated variables. Journal of Administration and Finance. 12[29]1-9: e61229109.

Introduction

Companies must use digital technology to overcome obstacles and remain in the market [Martini et al., 2023] and to achieve sustainable growth [Kim & Ha, 2023], as companies face great difficulties with monopolies [Sipos et al., 2024]. This is why it is important to include digital technology, as digital transformation has been a development related to labour demand [Cevallos et al., 2021], since companies seek to include professionals who use digital technology as an added value for greater productivity and competitiveness [Jaimes et al., 2024]. It is therefore necessary for entrepreneurs to adapt to the use of new digital technologies [Pacheco-Ruíz et al., 2020]. Therefore, it is of interest to thoroughly analyse technological adoption, particularly the adoption of mobile phones by entrepreneurs, and its impact on mobile payments can contribute to poverty reduction and the Sustainable Development Goals established by the United Nations [Suresh et al., 2025]. This is where the importance of analysing the use of mobile phones by entrepreneurs in work activities and to sell their products through payment applications comes in.

At the same time, access to mobile phone technologies must be considered, as it has shown a promising and relevant effect on well-being. It is also important to investigate its effect on other vulnerable groups, such as those headed by women [Ngwilizi & Selejio, 2025].

Similarly, entrepreneurs, although operating under severe resource constraints, have proven to be one of the key drivers of a country's economic growth and development. However, entrepreneurs face challenges ranging from a shortage of necessary resources, difficulty in accessing finance, lack of economies of scale, to greater vulnerability to unpredictable external factors [Suresh et al., 2025].

The research has identified the problem that entrepreneurs do not use mobile phones for work activities or for selling their products, which means that entrepreneurs have not triggered economic growth. Therefore, the objective of this research was to analyse the socio-economic status of entrepreneurs who use mobile phones for work activities and to sell their products or services, including their level of education, experience, and area of residence.

The research question posed was: Can a mobile phone increase the socio-economic status of an entrepreneur in Mexico? This will be answered in the results of this research.

The added value of this research is the interaction of mobile phone variables and their use in work activities and in the sale of products and services, as there are several studies that analyse mobile phones individually with other variables, but not with the interaction presented in this research.

In this research, after the theoretical background, an econometric model is presented using ordinal logistic regression, this model being the main contribution with the findings of the interaction between phone ownership and its use in work activities and in the sale of products or services.

Theoretical background

In Bangladesh, a study was conducted with 212 companies to analyse the implementation of strategies in businesses related to digital technology, mainly with the use of digital marketing through mobile devices. To this end, they carried out a study of structural equations by partial least squares.

In this research, they found a significant and positive effect of the use of digital marketing on company performance [0.444 p-value 0.001] in financial terms and concluded that MSMEs need to train their employees on the adoption of e-commerce in their regular operations.

It is therefore suggested that MSMEs learn and practise digital marketing tools and techniques, as well as big data analysis and social media analysis to ensure customer satisfaction, which leads to business sustainability and success, as they can predict customer demands in order to offer tailor-made products and services [Gao et al., 2023].

On the other hand, in Tanzania, research was also conducted with 277 owners and managers of manufacturing SMEs, using structural equation modelling with a partial least squares approach to assess product and market innovation in business performance.

ISSN: 2410-342X.
RENIECYT: 1702902

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They found a positive relationship between market innovation and business performance [β = 0.915; p < 0.01], indicating that companies that prioritise innovation in either products or processes can attract more customers and promote long-term growth by being more competitive through the use of innovative practices based on digital technology [Ndahani et al., 2024].

Similarly, in Pakistan, research was conducted with 282 microentrepreneurs and analysed a mobile payment system technology called 'e-paisa' that improved the well-being perceived by microentrepreneurs during the COVID-19 pandemic. It was found that the adoption of this mobile technology was positively related to the business success of microentrepreneurs [β = 0.201, 95% CI [0.101, 0.298]]. On the other hand, in terms of gender, women had a better perception [β = 0.236, 95% CI [0.122, 0.312]] than for men [β = 0.171, 95% CI [0.144, 0.251]], which acts as a catalyst for inclusion in female entrepreneurship in vulnerable communities [Shahid, 2024].

Similarly, in Spain, qualitative research was conducted with 31 older adults aged between 61 and 96, through an ethics review panel at the University of Luxembourg, and sociodemographic information was collected, including the number of internet devices in the home, age when they first used the internet, frequency of internet use, gender, profession and socioeconomic status.

To this end, a workshop called 'magic machine' was developed, with the aim of devising solutions and strategies to help them prevent situations of online manipulation and how to address a problem. Four main needs were identified to resist manipulation: knowledge, awareness, right to privacy, and control [Chamorro et al., 2024]. Similarly, in Tanzania, quantitative research was conducted with an empirical analysis of a sample of 1,641 households to analyse the causal effect of mobile phones on the participation of female-headed households in non-agricultural self-employment and income growth. and found that mobile phone technology significantly increased the probability of female-headed households participating in non-agricultural self-employment by 11.4% [p-value 0.032] and improved the share of income from self-employment enterprises in total household income by 7.9% [p-value 0.031].

Furthermore, female heads of household residing in urban areas, with higher levels of education and younger ages experienced greater income gains than their counterparts. Therefore, efforts that support and promote access to and use of mobile phone technology, coupled with higher levels of education among vulnerable groups, encourage job creation and improved incomes for these groups [Ngwilizi & Selejio, 2025].

In addition, in India, rural women with limited education are supported through digital financial inclusion, mentoring and training programmes to reach larger markets and thereby promote economic and social development. This has been achieved through e-commerce platforms that enable women entrepreneurs to run their businesses in rural and semi-urban areas by creating flexible, work-from-home models [Pal & Bhowmick, 2024].

Similarly, in China, quantitative and empirical research was conducted and access to information on entrepreneurship for disadvantaged groups was analysed using the China General Social Survey dataset for 2017, 2018 and 2021, through multi-stage and multi-level random sampling using a Probit model. It was found that access to information via the internet has contributed to a 1.6% increase in the probability of entrepreneurship for disadvantaged groups with characteristics such as agricultural households, low sociability and middle age.

This indicates that governments can improve the information environment, optimise information services, improve the awareness and information skills of disadvantaged groups. Similarly, it was found that mobile phone ownership in vulnerable groups is highly correlated with access to information, as it presented significant values [0.428 p-value 0.033] [Liu et al., 2025].

Similarly, in India, quantitative research was conducted with data from 410 micro-entrepreneurs from different regions who basically belonged to an informal and itinerant market and who used mobile payment technology in their businesses, through a system of structural equations by partial least squares and a hierarchical component model with a two-stage approach.

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It was found that mobile phones and mobile payments are significant values that influence economic strengthening for micro-entrepreneurs. This occurs with the adoption of mobile payment technologies such as QR codes, Google Pay, Amazon Pay, and Paytm, all of which have proven to be potential factors that reinforce people's behaviour in coping with resource scarcity, thus securing their livelihoods [Suresh et al., 2025].

On the other hand, quantitative and correlational research was carried out in Peru to analyse the effect of mobile phone use on the income of women in rural areas of Peru. The 2016-2022 National Household Survey was used for this purpose, through the Mincer model with socio-economic explanatory variables such as mobile phone ownership, years of education, work experience and the individual's own characteristics. It was found that in 2018, mobile phone ownership was associated with a 39.3% increase in income levels and in 2022, this effect was 49.9%; Therefore, the income of rural women in Peru is positively linked to mobile phone ownership, but it also depends on factors such as years of education, work experience, and participation in the labour market [Vela Meléndez et al., 2025].

Methodology

The research is descriptive and correlational in nature, as it presents a predictive model of socioeconomic status and the social variables that influence it. The data were collected from the 2024 National Survey on the Availability and Use of Information Technologies in Households [INEGI, 2025a].

Sample size

Individuals over the age of 16 were selected, and a question was filtered in which only those who had the option of being an employer or who hired workers for a salary or self-employed workers were selected.

Data on these individuals was cross-referenced in relation to their use of technology, specifically their possession of a mobile phone, as well as their use of the mobile phone for work activities and to sell their products or services online. The sample size was 30,804 individuals.

Study variables

The study variables used in this research, both dependent and independent, were some sociodemographic and technological variables related to mobile phones, all of which were used to create an econometric and predictive model of the socioeconomic status of people who own a business in Mexico, as described in Table 1.

Box 1

Table 1

Study Variables

Variable	Description
Socio-economic stratum [Y]	Dependent variable. This variable was calculated directly by INEGI based on the sociodemographic characteristics of individuals, taking into account their housing and certain indicators from the population and housing census, using a multivariate statistical method [INEGI, 2025b]. Ordinal numerical variable [Low Stratum = 1, Middle Stratum = 2, Upper Middle Stratum = 3, and High Stratum = 4]
Years of Education [YearsEduc]	Independent and numerical variable, the data was transformed by years of education considering the following educational levels: None = 0, Preschool = 3, Primary = 9, Secondary = 12, Baccalaureate = 15, Technical studies with secondary education = 15, Basic teacher training = 15, Higher technical studies with baccalaureate = 18, Bachelor's degree or engineering = 19, Specialisation = 20, Master's degree = 21, Doctorate = 25
Experience	An independent, numerical variable, it was an approximation of potential work experience and was calculated using the formula: experience = age - years of education - 6.
Area	The independent and numerical variable was the area according to the geographical location in which the entrepreneurs live, classified as urban or rural. This classification was carried out by INEGI and considered rural areas to be those with fewer than 2,500 inhabitants [INEGI, 2025b].
Possession of mobile phone [PosTel]	Independent and binary variable, it was related to whether the respondent had a mobile phone [Yes = 1, No = 0].
Mobile phone usage [UsoTel]	Independent and binary variable, it was related to whether the respondent used a mobile phone [uses mobile phone = 1, does not use mobile phone = 0].
Possession and use of mobile phones [PosyUso]	Independent variable, refers to the combined interaction of mobile phone ownership and use, calculated as the multiplication of both variables [Mobile phone ownership * Mobile phone use].
Use of Mobile Phones in Work Activities [UsoLab]	Independent and binary variable, refers to the use of mobile phones in work activities [If you use your mobile phone in work activities = 1, You do not use your mobile phone in work activities = 0]
Possession and use of mobile phones in work activities [PosyUsoLab]	Independent variable, refers to the combined interaction of mobile phone ownership and its use in work activities, calculated as the multiplication of both variables [Mobile phone ownership * Mobile phone use in work activities].
Use of mobile phones for sales [UsoVentas]	Independent and binary variable, refers to the use of a mobile phone for sales [If you use a mobile phone for sales = 1, You do not use a mobile phone for sales = 0]
Possession and use of mobile phones for sales [PosyUsoVentas]	Independent variable, refers to the combined interaction of mobile phone ownership and its use for sales, calculated as the multiplication of both variables [Mobile phone ownership * Mobile phone use for sales].

ISSN: 2410-342X.
RENIECYT: 1702902

Data análisis

With the selected variables shown in Table 1, an ordered logical model was constructed, as presented in Equation 1.

$$logit[P[Y \leq j]] = k_j + \beta_1(AñosEduc) + \beta_2(Experiencia) + \beta_3(Área) + \beta_4(PosTel) + \beta_5(UsoTel) + \beta_6(PosyUso) + \beta_7(UsoLab) + \beta_8(PosyUsoLab) + \beta_9(UsoVentas) + \beta_{10}(PosyUsoVentas) \quad [1]$$

Results

This section first presents the descriptive results to illustrate the behaviour of all variables.

Figure 1 shows the socioeconomic stratum of the entrepreneurs, and it is clear that the predominant socioeconomic stratum is stratum number 2. Similarly, Table 2 shows the level of education, and it can be seen that the majority have secondary, high school, and bachelor's degrees, but secondary education is the most common.

Box 2

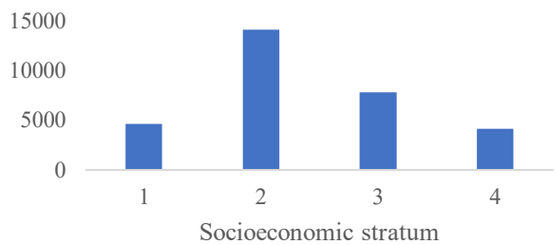

Figure 1
Socioeconomic status of entrepreneurs
Source: own elaboration based on the results

Box 3

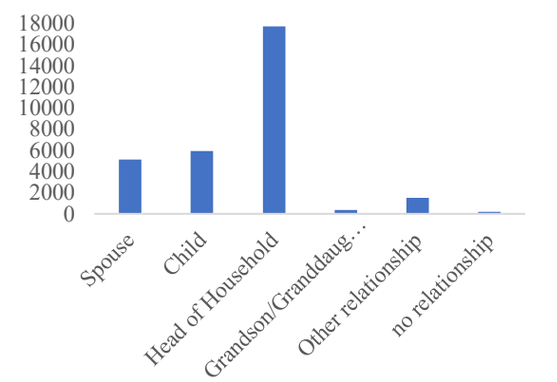

Figure 2
Family relationships in participants' households
Source: compiled by the authors based on the results

Box 4

Table 2
Educational background of the business owners who participated in the survey

Schooling	Quantity
None	1148
Pre-school	34
Primary	5212
Secondary	7827
High school	6718
Technical studies with secondary education	359
Basic teacher training	33
Higher technical studies with high school	637
Bachelor's degree or engineering degree	7800
Specialisation	124
Master's degree	765
Doctorate	147
Grand total	30804

Source: Prepared internally based on data from the INEGI survey.

Figure 2 shows the relationship between entrepreneurs, clearly indicating that the predominant relationship is that of head of household. Figure 3 shows the gender of the entrepreneurs who participated, revealing that the majority are men. Figure 4 shows the age of the entrepreneurs, revealing that the majority are between 25 and 60 years of age.

Box 5

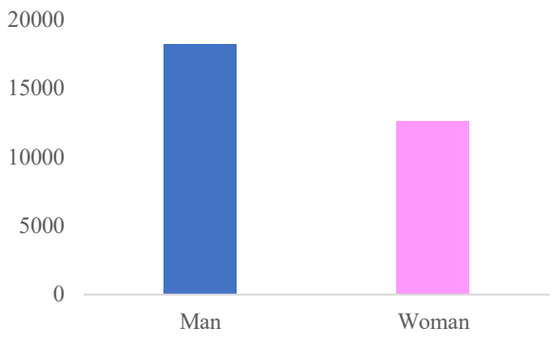

Figure 3
Gender of participating entrepreneurs
Source: own elaboration based on the results

ISSN: 2410-342X.
RENIECYT: 1702902

Box 6

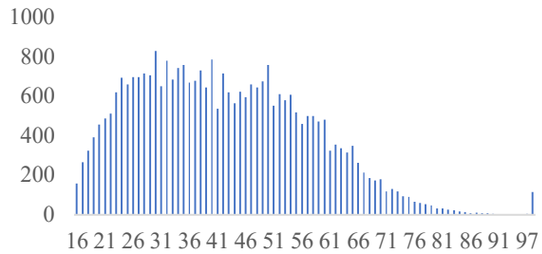

Figure 4
Age of entrepreneurs
Source: own elaboration based on the results

Figure 5 shows mobile phone ownership and reveals that most entrepreneurs have a mobile phone. On the other hand, Figure 6 shows mobile phone use in work activities, and similarly, a majority use it and a very representative number do not use it in their work activities. Likewise, Figure 7 shows mobile phone use for sales, and the majority of entrepreneurs do not use the phone, while a minority do use the phone for this purpose.

Box 7

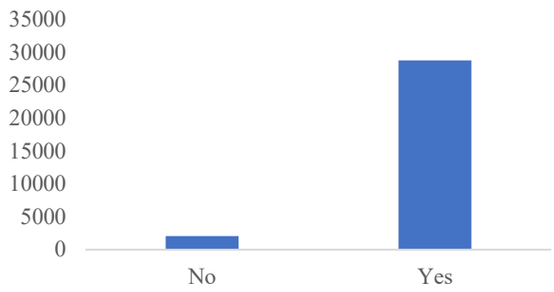

Figure 5
Mobile phone ownership
Source: own elaboration based on the results

Box 8

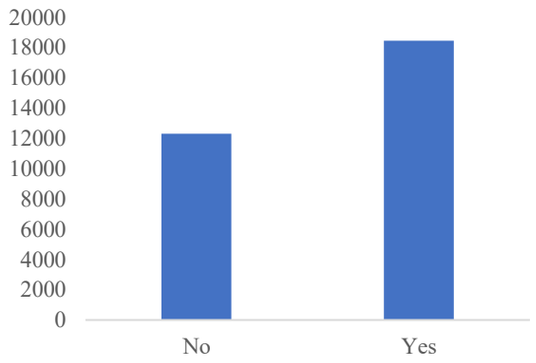

Figure 6
Use of mobile phones in work activities
Source: own elaboration based on the results

Box 9

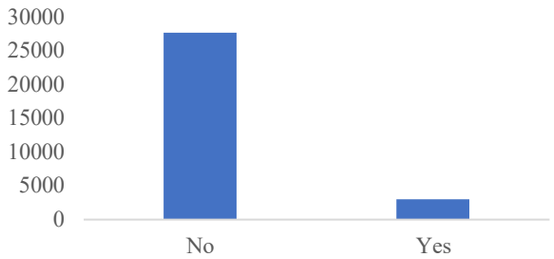

Figure 7
Use of mobile phones for sales
Source: own elaboration based on the results

Econometric model of socioeconomic status

Table 3 presents the results of the econometric model with socioeconomic status as the dependent variable and the other independent variables described in Table 1. The odds ratios are also presented, and the coefficients are very high for urban area values, as well as for mobile phone ownership and use and mobile phone ownership and use for sales.

Box 10

Table 3
Result of the econometric model of socioeconomic status

Estrato socioeconomico	Odds Ratio	Std. Err.	P>z
Years of Education	1.246	0.000	0.000
Experience	1.025	0.000	0.000
Urban Area	10.319	0.015	0.000
Mobile Phone Ownership	0.006	0.001	0.000
Mobile Phone Use	0.035	0.002	0.000
Mobile Phone Ownership and Use	11.605	0.748	0.000
Mobile Phone Use in Work Activities	0.783	0.009	0.000
Mobile Phone Ownership and Use in Work Activities	1.025	0.011	0.028
Mobile Phone Use for Sales	0.311	0.010	0.000
Mobile Phone Ownership and Use for Sales	2.684	0.086	0.000
Prob > chi2 = 0.0000			
n=30804			

Source: Prepared internally based on the results of the econometric model.

Discussion of Results

For each additional unit of years of education, socioeconomic status increases by 24% [value-p=0.000]. Similarly, when work experience increases by one year, socioeconomic status increases by 0.25% [value-p=0.000], which is directly related to other research [Vela Meléndez et al., 2025].

ISSN: 2410-342X.
RENIECYT: 1702902

Jiménez-García, Martha, Gómez-Miranda, Pilar, Soto-Mejía, Ana Karen and Hernández Horta, Ingrid Anai. [2025]. Determinants of the socioeconomic level of entrepreneurs in Mexico: a probabilistic analysis of mobile phone use and associated variables. Journal of Administration and Finance. 12[29]1-9: e61229109.
https://doi.org/10.35429/JAF.2025.12.29.6.1.9

On the other hand, living in an urban area results in a 931% increase in socioeconomic status, which clearly shows that rural communities that are obviously far from urban areas are greatly disadvantaged.

With regard to mobile technology specifically, owning a mobile phone decreases socioeconomic status by 0.994%, and using a mobile phone also decreases socioeconomic status by 0.965%. However, it should be noted that when there is a relationship between owning a mobile phone and using it at the same time, this can increase the socioeconomic level by 1060.5%, which implies that all microentrepreneurs should be trained to not only own a mobile phone but also use it so that together they can increase their socioeconomic status, as technology is considered a source of economic growth through technological innovation [Ndahani et al., 2024].

On the other hand, owning and using a mobile phone for work activities increases socioeconomic status by 0.25%. Among the most important findings is the ownership of a mobile phone and its use in the sale of products, as this shows an increase of 168%. This is of interest because, according to various authors, the use of mobile phones has a significant economic impact and contributes to economic development in general. Furthermore, it has been confirmed that the adoption of mobile payment technologies has been shown to increase income [Suresh et al., 2025].

Conclusions

In Mexico, the following aspects influence an entrepreneur's ability to increase their socioeconomic status: 1] years of education, 2] living in an urban area, 3] owning and using a mobile phone, since simply owning a mobile phone sometimes means it is not used, and when it is used, it can increase an entrepreneur's socioeconomic status, 4] Possession and use of a mobile phone for work activities, which implies that sometimes a mobile phone is owned but not used for work activities, i.e., it is basically used for other activities such as entertainment, 5] Possession of a phone and use for the sale of products and services, similarly, it must be considered that sometimes entrepreneurs have a mobile phone but do not use it to sell their products.

It is therefore recommended that the government implement public policies to train all entrepreneurs to achieve digital transformation through the use of mobile phones and learn how to apply this in their work activities and for the sale of their products, as well as in mobile payment activities.

Declarations

Conflict of interest

The authors declare that they have no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Contribution of the authors

Jiménez-García Martha: Contributed with the idea for the project, the development of the econometric model, methodology, analysis of the results, and conclusions.

Gómez-Miranda Pilar: Contributed to the introduction and analysis of the results.

Soto-Mejía, Ana Karen: Contributed to the document review and data cleaning.

Hernández-Horta, Ingrid Anai: Contributed to the methodology and analysis of results.

Availability of data and materials

The data can be found in the National Survey on the Availability and Use of Information Technologies in Households [ENDUTIH] 2024. INEGI. At the following link: https://www.inegi.org.mx/programas/endutih/2024/#datos_abiertos.

Funding

This work has been funded by the **Instituto Politécnico Nacional** through Project 20253947.

Acknowledgements

The authors of this research would like to thank the Instituto Politécnico Nacional and Project 20253947 for their support.

Abbreviations

CI	Confidence interval

ISSN: 2410-342X.
RENIECYT: 1702902

INEGI	National Institute of Statistics and Geography
MIPYMES	Micro, Small and Medium-sized Enterprises
Odds ratio	Statistical measure indicating how likely an event is to occur
Pymes	Small and Medium-sized Enterprises
Valor-p	Statistical measure indicating how likely it is to observe the data according to significance

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https://doi.org/10.35429/JAF.2025.12.29.6.1.9

Journal of Administration and Finance 12[29]1-8: e71229108
Article

Analysis of the technical and environmental feasibility of implementing microdams with recycled materials in rural areas

Análisis de la vialidad técnica y ambiental de la implementación de micropresas con materiales reciclados en zonas rurales

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[c] Tecnológico Nacional de México - Instituto Tecnológico Superior de Huichapan • LWK-3019-2024 • 0009- 0008-6963-3929 • 1249989

Classification:

Area: Humanities and Behavioural Sciences
Field: Sciences of Arts and Letters
Discipline: Architecture
Subdiscipline: Construction

https://doi.org/10.35429/JAF.2025.12.29.7.1.8
History of the article:
Received: September 20, 2025
Accepted: December 30, 2025

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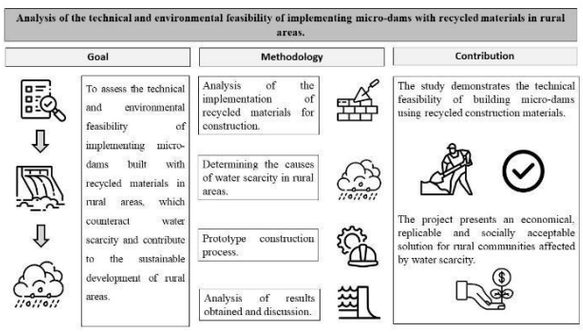
Abstract

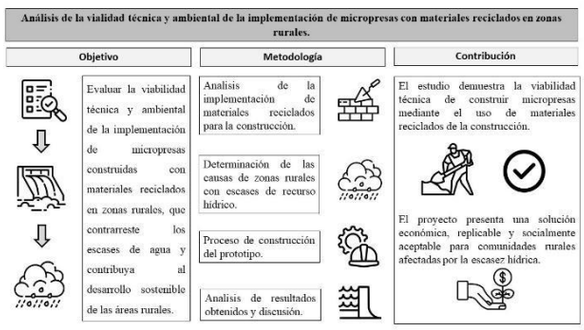
This project analyzes the technical and environmental feasibility of implementing micro-dams constructed with recycled materials and sustainable resources in rural areas. The research arises from the context of drought affecting more than 60% of Mexican territory, making the development of accessible alternatives for water harvesting and storage urgent. The proposal consists of the design and construction of a small- scale micro-dam, made with construction waste such as concrete, blocks, sand, and gravel, and waterproofed using nopal cactus mucilage as a natural and biodegradable alternative. The results obtained from monitoring the prototype during precipitation events allowed for the evaluation of its hydraulic and structural behavior, demonstrating adequate water retention capacity and favorable performance of the natural waterproofing agent. This approach contributes to the sustainable management of water resources, promotes the reuse of materials, and strengthens the resilience of rural communities to water scarcity and climate change.

Resumen

El presente proyecto analiza la viabilidad técnica y ambiental de la implementación de micropresas construidas con materiales reciclados y recursos sostenibles en zonas rurales. La investigación surge ante el contexto de sequía que afecta a más del 60 % del territorio mexicano, lo que hace urgente el desarrollo de alternativas accesibles para la captación y almacenamiento de agua. La propuesta consiste en el diseño y construcción de una micropresa a escala, elaborada con residuos de la construcción como concreto, block, arena y grava e impermeabilizada mediante el uso de mucílago de nopal como alternativa natural y biodegradable. Los resultados obtenidos a partir del monitoreo del prototipo durante eventos de precipitación permitieron evaluar su comportamiento hidráulico y estructural, mostrando una adecuada capacidad de retención del agua y un desempeño favorable del impermeabilizante natural. Este enfoque contribuye a la gestión sostenible del recurso hídrico, promueve la reutilización de materiales y fortalece la resiliencia de comunidades rurales frente a la escasez de agua y al cambio climático.



Microdam, Water resource, Recycling.



Micropresa, Recurso hídrico, Reciclaje.

Area: Promotion of frontier research and basic science in all fields of knowledge

Citation: Trejo-Torres, Zaira Betzabeth, Rodríguez-Uribe, Juan Carlos and Benitez-Alonso, Margarita. [2025]. Analysis of the technical and environmental feasibility of implementing microdams with recycled materials in rural areas. Journal of Administration and Finance. 12[29]1-8: e71229108.

Introduction

Currently, the world is increasingly affected by climate change and water scarcity. We need to research sustainable solutions that benefit vulnerable regions. That is why, at the global level, the analysis of the SDGs represents one of the greatest global consensuses. which were agreed upon in 2015 by the 193 member countries of the United Nations [UN] General Assembly and are represented by 17 goals and 169 targets whose purposes are to end poverty, fight inequality and injustice, and address climate change without leaving anyone behind. For the present research, we consider the analysis of SDG No. 6 - Clean water and sanitation, which guarantees the availability and sustainable management of water and sanitation for all; No. 11 - Sustainable cities and communities, focused on making cities and human settlements inclusive, safe, resilient and sustainable; and No. 13 - Climate action, focused on taking urgent action to combat climate change and its impacts.

This leads us to analyse proposals that favour the development of rural areas. Climate action, focused on taking urgent action to combat climate change and its impacts. This leads us to analyse proposals that favour the development of rural areas by promoting the quality of clean water supply, livestock and agriculture focused on sustainability.

Climate variability and events 2025

The study of the technical and environmental feasibility of implementing micro-dams with recycled materials in rural areas is focused on meeting the SDGs and minimising the effects of drought.

Justification

Micro-dams are artificial water bodies that have multiple uses, as they are used for domestic consumption, irrigation for agricultural activities, including watering holes for livestock, fishing, aquaculture and recreation. According to Hernández-Avilés et al. [2007], nearly 20 million people in Mexico are connected to these small bodies of water, which are at the heart of a series of economic and social activities that contribute to the general well-being of the population. [Aldama-Rojas, June 2011]

That is why the analysis of the technical and environmental feasibility of micro-dams is proposed in rural areas that benefit the sustainable growth of the population by promoting food production, thus meeting basic needs in the face of water scarcity.

Theoretical framework.

Some research has found that in the community of San Jerónimo Silacayoapilla, in the district of Nochixtlán, Oaxaca, Mexico, the process of building micro-dams using ferrocement began, as it is innovative in the construction of small dams. It has advantages such as the slenderness of its screen, its speed of construction and its cost-effectiveness compared to other construction systems such as reinforced concrete or masonry, mainly due to the transport of industrialised materials to inaccessible places such as the geography of San Jerónimo Silacayoapilla.

The construction of the dam will provide significant benefits to the quality of life in these types of dispersed communities, with the conscious intention that any productive project they develop will require water. [Margarito Ortiz Guzmán, August 2012]

The micro-dam consists of curved shells, which are built vertically, with three types of mesh frameworks and a 5-7 cm thick cement-sand mortar layer.

Article cement-sand mortar, between 5 and 7 cm thick.

The shell has intermediate reinforcements of the same material in a horizontal and vertical position, called tympanums and gussets, respectively. [Margarito Ortiz Guzmán, August 2012]

How does the micro-dam work?

Its main functions include:Water storage: It is used to collect and store water during the rainy season for later use during the dry season or in times of scarcity.Flood control: It helps regulate the flow of water in rivers and streams, reducing the speed and volume of water during periods of heavy rainfall, which mitigates the risk of flooding downstream.Aquifer recharge:

ISSN: 2410-342X.
RENIECYT: 1702902

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https://doi.org/10.35429/JAF.2025.12.29.7.1.8

They allow stored water to infiltrate the soil, contributing to the recharge of underground aquifers, which benefits the availability of water in wells and springs.

Irrigation: They supply water for agricultural irrigation, ensuring a constant source of water for crops.Sanitation and water supply: In some rural communities, micro-dams are used to provide drinking water or for wastewater treatment.Power generation: Although their capacity is limited, some micro-dams may include micro-hydro systems. [Trejo Torres, Rodríguez Uribe, & Velázquez Lucho, 2024]Materials and Methods Construction process.The construction of the micro-dam is carried out through a series of technical steps, which vary according to the size and function intended for the construction of the micro-dam, which depend on:Stage 1.- Site selection.This allows for the study of the terrain, identifying a location that allows for the capture of the greatest amount of runoff water, where the topography is the main natural element to consider, as well as ensuring that the terrain is stable and that there is no risk of landslides or erosion.

It is important to identify areas that are vulnerable to water scarcity due to droughts.Stage 2.- Technical design.At this stage, the dimensions of the micro-dam and the main function of the storage requirements are determined, the characteristics of the retaining wall are determined, and the recycled materials and key structural elements are selected.Since the publication of the General Law for the Prevention and Comprehensive Management of Waste, construction waste is considered special waste; its definition is: "Special Waste: This is waste generated in production processes that does not meet the characteristics to be considered hazardous or urban solid waste, or that is produced by large generators of urban solid waste." [Mena, 2016]

The recycling of construction materials is a key practice in the field of sustainable construction. Its main objective is to minimise the amount of waste generated during demolition, renovation and new construction, while reducing the need to extract and process new resources. This strategy not only helps to reduce the sector's environmental impact, but also promotes a circular economy that benefits both the environment and society. [ShiningMéxico, 2025]

Currently, one of the biggest environmental problems facing Mexico City is the amount of solid waste generated by its population. Of particular note is construction and demolition waste [CDW], which currently lacks adequate management to promote its reuse or recycling and amounts to 3,000 tonnes per day. [Rivera Mera, 2009]Block.

Blocks are defined as a basic element for the construction of walls. The types of blocks differ in their geometry and manufacturing processes. The raw materials for the production of concrete blocks are cement, sand, gravel or other stone aggregates, and water. Natural aggregates can be replaced by Article aggregates made from recycled concrete. [Castro, 2017]Brick. The era of fired brick began around 3,500 BC, with firing giving it a solidity similar to stone, but with the versatility of being able to be moulded before the firing process. Brick manufacturing was faster and cheaper than carving stones, which made fired bricks a highly valued commodity. Industrialisation allowed for greater diversity in brick designs and sizes. The standardisation of industrial processes enabled the creation of more uniform and higher quality bricks. [Luna A, 2023] Cement. Today, cement is one of the main materials used in construction, for houses, buildings and bridges. According to studies carried out by the Spanish Institute of Cement and its Applications [IECA], cement originated around 1600BC, as a result of a mixture of limestone, water, sand and aggregates.

This new material could be moulded while wet, as it hardened when dry, with remarkable strength and resistance. [Rocha D, 2020]Sand. Sand is known as a material whose particles vary in size between 0.063 and 2 millimetres. It is used in concrete mixtures according to the requirements of use: for example, S1, S2, S3, P1 and C2, where S is sulphate resistance, P is permeability and C is corrosion resistance. It is also one of the most abundant materials on the planet and, due to its characteristics, can be easily compressed and used to reinforce structures.According to ARQHYS magazine. Architecture, the granulometry of sand is classified into coarse, medium and fine sand.

ISSN: 2410-342X.
RENIECYT: 1702902

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Coarse sand is sand that passes through a 5 mm mesh but is retained by a 2 mm mesh; medium sand passes through a 2 mm mesh and is retained by a 0.5 mm mesh; fine sand passes through a 0.5 mm mesh but is retained by a 0.2 mm mesh. [Rocha D, 2020]Gravel. Gravel is an aggregate with a smaller grain size than crushed stone. It is classified according to size: Coarse: diameter of1.0 to 2.5 cm. Used for base formation and asphalt mixes, in roads and concrete. Medium: diameter from 0.7 to 1.0 cm.

Used for base formation and asphalt mix, in roads and concrete. Fine: diameter from 0.25 to 0.5 cm. It is mainly used in the composition of concrete and asphalt, and also in floors and facades. [Becerra Becerra, J. E. [2019].] Lime. Slaked lime is hydrated calcium oxide. It is a powerful base and has the appearance of white earth, hence its name “alkaline earth base”. Slaked lime does not lose its water until it reaches over three hundred degrees, at which point it becomes quicklime. [E, 1926]Nopal mucilage.

Nopal mucilage in general [Opuntia spp.], obtained from cladodes, is a hydrocolloidal, heteropolysaccharide substance [with residues of arabinose, galactose, rhamnose and xylose as neutral sugars]; its molecular structures are polyelectrolytes, highly branched and with a molecular weight [MW] in the order of millions of Da. [Vargas-Rodríguez, 2016]

Methodology

For this analysis, a micro-press prototype was constructed, which will allow for its evaluation and operation in rural areas or areas affected by drought, with the aim of being constructed from recycled materials.

The first step in implementing the prototype was to collect surplus materials from various construction sites to which we had access, as can be seen in Figure 1. These materials were selected based on their availability, physical condition and potential for reuse, as can be seen in Figures 2 and 3. Subsequently, a conditioning and preparation process was carried out, with the aim of facilitating their handling and ensuring proper behaviour when in direct contact with water, thus ensuring their functionality within the micro-dam construction system.

Box 1

Figure 1

Collection of excess sand and gravel

Source: [Own work 2025]

Box 2

Figure 2

Concrete waste, with sand and gravel.

Source: [Own work 2025]

The next step consisted of conditioning the collected materials, which involved selecting, sifting, and crushing the larger pieces, as can be seen in Figure 4.

This process resulted in a more homogeneous grain size, facilitating its handling and subsequent integration into the construction system. Likewise, the treatment of the material ensured better workability during its application and adequate performance within the micro-dam structure.

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Box 3

Figure 3

Concrete waste, with sand and gravel.

Source: [Own work 2025]

Box 4

Figure 4

Selection, crushing and screening of materials

Source: [Own work 2025]

Once the leftover materials had been collected and conditioned, the nopal mucilage was prepared, which is used as a natural waterproofing agent in the construction of the micro-dam, as can be seen in Figures 5 and 6. This process requires a prior period of rest and fermentation lasting several days, which is necessary for the mucilage to achieve the optimal physicochemical properties that guarantee its correct functionality and greater effectiveness as a waterproofing agent. Proper preparation of the mucilage is essential to improve the cohesion of the material, reduce permeability, and ensure better performance of the construction system in contact with water. reduce water infiltration and analyse its performance under controlled conditions.

Box 5

Figure 5

Selección de nopal, limpieza, pelado y triturado de la planta. *Fuente: [Autoria propia 2025]*

Box 6

Figure 6

Soaking the nopal cactus in water, lime and granulated salt.

Source: [Own work 2025*]*

This prototype is a fundamental step in assessing the technical and environmental viability of the proposed micro-dam, as shown in Figure 9.

Box 7

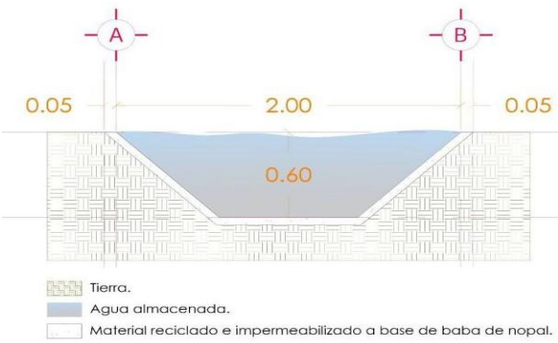

Figure 7

Scale model prototyping of the micro-enterprise design.

Source: [Own work 2025]

ISSN: 2410-342X.
RENIECYT: 1702902

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In order to validate the construction proposal, a scale model prototype was developed [see Figure 7], which allowed for the evaluation of the technical performance of the system and the generation of preliminary results, both favourable and unfavourable, for subsequent analysis. The prototype is 2.00 m wide and 0.60 m deep, and incorporates a 5 cm thick base made from recycled construction waste materials, as can be seen in Figure 8.

Box 8

Figure 8

Construction of the excavation for the prototype

Source: [Own work 2025]

Likewise, the structure was waterproofed by applying nopal mucilage, used as a natural waterproofing agent, with the aim of

Box 9

Figure 9

Final prototype, with a layer of recycled materials and application of a layer of natural waterproofing

Source: [Own work 2025]

Box 10

Figure 10

Filling in the micro-company

Source: [Own work 2025]

Its operation was monitored during the first five days after filling the prototype, at two times of day, 8:00 a.m. and 6:00 p.m., to determine whether water loss was due to evaporation or filtration. The data are recorded in Table 1.

Box 11

Table 1

Recording of results and measurements

hour	Día 1	Día 2	Día 3	Día 4	Día 5
8:00	60cm	56 cm	53 cm	51 cm	47 cm
18:00	58 cm	55cm	51cm	48 cm	45 cm

Results

Once construction of the scale model prototype was complete, the observation and evaluation of its hydraulic and structural behaviour began during the first rainfall in May 2025, which allowed for the collection of surface runoff water, enabling analysis of the system's performance under real operating conditions.

The structure performed well mechanically, with no cracks, detachments or significant deformations observed, confirming the correct integration of the recycled materials, as can be seen in Figure 10.

ISSN: 2410-342X.
RENIECYT: 1702902

Trejo-Torres, Zaira Betzabeth, Rodríguez-Uribe, Juan Carlos and Benitez-Alonso, Margarita. [2025]. Analysis of the technical and environmental feasibility of implementing microdams with recycled materials in rural areas. Journal of Administration and Finance. 12[29]1-8: e71229108
https://doi.org/10.35429/JAF.2025.12.29.7.1.8

Conclusions

The results obtained during the monitoring period of the micro-dam prototype are presented in Table 1, which records the water levels measured at 8:00 a.m. and 6:00 p.m. for five consecutive days. On the first day, the micro-dam reached a maximum height of 60 cm in the morning, decreasing to 58 cm in the afternoon, which shows a minimal loss mainly attributable to natural processes such as evaporation.

Over the following days, a gradual decrease in the stored water level was observed. By day five, the level had dropped to 47 cm in the morning and 45 cm in the afternoon, representing a moderate cumulative reduction in relation to the initial volume. This behaviour indicates that the structure achieved adequate water retention, without presenting abrupt losses that could be associated with significant leaks in the base or walls.

Analysis of these results suggests that the recycled materials used in construction, in combination with nopal mucilage as a natural waterproofing agent, performed favourably in terms of water retention. Although 100% efficiency was not achieved due to the heterogeneous nature of the construction waste used, the behaviour observed was stable and functional for temporary water storage purposes.

Likewise, the data reflect the influence of environmental conditions on the system's retention capacity. During the evaluation period, corresponding to the month of May 2025, high temperatures were recorded, which increased the evaporation rate and contributed to the progressive decrease in the water level. This factor confirms that environmental and climatic impact is a determining factor in the performance of this type of infrastructure, particularly in regions with high temperatures and prolonged periods of low water flow.

Overall, the results obtained allow us to conclude that the micro-dam prototype presents a favourable and viable technical response for its application in rural communities, offering a sustainable alternative for the storage of runoff water. However, it is recommended that complementary strategies be considered to reduce evaporation, as well as conducting tests on a larger scale and in different climatic periods, in order to strengthen the efficiency and durability of the system.

It is also considered that an analysis should be carried out to cover the water storage to prevent the accumulation of bacteria.

Declarations

Conflict of interest

The authors declare that they have no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Contribution of the authors

Trejo-Torres, Zaira Betzabeth: Contributed to the research idea and the integration of the research.

Rodríguez-Uribe, Juan Carlos: I contributed to the research and methodology advice.

Benitez-Alonso, Margarita: I contributed to the advice for the construction of the prototype.

Availability of data and materials

The data obtained in this research are available upon request to the corresponding author. This includes the experimental results and the methodological process for the development of the prototype.

Funding

The research did not receive any funding.

Acknowledgements

We would like to thank the Instituto Tecnológico Superior de Huichapan for providing the facilities and equipment for this research. We would also like to thank Oscar Hurtado Molina, a 9th-semester architecture student, for his contribution to this research.

Abbreviations

ODS	Sustainable Development Goals.
RC&D	Construction and Demolition Waste.

ISSN: 2410-342X.
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ISSN: 2410-342X.
RENIECYT: 1702902

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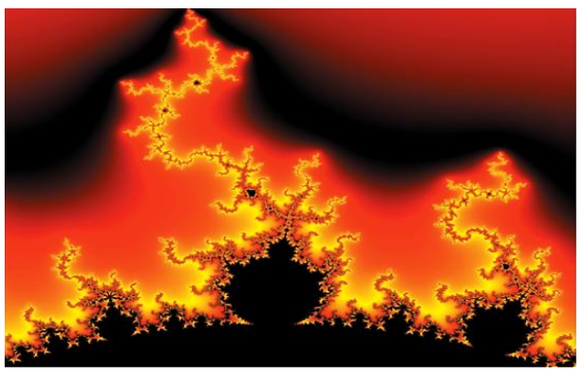

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Acknowledgements

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