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Characterization of a Mexican MSME Technological Observatory through the Viable System Model

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Abstract: The viable system model (VSM) is a conceptual framework for analyzing and designing complex organizations, which was developed by Stafford Beer in the 1970s. It is based on the idea that every organization is a system composed of a set of interconnected subsystems that must work together effectively to achieve its goals. One of the key scientific novelties of using the VSM in technological issues is its emphasis on adaptability and resilience. The VSM recognizes that organizations must be able to adapt to changing environments and circumstances in order to survive and thrive, and that this requires a flexible and responsive organizational structure that is capable of learning and adapting over time. By using the VSM to design and manage their technological systems, organizations can create more adaptive and resilient systems that are better able to respond to changing technological and market conditions. The current dynamics of the market push companies to look for ways to improve their competitive position by relying on instruments that facilitate the effective acquisition, processing, and analysis of large amounts of data from different and dispersed sources; in response to this need, various tools for research and information processing have emerged. One of them is the technological observatories that appeared in the nineties. They are considered tools that assist in the design of strategies, the decision-making of companies, and the development of public policies. The following research aims to characterize a technological observatory for MSMEs in Mexico based on the model of viable systems (VSM); its intelligence area is validated through a prospective model for the next five years using the I Think 8.0 software. The methodological strategy is based on the mixed sequential explanatory method; in the first instance, a quantitative analysis is carried out on the structure, processes, human resources, and innovation of twenty technological observatories of the business sector that operate worldwide, after which a qualitative analysis was elaborated established in thematic axes on the opinion of experts in areas of public policy, technologies, knowledge transfer, education, both contributions supported to generate an overview of the current state of technological observatories in Mexico and worldwide, then obtain the necessary inputs to develop the proposed model. As a result, an observatory model was obtained for MSMEs with good profitability and permanence over time, thanks to their anticipated strategies based on the perspective regarding their management.

Keywords: MSMEs, observatory, foresight, viable systems, competitiveness.

通过可行系统模型表征墨西哥中小微企业技术观测站

摘要：可行系统模型(VSM)是用于分析和设计复杂组织的概念框架，由斯塔福德啤酒在 1970 年代开发。它基于这样一种理念，即每个组织都是一个由一组相互关联的子系统组成的系统，这些子系统必须有效地协同工作以实现其目标。在技术问题中使用 VSM 的关键科学创新之一是它强调适应性和弹性。VSM 认识到组织必须能够适应不断变化的环境和情况才能生存和发展，这需要一个灵活且反应迅速的组织结构，能够随着时间的推移学习和适应。通过使用 VSM 设计和管理他们的技术系统，组织可以创建更具适应性和弹性的系统，能够更好地响应不断变化的技术和市场条件。当前的市场动态促使公司寻找方法来提高其竞争地位，方法是依靠能够促进有效采集、处理和分析来自不同和分散来源的大量数据的工具；为了满足这一需求，出现了各种研究和信息处理工具。其中之一是九十年代出现的技术天文台。它们被认为是有助于战略设计、公司决策和公共政策制定的工具。以下研究旨在基于可行系统模型(VSM)描述墨西哥中小微企业的技术观察站；它的情报领域通过使用我认为 8.0 软件的未来五年预期模型进行验证。方法论策略基于混合序贯解释法；首先，对全球运营的 20 个商业部门技术观察站的结构、流程、人力资源和创新进行了定量分析，然后根据专家的意见在主题轴上进行了定性分析 在公共政策、技术、知识转移、教育等领域，这两项贡献都支持对墨西哥和世界范围内的技术观测站的现状进行概述，然后获得必要的投入来开发拟议的模型。结果，由于基于管理观点的预期战略，获得了具有良好盈利能力和长期持久性的中小微企业的观察模型。

关键词: 中小微企业、天文台、远见、可行系统、竞争力。

Introduction

The demand for advanced services through computer systems, the rise of the Internet, and the spread of personal computers have highlighted the need to develop applications that exhibit a certain level of intelligence in the process of information retrieval, where interaction with the user and connectivity of different systems must be especially relevant aspects [1].

From there, the need to obtain and control information on essential strategic parameters, that is, on competitors and on the environment in which business activity takes place, has become one of the priority objectives for the survival not only of private companies but also state-owned enterprises.

Since then, economic issues have become part of the security concept. As a result, the intelligence services have also devoted part of their efforts in recent years to developing intelligence with economic content and objectives in the context of what has been called intelligence culture. The latter indicates the considerable evolution that has occurred in the concept of economic intelligence, whose vast dimensions have become evident with the development of terms such as technological or corporate surveillance (Technology Watch), business intelligence (enterprise intelligence), commercial intelligence, business or market intelligence (business/market intelligence), or competitive Intelligence [2].

According to Nelson and Winter [3], the academic study of the phenomena related to the evolution of the economy is critical in terms of access to markets, where the different econometric, financial, trend, demand, and focus variables must be considered to generate development, welfare, and competitiveness in emerging economies, as an essential mechanism for the effective strengthening of different organizations, regions, and sectors of a country [4].

On the other hand, in 1967, Harold Wilensky proposed the concept of organizational intelligence [5] that intelligent information generates indicators and concluded that this type of intelligence dramatically impacts the efficiency and effectiveness of the organization since the information obtained can support decision-making.

Another of Wilensky's contributions is the concept

of business intelligence in the 90s, with a more comprehensive character compared to traditional methods of monitoring the environment, such as passive surveillance (scanning) and active surveillance (monitoring) [6]. Under increasing market pressure, companies are trying to improve their competitive position by looking for tools that facilitate the effective acquisition, processing, and analysis of large amounts of data from different and dispersed sources, which would serve as a basis for discovering new knowledge [7].

Technology observatories are potential tools that can respond to information demands in any sector (academic, business, technology); the observatory concept arises from studying stars in ancient civilizations around 4,600 BC [8, 25]. An observatory is a tool that collects information and integrates it to provide reflections on the national research and development activity under national methodologies and standards [9].

According to Bouza Betancourt [10], a Technology Observatory captures external information to transform it into specific knowledge that leads its users to make decisions.

In 1990, the first science and technology observatory in the world was created, and this organizational model has multiplied in several countries [9-11]; as part of the evolution of the current observatories, these are presented as a tool that helps in the design of strategies, the decision-making of companies, the development of public and institutional policies, the determination of the research approach, and the creation of action programs in social agents [12, 13].

Worldwide we can locate various technological observatories that provide strategic business information, such is the case of the Virtual Observatory of Technology Transfer (OVTT) [13] which is an institutional project developed by the University of Alicante (UA), in collaboration with Banco Santander (Santander Universities), to promote the transfer of knowledge, technology, innovation and entrepreneurship in Latin America [14]; another example is the Industrial Technology Foresight Observatory (OPTI), which generates a knowledge base on the most relevant technological trends for future economic and social development [12, 15], the European Cluster Observatory is a free and easy-to-use online platform that provides a single point of access to cluster data and analysis, cluster organizations and conditions of the regional microeconomic framework in Europe [14]; projects such as those mentioned above can be located in different parts of the world, with different scopes and aimed at other sectors.

In Mexico, seven technological observatories have been detected: OT Technopoli of the National Polytechnic Institute (IPN) that provides business intelligence information and technical surveillance of various sectors, OT Strategic Technological FEMSA-ITESM that offers information on business clusters and mega trends, OT of the Autonomous University of the State of Hidalgo (UAEH), which is a virtual technological field that facilitates, develops, optimizes the linkage, communication, collaboration between companies, educational institutions and research centers, OT of the Potosino Institute of Scientific and Technological Research (IPICYT), who performs search and analysis of scientific, technological, economic and market information, valid for the evaluation, validation and prospective of opportunities of a scientific-technological and / or business nature projects, both for academia and for companies, OT of the University of Sonora (UNISON), in which technologies developed in research projects can be offered and published, OT of the Technological Park of Guanajuato which is a web platform that will allow users to have access to current information on science, technology and innovation, OT of the company Actitud Innovación Tecnológica A.C. that monitors new scientific and technological advances, as well as the early detection of new markets and trends [17].

Based on the definitions raised above, it can be concluded that an OT measures and processes elements related to technology to alleviate searching for relevant information that pays homage to the job or personal interests of clients, thanks to the integration into an information tool circumscribed to specific topics, that provides reports, summaries, and alerts, which allow users to make decisions [22-24]. However, one of the deficiencies detected in the technological observatories in Mexico is that a methodology still needs to be located in the scientific texts on which its structure and operation are based, in addition to in-depth studies in Mexico that measure its impact on the business sector.

In Latin America, technological observatories have yet to gain importance, even though they can generate knowledge networks that benefit various public and private actors to develop strategies and design public policies.

On the other hand, the model of viable systems is derived from Beer's experience in cybernetics and in the biological functions of organisms, a viable system is defined as one that has the ability to produce by itself to adapt to changing environments [18], for this organizations need to become ultra stable or be in the process of applying this type of system, organizations are able to adapt adequately to their chosen environment, or adapt their environment to their liking, even if they are in a situation that has not been foreseen, provide a methodology to technological observatories through viable systems for their creation, improve their implementation and ensure their permanence over time, derived from this model arises a science called "Organizational Cybernetics", that

dedicates study to organizations with the purpose of exposing the degrees of complexity of the systems, with the pertinent information to be able to keep adequate control of the situations that arise within the organization [12].

In 2002, the SME Observatory of Mexico was a project promoted by the IDB and developed by the Università di Bologna, with representation in Buenos Aires, and the Intersectoral Commission on Industrial Policy of the Ministry of Economy of the Government of the United Mexican States [29]. However, the absence of rigorously comparable studies over time, both from the sectoral and dimensional points of view, is verified even in Latin American countries [30].

For the elaboration of this research, we searched for various studies related to SME observatories at national and global levels using keywords such as observatories, MSMEs, technological observatories, methodology, foresight, economic intelligence, and technical surveillance. These searches are performed in databases in Spanish and English, such as EBSCO, Web of Science, Google, Academic, Redalyc, ILO, IDB, and OECD.

1. Materials and Methods

A methodological strategy is built based on the mixed sequential explanatory method to support the proposal of the MiPymes observatory model described in this document and [21]; the main steps of the research process are summarized in Fig. 1. A quantitative analysis is carried out to obtain an overview of the operation of other observatories in Mexico and around the world; searches are carried out with the word *clbird* in various scientific databases to locate observatory sites, technological platforms, and projects related to the monitoring and statistics of SMEs in other countries, preferably based on [10]. In the cases of Latin America and Europe, it was possible to homogenize the information of each observatory through various dimensions such as its structure, financing, methodologies used, and organic design [10].

A qualitative analysis is carried out through semi-structured interviews because they present a greater degree of flexibility, start from planned questions, and can be adjusted to the interviewees [22, 23]; these interviews are carried out with experts who work or have knowledge about the operation of a MiPymes observatory in Mexico, also considered those people who participate in technological projects related to SMEs or have contributed to the creation of economic-based technological platforms.

For the calculation of the sample, the formula for small populations is considered as follows [31]:

$$n \geq \frac{n*N}{n*N} \qquad (1)$$

where n - sample size and N - population size.

Subsequently, with the opinion of these experts, a thematic analysis is carried out, which is a method to identify, analyze, and report patterns within the data provided by the experts and organizes and describes a set of data in detail [19].

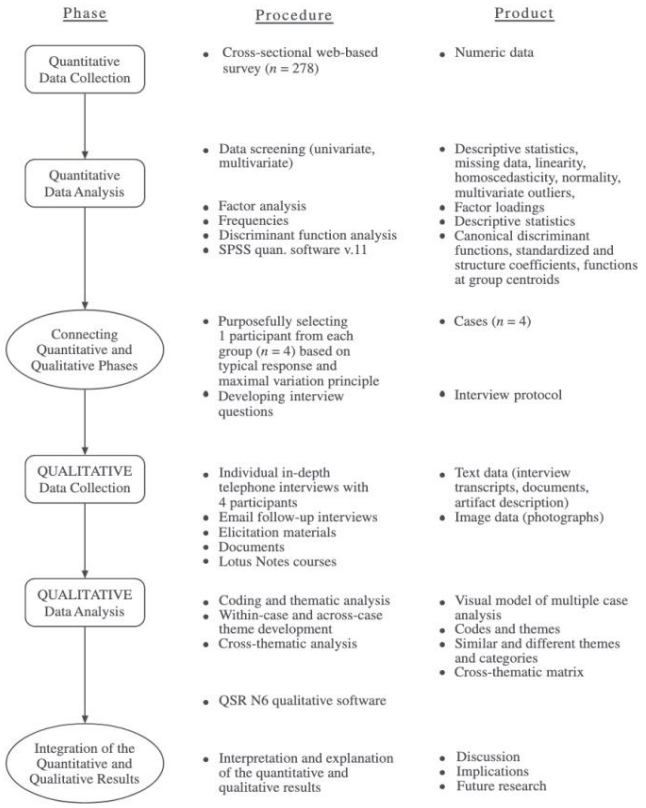

Fig. 1 The mixed sequential explanatory method used in this research [28]

2. Results and Discussion

The analysis of other observatories and experts' opinions greatly supports providing the necessary inputs to generate a model of an observatory for MSMEs based on viable systems. In the findings of the observatories analyzed and the interviews with experts, the following can be concluded regarding technological observatories (OT):

2.1. What Are They? Moreover, What Are They For?

An OT is an information tool; the observatories of MSMEs provide sectoral indicators, market dynamics, human resources, and financial information; another function is to generate spills of knowledge among various actors to implement strategies that improve the environment where this type of companies is developed and serves as a point of reference to strengthen public policies since they will be based on scientific studies or key indicators that allow its proper execution.

2.2. Who Uses Them?

These tools are aimed at all those actors that comprise the entrepreneurial ecosystem, mainly MSMEs. However, researchers involved in innovation, entrepreneurship, and economics use them more

frequently.

On the other hand, for the public sector, it is a tool of vital importance that serves as a reference to obtain information that supports the formulation of various strategies.

2.3. What Is Its Scope?

The data presented by a technological observatory of a business nature are valid for one year and are usually national; only some have an international presence since the institution that finances it economically depends a lot on it.

2.4. How Is a Business Technological Observatory Structured?

Very few observatories have actual physical space for their operation; however, because they are technological tools, they use various programs specialized in intelligence and data analysis, programming, and visualization of interfaces. Some programs and platforms used to program, design, and present information to the end user are SQL Server, ICP .Net Developer, Jumla, Drupball, Mateo Patent, IHS Goldfire, ORBIS, and Gartner.

2.5. Trending

Some sciences that have emerged in recent years and that are important to improve the indicators and data provided by the observatory are scientometrics, webometrics, and modeling; on the other hand, one of the challenges that we want to solve in the future is to generate a model of self-sustainability and independence of the observatory in the execution of its operations.

Of the observatories analyzed at international and national levels, only the Observatory of Industrial Technological Foresight (OPTI) [12, 15] performs predictions based on the Delphi method, which is considered a qualitative method that analyzes the opinion of experts to generate future scenarios.

The previous thematic analysis allowed obtaining the necessary inputs for the generation of a technological observatory for MSMEs, where the methodology for its operation is based on the theory of viable systems and its management in future applications to each of its departments; the results of the generated model are presented.

2.6. Model “Observa MiPymes”

"Observa MiPymes" is a Mexican business technological observatory designed to improve the quality of information of Mexican MSMEs by implementing foresight techniques and data analysis to different indicators already existing for this type of company. Fig. 2 shows the generalized design of the proposed model for this observatory, which has five strategic areas: local environment and operational area (A1), coordination (A2), control and audit (A3), intelligence (A4), and policies (A5).

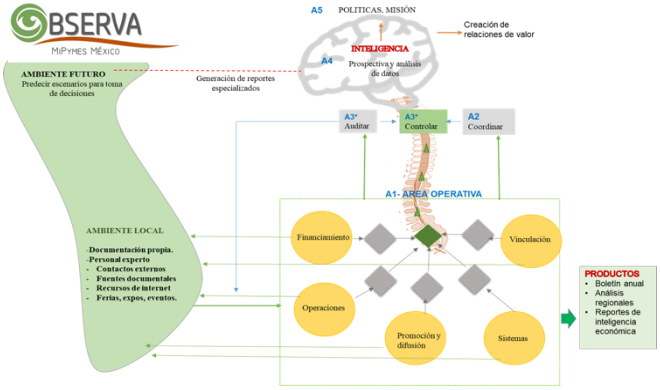

Fig. 2 The model of the virtual technological observatory “Observa MiPymes” (Own elaboration)

The local environment is considered all those sources of information that provide indicators or statistics of MSMEs in Mexico; these data are primarily open and provided by government sources, organizations, and non-profit associations:

1. ***Primary sources of the local environment:***

- *Own documentation or related to the organization:* Surveys carried out by the same observatory;
- *The expert staff of the observatory:* senior and junior researchers and fellows who contribute knowledge to various projects;
- *External contacts of interest:* external researchers who collaborate occasionally, companies and associations willing to contribute valuable knowledge to the observatory;

2. ***Secondary sources of the local environment:***

- *Documentary sources:* repositories of universities containing research related to MSMEs;
- *Information resources on the Internet:* databases, specialized pages, blogs;
- Attendance at congresses, seminars, fairs, and exhibitions.

2.7. Operational Area (A1)

The operational area of the observatory comprises semi-autonomous subsystems that achieve the objective of the system; this area is in constant reception of the changes of the external environment and seeks a way to adapt them to the organization, that is, if the sources of information have been updated from their place of emission, the observatory must be aware of these changes to update the indicators in the operations of the observatory itself, however, when this area is unable to respond to external changes, it is the responsibility of the other regions to respond to these situations [16].

2.8. Coordination (A2)

Once the indicators have already been stored in the content manager, the coordination will be the area in charge of providing constant feedback to the various

sections in which the data will be classified; it is also responsible for monitoring the operation of the subsystems of the operational area; its purpose is to prevent and reduce errors in the execution of operations.

2.9. Audit and Control (A3 and A3*)

This area develops processes to support the strategic and operational activities of the Observatory; within it, the policies previously designed in the strategic part (A5) are implemented, and the technical, human, and financial resources that allow the proper functioning of the system are provided.

2.10. Strategic Intelligence (A4)

When the information has been treated in the active part (S1) and has passed the quality processes of S2 and S3, it is taken to a higher level that is known as "Intelligence" in this area is where techniques such as data mining will be applied to detect clusters, system simulation to predict future scenarios, business intelligence or competitive surveillance that generate specialized reports for the various products and services of the market, these indicators may be displayed on the Internet platform, mobile application and electronic bulletins that are sent to subscribers of the forum.

2.11. General Management (A5)

Finally, the general management area is the political figure of the institution; it is responsible for generating value relationships with various actors so that they are interested in contributing to improve, finance, or reward various value resources that can improve its operation.

2.12. Prospective Model in the Management of Observa MiPymes

The previous model proposed includes an area of Intelligence that allows the application of various techniques for the proper treatment of data and thereby creates future scenarios; within this area, it is considered that foresight is a technique that has allowed to validate of the self-management of Observa MiPymes anticipating its operation in the following five years for an adequate execution of strategies that will enable its subsistence. Therefore, a foresight model is designed that comprises three areas: users, human resources, and operations. These can be viewed across the board in Fig. 3.

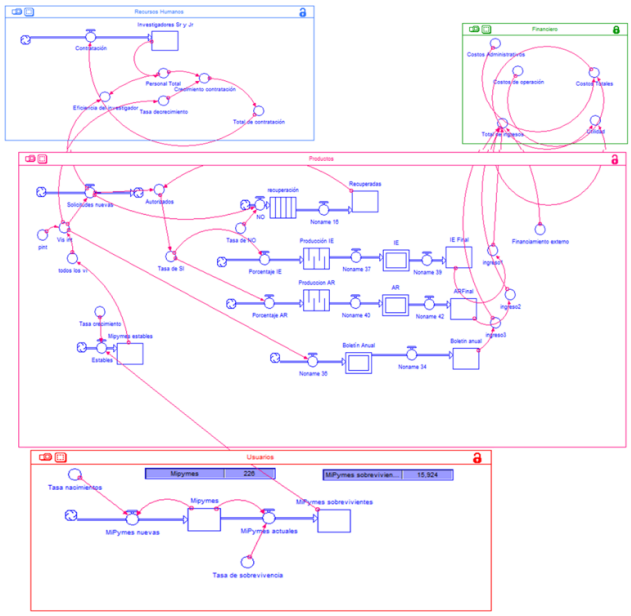

Fig. 3 A validation model for the management area of the observatory "Observa MiPymes" (Own elaboration based on (Systems, 2018))

The previous validation design is subject to some restrictions in each of its components, and runs are executed within five years to determine if the execution of the platform will be feasible in the future. For example, Table 1 shows the following results.

Table 1 Results of the 2018-2028 validation for Observa MiPymes (Own elaboration based on (Isee Systems, 2018)

ALL VI	2859.7
VIS INT	315
Recovered	151
Authorized	466
Sr and Jr researchers	7
Researcher efficiency	45
Final IE	21
Final AR	21
Annual newsletter	5

Therefore, the future scenarios predicted by the model are as follows: 2,859 MSMEs will visit the technological observatory within five years, of which a convenience rate of 11% is applied; that will be the possible interest in products of the observatory, which gives 315 formal requests for information.

Initially, it is desired that the observatory will have five senior and junior researchers to develop the projects. However, the greater the demand, the more the number of hires will increase, and it is expected that there will be seven researchers.

In the next five years:

1. The researcher's efficiency in five years is 45

projects for each one, i.e., each researcher is expected to work annually on one or two annual projects simultaneously or consecutively;

2. The observatory will generate 21 economic intelligence reports and 21 regional analysis reports over five years, i.e., annually, it must make eight specialized reports in any of these two areas, which agrees with the goal established annually by the technological Observatory of the University of Hidalgo [26, 27];

3. The viability of the observatory is also measurable in terms of its financial resources. These are obtained from requests for information and external contributions, managed through an area responsible for linking the observatory with the business, social, and political sectors to receive various donations or grants. In five years, it is estimated that the observatory will have external contributions of $200,000 annually with a gross profit of $507,500.

2.13. Comparison of Observa MiPymes with Other Observatories

A comparison of Observa MiPymes with other similar observatories in Mexico is made, where it can be seen that their differentiator is the application of data analysis, business intelligence, and perspective techniques both to their performance indicators and treating hands provided to the user. This comparison is shown in Table 2.

Table 2 Comparison of Observa MiPymes with other technological observatories in Mexico (Own elaboration)

Features	See MSMEs	OSSE (Social Economy Observatory)	FEMSA-TEC Technology Observatory	ONE (National Observatory of the Entrepreneur)	OTECH
Management from forward-looking planning	✓	X	x	x	X
Financing of various public and private actors	✓	x	✓	x	X
Management of data analysis, intelligence, and foresight techniques to improve the quality of information	✓	X	x	x	x
The temporality of the data and indicators generated by the Observatory	✓	✓	✓	x	x
Open access to indicators	✓	✓	✓	✓	✓
Knowledge transfer	✓	✓	✓	✓	✓
Generation of networks composed of various stakeholders in MSMEs	✓	✓	x	✓	x

3. Conclusion

Improvement in access to information and knowledge management facilitated by the development of communication technologies and networks will be one of the critical elements of a future society. However, MSMEs in Mexico have a complex structure that has yet to be fully understood. In addition, only a few programs promote the development of strategies and public policies that benefit this type of company based on data analysis through technological tools.

3.1. Main Findings of This Study

The observatories, as information tools, offer various actors a wealth of devices that allow them to generate knowledge transfer and support in a context of dynamic and global competition, enabling them to act with certainty. Although the observatories, like the companies, have had to adapt to various technologies that allow them to survive, in developed countries, the prospective analyses have become an instrument of competitiveness to face uncertainty; that is why the foresight applied to the management of this type of organisms serves as an excellent ally to guarantee their subsistence and viability over time; as previously visualized, the foresight applied to various indicators of the observatory will greatly support making appropriate decisions for their operation.

Predicting future scenarios to make better decisions in the present is one of the main objectives of foresight, and that is why the proposal of the observatory model that is announced in this research work has as its primary differentiator the use of foresight in the management of the observatory to be able to make strategic decisions that allow its subsistence [20].

The main contributions of this research are:

1. A proposal on the methodology that can be used to create technological observatories in a scientific document;

2. The generation of a technological observatory model based on foresight from its management to the indicators it shows to the user. "Observa MiPymes" is a proposal that can predict its operation in the first five years thanks to the combination of viable systems with system simulation. It is one of the first mixed-method prospects implemented in Mexico;

3. A proposal that significantly supports the national management of MSMEs' knowledge and keeps it constantly updated;

4. A technological observatory will always serve as a link between various actors in a productive sector. Therefore, it is considered a proper proposal for the benefit of society.

Mexico must conduct ongoing initiatives to begin to operate observatories efficiently, which will allow the country to combat the knowledge gap at the local, regional, or national level, guaranteeing timely, reliable, and quality information.

3.2. Comparison with Other Studies

Currently, there are no works related to our research in Mexico. However, some similar works found in the literature are:

- *"Application of the Viable System Model in the Viability Analysis of a Public University" by J. Reyes et al. (2019):* This study applies the VSM to analyze the viability of a public university in Mexico, highlighting the strengths and weaknesses of the university's organizational structure; we observe that these strengths and weaknesses were observed similarly.

- *"Using the Viable System Model to Assess the Viability of a Family Business" by E. Nava et al. (2019) and "Assessing the Viability of a Non-Profit Organization Using the Viable System Model" by S. Sánchez et al. (2018):* In these studies, the VSM was applied to analyze the viability of a company and as a tool to determine its strengths and weaknesses; both studies were conducted in Mexico. Our research also allowed us to generate recommendations for improving organizational structure and processes.

In general, these studies demonstrate the applicability of the VSM to analyze and assess the viability of organizations in various contexts, including MSMEs.

3.3. Implications of Study

VSMs have become an essential tool for various natural language processing tasks, including information retrieval, topic modeling, text classification, and machine learning. The implications of using VSMs in scientific research are that it enables researchers and practitioners to achieve more accurate and efficient results in these areas.

3.4. Strengths and Limitations

The viable system model (VSM) applied in this research is a management model that helps organizations achieve viability and adaptability in complex environments. Here are some strengths and limitations of this model:

A) *Strengths:*

a. *Systemic perspective:* The VSM provides a systemic perspective that helps organizations understand the relationships and interdependencies between different parts of the system;

b. *Flexibility:* The VSM is designed to be adaptable to different contexts, making it useful for a wide range of organizations and industries;

c. *Scalability:* The model is scalable, which means it can be applied to different levels of the organization, from individual teams to the entire enterprise;

d. *Resilience:* The VSM is designed to help organizations build resilience to change and uncertainty by creating a structure that supports continuous adaptation and improvement;

e. *Holistic approach:* The model takes a holistic approach to management, integrating various functions and departments within the organization.

B) *Limitations:*

a. *Complexity:* The VSM is a complex model that can be difficult to understand and implement, requiring significant expertise and training;

b. *Time-consuming:* Implementing the VSM requires significant time and resources, which may be a barrier for smaller organizations with limited budgets;

c. *Lack of empirical evidence:* While the VSM has been used in various industries, there is limited empirical evidence to support its effectiveness;

d. *Resistance to change:* Implementing the VSM may face resistance from employees who may not be familiar with the new system or are resistant to change;

e. *Cultural fit:* The VSM may not be suitable for all organizations, particularly those with different cultural or social norms, making it less effective in some contexts.

Overall, the viable system model is a powerful tool for organizations seeking to improve their adaptability and resilience, but it requires careful consideration of its strengths and limitations to determine its suitability for a particular context.

4. Recommendations and Future Research

The actions that Mexico must undertake are to strengthen and create initiatives based on public policy to start operating observatories efficiently, with resources that allow the country to combat the knowledge gap at the local, regional, or national levels, and guarantee that the use and management of information is timely, reliable, freely accessible, and of high quality.

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