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Operational Optimization in Chilean SMEs through Information and Communication Technologies

Optimización Operativa en las PYMEs Chilenas a través de las Tecnologías de la Información y la Comunicación

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Abstract

Objective: This study analyzes the impact of Information and Communication Technologies (ICT) on the operational efficiency of Chilean Small and Medium Enterprises (SMEs), aiming to identify the most relevant digital tools to support their development and guide public policy.

Method: We used microdata from the Fifth Longitudinal Survey of Enterprises (ELE5). An ANOVA was applied to assess differences in ICT adoption across economic sectors, and a factorial analysis was conducted to identify the most influential technological dimensions.

Results: Four key ICT dimensions—transactional, informational, infrastructure, and strategic—were found to significantly influence SME operations. The results highlight that ICT adoption varies notably across sectors, suggesting that its impact is not uniform.

Limitations: The analysis relies on cross-sectional data from 2017, limiting causal interpretations and

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excluding post-pandemic digital developments. Furthermore, binary variables reduce the granularity of technological usage assessment.
Main findings: ICTs play a strategic role in enhancing the operational efficiency of SMEs in Chile. The study provides empirical evidence to inform policy design aligned with the Digital Agenda 2030, offering a valuable baseline for future research and decision-making in emerging economies.

Información del artículo	**Resumen**
Recibido: 17 marzo 2025 Aceptado: 07 julio 2025 Clasificación JEL: O33, L25, L86, M15, Q55. Palabras clave: tecnologías de la información y la comunicación (TIC), pequeñas y medianas empresas (PYMEs), productividad, desarrollo operativo, análisis cuantitativo, políticas públicas.	**Objetivo:** Analizar el impacto de las Tecnologías de la Información y la Comunicación (TIC) en la eficiencia operativa de las pequeñas y medianas empresas (PYMEs) chilenas, con el fin de identificar qué herramientas tecnológicas son más relevantes para fortalecer su desarrollo y orientar políticas públicas eficaces. **Método:** Se utilizaron microdatos de la Quinta Encuesta Longitudinal de Empresas (ELE5), aplicando un análisis ANOVA para evaluar diferencias sectoriales en el uso de TIC, y un análisis factorial para identificar las dimensiones tecnológicas más influyentes. **Resultados:** Se identificaron cuatro dimensiones clave de las TIC (transaccional, informacional, infraestructura y estratégica) que inciden significativamente en la operación de las PYMEs. Los resultados muestran diferencias sectoriales relevantes en el uso de tecnologías, lo que indica que su impacto no es homogéneo. **Limitaciones:** El estudio se basa en datos transversales de 2017, lo que impide observar efectos causales o post-pandemia. Además, existen variables binarias que limitan la profundidad del análisis. **Principales hallazgos:** Las TIC tienen un rol estratégico en la eficiencia operativa de las PYMEs chilenas. El estudio proporciona una base empírica útil para el diseño de políticas públicas alineadas con la Agenda Digital 2030 y el fortalecimiento del ecosistema emprendedor en contextos emergentes.

Introduction

In the current globalized economy, Information and Communication Technologies (ICTs) have emerged as key driving factors of productivity, competitiveness, and innovation for Small and Medium-Sized Enterprises (SMEs). SMEs represent over 95% of all firms worldwide, accounting for up to 60% of global employment and contributing nearly 50% of GDP in many economies (OECD, 2021). However, despite their economic significance, SMEs face significant barriers, such as limited access to technological infrastructure, human capital, and funding, particularly in

developing economies (Ayyagari et al., 2007). Integrating ICTs effectively can mitigate these challenges by improving operational efficiency, facilitating decision-making processes, and expanding access to global markets (World Bank, 2020).

Building on this global perspective, Chile represents a compelling case for examining ICT adoption in SMEs. As one of Latin America's most dynamic economies, Chile has faced substantial economic challenges in recent years due to disruptive events. The social unrest, known as "Chile Despertó" (Chile Woke Up), began on October 18, 2019, in Santiago and quickly spread to other major cities. Triggered by an increase in public transportation fares, the protests escalated into widespread demonstrations, looting, and violent disturbances (OHCHR, 2019). This period of instability was further exacerbated by the global COVID-19 pandemic, caused by the SARS-CoV-2 virus, which emerged in December 2019. The pandemic severely impacted economies worldwide, with Chile experiencing significant economic disruptions (World Bank, 2020).

In this context, Small and Medium-Sized Enterprises (SMEs) were particularly vulnerable. According to data provided by the Euro-Chile Foundation, 73% of SMEs lost more than half of their usual revenue, and 45% of them reported they would not be able to continue operating in the event of a second wave of restrictions (EuroChile, 2020). In Chile, SMEs are defined as businesses with annual sales ranging between UF 2,401 and UF 100,000, where the Unidad de Fomento (UF) is an inflation-indexed monetary unit widely used in the country (Figueroa et al., 2004).

Given the critical role of SMEs in generating employment and fostering economic growth, enhancing their operational efficiency has become a priority. ICTs have been widely recognized as tools that can transform business operations, improve internal communication, and streamline processes, even in volatile economic environments (Chernova & Mitrofanova (2023). Additionally, ICTs facilitate supply chain integration and the efficient exchange of information among business partners, allowing firms to adapt to challenging conditions (Omar et al., 2010).

Furthermore, the adoption of ICTs enables SMEs to compete in globalized markets, leverage socio-economic changes, and seize opportunities presented by international trade (Sabido et al., 2013). The Economic Commission for Latin America and the Caribbean (ECLAC) emphasizes that SMEs in the region must be prepared to embrace new levels of technological advancement, organizational structures, and

communication standards to remain competitive (CEPAL, 2007). Policymakers worldwide increasingly recognize the importance of ICTs in fostering transparency, operational efficiency, and sustainable development (Kendall, 2020).

Chile is at a pivotal moment to capitalize on ICT adoption for SMEs. This research seeks to answer the question: Through which Information and Communication Technologies can we encourage and improve the operational efficiency of small and medium-sized enterprises? We focus particularly on policy measures that Chile can implement to enhance the operational development of ICTs in SMEs following the 2019–2020 economic crisis.

To address this question, we adopt a quantitative methodology using data from the Fifth Longitudinal Survey of Enterprises (ELE5) conducted in 2017. This survey is designed to be both a cross-sectionally and longitudinally representative, covering a total of 339,002 enterprises. We employ two quantitative techniques: first, an analysis of variance (ANOVA) to determine the utilization of ICTs across different economic activities within Chilean SMEs; and second, a factorial analysis to identify the most relevant technological dimensions. This approach enables us to propose actionable measures that the Chilean government can adopt to support SMEs in improving their operational efficiency and economic productivity.

The article is organized into six sections. Section 2 reviews theoretical and empirical literature on ICTs and SMEs. Section 3 presents the research hypotheses. Section 4 details the empirical methodology and results. Section 5 discusses key findings and public policies proposals aligned with Chile's Digital Agenda 2030 (Chile Agenda, 2021). Section 6 concludes with implications for policy and SME development.

1. Theoretical Framework

1.1 Information and Communication Technologies in Small and Medium-Sized Enterprises

The impacts generated by steam engines, electricity, and fuel during previous industrial revolutions have now been succeeded by Information and Communication Technologies. These technologies—encompassing hardware, software, communications, and associated services—have fundamentally altered processes and activities across all aspects of life (Tricoci, 2015).

ICTs are regarded as general-purpose technologies that affect the entire economy. This includes communicative devices and applications such as radios, televisions, mobile phones, computer networks, satellite systems, videoconferencing, and e-learning (Van Ark et al., 2011). These advancements have brought about a transformation in education, employment, and production systems, giving rise to new paradigms.

Unlike past technological advancements that focused on knowledge production, the current revolution centers on the application of knowledge and information for generating new knowledge and improving communication. This creates a cumulative feedback loop between innovation and its uses (Avgerou et al., 2006). Thus, these new technologies are not mere tools but processes to be developed, leading to significant changes in the traditional work environment.

The integration of ICTs enables firms to enhance both internal and external operations, providing substantial benefits while maintaining competitive advantages (Dibrell et al., 2008). Consequently, it is essential for SMEs to increasingly adopt ICTs as part of their business activities and invest in technological infrastructure.

Studies such as Naggi (2011) demonstrate that the adoption of ICTs is significantly related to employee performance in SMEs, particularly when accompanied by appropriate training and managerial support. Similarly, ICT adoption enables SMEs to compete globally, develop closer relationships with customers and suppliers, and embed technology into their commercial strategies (Tarutė & Gatautis, 2013).

The upward trend in ICT adoption among SMEs over the last decade stems from two main factors: (1) changes in economic market dynamics and (2) the positive impact of ICTs on business goals (Oyelaran & Lal, 2006). However, despite their benefits, SMEs often face financial constraints that limit their ability to adopt emerging technologies such as software, hardware, and infrastructure (Molina-Ycaza et al., 2016).

The degree of ICT integration and usage has a significant impact on SME performance. However, ICT adoption alone is insufficient—its proper integration and alignment with business processes are critical for achieving improved performance (Azam, 2015). ICT platforms such as mobile devices, the Internet, and computers offer four main benefits to SMEs: (1) increased visibility, (2) better access to information, (3) the ability to overcome traditional trade barriers, and (4) improved financial

transactions (Tarute & Gatautis, 2013). Aligning ICT investments with internal capabilities and organizational processes further enhances these outcomes (Consoli, 2012).

1.2 Effects of Information and Communication Technologies by Economic Activity

As SMEs seek to improve their efficiency, competitiveness, and reach in an increasingly globalized market, analyzing the effects of ICTs across different economic sectors becomes essential. This analysis provides a holistic understanding of how ICTs are redefining SME operations in diverse economic contexts:

1. *Agriculture, Forestry, and Fishing (Sector A):* The optimization of regional agricultural development through ICTs requires targeted policies to overcome barriers limiting adoption in less advanced areas (Hopkins, 2012). ICTs have the potential to facilitate access to and organization of knowledge for farmers, yet significant challenges remain. Regional evidence highlights persistent barriers to ICT dissemination and adoption, emphasizing that implementation alone cannot resolve existing disparities.
2. *Mining and Quarrying (Sector B):* In mining, ICTs play a crucial role in optimizing processes, from designing efficient networks to determining the precise amount of explosives and accessories required. These technologies enhance safety in underground environments while improving operational efficiency (De Piero et al., 2019; Alvarado et al., 2015).
3. *Manufacturing (Sector C):* In industries transforming raw materials into products, ICT adoption is vital for improving production efficiency. However, the perceived high cost of technology remains a challenge for SMEs (Peñaloza, 2018). ICTs allow for faster production processes, better resource utilization, and enhanced service delivery (Valderrama & Neme, 2011).
4. *Electricity, Water, and Gas Supply (Sectors D-E):* ICTs serve as strategic tools in managing water, gas, and electricity systems. Technologies such as Geographic Information Systems (GIS) enable better organization, storage, analysis, and modeling of real-time data (Saenz, 2015).
5. *Construction (Sector F):* Construction projects are inherently complex, requiring robust decision-making processes. ICTs, particularly systems like OLAP and Data Warehousing, have proven effective in improving decision-making and

comprehensively integrating the construction process (Martínez & Marín, 2013).

6. *Wholesale and Retail Trade, Vehicle Repair (Sector G) and Services (Sectors L-N):* ICTs, including the Internet and online platforms, have enabled businesses to thrive by providing consumers with a safe, convenient, and cost-effective environment for transactions (Rodríguez, 2018).
7. *Transportation and Storage (Sector H):* The application of ICTs in logistics operations improves service quality, reduces costs, and enhances decision-making processes (Berrones-Sanz, 2012). Similarly, in Accommodation and Food Services (Sector I), ICTs facilitate the storage, processing, and distribution of information, improving efficiency and service delivery (Rodriguez, 2016).
8. *Financial and Insurance Activities (Sector K):* The financial sector has undergone significant transformation due to ICTs, evolving from a money management model to one centered on information processing and administration. ICTs are now an inseparable component of financial systems (Ontiveros, 2011).

A detailed analysis of ICT shows impacts across various economic sectors highlighting their transformative potential. While ICTs can address regional disparities in agriculture, they optimize safety and operations in mining and enhance production in manufacturing. In sectors like utilities, construction, and financial services, ICTs provide critical tools for decision-making and efficiency. Ultimately, aligning ICT adoption with organizational capabilities remains essential for SMEs to fully realize these benefits.

2. Hypotheses

- **Hypothesis 1 (H1):** At least one economic sector will exhibit a significant influence of ICT-related dimensions on the operational development of SMEs. This hypothesis evaluates how sector-specific characteristics affect the adoption and use of ICTs in business operations.
- **Hypothesis 2 (H2):** The incentivized use of specific ICTs can enhance SME operational performance by optimizing processes, resource management, and decision-making, leading to greater efficiency and productivity. This hypothesis underscores the role of ICTs in automation, data analysis, and communication, ultimately improving business competitiveness.

3. Empirical Analysis

In this section, we present the data and methods used to test the proposed hypotheses.

3.1 Data

We utilized the 2017 Longitudinal Survey of Enterprises (ELE 5), conducted by Chile's National Institute of Statistics (INE) and the Ministry of Economy. This survey covers key dimensions for business development, such as: technology, training, productive linkages, research, and human and financial resources.

The ELE 5 sampling design is probabilistic and stratified, where the strata are defined by economic activity section and firm size. Economic activity sections follow the national adaptation of the International Standard Industrial Classification (ISIC4.CL 2012), while firm size is determined based on total annual sales measured in "*Unidades de Fomento (UF)",* which is an inflation-indexed monetary unit widely used in Chile to adjust prices, contracts, and economic indicators, ensuring values remain stable relative to inflation (INE, 2020).

The survey was administered to 339,002 companies, excluding those with annual sales of USD $31,595 or less. The sample is representative in terms of firm size (micro, small, medium, and large, based on sales) and economic sector (INE, 2020). However, only 6,480 surveys were successfully completed after undergoing rigorous review and validation processes. These companies represent businesses that began operations in 2016.

Focusing exclusively on SMEs, we filtered companies with annual sales in the range of 2,401 UF to 100,000 UF, which are classified as SMEs in Chile (SII, 2020). This filtering reduced our sample to 2,643 firms, enabling us to work with microdata.

The pre-processing of the data involved eliminating missing values. Specifically, the rule applied was as follows: if a value was missing, we attempted to infer the missing response based on other available data to preserve the case. If this was not possible, the entire case was removed (Table 1).

Table 1
Total SMEs Distributed by Industry According to Annual Sales in UF

Economic Activity	Medium-Sized	Small 2	Small 1	Total SMEs
Agriculture, Forestry, and Fishing (A)	90	113	51	254
Mining and Quarrying (B)	37	89	24	150
Manufacturing Industries (C)	37	80	197	314
Electricity, Water, and Gas Supply (D-E)	25	0	0	25
Construction (F)	77	122	82	281
Wholesale and Retail Trade; Vehicle Repair (G)	272	120	63	455
Transportation and Storage (H)	35	67	48	150
Accommodation and Food Services (I)	29	22	10	61
Information and Communications (J)	16	24	28	68
Financial and Insurance Activities (K)	104	0	0	104
Service Activities (L-N)	112	74	84	270
Professional, Scientific, and Technical Activities (M)	56	191	101	348
Other Services, Arts, Entertainment, etc. (R-S)	24	111	28	163
Total	**914**	**1013**	**716**	**2643**

Source: Own elaboration based on data from the Longitudinal Survey of Enterprises (ELE5).

The ICT variables considered are ordinal, as they represent categories with an implicit ranking (e.g., the company uses or does not use a specific technology). Annex 1 presents the descriptive statistics for each of these variables.

Below, we list the selected variables related to the incidence of ICT usage, supported and framed by previous literature:

Table 2
List of ICT Usage Intensity and Organizational Performance Variables

Variable	ELE-5 Code	Description	Literature
Computer	Computador	Number of active desktop and portable computers used by the company.	(Ministerio de Economía, 2020; Dibrell, Davis, & Craig, 2008)
Smartphone	J008	Number of active smartphones in use.	(Ministerio de Economía, 2020; Figueroa, Lizana, Sánchez, & Silva, 2004)

Administrative Software	J076	Use of financial software, ERP, and other tools to manage and integrate information processes across company departments.	
Sales and Marketing Software	J012	Use of sales, marketing, and customer management software.	(Subsecretaría de Economía, 2006; Hernández, Fernández, & Baptista, 1996; Medina & Posso, 2018; Castillo, 2019; Trillo & Hernández, 2013; Alvear & Ronda, 2005)
Industry-Specific Software	J013	Use of software tailored to the company's sector (e.g., reservation systems, process control).	
Cloud Computing Software	J014	Use of cloud computing software for internet-based computing services, including storage capacity and computational power.	
IT Security Software	J015	Use of IT security software (e.g., antivirus, firewall).	
Dial-Up and Broadband Connection	J078	Use of dial-up and broadband connections.	(Consoli, 2012; Oyelaran & Lal, 2006; Ramaswamy, 2016)
Fixed Broadband (ADSL or Cable)	J017	Use of fixed broadband connections (ADSL or cable).	
Dedicated Internet	J018	Use of dedicated internet services (e.g., fiber optic or private IP network).	
Smartphone or Tablet Usage	J020	Use of smartphones or tablets with independent internet access (via SIM or mobile chip).	
Email	J024	Use of email and instant messaging.	(Sabido, García, & Góngola, 2013)
Company and Product Information	J041	The company's website provides details about the business, its products, and services.	(Santoleri, 2013)
Product or Service Sales via Website	J043	The company's website allows for product and/or service sales.	(Dibrell, Davis, & Craig, 2008)
Online Payments	J044	Use of the company's website for online payments.	(Santoleri, 2013; Subsecretaría de Economía, 2006)
Online Reservations	J079	The company's website allows customers to make online reservations.	(Santoleri, 2013; Gopalakrishnan & Damanpour, 1997)
Internet Purchases	J083	Number of companies that generate purchases through the internet.	(Santoleri, 2013)
Internet Sales	J084	Number of companies that generate sales through the internet.	(Santoleri, 2013)
Social Media	J080	Number of companies that use social media platforms.	(Tricoci, 2015; Van Ark, Gupta, & Azeez, 2011)

Source: Own elaboration.

3.2 Methodology

This research employs two quantitative techniques. The first is an Analysis of Variance (ANOVA), which aims to determine the significance of the use of Information and Communication Technology (ICT) variables across different economic activities of Chilean SMEs. The second technique is Factor Analysis, designed to reduce data dimensionality. Its objective is to identify the minimum number of dimensions capable of explaining the maximum amount of information contained in the dataset (Gonzalez, 2009). As part of this analysis, we will generate ICT factors relevant to small and medium-sized enterprises.

To simplify the subsequent formation of ICT usage clusters, we have chosen to organize the variables based on the categorization proposed by Aral and Weill (2007). This classification comprises of four ICT groupings, enabling a more fluid and effective structuring of the variables according to their nature and application in each economic sector.

Below is a summary of the four main classifications, along with their expected operational benefits:

Table 3
ICT Classification and Expected Operational Performance (Aral & Weill, 2007)

ICT Asset	Strategic Purpose	Expected Operational Benefits
Infrastructure	Foundation of shared IT services. Provides a flexible base for future business initiatives (e.g., servers, networks, computers).	-Short term: higher costs, lower profitability (due to disruptions). - Increased market value. -Long term: higher benefits, lower costs.
Transactional	Automates processes, reduces costs, and increases business volume per unit cost.	- Reduces costs.
Informational	Provides information for management, accounting, reporting, decision support, planning, control, analysis, and data mining.	- Lower costs. - Higher profitability. - Increased product innovation.
Strategic	Supports entry into new markets, provides new services, or enables new products.	- Higher profitability. - Increased product innovation.

Source: (Oliva, Carvajal, & Cataldo, 2018)

4. Discussion and Results

4.1 General ANOVA Analysis of the Model

This section analyzes whether the use of Information and Communication Technologies (ICT) significantly influences the operational performance of Chilean SMEs across different economic sectors. To do so, we applied a one-way Analysis of Variance (ANOVA), a statistical method used to determine whether there are significant differences in the means of a dependent variable across multiple groups (Gonzalez, 2009).

In our case, we used the variable "CIIU_RECO" (economic sectors) as the factor and considered ICT indicators as the dependent variables. The null hypothesis assumes no significant differences in ICT usage across sectors, implying a uniform impact. Conversely, the alternative hypothesis—tested in this study—proposes that at least one ICT variable differs significantly between sectors, indicating a differentiated effect on operational capabilities.

Although the data used in this analysis are based on a 2017 pre-pandemic survey (ELE5), the findings provide a valid structural benchmark for understanding ICT adoption in SMEs. Scientific literature confirms that the COVID-19 pandemic accelerated digital transformation globally: over 70% of SMEs increased their use of digital tools between 2020 and 2021 (OECD, 2021). Moreover, technologies such as artificial intelligence, automation, and digital platforms became essential for maintaining business continuity and boosting resilience (McKinsey, 2023).

However, most of the post-pandemic research has focused on large enterprises or digitally mature/advanced firms, leaving a gap in the literature regarding SMEs, especially in emerging economies. Therefore, this pre-pandemic diagnostic remains highly relevant for identifying foundational ICT adoption patterns in SMEs—particularly those underrepresented in recent data. These patterns offer a critical baseline to assess the evolving impact of emerging technologies on SME competitiveness, productivity, and digital strategy (Zafar, 2022).

Table 4 summarizes the ANOVA results and identifies the sectors in which ICT variables show statistically significant differences, supporting the hypothesis that ICT adoption impacts operational development heterogeneously across economic sectors.

Table 4
General ANOVA Model: Test of Between-Subject Effects

Variable		Sum of Squares	df	Mean Square	F	Sig.
Computer	Between Groups	173,855.655	12	14,487.971	17.746	0
	Within Groups	2,147,120.230	2630	816.396		
	Total	2,320,975.890	2642			
Smartphone	Between Groups	5,844.089	12	487.007	5.282	0
	Within Groups	242,476.422	2630	92.196		
	Total	248,320.512	2642			
Administrative Software	Between Groups	15.739	12	1.312	6.892	0
	Within Groups	485.253	2550	0.190		
	Total	500.991	2562			
Sales and Marketing Software	Between Groups	25.555	12	2.130	18.705	0
	Within Groups	290.319	2550	0.114		
	Total	315.874	2562			
Industry-Specific Software	Between Groups	21.266	12	1.772	12.922	0
	Within Groups	349.725	2550	0.137		

	Total	370.991	2562			
Cloud Computing Software	Between Groups	8.438	12	0.703	6.459	0
	Within Groups	277.586	2550	0.109		
	Total	286.024	2562			
IT Security Software	Between Groups	21.391	12	1.783	7.962	0
	Within Groups	570.878	2550	0.224		
	Total	592.269	2562			
Dial-Up Connection, Narrowband	Between Groups	0.592	12	0.049	1.921	0.028
	Within Groups	67.554	2630	0.026		
	Total	68.146	2642			
Fixed Broadband (ADSL or Cable)	Between Groups	13.769	12	1.147	4.912	0
	Within Groups	614.388	2630	0.234		
	Total	628.157	2642			
Dedicated Internet (Fiber Optic or Private IP Network)	Between Groups	28.619	12	2.385	11.756	0
	Within Groups	533.527	2630	0.203		
	Total	562.146	2642			
Mobile Broadband (USB)	Between Groups	5.427	12	0.452	3.884	0
	Within Groups	306.265	2630	0.116		
	Total	311.692	2642			
Email	Between Groups	0.038	12	0.003	0.915	0,531
	Within Groups	8.930	2567	0.003		
	Total	8.969	2579			
Company and Product Information	Between Groups	66.247	12	5.521	24.501	0
	Within Groups	578.405	2567	0.225		
	Total	644.651	2579			
Online Reservations	Between Groups	6.347	12	0.529	14.246	0
	Within Groups	95.298	2567	0.037		
	Total	101.645	2579			
Online Product or Service Sales	Between Groups	2.935	12	0.245	5.330	0
	Within Groups	117.813	2567	0.046		
	Total	120.748	2579			
Online Payments	Between Groups	1.243	12	0.104	2.468	0.003
	Within Groups	107.720	2567	0.042		
	Total	108.963	2579			

Social Media	Between Groups	27.639	12	2.303	12.175	0
	Within Groups	485.621	2567	0.189		
	Total	513.260	2579			

Degrees of Freedom (df): Indicates how many values in a distribution are allowed to vary.
Significance (Sig.): The p-value indicates the probability of observing the results if the null hypothesis (no significant differences between groups) is true. A low p-value (typically <0.05) suggests there is enough evidence to reject the null hypothesis.
F-Statistic (F): The F-ratio compares the variability between groups to the variability within groups in the ANOVA test.

Source: Own elaboration based on data from the Longitudinal Survey of Enterprises (ELE5).

Based on Table 4, a one-way ANOVA test was conducted by performing nineteen pairwise comparisons between variables. The independent variable considered was "CIIU_RUBROS", representing the economic activities of SMEs, while the dependent variables were: Computer, Smartphone, Administrative Software, Sales and Marketing Software, Industry-Specific Software, Cloud Computing Software, IT Security Software, Dial-Up Connection, Broadband, Fixed Broadband (ADSL or Cable), Dedicated Internet, Use of Smartphone or Tablet, Email, Company and Product Information, Online Product or Service Sales, Online Payments, Online Reservations, Internet Purchases, Internet Sales, and Social Media.

A significant difference was observed in the majority of the ICT variables based on the p-value criterion (Sig. ≤ 0.05). This indicates that statistical evidence was found to reject the null hypothesis for most ICT variables, suggesting that these differences are statistically significant at a 5% significance level. Consequently, at least one ICT variable plays a relevant role in the operational development of various economic activities.

In other words, there is a statistically significant relationship between the use of ICT variables and the economic activities of small and medium-sized enterprises, which supports their operational development. However, the variable "Email" did not show a significant difference. This could be attributed to its status as one of the oldest operational technologies in the market (Albarrán, 2001).

4.2 Factor Analysis

Factor analysis was employed to identify the most relevant ICT categories among small and medium-sized enterprises (SMEs) across various economic activities. This analysis aims to generate one or more policy proposals that support the operational development of these enterprises. To achieve this goal, the variable "size" was recoded, excluding the "Large" enterprises category. Only the categories "Medium," "Small 1," and "Small

2" were retained, creating a new single category variable, which we named "SME."

Table 5
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**0,721**
Bartlett's Test of Sphericity	Approx. Chi-Square	6899,908
	Df.	105
	Sig.	0

Source: Own elaboration based on data from the Longitudinal Survey of Enterprises (ELE5).

According to Table 5, the KMO value of 0.721 confirms that the correlation structure among the variables is suitable for factor analysis. This value exceeds the typically acceptable threshold of 0.6 and approaches what is considered a good value of 0.7. Similarly, Bartlett's test, with a chi-square statistic of 6,899 and a p-value of 0.000, provides strong evidence to reject the null hypothesis, indicating significant correlations among the variables in the population.

This analysis was further refined using anti-image correlation matrices, which enabled us to exclude certain variables with limited relevance for SMEs. For instance, the variable *"Dial-Up Connection"* was removed due to a p-value exceeding 0.05, suggesting its usage is predominantly associated with large enterprises rather than SMEs.

Table 6
Total Variance Explained

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% de of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3,125	20,836	20,836	3,125	20,836	20,836	2,222	14,797	14,797
2	1,997	13,311	34,147	1,997	13,311	34,147	1,766	11,772	26,569
3	1,181	7,875	42,023	1,181	7,875	42,023	1,685	11,235	37,804
4	1,045	6,965	48,988	1,045	6,965	48,988	1,678	11,183	48,988
5	0,97	6,468	55,456						
6	0,934	6,225	61,681						

7	0,889	5,925	67,606
8	0,846	5,638	73,245
9	0,779	5,194	78,439
10	0,723	4,823	83,262
11	0,676	4,509	87,771
12	0,628	4,187	91,958
13	0,589	3,927	95,885
14	0,386	2,576	98,462
15	0,231	1,538	100

Extraction Method: Principal Component Analysis.

Note: Only cases where SME = SME were used during the analysis phase

Source: Own elaboration based on data from the Longitudinal Survey of Enterprises (ELE5).

Table 6 presents the decomposition of variance across the various factors. As shown, the first four components explain **49% of the total variance**, leading to the generation of **four dimensions**. This suggests that nearly half of the variance can be attributed to these four factors.

It is important to note that the remaining 51% of the variance could be explained by other ICT variables or by additional factors not included in this study. However, derived from the literature reviewed (as summarized in Table 2), we focused on the most significant ICT variables that directly impact small and medium-sized enterprises.

Table 7
Rotated Component Matrix

	Component			
	1	2	3	4
Online Product or Service Sales	0,878*	0,103	-0,016	0,039
Internet Sales	0,855*	0,079	-0,055	0,094
Online Payments	0,653*	0,147	0,166	-0,012
Company and Product Information	0,133	0,619*	0,092	0,18
Social Media	0,18	0,515*	-0,041	0,159
Sales and Marketing Software	0,06	0,496*	0,095	0,04
Administration Software	-0,09	0,487*	0,291	0,156
Reservations	0,325*	0,467*	-0,095	-0,049
Computers	0,04	0,13	0,868*	0,043
Smartphone	0,029	0,041	0,841*	0,216
Use of Smartphones or Tablets with Internet Access (SIM or Mobile Chip)	0,051	-0,253	0,053	0,739*
IT Security Software	-0,07	0,378	0,115	0,591*
Cloud Computing Software	0,006	0,296	0,113	0,511*
Internet Purchases	0,339*	0,179	-0,088	0,455*
Specialized Software	0,012	0,183	0,212	0,411*

Extraction Method: Principal Component Analysis

Rotation Method: Varimax with Kaiser Normalization
a. Rotation converged in 5 iterations.
b. Only cases where SME = SME were included during analysis.

Source: Own elaboration based on data from ELE5.

Table 7 presents the rotated component matrix, showcasing the factorial solution for the selected ICT variables. Four significant dimensions were identified, marked with an asterisk (*), which provide a clear structure for categorizing ICT tools. These dimensions align with the classification proposed by Aral & Weill (2007):

1. *Transactional Dimension:* This factor captures technologies that facilitate online business processes, including "Online Product or Service Sales," "Internet Sales," "Online Payments," and variables like "Reservations" and "Internet Purchases." These technologies play a key role in reducing costs and sales process automation.
2. *Informational Dimension*: This factor includes ICT tools that provide critical business insights and improve communication, such as "Social Media," "Company and Product Information," "Sales and Marketing Software," and "Administration Software." These technologies support better decision-making and enhance internal and external communication.
3. *Infrastructure Dimension*: This group reflects the foundational ICT tools for business operations, including "Computers" and "Smartphones." These technologies are essential for basic operational functionality in SMEs.
4. *Strategic Dimension:* This factor includes technologies that enable broader strategic goals, such as "IT Security Software," "Cloud Computing Software," "Use of Smartphones or Tablets with Internet Access," and "Specialized Software." These tools support new market entry strategies, enhanced services, and product innovations.

4.3 Public Policy Proposals by Axis

Before presenting the policy recommendations derived from this study, it is necessary to reflect briefly on the analytical scope and methodological boundaries that frame the interpretation of our findings. Acknowledging these limitations not only enhances the transparency of the research but also provides direction for future academic and policy study in this field.

First, the analysis is based on cross-sectional data from the 2017 Fifth Longitudinal Survey of Enterprises, which restricts the ability to assess

causal relationships or long-term effects of ICT adoption. Second, the database does not capture post-pandemic technological dynamics, particularly the emergence of advanced tools such as artificial intelligence, automation, or digital collaborative platforms, which limits the contemporaneity of some conclusions. Third, most ICT variables are binary, lacking granularity on usage intensity or technological maturity. Finally, some economic sectors with low representation in the sample have limited statistical reliability, which restricts the validity of sector-specific comparisons. These limitations, while not undermining the validity of the results, do signal important opportunities for future research with updated and diversified methodological approaches.

Transactional Axis Policies

The transactional axis includes ICT tools such as online product or service sales, internet sales, online payments, online purchases, and reservation systems, all of which are closely tied to digital commerce. Small and medium-sized enterprises (SMEs) face significant challenges regarding trust and the security of transactions (OECD, 2004), which often leads buyers to favor larger companies, particularly with the rise of social media platforms.

As shown in Table 8, 68% of medium-sized enterprises and 74% of small enterprises do not engage in e-commerce or online transactions, despite its critical role in improving operational productivity (Tarazona et al., 2013).

Table 8
Distribution of Enterprises by E-commerce Engagement in 2017 and Size

E-Commerce	Purchases Sales	Purchases Only	No E-Commerce
Large	8%	23%	63%
Medium	7%	23%	68%
Small	8%	17%	74%
Micro	4%	14%	80%

Source: Own elaboration based on data from ELE5.

To address this, public policies are needed to boost confidence both for buyers, who require secure online platforms, and for sellers, who must be equipped to launch e-commerce platforms effectively.

One proposal is to promote business incubators – structured programs that support SMEs through mentorship, resources, and technology adoption – to help them develop their business ideas effectively. These

incubators, potentially through partnerships with public and private universities, would provide technological mentorship and accelerate the adoption of ICT tools. Additionally, incentives could be introduced for creating national platforms for instant payment solutions, supported by fiscal benefits for SMEs.

These measures would reduce transaction costs and increase trust in SMEs' digital commerce capabilities, enhancing operational efficiency and improving buyer confidence.

Informational Axis Policies

ICT tools such as social media, marketing software, administration software, and reservation systems play a key role in operational efficiency by enabling data management, reporting, and strategic planning. However, Chile faces significant challenges, such as low educational quality and labor instability, particularly in small enterprises and freelance work (Chile's National Productivity Commission, 2018; Carrillo et al., 2018).

To address these challenges, public policies should focus on integrating ICT-learning into educational curricula, combining theoretical knowledge with practical applications. This would equip students with digital skills relevant to the labor market and strengthen SME productivity through effective use of technologies.

Additionally, advanced technologies such as Artificial Intelligence (AI) and Augmented Reality (AR) could revolutionize SME operations. Establishing National Predictive Analytics Centers that combine AI with ICT would automate processes, reduce manual workloads, and improve operational efficiency, thereby contributing to economic growth and production increases.

Infrastructure Axis Policies

Infrastructure tools, such as computers and smartphones, are fundamental for business operations. According to the ELE5 survey, 97.8% of Chilean SMEs have at least one of these devices, yet 2.2% lack access, which represents a significant challenge. Limited access to basic infrastructure restricts operational development and highlights the need for government subsidies and technological support.

To further enhance infrastructure, International Business Intelligence Platforms should be developed to enable SMEs to leverage advanced ICT tools such as data analytics and machine learning. These platforms would facilitate strategic decision-making and improve competitiveness in global markets (Wamba et al., 2017).

Additionally, creating collaborative networks among SMEs, supported by ICT tools, would foster resource sharing and interconnection in key areas such as supply chain management, research and development, and marketing. These collaborative efforts would optimize operational efficiency, create employment opportunities, and strengthen Chile's economic foundation (Kusmantini et al., 2020).

Strategic Axis Policies

The strategic axis includes ICT tools such as smartphones or tablets with internet access (SIM or mobile chip), IT security software, cloud computing software, specialized software, and internet purchases. These tools are essential for accessing new markets, delivering new services, and driving innovation.

Strategic ICT tools must be integrated into SMEs' operational models, as they enable businesses to make accurate predictions, monitor performance in real-time, and align operations with strategic goals (Ca' Zorzi, 2011). However, advanced technologies such as IT security software and cloud computing often remain out of reach for SMEs due to high investment costs.

To mitigate this, the government could establish agreements with ICT providers to reduce software costs by 46% for SMEs, making these tools more accessible. Additionally, municipal support programs should be implemented to train SME staff on effective software utilization, fostering a critical and analytical approach to data-driven decision-making.

Programs for Access to Emerging Technologies could further enhance SME capabilities by promoting collaboration with software developers. Such programs would enable SMEs to adopt advanced technologies, including AI, blockchain, and AR, while fostering partnerships within a digital business ecosystem. This ecosystem would provide integrated platforms for communication, intellectual exchange, and joint project management, ultimately driving innovation and improving operational efficiency.

Conclusions

This study highlights the critical role that Information and Communication Technologies (ICTs) play in the operational performance of Chilean SMEs. Based on robust statistical analyses, the findings indicate that ICT adoption is not uniform across sectors and that certain technologies—particularly those related to internal communication, strategic control, and administrative automation—contribute significantly to operational efficiency. These insights are essential for informing public policy measures aimed at reducing technological gaps and enhancing productivity in SMEs.

By identifying four core ICT dimensions, this research provides a structural framework to support policy implementation aligned with Chile's Digital Agenda 2030. However, the study also acknowledges methodological limitations such as the cross-sectional nature of the data, potential biases in sectoral representation, and the pre-pandemic timing of the dataset. Despite these limitations, the results remain relevant as a foundation for understanding ICT dynamics in the SME sector.

Future research should address these limitations by incorporating longitudinal data to track the evolution of ICT adoption over time, particularly in response to post-pandemic transformations and the emergence of advanced technologies like artificial intelligence and automation. Additionally, qualitative approaches—such as case studies or in-depth interviews with SME owners—could provide rich, context-specific insights into the barriers and motivations surrounding digital transformation.

Comparative studies between Chile and other Latin American countries could also be valuable for identifying regional patterns and policy gaps. Exploring variables such as digital literacy, institutional support, and access to financing could deepen understanding of the systemic conditions that shape ICT adoption in SMEs. These areas of investigation would contribute to designing more inclusive, adaptable, and resilient public policies that encourage sustainable innovation across diverse entrepreneurial ecosystems.

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Appendix 1
Descriptive Statistics for ICT Usage Variables

Descriptive Statistics					
	N	Mínimum	Máximum	Mean	Standard Deviation
Smartphone	2643	0	300	3,23	9,695
Computer	2643	0	950	8,3787	29,63937
Administration Software	2563	0	1	0,27	0,442
Sales and Marketing Software	2563	0	1	0,14	0,351
Specific-purpose Software	2563	0	1	0,18	0,381
Cloud Computing Software	2563	0	1	0,13	0,334
IT Security Software	2563	0	1	0,36	0,481
Dial-up Connection, Narrowband	2643	0	1	0,03	0,161
Fixed Broadband, ADSL or Cable	2643	0	1	0,61	0,488
Dedicated Internet (Fiber Optics or Private IP Network)	2643	0	1	0,31	0,461
Mobile Broadband via USB	2643	0	1	0,14	0,343
Smartphone or Tablet with Internet Access (SIM or Mobile Chip)	2643	0	1	0,27	0,443
Email	2580	0	1	1	0,059
Company and Product Information	2580	0	1	0,49	0,5
Online Reservations	2580	0	1	0,04	0,199
Online Sales of Products or Services	2580	0	1	0,05	0,216
Online Payments	2580	0	1	0,04	0,206
Social Media	2580	0	1	0,27	0,446
Online Purchases	2580	0	1	0,27	0,442
Online Sales	2580	0	1	0,07	0,26
Valid N (listwise)	2545				

Source: Authors' elaboration based on data from ELE5.