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Information Technology Governance in Colombian Small and Medium Companies: An Exploratory Study Using Data Analysis.

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***Abstract*—** Information Technology (IT) is a resource for achieving strategic business objectives. However, many Small and Medium-sized Enterprises (SME's) do not consider IT a strategic area. This article explores the perception of IT governance in Colombia among IT professionals. It presents the design, data analysis, and results of a survey based on the Governance of Enterprise IT framework. The survey was conducted in 2019 and 2020, obtaining responses from 151 IT professionals that worked in 48 SME's and 90 from large companies. Data were analyzed with WEKA and KNIME, applying classification, segmentation, and association techniques. Results indicate that: (1) SME's associate IT investment with the generation and improvement of products and services; (2) employees' and users' performance is higher when they work in companies with managers that have a high commitment to IT governance; and (3) 95% of companies with high implementation levels of IT governance consider IT very important in their strategies.

Keywords: IT Governance, SME's, data analytics, data mining.

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I. INTRODUCTION

Information Technology (IT) is an essential resource for achieving companies' strategic objectives, due to the need to incorporate automated processes that provide information platforms, save resources, and minimize risks by responding to changes in the environment [1]. However, for many Small and Medium-sized Enterprises (SME's), IT is still considered a support area rather than a strategic area, which limits their competitiveness in a globalized and dynamic world [2], [3].

Therefore, SME's need strategies for implementing IT Governance (ITG) that consider their particular context, including: external factors like economic, political, and social dynamics; internal factors like organizational culture and IT's alignment with business objectives (Authors, 2020); the limited economic and personnel resources for the technology area; the lack of organizational policies that support IT development; and the lack of follow-up strategies and action plans that make technology investments sustainable.

Tools such as perception surveys are used to investigate and promote ITG best practices. For example, Bermejo et al. [4] applied factor and cluster analysis to identify Brazilian companies' organizational profiles by analyzing practices, business performance, and ITG maturity. Likewise, DuMoulin [5] applied a survey to IT governance specialists in Africa, Asia, Australia, New Zealand, Canada, Europe, Mexico, the Middle East, and the U.S.A. to examine the challenges of adopting IT governance principles to produce tools that support this process [6] based on 35 case studies, confirm the positive correlation between IT governance maturity and IT governance performance. Both Internal IT organization structure and organizational relationships, and quality management maturity, show the strongest positive correlation with IT governance performance.

Moreover, the results of the study presented by [7] suggest that the utilization degree of IT governance mechanisms varies according to the IT mode (defensive or offensive), and is higher when a company is in offensive IT mode. Finally, [2] empirically validates that IT governance is an enabler of IT capability and proposes a comprehensive measure of IT governance based on secondary data, and examining the impact of IT governance and IT capability on firm performance.

Our work seeks to analyze and understand the perception of ITG in Colombian SME's, considering their differences and commonalities with large companies. This article presents the design, results, and data analysis of a survey based on the Information Systems Audit and Control Association (ISACA)´s Governance of Enterprise IT (GEIT) framework [8]. The survey on the perception and challenges of GEIT was conducted between 2019 and 2020 with IT professionals working in several verticals (technology services, consulting/ finance/banking, telecommunications, and manufacture).

The remainder of this article is organized as follows: Section II reviews the related literature; Section III presents the research method; Section IV describes the results; and Section V summarizes and concludes.

II. THEORICAL FRAMEWORK

The conceptual framework for the addressed problem and its analysis are described now.

a. IT Governance

One of the key processes that support and monitor IT management is Information Technology Governance (ITG), which allows the organization´s top management to guide IT evolution and use by defining what to do (objectives) and how to do it (means) [9].

Since the late 1990's, the concept of ITG [10] has received increased attention from organizations, academics, and practitioners. ITG has been defined as the process by which IT decisions are made, realized, and transformed [11]. This process follows the formulation and implementation of strategies through organizational processes, structures, and mechanisms that support IT-business alignment and creation by balancing risks and opportunities [10].

All of the above is done to generate value for the business and satisfy the company's present and future demands [12]. It is worth mentioning that, due to the competitive market of the 21st century, companies, regardless of size, have recognized the importance of implementing frameworks, international standards, and good practices to manage their IT resources [13]; seeking to meet the need to automate processes, provide information platforms, save resources and minimize risks using technology [1].

Lezama et al. [14] argue that the successful implementation of ITG must consider the use of a common language, which fosters communication among all parties and a shared commitment to compliance with the policies and procedures defined by the steering committee [13].

b. Governance in SME's

SME's are a key vehicle to lift people out of unemployment and underdevelopment (Ajibade & M. Mutula [15]. Indeed, Frogeri et al. [16] argue that SME's provide about 90% of the basis for emerging economies of enterprises worldwide, and require organizational innovation to serve suppliers and customers, increase market performance, strengthen competitiveness, and achieve stable success [17].

Clearly, IT has become the backbone of SME's, fundamental for daily activities and for development. However, most methodologies proposed for improving information systems are focused on large companies rather than SME's [18]. Thus, SME's fail to effectively apply mechanisms that align IT strategies and business, such as standards, tools, techniques, or externally developed frameworks like COBIT, ITIL, and ISO/IEC 38500 [12].

Olutoyin and Flowerday [19] consider that the components of ITG cannot be practically implemented in SME's' context because the structural controls in the environment are not mature enough to support compliance. Likewise, Bergeron et al. [4] argue that the small numbers of employees in SME's fosters high levels of trust and reduces the need for owners and managers to create and implement ITG mechanisms.

Finally, Ruithe et al. [20] notice that, in SME's, the lack of organizational structure make IT governance informal with ambiguous and generic regulations, and argue that in practice IT governance should be designed primarily around the organization's applications.

c. Analysis of IT governance data.

Data analysis encompasses a set of techniques that seek to uncover existing relationships of non-trivial information that reside implicitly in the data, which was previously unknown and may be useful for some processes. Data analysis techniques INCLUDE classification, segmentation, and association, based on artificial intelligence and statistical analysis [21]-[24] (see Table I).

Table 1: Data mining techniques.

Technique	**Objective**	**Algorithm**
Classification	Predicting or estimating an event associated with a specific value of a categorical or continuous variable. Generally, work on historical data where there is a known outcome, which is why models are built on training data and validated on test data.	– Decision table – Decision trees – Rule induction – Bayesian – Exemplar-based – Neural networks – Fuzzy Logic – Genetic techniques
Segmentation	Create similar groups and describe them when the specific outcome is unknown (e.g., identify new patterns of fraud).	– k-means – Canopy clustering
Association	Performing the automatic search for rules that relate sets of attributes to each other. The algorithms associated with this technique are referred to as unsupervised, as there are no known a priori relationships against which the validity of the results can be tested, but rather whether these rules are statistically significant.	– A priori

Fuente: Elaboración propia.

Each technique is operationalized in practice with a step-by-step algorithm; the algorithm chosen for each technique in Table 1 to analyze data in this study were:

1) *Classification*: we chose Decision Trees, commonly used in data mining and with the advantage of allowing qualitative analysis using hierarchical categories to organize data; these categories are formed with a probabilistic utility criterion, using decision rules presented as trees, where the total population (root node) is successively divided (branches-intermediate nodes) until segments of similar behavior (leaf nodes) are obtained with the target variable [21].

2) *Segmentation*: we used Clustering, which allows solving classification problems by describing data using classes, associations, and structures that are not evident a priori but can be useful once they have been found. Its objective is to arrange the information in groups (clusters) so the degree of association/similarity among members of the same cluster is stronger than among members of different clusters [24]. Among clustering algorithms, K-means is the most widely used in scientific and industrial applications; its name comes from the fact that it represents each of the clusters by the average (or weighted average) of its points, i.e. its centroid. This method can only be applied to numerical attributes, but the centroid representation has the advantage of an immediate graphical and statistical meaning [22].

3) *Association*: We used the Apriori algorithm, which establishes minimum values for the support and expectation measures of a rule [23].

Of course, these techniques are continuously evolving as a result of advances in databases, artificial intelligence, expert systems, statistics, visualization, information retrieval, and high-performance computing [25].

III. RESEARCH METHODOLOGY

To analyze and understand the perception of the state of ITG implementation in Colombian SME's, we conducted in 2019 and 2020 a semi-structured survey of IT professionals undertaking a professional master degree. We adopted convenience sampling to select professionals working in companies with several contexts, sizes, and industry sectors, allowing to find trends and hint possible results that fed the final study's development.

The survey was based on the GEIT survey of ISACA, to allow finding and analyzing ITG research developments in SME's. Figure 1 shows the data analysis process with the data mining methodology presented by [27].

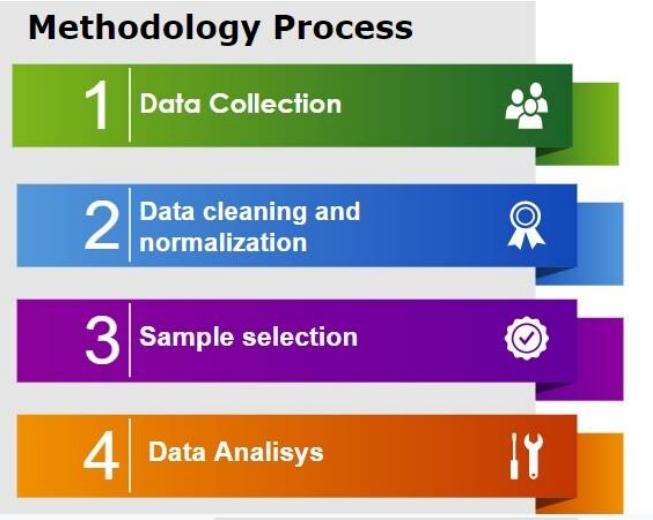

Figure 1: Methodological process for data analysis.
Source: Prepared by the authors.

a. Data collection

We adopted the following contact strategy for the data collection. The survey was conducted in 2019 and 2020 to IT professionals (Authors, 2021). An initial talk explained the research objective, and information was shared with ITG concepts to ensure that all interviewees had the same interpretation during the interview. Finally, they were invited to participate utilizing an online survey with open-ended, multiple-choice, and perception questions, grouped into three sections: 1) Organizational Characterization, 2) IT Strategic Alignment, 3) IT Projections and Incidents in the organization, as shown in Table II.

Table 2: Division of the survey by section.

Section	Total Questions	Objective
Characterization of the Organization	11	Identify the profile, sector, and origin of the company in which the respondent works
Strategic Alignment of IT	5	Identify if an IT department exists, the importance of this in the company's strategy and vision, the level of relationship between management and IT governance along with the benefits and plans for IT within the company.
Projections and Incidents of IT in the organization	11	Identifying the current use of technology to support processes along with frameworks or standards to support IT governance ultimately identifies IT-related issues

Source: Prepared by the authors.

b. Tools for data cleaning, normalization and analysis

The study data analysis was done using WEKA (the Waikato Environment for Knowledge Analysis) and KNIME (Konstanz Information Miner) [22], [26], [27], both described in Table III.

Table 3: Data mining techniques.

Tool	Description	Functionalities
WEKA	Environment for experimentation that allows the application, analysis, and evaluation of data through the most relevant data analysis techniques, mainly from machine learning, on any set of user data.	It provides a collection of algorithms for data pre-processing and data mining, including regression, classification, clustering, association rules, and selection algorithms
KNIME	Open-source software to develop workflows that can be easily extended with other tools such as WEKA.	Solve strongly typed data problems utilizing multiple nodes for data analysis and machine learning, guaranteeing the same results on different operating systems. It is worth mentioning that this platform allows the workflows creators to document the steps performed in detail.

Source: Prepared by the authors.

The collection process yirld 151 records, which were downloaded in CSV format, and imported into KNIME, where data was cleaned and normalized to balance loads and eliminate duplicates. This process resulted in a total of 138 records containing information from both large and small companies.

c. Sample selection

Using the sample calculator and the statistical equation (1) for population proportions described below, the sample to be taken for analysis with a 10% margin and a 90% confidence level must have at least 46 of the 138 normalized data.

$$n = \frac{z^2(p*q)}{e^2 + \frac{(z^2(p*q))}{N}} \qquad (1)$$

Where: n = Sample size, z = Desired confidence level, p = Proportion of the population with the desired characteristic (success), q = Proportion of the population without the desired characteristic (failure), e = Level of error willing to commit, N = Population size.

Based on this information, and taking into account that this study focuses on SME's, which have less than 250 employees [28], using KNIME on the model presented in Figure 2, a selection of these specific data yield 48 datapoint.

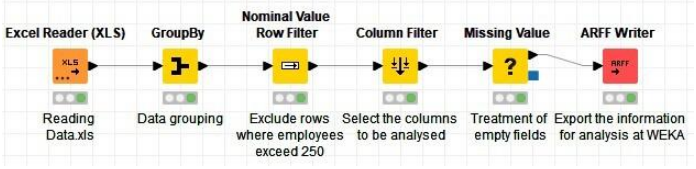

Figure 2: Model in KNIME to select the analysis sample.
Source: Prepared by the authors.

After applying the criteria of the proposed methodology to the 151 records obtained in the survey, we left 48 records as shown in Figure 3.

Figure 3: Data analysis results map.
Source: Prepared by the authors.

d. Data Analysis

After the previous steps, the sample information was analyzed. Table 4 presents a profile of the students surveyed and general information about the enterprises, all of which are SME's.

An association, classification, and cluster analysis were carried out with WEKA, allowing to relate the test results with identification and analysis of research advances in IT governance in SME's.

IV. RESULTS

The analysis results stage used the data gathered and treated in the previous sections.

a. General features

Survey participants work 64.6% in private companies, 29.1% in government sector, and 6.3% in the mixed sector. Figure 4 shows the relationship between IT department existence and the company kind (i.e. government, commercial, and mixed), allowing to conclude that regardless of the company's origin, most of the SME's surveyed SME's have an IT department.

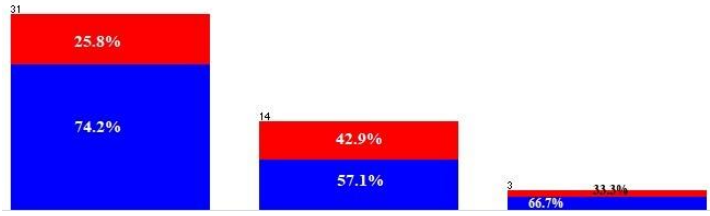

Figure 4: Relationship of the company's sector to the existence of an IT department.
Source: Prepared by the authors.

It also shows that public government companies generally have national scope, whereas private companies have local or regional scope.

b. Classification of SME's by sector and strategic alignment of IT

We noticed that 85.7% of the professionals working in SME's in the services and technology sector consider IT to be more important in its strategy, versus 80% in private sector consider IT to be not very important in the company's strategy (see Table IV).

Table 4: Relationship of the sector to the importance of IT in the company's strategy.

Sector	Importance of IT in the company's strategy	Not very important IT in the company's strategy
Goods and services	85.7%	14.3%
Business	20%	80%
Education	90.9%	9.1%
Government	66.7%	33.3%
Technology services	94.7%	5.3%

Source: Prepared by the authors.

c. Classification by data analysis technique

The following subsections describe the results obtained using WEKA for data analysis through classification, clustering, and association on the variables presented in figure 5.

Figure 5: Data mining process.
Source: Prepared by the authors.

d. *Classification*

Using WEKA's J48 algorithm, which functions as an algorithmic decision tree to classify the data and produce predictions [29], showed that 81% of professionals working in SME's stated that their do companies have an IT area, and they consider its management to be very important to support the company's strategies.

Figure 6 shows that depending on the company type, one of the benefits of making IT investments is improving customer service (if it is commercial) or generating new or improved products (if it has mixed origin). However, if the SME is government-owned, the expected benefit of IT investments depends on the relationship between management and ITG: if it is high, its improved information security; if it is moderate, it yields new or improved products and services; and if it is low, improved customer service.

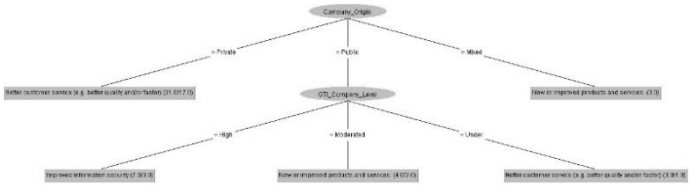

Figure 6: Relationship of the company's origin to the benefits of IT investments in the company.
Source: Prepared by the authors.

e. Cluster

We used the Simple K-means clustering algorithm, one of the fastest and most efficient, which specifies the number of similar categories into which we want to divide the dataset [30]. Using two groupings with 77% and 23% of the data, we found that one of the most significant differences between SME's is the ITG application level in company management: this is moderate for technology service companies, and high for education companies.

On the other hand, technology service companies' plans are based on selective escalation based on potential/expected contribution to business value, whereas the academic sector classifies IT plans as uncertain. Also, the reasons that companies cancel IT-related projects before they become fully implemented are mainly related to budget overruns and changes in business needs.

Finally, it should be mentioned that many professionals working in technology companies state that no ITG frameworks or standards are used, while those working in companies in the education sector do use these tools to support IT management.

f. Association

Association analysis was performed with the main WEKA algorithm, i.e. Apriori, which only looks for rules between symbolic attributes, so all numerical attributes must be discretized beforehand. This analysis yielded a set of rules relating to the company management level concerning IT governance, the existence of an IT department, and the importance of IT in the company's strategy. Specifically, we observed:

- In 100% in SME's with an IT department, they use IT governance frameworks or standards like ISO, ITIL, TOGAF, COBIT and CMMI, and IT is very important in the company strategy.
- In 100% of the sampled technology service companies that have an IT department, they consider IT to be very important in the company's strategies, and 71.3% use IT frameworks or standards, like above.
- 95% of companies with an IT department and with not canceled projects before planned, consider that IT is very important in the company strategy.

- 94% of private companies with 50-250 employees consider IT to be very important in their strategy. However, the remaining 6% are government-owned companies, where respondents commented that IT is not very important because of insufficient IT staff, lack of innovation, high IT costs with low or unknown return on investment, and outsourcing-related issues.

g. Other results

Other results are concerned with information on most used standards, emerging technologies, and most frequent IT problems in the SME's' context in the sample. Finally, a comparison between SME's and large companies in the sample is presented.

- The most used standard among SME's was ISO (33.3%), followed by ITIL (12.5%).
- The technologies currently most used to support processes in SME's are Data Analysis (58.3%) (including Data Mining, Business Intelligence, and Big Data Analytics), Social Media (43.8%), and Automation (22.9%).
- The technologies that SME's plan to implement in the short term are Data Analytics (62.5%) which includes Data Mining, Business Intelligence, and Big Data Analytics, followed by Social Media (29.2%) and Automation (22.3%), omitting technologies such as artificial intelligence and virtual reality.
- The IT-related problems most experienced in the last 12 months include insufficient staffing, project cost overruns, lack of innovation, security difficulties, and disconnection of IT from the business. These are presented in Figure 7, which was generated with Voyant-Tools.

Figure 7: IT-related problems experienced in companies over the last 12 months.
Source: Prepared by the authors.

- The IT support level in a company strategy and vision is moderate for SME's but high for large companies. Also, SME's in the sample associate IT investment with generation and improvement of products and services, whereas large companies associate it with better quality and better customer service. Finally, SME's consider IT investment plans to be uncertain, while large companies make selective increases based on the business value contribution.

V. CONCLUSIONS

This study involved the application of a survey of 138 IT professionals in 2019 and 2020, and data analysis using classification, segmentation, and association methods using WEKA and KNIME.

One finding is that plans for Colombian technology services SME's plans are based on selective escalation based on potential/expected contribution to business value, whereas the academic sector classifies IT plans as uncertain. We attribute this to companies not seeing clear advantages (e.g. improved their plans for innovation and increased quality product and development) of implementing IT strategies and models.

Another finding is that IT was considered necessary for all internal and external processes within companies, as it is the medium that supports all technology. For this reason, each IT-defined strategy must necessarily be linked to the technological tools and resources currently available to the company.

Also, although the IT component in SME's can be evaluated in yearly audits, they show failures in implementing processes like IT governance because it is limited to compliance with online governance policies, software licensing, and control of computer equipment.

On the other hand, it was found that the performance of employees and users is higher when they work in companies where managers have a high commitment to IT management because communication among several parties is encouraged. It was also identified that good information management, IT protocols, and standards, guarantee data integrity and security, which allow the company to be more competitive in the market.

Finally, some companies that have an informal IT approach still have problems that arise from low budgets, such as insufficient staffing, project cost overruns, lack of innovation, security difficulties, and disconnection of IT from the business.

VI. DISCLOUSURE STATEMENT

The authors report no competing interests to declare.

VII. ACKNOWLEDGMENT

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