Leveraging business intelligence for strategic growth: a case study of small and medium-sized enterprises (SMEs) in the construction industry

Aprovechando la inteligencia empresarial para el crecimiento estratégico: un estudio de caso de las pequeñas y medianas empresas (PYMES) en la industria de la construcción

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ABSTRACT

The present study uses Business Intelligence methodologies and tools in the public procurement system to improve the management and decision-making of small and medium-sized enterprises (SMEs) in the construction industry in two regions of Chile. The data of transactions carried out in public purchases allows the generation of commercial strategies to improve their results. The information available on the public procurement platform was compiled for this purpose. Then, a Business Intelligence model based on the HEFESTO methodology was applied to develop a decision-making support platform prototype adapted for SMEs. The prototype is useful for analyzing public purchases, awarding tenders in specific geographic areas and economic sectors, and providing growth potential for SMEs. Likewise, the analysis of the current situation of the construction industry in the Biobío and Ñuble Regions, previous research related to the subject, and the analysis of the strategies used by SMEs operating in that market were considered. Using Business Intelligence in Public Procurement for SMEs in the construction industry provides a strategic ability to improve in such a competitive market. Digital platforms in public procurement make it possible to use a large volume of data to improve company management, and SMEs can now use them.

Keywords: Business intelligence, public procurement, enterprise, construction industry.

RESUMEN

El presente estudio utiliza metodologías y herramientas de Inteligencia de Negocios en el sistema de compras públicas, para mejorar la gestión y toma de decisiones de una pequeña y mediana empresa (PYME) del sector construcción en dos regiones de Chile. Los datos de las transacciones realizadas en las compras públicas permiten generar estrategias comerciales para mejorar sus resultados. Para ello se recopiló la información disponible de la plataforma de compras públicas. Luego, se aplicó un modelo de Inteligencia de Negocios basado en la metodología HEFESTO para desarrollar un prototipo de plataforma

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de apoyo a la toma de decisiones adaptada para Pymes. El prototipo es útil para el análisis de compras públicas, para la adjudicación de licitaciones en áreas geográficas y sectores económicos específicos, brindando potencial de crecimiento a las PYME. Asimismo, se consideró el análisis de la situación actual del sector construcción en las regiones del Biobío y Ñuble, investigaciones previas relacionadas con el tema y el análisis de las estrategias utilizadas por las Pymes que operan en ese mercado. El uso de Inteligencia de Negocios en Contratación Pública para las Pymes del sector de la construcción les confiere una capacidad estratégica que les permitirá mejorar en un mercado tan competitivo. El uso de plataformas digitales en la contratación pública permite disponer de un gran volumen de datos para mejorar la gestión de las empresas y ahora pueden ser utilizados por las PYMES.

***Palabras clave**: Inteligencia de negocios, contratación pública, empresa, industria de la construcción.*

INTRODUCTION

Small and medium-sized enterprises (SMEs) in Chile can sell their services and products to more than 850 state agencies through public procurement [1]. The entity responsible for the management of public procurement platforms is *ChileCompra*, in which data analysis is conducted to benefit the knowledge of its users, which uses publication data and not from the allocation of public purchases [2], [3], [4]; this does not help in the decision-making of the administrators of an SME, especially when applying for some sectors or cases in which many times they do not apply for not having enough information. The primary challenge lies in the low level of participation by companies in the public market, either due to a lack of awareness about the use of digital platforms, the low system credibility, or to ignoring its existence [2], [5], [6].

Consequently, to overcome the lack of knowledge about public procurement, it is proposed to innovate with a platform prototype that considers data from the entire public procurement process and significantly collaborates for its adjudication. The implementation of innovative public procurement can foster a knowledge-intensive entrepreneurial spirit, an area that remains largely unexplored [7], [8], [9]. The proposed platform was developed using Business Intelligence methodologies and tools, with which different types of organizations can support decision-making based on accurate and timely information, guaranteeing the generation of the necessary knowledge that allows the choice of the most optimal alternative for organizational success [10], [11], [12].

Conversely, the investment projections in the construction industry are 2.4%, which will result in the creation of new job opportunities and an increased number of tenders offered by the State. In the Biobío and Ñuble Regions of Chile, South America, construction is the sector with the most incipient employment [13], [14]. Consequently, an increased allocation of tenders in this sector will facilitate revenue growth for small and medium-sized enterprises.

Notably, the growth of SMEs is generally associated with employment generation, innovation, and economic prosperity [15], [16]. Thus, this work contributes to the development of SMEs by providing a valuable instrument that can enhance their business opportunities.

CONCEPTUAL FRAMEWORK

Business intelligence

Business Intelligence (BI) can be defined as the process of transforming data into information and then knowledge [11]. Knowledge is generally obtained about customer needs, decision-making processes, competition, industry conditions, and general economic, technological, and cultural trends. BI originated in the industrial world in the early 90s, when managers demanded that they analyze the company's data efficiently and effectively to better understand their business and improve the decision-making process [11]. It is an interactive process of exploring and analyzing structured information about a domain (usually stored in a data warehouse) to identify trends or patterns from which to derive ideas and draw conclusions [17]. The BI process includes communicating findings and making changes. The domains include clients, suppliers, products, services, and competitors [18], [19], [20]. Therefore, the concept of Business

Intelligence allows the process of transforming data into knowledge, thus addressing the main questions that arise, such as: What data will be used? How will the data be managed? Moreover, in what context will the data be used?

Implementing decision support systems in small and medium-sized enterprises (SMEs) is necessity, aggravated by the competition and competitiveness practiced by large companies, requiring SMEs to make additional efforts to produce competitive market prices [21]. Today, most companies have information technology (IT) systems that facilitate the collection, processing, transmission, and dissemination of data [22], [23], [24]. IT systems are designed to record large amounts of data derived from the operational activities of companies. The data recorded by the IT systems allow commercial managers to extract information and knowledge of commercial and market trends, which is why this knowledge is essential for the decision-making of those entrusted with business management responsibilities [25].

The most significant challenges for SMEs are placing their products in the market at competitive prices and the profitability of their commercial costs [26]. Which BI tools can address these issues? These tools allow the grouping and organization of large amounts of data to gather relevant information to support decision-making processes [21], [27], [28]. Additionally, these tools enable the creation of graphs, tables, reports, and statistics; this makes it easier for managers to detect anomalies and identify relevant business trends. Therefore, BI processes are crucial for sales and marketing operations [29], [30].

Business intelligence and public purchases: situation in SMEs

The implications of BI and analysis in the public procurement sector remain an emerging area in literature. This analysis focuses on policy implications and the demand (state) perspective. As explained later, most of these studies were conducted in Northern Europe and the United Kingdom.

Previous research has attempted to identify the functioning of the public procurement market and the impact of incentives on suppliers (at the market level); this has encompassed the management of agreements (including the post-contract one), supplier relationship management (SRM), and the professional development of market operators [31], [32], [33].

Other works have examined the entire public procurement process and the position of electronic purchasing in the institution's purchasing flow. This is to identify the necessary knowledge and contribution of artificial intelligence and the respective techniques to support these visions [34]. Karjalainen and Kemppainen [35] analyzed the suppliers of municipalities and government institutions separately and identified a lack of technical and administrative expertise within the public procurement process, in addition to a low participation of SMEs. The low participation of SMEs can be attributed to their inability to process orders or invoices electronically. The level of innovation generated by the country's public procurement system is associated with purchasing new products and services. However, networks and alliances with other companies improve management in SMEs when the buyers (customers) are private. Therefore, this represents a better alternative for SMEs than associating with public or private research and development actors by developing new products and services for the public sector [7].

Implementing self-declared financial capacity and feedback mechanisms can enhance the fulfillment of SMEs in open tenders. The opposite effect occurs when implemented measures increase the transaction costs, group the tender, or promote consortium bids [36], [37]. A more detailed analysis by Flynn and Davis [36] reveals that the level of participation and knowledge of the regulations positively influence the degree of compliance of SMEs. On the demand side, the perceived importance of access to SMEs, whether as a semi-state organization, a concessionaire, basic services, a municipality, or an educational institution, has the opposite effect on the degree of compliance. Flynn and Davis [38] argued that, despite the similarities with large companies, the disadvantage of SMEs has specific factors; these include the resources available to access more and larger tenders and the ability to increase the award rate. Managers then need to focus on the latter, and authorities must understand these differences between SME providers across various sectors [39]. Loader and Norton [39] also emphasized these differences and analyzed the heritage construction industry in the United Kingdom. They concluded that the publicly

funded capital construction industry behaves differently from the rest of the public construction tenders; due to the uncertainty of the work and the key role of the architect, which requires the specialized participation of the public buyer or technical counterpart. They also analyzed that SMEs tend to provide the service directly instead of outsourcing, do not create consortiums or associations and have a history of related work that benefits them.

Sourani and Sohail [40] analyzes the barriers by incorporating sustainability into the requirements of public purchase. Among the barriers identified are aspects such as financial and cost restrictions, lack of vision and knowledge (regulations, incentives, best practices), time constraints and resistance to change, and poor links (R&D, industry, others). The entities capable of removing these barriers are the government, professional organizations, universities, the supply chain, and finally the customers [40]. BI is essential for any company; however, only some studies examine the gap in market intelligence practices in SMEs. Folsom [41] identified that the practices most used by SMEs were to observe the competition and interact with suppliers and distributors, although, according to the perception of managers, market intelligence is not considered a critical activity. Ojiako, Chipulu, Karatas-Ozkan, Siao, and S. Maguire [42] also found that business intelligence is scarcely applied in SMEs, as there is either no interest or a lack of management skills. Thus, several researchers have sought to incorporate intelligence into public procurement systems to make the intermediation of institutions more effective. In other words, to develop intelligent public procurement processes [43].

On the one hand, the findings of Ojiako *et al.* [42] suggest that business proactivity depends on business intelligence and knowledge management. They influence the effectiveness of these practices and communication channels and manage to maintain business opportunities and the size of the company; this reinforces the idea that using business intelligence (BI) among SMEs can enhance their decision-making capabilities. On the other hand, from the perspective of entrepreneurial guidance, SME administrators' proactivity allows them to seek information about business opportunities in the public sector and participate in the subsequent bidding process. Thus, authors such as Saastamoinen, Reijonen, and Tammi [7] advocate for promoting this practice to increase the innovation generated by the public procurement system.

Data Warehouse (DW)

In the mid-1990s, BI became an object of interest in the academic world, and ten years of research managed to transform a set of naive techniques into a well-founded approach to information extraction and processing [11]. Finally, the main results obtained on topics such as OLAP, multidimensional modeling, design methodologies, optimization, and indexing techniques converged to define modern data warehousing (DW) systems architectures. Suppliers subsequently absorbed them to form a broad set of supporting software solutions [11]. In this sense, DW is defined as a collection of data-oriented to a field (company, organization), integrated, non-volatile, and time-varying, which helps the process of support systems for decision-making [44], [45]. Data storage involves moving data from source systems to an integrated data warehouse. These source systems typically represent heterogeneous technical platforms and data structures [46]. The sources may reside within the organization, be supplied by an external data provider, or come from a business partner.

Some basic concepts must be understood before applying business intelligence; these are presented below [17], [18], [19].

- Events: They are a collection of data. Each event represents a part of the business, a transaction, a situation, a circumstance, or an occurrence.
- Dimensions: They are a collection of members, units, or individuals of the same type.
- Measures: are numerical attributes of an event that represent the behavior of the business within a single dimension.
- DW Star Model: Only one event table, encircled by dimension tables, contains the data to perform the analysis; this table is wrapped in several smaller tables.
- OLTP: Online Transactions Processing is the process of using data from the Web.
- ETL (Extract, Transform, and Load): It is the process of extracting, transforming, and loading data.

Creating a BI environment involves building an analytical data store for managers [46]. In many institutions, the most important decision metrics

are calculated based on information collected from multiple systems [12]. For this reason, Business Process Modeling (BPM) is an important technique for collecting this information and, together with the data warehouse, is a method for integrating different sources of information [12], [47], [48].

ChileCompra platform

"*ChileCompra*" is the institution that manages Chile's public procurement platform and operates with a unique regulatory framework based on transparency, efficiency, universality, accessibility, and non-discrimination [1], [2], [3], [4].

The e-commerce portal, through its various services such as "Chile Proveedores" (Chile Suppliers), "Mercado Público" (Public Market), and "Analiza" (Analyze), provides detailed information on transactions conducted between offers from State entities of which over 850 State entities participate. The Central Government, Ministries, Public Services, Municipalities, Hospitals, Armed Forces, and organizations that voluntarily added their tenders to this platform. Likewise, more than 120,000 suppliers are duly registered to participate in this awarding process, of which 90 percent are awarded to micro and small companies [1].

METHODOLOGY

We propose using the HEFESTO methodology to develop a solid Business Intelligence proposal aimed at optimizing public procurement. By following the steps, we define key indicators, build a robust data model, and design a reporting system that allows decision-makers to gain valuable insights into public procurement performance, thus facilitating more efficient and transparent resource management.

HEFESTO

The HEFESTO methodology can be used in any lifecycle that does not require extensive requirements and analysis phases to deliver an implementation that meets part of the user needs [49], [50]. Table 1 shows the stages of the HEFESTO methodology.

However, the HEFESTO methodology is a data warehouse construction framework consisting of four main stages: requirements analysis, OLTP analysis, logical data warehouse modeling, and ETL processes. The first stage involves identifying user requirements and establishing a conceptual model [49], [52]. The second stage analyzes OLTP sources to determine how indicators will be calculated. The third stage defines the logical data warehouse structure based on the conceptual model [51], [53]. Finally, ETL processes are implemented to extract, transform, and load data into the data warehouse.

Business intelligence proposal for public purchases

The research proposal is based on the use of Business Intelligence through the HEFESTO methodology, which has yet to be used in public procurement.

Table 1. Stages of HEFESTO methodology.

Stages	Requirements
1) Requirement's analysis.	Identify requirements. Identify indicators and analysis perspectives. Conceptual model.
2) Analysis of OLTP (Online transactional processing).	Indicator's determination. Establish correspondences. Granularity level. Expanded conceptual model.
3) Logical model of DW (Data Warehouse).	The logical model is based on the conceptual model. The type of data warehouse representation must be defined. Dimension and fact tables are designed. Relationships between tables are established.
4) ETL Process (Extract, Transform and Load).	ETL processes are used to validate data. The software can be used to automate ETL tasks. ETL tasks include extracting data, integrating it, filtering it, and cleaning it up.

Source: Adapted from [49]-[53].

Table 2 shows the proposed attributes of the Business Intelligence prototype.

The research first focused on SMEs since they have some capital restrictions on project execution. Subsequently, the Pareto chart (3 levels) was employed to narrow the research since, in general, 80% of the total results come from 20% of the elements [54].

- The first-level Pareto diagram analyzed the type of government agency that provides them, where municipalities represent more than 80 percent.
- In the second-level Pareto chart, the type of item was analyzed, indicating that the Construction of Civil Works and Infrastructure category accounts for over 72 percent.
- In the third-level Pareto chart, municipalities were identified with 80 percent of the bidding bids in the Civil Works and Infrastructure category.

The data used come from a bid's tender and transaction process from January 2012 to June 2018.

RESULTS

The results obtained after developing the Business Intelligence (BI) platform prototype using the HEFESTO methodology are presented below. Through the examination of 12 key queries, it was identified that the type of budget in the tender (published or unpublished) is a determining factor in the analysis. This finding, particularly evident in 2017, where both types of budgets reached an almost equal distribution, is further explored in the following sections, where the bid amounts and the probability of award are analyzed, and illustrative practical cases are presented.

Development of the BI platform prototype

1) *Requirement's analysis*

The questions based on the user's requirements for public purchases and whose data can be obtained from the different platforms of *ChileCompra* are: How many bids are offered by the different public entities each time, and who are the main competitors? What bid amounts are offered by the different public entities each time, and who are the main competitors?

Identified indicators:

- Number of bids.
- Total amount of bids.

Identified perspectives:

- Tenders: All those awarded are considered and their attributes are available on the *ChileCompra* platforms.
- Competitors: Any company awarded one or more tenders and duly registered in Chile Suppliers.
- Public Organization: State agencies that have publicly offered their purchases and contracts in *ChileCompra*.
- Time: The date of publication of the tender is considered.

Table 2. Business Intelligence platform proposal.

Attributes	Characteristics
Platform	Business Intelligence Proposal of the Project.
Focus	Hybrid (Horizontal). Focus on where data is analyzed only when necessary for the user's requirements.
Data warehouse	Data warehouse.
Methodology	HEFESTO.
Data Orientation	Areas of interest.
Level of data detail	Scalable depending on user requirements.
Display	Descriptive statistics.
Bidding Data	• Offer Period. • Transaction Period.
Knowledge for the user	• Identification of the general behavior of Public Organizations. • Identification of seasonings and patterns of the field, generation of strategies to a postulation.

2) ***Analysis of the OLTP (Online Transactional Processing)***

This stage determines how the indicators will be identified. The consultation model analyzes factors that influence the awarding of tenders, considering a specific period from January 2012 to June 2018. In addition to the evaluation of the characteristics of the suppliers and the conditions of the tenders, the economic amount offered by the state agency for each contract is included, which allows the identification of possible correlations between the value of the tender and the probability of award. Once the indicators have been identified, the available OLTPs are analyzed. Figure 1 illustrates the relationship diagram.

Then, the fields that are useful for creating the data warehouse are selected based on the user requirements and their level of granularity. Finally, the correspondence between the available data is established.

3) ***Logical model of DW (Data Warehouse)***

The star logical DW model is created, and perspectives are transformed into dimensions, along with changes in the names of perspectives or fields, to improve user understanding. At this stage, the fact table and dimensions must be integrated to visualize the data warehouse model better, Figure 2.

4) ***ETL (Extract, Transform and Load)***

- Extraction: Adjudicated tenders were tracked on the "Public Market" platform, obtaining 6,315 tenders. The results were then downloaded into an Excel spreadsheet.
- Transformation: Tenders were filtered according to the scope, and of data from selected fields was manually loaded, considering a total of 2017 tenders.
- Load: After the previous stages, the worksheet was ordered, where color was assigned to differentiate bidding data, supplier company, and bidding organization. This procedure is completed for better data visualization and later analysis.

Display

In general, the use of the HEFESTO Methodology allowed 12 consultations. Of these, the type of budget in a tender (published and unpublished) was identified as a relevant category since in 2017, the percentages are each close to 50 percent, Figure 3.

Therefore, it was decided to build a query model based on this category (Figure 4). The process starts with evaluating the general supplier factors. From these, the analysis is divided into three specific dimensions of the tender: tender factors *L1*, *LE*, and *LP*. Subsequently, the application amount is considered, and the award probability is calculated. This probability is estimated based on the factors previously assessed. Variables such as the supplier's experience, the quality of the proposal, and compliance with technical requirements can influence it. Finally, the model culminates in an award decision.

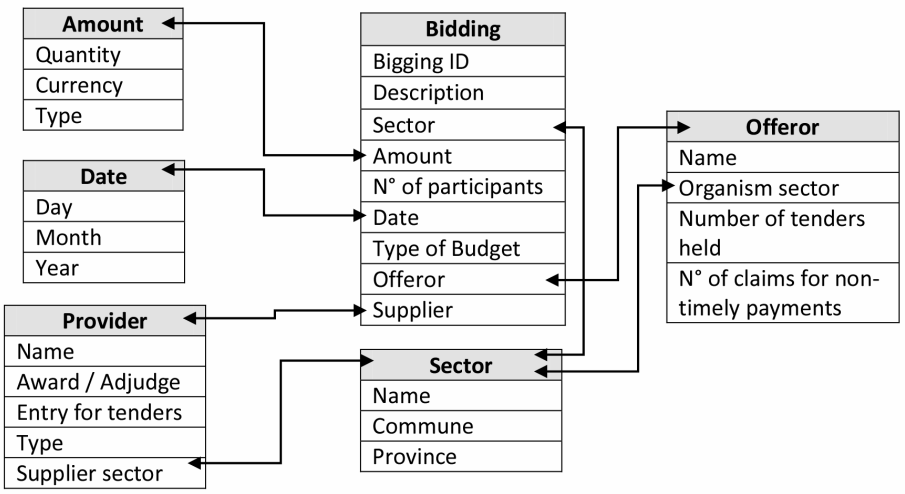

Figure 1. Relationship entity diagram.

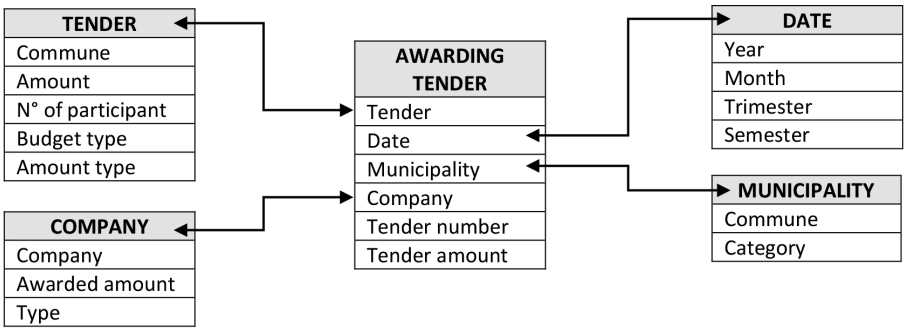

Figure 2. Logical model of DW.

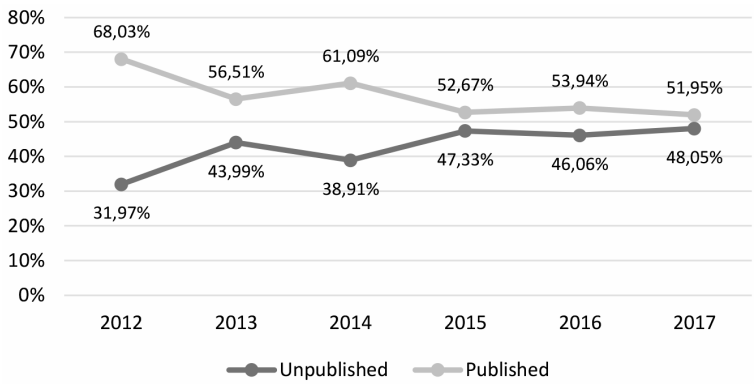

Figure 3. Type of budget.

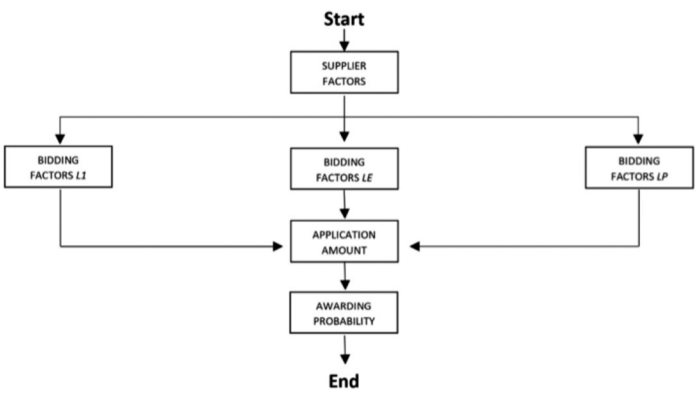

Figure 4. Query model.

Then, it is possible to identify the factors that influenced an award. For each dimension, the criteria that best represent it are selected.

- Tender dimension: These are indicated by the municipalities that pay a higher proportion of award amounts to the bid amount.
- Date dimension: Quarters are identified, where more public contracts are offered.
- Commune Dimension: The commune category offering the highest bid percentage is identified.
- Company Dimension: The companies that have received the most bids are identified. Table 3 displays the published budget criteria.

Table 3. Dimensions, published budget.

Dimensions	L1	LE	LP
Tender Dimension:	San Pedro: 90% Concepción: 89% Santa Bárbara: 88%	Cañete: 93% San Nicolás: 89% San Carlos: 87%	Negrete: 153% Laja: 128% Florida: 89%
Date Dimension	The first quarter is where the largest amount is offered with 29.72 percent, followed by the third quarter with 25.47 percent.	The third and first trimesters are the most active with 27.88 and 26.35 percent, respectively. The remaining quarters have the same number of public offers, with 22.88 percent.	The first and second quarters are the ones in which most of these types of bids are offered, with 32.9 and 24.84 percent, respectively.
Municipality Dimension	The municipalities that offer the most public tenders are Category B with 35 percent, second Category C communes with 29 percent and Communes E, with 13 percent.		
Company Dimension	1. Supplier A, with 45 tenders awarded. 2. Supplier B, with 29 tenders awarded. 3. Supplier C, 29 tenders awarded.		

Table 3 shows that for public bidding less than 100 UTM (*L1*), San Pedro is the municipality that pays a significant proportion of the awarded amount. In the first quarter, it is where the largest number of public contracts are offered.

For public tenders between 100 UTM and 1000 UTM (*LE*), Cañete is the municipality that pays a greater proportion of the amount awarded. In the third and first quarter, the largest number of public contracts are offered.

For the public tender between 1000 UTM and 2000 UTM (*LP*), Negrete is the municipality that pays a more significant proportion of the amount awarded. The largest number of public contracts are offered in the first and second quarters. Table 4 shows the criteria for the unpublished budget.

Table 4 shows that for public bidding less than 100 UTM (*L1*), San Carlos pays the highest proportion of the amount awarded in the fourth and first quarters, where the largest amount of public procurement is offered. For the public bidding between 100 UTM and 1000UTM (*LE*), Curanilahue is the municipality that pays a greater proportion of the amount awarded. The largest number of public contracts is offered in the third and first quarters. For the public bidding between 1000 UTM and 2000 UTM (*LP*), Hualpén is the municipality that pays a greater proportion of the amount awarded in the first and second quarters, where the largest amount of public procurement is offered.

Application amounts

1) *Published Budget*

The model will be contrasted through a simple linear regression analysis, an analytical technique that establishes a functional relationship between a dependent variable and an independent or explanatory variable, in which the regression coefficients are estimated; this determines the effect that the variation of the independent variable has on the behavior of the dependent variable. The R^2 and corrected R^2 are used as indicators of the significance of the model to measure the goodness-of-fit. The above, in Table 5.

Regarding R2, we can say that it represents a significant value, close to 1, for each type of bidding. Thus, the linear model is adequate to describe the relationship between these variables.

Next, in Table 6, an analysis of variance or ANOVA is observed to contrast the null hypothesis that the response variable is not affected by the independent variable. We observe that the result of the variance analysis yields a value of significance of 0.000. Therefore, we reject the hypothesis that the observed variability in the response variable can be explained by chance, and it is accepted that there is some association between the dependent variable (Amount tendered) and the independent variable (Amount Tender).

For the three models, the variable bid amount shows significant values in the statistics influencing the

Table 4. Dimensions, Non-published budget.

Dimensions	L1	LE	LP
Tender Dimension:	San Carlos: 293% Coihueco: 124% Cañete: 87%	Curanilahue: 65% Arauco: 51% Lebu: 47%	Hualpén: 248% Cañete: 210% Curanilahue: 179%
Date Dimension	The fourth and first quarter is where the largest amount is offered with 28.84 and 27.44 percent, respectively. Therefore, 56.28 percent is represented in the quarters.	The fourth and third quarters are the most active with a total of 55.8 percent.	The first quarter is where most of this type of bidding is offered with 31.8 percent.
Municipality Dimension	Municipalities with the highest number of bids with non-public budgets are Category B Communes with 30 percent, Category C municipalities with 29 percent and category A municipalities with 22 percent.		
Company Dimension	1. Supplier D, with 18 tenders awarded. 2. Supplier E, with 16 tenders awarded. 3. Supplier F, with 15 tenders awarded.		

Table 5. Model summary.

MODEL	R	R Square	R Square adjusted	Standard error of the estimation
L1	0.961	0.923	0.922	273776.203
LE	0.962	0.964	0.964	1821099.194
LP	0.987	0.975	0.975	45387513.56

Table 6. ANOVA.

Model	Items	Sum of squares	gl	Quadratic mean	F	Sig
L1	Regression	1.867E+14	1	1.867E+14	2490.497	0.000
	Residue	1.567E+13	209	7.495E+10		
	Total	2.023E+14	210			
LE	Regression	6.403E+16	1	6.403E+16	19306.342	0.000
	Residue	2.384E+15	719	3.316E+12		
	Total	6.641E+16	720			
LP	Regression	4.928E+19	1	4.928E+19	23921.850	0.000
	Residue	1.273E+18	618	2.060E+15		
	Total	5.055E+19	619			

subsidiary amount tendered. The models expressed in equations (1)-(3), obtained from the linear regression according to the type of tender are detailed below.

$$\text{For L1: } y = 0.795x + 71075 \quad (1)$$
$$\text{For LE: } y = 0.805x + 42422 \quad (2)$$
$$\text{For LP: } y = 0.825\,x - 734358 \quad (3)$$

- The table shows that for public bidding lower than 100 UTM (*L1*), when the amount increases by one peso, the award increases by 0.79 Chilean pesos.
- For public tenders between 100 UTM and 1000 UTM (*LE*), when the amount increases by one peso, the award amount increases by 0.8 Chilean pesos.
- For public tender between 1000 UTM and 2000 UTM (*LP*), when the amount increases by one peso, the award amount increases by 0.82 Chilean pesos.

2) ***Unpublished Budget***

In this case, it was not possible to predict the ideal application amount, the simple linear regression

technique was not reliable, and a very low model fit was obtained. Therefore, we worked with the ratio of the award amount to the number of applications for each category of the municipalities, which allowed us to identify which commune pays better according to the bidding process.

On the one hand, Table 7 shows that for public bidding below 100 UTM (*L1*), the semi-urban and rural communes with low development are the ones that pay the best for this type of bid with 50 percent, followed by the large metropolitan communes with average development with 37 percent. On the other hand, the medium urban communes with medium development are the ones that pay less at 27 percent.

For the public bidding between 100 UTM and 1000UTM (*LE*), the semi-urban and rural communities with medium development pay the best for this type of bid at 48 percent, followed by the medium urban communes with medium development at 43 percent. Furthermore, the largest urban communes with medium development are the ones that pay the worst at 29 percent.

3) ***Probability of adjudication***

For the public tender between 1000 UTM and 2000 UTM (*LP*), all the communes have a reasonable payment (> 80 percent), and the large metropolitan communes with medium development stand out at 137 percent. From the last stage, to determine the probability of adjudication using the aforementioned application amounts, we first analyzed the monthly averages of the participating supplier companies. Then, it is possible to know the awarding probability for a company according to the following criteria (Table 8). Therefore, the awarding probabilities are observed in Table 9.

Practical cases

In July 2018, one tender was analyzed for each type of budget to check or verify whether the obtained results collaborate in the decision-making process when applying for a tender. The bids analyzed are detailed in the corresponding tables (Table 10 and Table 11).

CONCLUSIONS

At the end of the project, it is concluded that using Business Intelligence methodologies and tools is applicable in the public procurement system for an SME in the construction industry and in Biobío and Ñuble Regions of Chile. Gaps in relevant information were found in comparison with the current *ChileCompra* reports. For administrators of construction SMEs, the inclusion of transaction data between the public entity and the supplier

Table 7. Payment proportion, unpublished budget.

Category	L1	LE	LP	Average category/ Commune
Semi-urban and rural communities, low development.	50%	35%	94%	60%
Semi-urban and rural communities, medium development.	31%	48%	116%	65%
Greater urban communes, with medium development.	29%	29%	80%	46%
Medium-sized urban communes with medium development.	27%	43%	108%	59%
Medium-urban communes with medium development.	37%	40%	137%	71%
Average/tender type.	35%	39%	107%	

Table 8. Likelihood criteria.

Company No.	Probability awarding for each company
1	100%
2	50%
3	33.30%
4	25%
5	20%

Table 9. Awarding probability.

Month	Unpublished budget			Published budget		
	L1	LE	LP	L1	LE	LP
January	20%	33%	33%	50%	50%	33%
February	33%	33%	50%	50%	50%	33%
March	33%	50%	33%	50%	33%	33%
April	25%	33%	33%	50%	33%	33%
May	33%	50%	33%	50%	33%	33%
June	25%	33%	33%	33%	33%	50%
July	33%	33%	33%	50%	33%	33%
August	33%	33%	33%	50%	33%	33%
September	33%	50%	33%	33%	50%	33%
October	33%	50%	33%	33%	50%	50%
November	33%	50%	50%	50%	50%	50%
December	50%	50%	50%	100%	33%	50%

Table 10. Case study of published budget.

Data	Strategy
Bid ID: 3976-52-L118	• Identify the dimensions of the type of tender and type of budget. • For the application amount. * Consider the regression equation: $y = 0.7951x + 75.075$, replacing Y: 1671,308 USD * Consider tender dimension. The commune of Santa Bárbara pays a proportion of 88% of the amount awarded to the published amount.
Budget type: Published	
Type: L1	
Commune: Santa Bárbara	
Tender amount: 1969,542 USD	
Amount awarded: 1626,702 USD	

Source: Prepared by the authors.
Notes: USD 712,468 value. August 19, 2019, time 16:07 UTC; regarding the amount of the tender award with the regression equation there was a variation of approximately 2.7 percent.

Table 11. Case study of unpublished budget.

Data	Strategy
Bid ID: 4429-28-LE18	• Identify the dimensions of the type of bid and type of budget. • For the application amount * Consider tender dimension. The commune of *Hualpén* pays a proportion of 22% of the amount awarded to the published amount. Replacing 14.723,220 USD.
Budget type: Unpublished	
Type: LE	
Commune: Hualpén	
Bid amount: Unpublished, between 100 and 1,000 U.T.M.	
Amount awarded: 21.544,834 USD.	

Source: Prepared by the authors.

provides a relevant background for the generation of application strategies. The proposed objectives were achieved through research on the theory of Business Intelligence and the functionalities of the platforms responsible for public procurement in Chile. Also, the descriptive analysis considered the analysis of the current situation of the construction industry in the Biobío and Ñuble Regions, previous

research related to the subject, and the analysis of the strategies used by the SMEs that operate in this market. All this is to propose a prototype of Business Intelligence in public procurement for the bidder.

The Business Intelligence methodology used is HEFESTO. It consists of four stages. It is recommended that the identification of user requirements be emphasized since this addresses the subsequent stages. In the fourth stage of data extraction, transformation, and cleaning, more time may be needed because the existing data on the bidding process are extracted manually on *ChileCompra's* different platforms. Having completed this stage with Microsoft Excel tools provides a considerable advantage for smaller companies, as it does not involve additional costs.

The results show that the published and unpublished budget types are determining factors, as they represented 51.95% and 48.05%, respectively, in the last period. Besides, some factors influence the amount, pattern, and seasoning of the awards that are identified in the tender offer periods. Regarding the plaintiff, the municipalities' participation is discovered, and which of them pays a higher percentage for the published amount. Regarding the competitors, the companies with the highest number of awarded bids and monthly averages of participants are identified for tender types *L1*, *LE,* and *LP*. In addition to the above, suitable nominations amounts are proposed for the type of budget published, where the hypothesis of the relationship between the bid amount and the awarded amount is verified using the simple linear regression model. Also, the payment ratio of the different municipalities is used for the type of unpublished budget. Furthermore, the probabilities of award by month (seasonality) of application for each type of budget are disclosed. The inclusion of the descriptive statistics tool is crucial for the user's easier visualization of the results.

Construction SME managers are recommended to implement the prototype of the proposed platform and update it in six months; this would guarantee a shorter time to incorporate the data due to the smaller amount of them and identify the changes in the bidding factors over time. The proposed sequence for applying for a tender, in the first instance, is as follows: a) identify the type of budget of the tender; b) consider the proposed criteria; c) estimate an appropriate amount of application in different cases; and d) offer in periods where the probabilities according to participating companies are equal to or greater than 33 percent. Future research is suggested to replicate this study in other geographic areas with lower levels of competition. In addition, the *ChileCompra* platform is proposed to expand data availability by providing detailed reports on public procurement transactions, including those of the requesting entity and the supplier.

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