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The adoption of ICT as an enabler of frugal innovation to achieve customer satisfaction. The mediating effect of frugal innovation

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Abstract

The purpose of this research empirically examines the influence of information and communication technologies (ICTs) adoption and frugal innovation on customer satisfaction among small and medium-sized (SMEs) Colombian firms and determine whether the frugal innovation has a mediating role on the relationship between ICT adoption and customer satisfaction. A quantitative approach and cross-sectional design was applied through the Structural Equation Modeling. A simple random sampling technique and a self-administered questionnaire were used to gather data from a sample of 145 business owners in the Department of Bogota, Colombia. The outcomes indicate that ICT adoption has a significant influence on both frugal innovation and customer satisfaction. Furthermore, greater levels of frugal innovation increase customer satisfaction. Moreover, the frugal innovation demonstrated to play a significant partial mediating effect on the relationship between ICT adoption and customer satisfaction.

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Keywords: ICT adoption; Frugal innovation; Customer satisfaction; PLS-SEM; SMEs.

1. Introduction

The 21st century has been defined by rapid technological change, where innovation is at the center of competition in order to meet customers' needs in a more efficient and sustainable way [1]; furthermore, the COVID-19 outbreak placed companies all over the world -especially SMEs- under ever more pressure to adopt ICT as a survival strategy [2]. The challenge for SMEs in developing countries is greater, as they must do more

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with even less [3]. In this context, ICT adoption has proved to have a positive impact on innovation in these firms [4]; moreover, ICT as a mean of knowledge management [5] makes possible a better integration between companies and customers, improving frugal innovation capabilities, which help develop affordable and sustainable products with great value for the market [6].

The frugal innovation (FI) phenomenon has gained significant attention recently, not only in the context of other cutting edge phenomena as Industry 4.0 [7] but also after a game-changing event as COVID-19 [8]. FI, as part of the new technological paradigm [9], aims to incremental innovations at reduced costs, especially in emerging economies [10]. This approach has been evolving and diffusing not only in emerging markets but also in developed ones [6], thanks to both its capability to connect and to create new markets and customers [11] and its cost-cutting approach [12]. In this vein, this article aims to empirically demonstrate the impact of FI and ICT adoption on customer satisfaction (CS), in SMEs of a Latin-American country. On the one hand, previous research has found positive relationships among those variables, but has been focused on traditional innovation [13]; on the other hand, ICT has shown positive impact on CS [14], but without exploring the mediating effect of FI.

This research makes a significant contribution in a field of study that has been traditionally focused in Asia, producing information relevant for Latin-American SMEs and practitioners, researchers, and business leaders. Accordingly, this study provides empirical evidence of the relation among the three variables of interest, especially, the direct and indirect effects of ICT adoption on CS, by using FI.

2. Literature review

The benefits of ICT in industry are increasing. The adoption of ICT facilitates the management of information and directs it to the specific needs of an organization [15]. The constant transformation of global markets requires companies to be informed and communicated to make productive and strategic decisions [16]. In the literature, when ICT adoption is related to innovation, the postulate is that the available resources are unlimited to best configure the activities that generate and materialize new ideas [17]. FI, under the effectuation approach [18], has been defined as the efficient use of available resources in the innovation process, thus reducing possible expenses and waste [19]. In previous studies, ICTs have an essential role in making communication efficient and reducing its complexity to take advantage of operational resources with greater precision [20]. The technological configuration used has relevance in how frugality is adopted in the company [21]. Studies such as those by Howell et al. [21], and Ahuja and Chen [22] have established the direct relationship in a significant and positive way of the adoption of ICT over FI. For this reason, the following hypothesis is postulated:

H1: ICT adoption has positive and significant effects on frugal innovation.

Today, ICT adoption is essential for not only sharing information internally, but also externally with other companies [23]. Information and communication are essential elements for the relationship with clients [24]. For Sisay [25], strengthening market intelligence with information generation, management and exploitation activities are key to identifying market needs by taking a market-oriented approach. The studies conducted in establishing a relationship between ICT adoption and CS have been diverse. On the one hand, Epaminonda et al. [26] rejected the hypothesis about the influence of ICTs on CS, however, the most important finding on their analysis was that elements such as accessibility and reading of information have a positive influence on satisfaction because they support the objectives and strategies of the organization, while the technical problems arising from the management of ICTs negatively affect user satisfaction. Although, for Chevers and Spencer [27], they found positive and significant results in satisfaction, highlighting the control of the activities required by the client. Likewise, for Moliner-Velázquez et al. [28] indicated that clients positively value their experience with the company when ICTs are involved in the processes, influencing market loyalty.

H2: ICT adoption has positive and significant effects on customer satisfaction.

The main theoretical challenge of FI and its relationship with CS, is to modify the perception of constrained-based innovation as an innovation that prioritizes the frugality of resources and not the attention to the fundamental needs of the client [19]. It is necessary to understand that the disruptive posture of FI solves problems under difficult conditions in organizations, assuming that the relevant knowledge and available skills are sufficient to meet customer requirements [29]. The success of FI will largely depend on the commercial success of the market [30]. According to Niroumand et al. [12], SMEs require FI to keep optimizing production processes at the best possible profit margin with little waste of resources and time. FIs are important in emerging markets where low-income customers satisfy their needs for quality, ease of use, and reparability with low-cost products [31]. There are different ways to reduce product costs and therefore does not affect the relationship with customers (local materials, traditional process, inter alia). For this reason, in this study the relationship between FI and CS is essential to know its impact:

H3: Frugal innovation has a positive and significant effect on customer satisfaction.

By adopting ICTs in the industry, one takes advantage of innovative ideas and actions with greater speed, resulting in a more proficient innovation process for the needs of both the company itself and the clients [24]. However, few times a company has infinite resources to be able to undertake innovative actions. From a manufacturing perspective, the flexibility of processes, labor and workplaces helps reduce costs without affecting business networks [12]. For Ahuja [22], for a balanced cost-benefit relationship between the ICT capabilities of a company and its market, the FI offers a solution to compete with affordable products and services. In this sense, to contribute to the theoretical discussion, the mediating effect represented by FI is proposed:

H4: Frugal innovation mediates the relationship between ICT adoption and customer satisfaction.

3. Methodology

Empirical explanatory research was conducted with a causal, non-experimental, cross-sectional design and a quantitative approach with a test of causal hypotheses using the statistical technique known as Partial Least Squares Structural Equation Modeling (PLS-SEM), based on the Smart PLS[®]3 statistical software [32]. First, the measuring model was estimated and then the structural model was assessed as a hierarchical component model [33], using the indicator repetition approach [34], [35]. The database of the Bogotá Chamber of Commerce [36] was taken as a reference for developing of this study, considering a sample of 145 SMEs (1 to 200 employees), with a confidence level of 95% and a margin of error of 6%, $P=Q=0.5$. The survey was applied randomly and answered by the managers or owners of these firms from February to April 2018.

To measure ICT adoption, the higher-order scale (HOC) adapted from Chen and Tsou [37] was applied, which consists of four dimensions of reflective type: ICT infrastructure, measured by four indicators; strategic alignment, measured through four indicators; organizational structure, measured by five indicators; and individual learning, measured with five indicators. All of them measured using a five-point Likert-type scale, where 1 was determined for “Totally disagree” ranging to 5 for “Totally agree”. To measure FI, the higher-order scale (HOC) of reflective type proposed by Rosseto et al. [38], which measure substantial cost reduction, measured using three indicators; creation of a frugal ecosystem, measured using three indicators; and focus on core functionalities and performance, measured using three indicators. All of them measured with a five-point Likert-type scale, where 1 was determined for “Totally disagree” ranging to 5 for “Totally agree”. To measure CS, the lower order construct (LOC) proposed by Zhang et al. [39] and taken from Cuevas-Vargas [34] was used, which measures the level of satisfaction of SME clients, through a six indicator scale in a reflective type. All of them measured using a five-point Likert-type scale, where 1 was determined for “Low” ranging to 5 for “High”.

To evaluate the reliability and validity of the scales, and the measurement model was estimated using the PLS-SEM. Based on the results presented in Table 1, the high internal consistency of all reflective constructs of the measurement model stands out. This is because the composite reliability (CR) exceeded the critical value of 0.708

suggested by Hair et al. [40], as well as ρ_A , for each one of the constructs was greater than the critical value of 0.7 [41]. In the same way, the constructs exceeded the critical value of the average variance extracted (AVE) of 0.5 [42]. Moreover, all the factor loadings were statistically significant ($p < 0.001$). These psychometric tests guarantee converging reliability and validity of the scales.

Table 1. Measurement Model assessment

| LOCs | Indicators (manifest variables) | Mean | Loading | AVE | CR | rho-A |
|--|---|-------------------|---------|-------|-------|-------|
| ICT infrastructure (LOC1) | ICT hardware establishment | 2.70 | 0.971 | 0.938 | 0.984 | 0.978 |
| | ICT software purchasing and maintenance | 2.70 | 0.976 | | | |
| | ICT staffing | 2.63 | 0.962 | | | |
| | Implementing new ICT applications | 2.52 | 0.965 | | | |
| Strategic alignment (LOC2) | Aligning ICT strategies to business strategies | 3.17 | 0.904 | 0.863 | 0.962 | 0.952 |
| | Developing ICT projects to support business strategies | 2.83 | 0.944 | | | |
| | Updating ICT applications for business strategic goals | 2.84 | 0.939 | | | |
| | Deploying ICT strategies for business processes | 3.04 | 0.927 | | | |
| Organizational structure (LOC3) | Employee empowerment | 2.75 | 0.899 | 0.849 | 0.966 | 0.958 |
| | Business function integration | 3.09 | 0.917 | | | |
| | Work activities coordination | 2.90 | 0.948 | | | |
| | Departmental operations mobility | 3.12 | 0.887 | | | |
| Individual learning (LOC4) | Decision making quick response | 2.88 | 0.953 | 0.929 | 0.985 | 0.981 |
| | Providing ICT related training | 2.72 | 0.913 | | | |
| | Being familiar with ICT applications | 2.92 | 0.979 | | | |
| | Adapting to use ICT applications | 2.93 | 0.980 | | | |
| | Possessing ICT knowledge and skills | 2.88 | 0.980 | | | |
| Substantial cost reduction (LOC5) | Less resistance to ICT applications | 2.83 | 0.966 | 0.867 | 0.929 | 0.848 |
| | Significant cost reduction in operational process | 3.58 | 0.935 | | | |
| Creation of a frugal ecosystem (LOC6) | Significant reduction of product's final price | 3.28 | 0.928 | 0.848 | 0.918 | 0.829 |
| | Environmental sustainability in operational process | 3.37 | 0.930 | | | |
| Focus on core functionalities and performance (LOC7) | Efficient and effective solutions to customers | 3.38 | 0.911 | 0.639 | 0.841 | 0.733 |
| | Core functionality of product rather than additional functionalities | 3.88 | 0.777 | | | |
| | Ease of use of product/service | 4.37 | 0.858 | | | |
| Customer satisfaction (LOC8) | The question of durability of product does not spoil easy | 4.49 | 0.760 | 0.785 | 0.956 | 0.952 |
| | Our customers keep doing business with us | 4.50 | 0.906 | | | |
| | Our customers are satisfied with the ratio of price and functions | 4.53 | 0.954 | | | |
| | Our customers perceive they receive their money's worth when they purchase our products | 4.50 | 0.936 | | | |
| | Our customers are satisfied with product's quality | 4.53 | 0.956 | | | |
| HOCs | Our firm has a good reputation for our products/services | 4.44 | 0.793 | 0.506 | 0.858 | 0.821 |
| | Our customers are loyal to our products | 4.01 | 0.749 | | | |
| ICT adoption | Latent variables (LOCs) | Path Coefficients | AVE | CR | rho-A | |
| | LOC1 – ICT infrastructure | 0.937*** | 0.794 | 0.986 | 0.985 | |
| | LOC2 – Strategic alignment | 0.923*** | | | | |
| | LOC3 – Organizational structure | 0.956*** | | | | |
| LOC4 – Individual learning | 0.949*** | | | | | |
| Frugal innovation | LOC5 - Substantial cost reduction | 0.838*** | 0.506 | 0.858 | 0.821 | |
| | LOC6 - Creation of a frugal ecosystem | 0.835*** | | | | |

| | |
|--|----------|
| LOC7 - Focus on core functionalities and performance | 0.655*** |
|--|----------|

NOTE: Significance level: *** = $p < 0.01$; ** = $p < 0.05$; NS = Non-significant.

In terms of the evidence of discriminant validity, we applied two tests in order to guarantee that each latent variable measures what in fact should be measured. First, the Heterotrait-Monotrait ratio criterion (HTMT₉₀) [43], whose values of the correlations among the reflective constructs were found to be below 0.90 [34], [43]. Regarding the Fornell-Larcker criterion, the square root of the AVE of each one of the constructs, demonstrated to be greater than their correlations relative to any other construct [42]. Based on these criteria, it can be concluded that the data is reliable and acceptable to test the hypotheses using PLS-SEM.

4. Results and discussion

To test the research hypotheses, the structural model was analysed by means of bootstrapping through Smart PLS^{®3} [32]. The results indicated that there is evidence to obtain the confidence intervals required to evaluate the accuracy of the parameters. The structural model has predictive relevance due to that FI ($R^2 = 0.246$) and CS ($R^2 = 0.182$), both endogenous constructs have an explanatory capacity because the R square values are above and close to 0.20 [40], respectively, so that, the model has quality and therefore, its results are useful in business decision-making. On the other hand, the predictive relevance of the endogenous constructs was evaluated through the blindfolding technique of the Stone-Geisser Q^2 test, having obtained Q^2 values greater than zero [44].

Table 2. Results of the structural model with PLS-SEM

| Hypotheses | Path | β | <i>p</i> -value | f^2 | Q^2 | Decision |
|------------|--|---------|-----------------|-------|-------|-----------|
| H1 | ICT adoption → Frugal innovation | 0.496 | 0.000 | 0.326 | 0.114 | Supported |
| H2 | ICT adoption → Customer satisfaction | 0.291 | 0.001 | 0.078 | | Supported |
| H3 | Frugal innovation → Customer satisfaction | 0.199 | 0.033 | 0.037 | 0.133 | Supported |
| H4 | ICT adoption → Frugal innovation → Customer satisfaction | 0.099 | 0.051 | N/A | | Supported |

f^2 effect sizes: >0.02= small effect; >0.15 = medium effect; >0.35 = large effect [45]
NOTE: Total effects of ICT adoption on customer satisfaction ($\beta = 0.390$, *p*-value = 0.000)

Concerning the first hypothesis H₁, the results obtained and are presented in Table 2 ($\beta=0.496$, $p<0.01$) indicate that ICT adoption has positive and significant effects on FI. Therefore, H₁ is supported because the adoption of ICT has had an impact of 49.6% on FI, and according to Cohen [45] test, it has practically a large effect, indicating that ICT adoption has a large contribution to the prediction power of FI. Regarding H₂, the results indicate that ICT adoption has positive and significant effects on CS ($\beta = 0.291$, $p < 0.01$). Therefore, H₂ is supported because ICT adoption has a significant impact of 29.1% on CS, and according to Cohen [45], it has a small contribution to the predictive power of CS in Colombian SMEs. As for H₃, the results evidence that FI has positive and significant impact on CS ($\beta = 0.283$, $p < 0.05$). Therefore, H₃ is supported because FI has a significant impact of 19.9% on CS, and according to Cohen [45], FI has a small contribution in the predictive power of CS in Colombian SMEs. Finally, to demonstrate the total effects of ICT adoption on CS, indirect effects were evaluated, to know the mediating role of FI on the relationship between the adoption of ICT and CS, the results indicate a positive and significant indirect effect ($\beta=0.099$, $p<0.1$), which shows the mediating effect of FI and, based on the criteria of Zhao et al. [46], it is a partial mediating effect considered as complementary mediation since both the indirect and direct effect is significant and positive, getting a total positive and significant effect of ICT adoption on CS ($\beta=0.390$, $p<0.01$). Therefore, H₄ is supported.

Additionally, the importance-performance Map Analysis was applied in order to identify the performance of every construct. The findings indicate that Colombian SMEs of this study have a low performance of ICT

adoption (46.33), but for each percentage point that the ICT adoption is improved, it will contribute in 0.185 to increase the current CS (77.96), likewise, it will contribute significantly to improve the current FI performance (65.77) by 0.330. Moreover, if the level of FI improves, it will increase the performance of CS by 0.142.

The results confirmed that ICT adoption, FI and CS are positively correlated. For the first assumption, the influence of ICT adoption on FI was demonstrated theoretically and empirically, being like the similar results of Howell et al. [21], and Ahuja and Chen [22]. Likewise, for the ICT adoption and CS relationship, positive and significant results were obtained, unlike the study by Epaminonda et al. [26]; although, similar to the works of Chevers and Spencer [27], and Moliner-Velázquez et al. [28]. Similarly, positive, and significant results were confirmed for the effects of FI on CS, similar to those obtained by Niroumand et al. [12] and Singh et al. [29].

The main contribution of this work is to establish the mediating effect that FI exerts in the existing relationship between ICT adoption and CS, according to the results, significant and positive results were obtained, although the literature has indicated, at least theoretically, the mediating role of FI [12], [22]. Our study contributes to the discussion about the benefits of having an effectuation approach [47] to materialize ideas from frugality. Therefore, an austere approach to innovation has effects in three main senses: First, properly increasing innovation activities from a position conscious of the value of available resources [30]. Second, to have innovation processes directed toward the needs of consumers [21]. And third, to mediate the relationship between the technology used to communicate and the development of its market [22].

5. Conclusions

In accordance with the objectives of this research, it is concluded that ICT adoption is critical for CS. Due to the fact that the results obtained proved to be significant and positive, it is inferred that the capacities developed with ICTs provide the company with the means to configure its attention to the needs of its clients and, with this, make strategic decisions accurately and clear [16]. Similarly, the frugality with which innovation processes are performed constitutes an important element to face, scale and adapt products or services that the market values. In this sense, clients are remunerated for the approach used to reduce waste and take advantage of the time available to innovate, considering the requirements they have as a client.

There are different important implications for companies, academia and policy makers that help to incorporate new perspectives of innovation. First, the industry benefits from adopting resources and capabilities that help them spread their costs in the activities most pressing for their growth. Second, the literature is strengthened by discussing theoretically and empirically the relationships that favor frugality. Since, as a topic that is increasingly used to solve the deficiencies in companies with the four principles of the FI: experimentation, flexibility, affordable loss, and pre-commitment. Third, policymakers have greater knowledge of capabilities that favor communication and collaboration of the business network from a responsible basis with resources without affecting the income that companies have.

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