Creation of an Instrument to Measure the Impact of a Cluster on its Members' productivity

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Abstract

The home appliance industry, which includes electrical or mechanical devices used in a household, is a multi-billion-dollar industry. The state of Nuevo León is the main producer of household appliances in México and is also accountable for a large contribution of the national exports of this sector. For this reason, a Home Appliance Cluster exists, which is devoted to increasing this region's competitiveness. By using a systematic literature review, a knowledge gap was discovered, regarding the factors of a cluster that determine the productivity of companies in this industry. Literature shows few to almost non-existing measurement instruments to analyze the impact that active participation within a cluster has on firm's productivity. The present research finds three factors that come from belonging to a cluster and have an impact on firms' productivity: geographic proximity, social capital and innovation. These factors, in the form of constructs, were put together to create a measurement instrument that will allow us to quantify the impact on firms' productivity. The instrument was validated in three steps: through concordance and relevance tests, a tuning meeting with clusters' heads, and, when all data was gathered, construct validation using Cronbach's alpha. This study presents an analysis of each factor, and the process of the creation of a measurement instrument.

Keywords
Measurement instrument, Total Factor Productivity, Geographic Proximity, Social Capital, Innovation.

1. Introduction

The Home Appliance Industry, which includes electrical or mechanical devices used in a household, is a multi-billion-dollar industry with a worldwide consumption forecast of nearly 590 billion USD generated in revenues by 2020 (Statista, 2018). The Mexican state of Nuevo León is the main producer of household appliances in the country, contributing with 40% of the national manufacturing of this type of goods (Redacción Manufactura, 2018), and is also accountable for 30% of the national exports of the sector (CLELAC, 2015). By using a Systematic literature review, a knowledge gap in this topic was discovered. Literature shows few to almost non-existing measurement instruments to analyze the impact that active participation within a cluster has on a firm's productivity.

The present research finds three factors that come from belonging to a cluster and have an impact on firms' productivity: geographic proximity, social capital and innovation. These factors, in the form of constructs, were put together to create a measurement instrument that will allow us to quantify the impact on firms' productivity. Furthermore, literature demonstrated that productivity is an ambiguous term. Therefore, a true definition was created based on literature and the real measurements used by the firms involved.

The results of the literature review concluded on three independent variables (constructs), and one dependent variable, Productivity.This study presents an analysis of each one of these factors, and how an instrument was created to measure the impact of a cluster on its members' productivity.

The creation of the instrument was based on various empirical studies and reliable theoretical studies. The instrument consists of a self-applied perception survey, obtaining information from high management from the Home Appliances Cluster of Nuevo León (CLELAC). The instrument was validated in three steps: First, through concordance and relevance tests. Second, there was a tuning meeting with clusters' heads; and afterwards, construct validation took place when all data was gathered, with the use of Cronbach's alpha.

1.1 Objectives:

The general objective of this research study is to create a Measurement Instrument, guided by literature and the expertise of the industry, which helps measure the factors of a cluster that impact on firm's productivity. As a specific objective, we seek to validate the instrument to ensure its legitimacy.

2. Literature Review: Dependent and Independent Variables

2.1 Dependent Variable: Productivity

Firm concentration and associated clustering have long been recognized as a facilitator for industrial growth, in theoretical literature and by policy makers who have used industrial policy to encourage geographic clustering (Howard et al., 2016). Many geographic areas have evident natural leads that result in cluster formation (Newman, 2015). According to Howard et al. (2016), firms in clusters are expected to be more productive than non-clustered firms.

Productivity in simple terms is the ratio of output to input which means that an increase in productivity either implies an increase at the level of outputs relative to the inputs or a decrease at the level of inputs relative to the outputs (Gurellier, 2010). Although, the definition of productivity is quite straightforward, the measurement of productivity borders problems, which are the presence of various inputs and outputs (Rogers, 1998), the definition of units of measurement, evaluating qualitative changes, and getting reliable data for inputs and outputs properly (BFC, 2006). According to the OECD Productivity Manual (2001), at a national level, the following are the major productivity measures:

- Single Factor Productivity measures:

    - Labor Productivity
    - Capital Productivity
- Multifactor Productivity Measures (MFP)
    - Capital Labor MFP
    - Capital Productivity
    - KLEMS multifactor productivity

For the purpose of this study, Multifactor Productivity (MFP) and Total Factor Productivity (TFP) are going to be taken as equal, since OECD (2001) indicates these terms are synonyms.

After revising distinct documents, an analysis was made to locate which type of productivity measure is of better use when studying a firm within the manufacturing sector: Labor Productivity (LP), Capital Productivity (CP), Total Factor Productivity (TFP), and the variation on Total Factor Productivity (ΔTFP). The results showed that the most used measures were TFP, LP, CP, and ΔTFP, in that specific order.

These results, together with a survey carried out to the managers of the companies, led us to the conclusion that Total Factor Productivity is the most suitable and used measurement for productivity within clusters' members.
Total Factor Productivity is affected by several factors, such as workforce, raw materials, integration with suppliers, new technologies, and strategic analysis (Guardin, 2014). Other authors, like Howard et al (2016), mention social capital, new knowledge and technologies; whereas Carmino (2018) refers to geographic concentration as one of the main factors that affect TFP in manufacturing companies.

2.2 Geographic Proximity

According to plenty of literature, proximity is a determinant to a cluster member's productivity. This study will analyze the effects of proximity on productivity as in terms of geographic location, the implications of local provisioning, and supply chain integration. (See Figure 1)

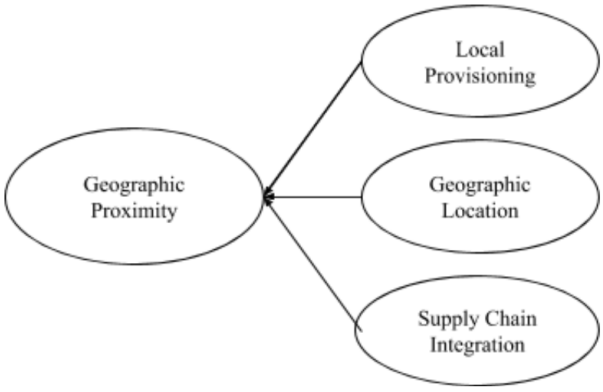

Figure 1: Geographic Proximity Construct and its Observable Variables

2.2.1 Geographic Location

Starting with the geographic location of the cluster members', literature says that the local resources, size (these two being the structural firm information), and closeness between firms affect directly the productivity growth perceived by them.

Location and its resources are an important factor to take into account when evaluating the productivity growth of a firm inside a cluster, since it has been empirically proven that urban manufacturing firms are found to have lower productivity because of higher wages, rents, and inadequacy of social overhead capital in an urban area (Tripathi,

2014). On the other hand, Prim's study (2016) demonstrated that location resources have a high impact on costs and efficiency, and that firms can take advantages from the location, particularly from the economies of scale.
The proximity resulting from clustering facilitates special access, closer relationships, better information, powerful incentives, and other advantages in productivity, that are harder to get from a distance (García, 2012). For these positive spillovers to be fully enjoyed and resources to be shared, firms must be close enough geographically (Doyle et al, 2007).

2.2.2 Local Provisioning

Changing to the implications of local provisioning on a cluster member's productivity, literature shows that sourcing locally provides benefits on transporting costs, better communication with suppliers, and other advantages over distant outsourcing.

Firms in a cluster can benefit from productivity improvements due to reduced transport costs (Chhair et al, 2014). As Howard et al (2016) says, the further the distance inputs and outputs need to be transported, the greater the transaction costs. Bigsten et al (2011) also implies that shared infrastructure within members of the cluster can help minimize transaction costs. There are also other benefits when sourcing locally instead of from distant suppliers, such as the elimination of importing costs and delays, the minimization of inventory, and the lower risk of suppliers overpricing (Porter, 1998; Porter, 2017).

According to empirical research made by Di Bernardino et al (2016), local sourcing makes a positive contribution to the productivity growth of the industrial sector, while non-clustered manufacturing firms do not show such positive trends, thus confirming the existence of a clustering effect.

2.2.3 Supply Chain Integration

Finally, Geographic Proximity will also embrace the Supply Chain Integration level that each of the members perceive in their firm. For this topic, Klier and McMiller (2015) mention that the supply chains of manufacturing industries consist of many companies, ranging from large, global suppliers, to small, family-run businesses.

Supply chain integration (SCI) can be broadly defined as the extent to which supply chain members work cooperatively together to achieve mutually beneficial outcomes (O'Leary-Kelly and Flores, 2002). It aims at linking more efficiently the elements of the supply chain to make sure that the needs of the customers are closely met by the suppliers in terms of costs, availability and time. For this to happen, there must be a relationship of physical calibrated flows between parts and raw material suppliers, manufacturers, and distributors (Rodrigue 2006).

In conclusion, the construct of proximity is integrated by three independent variables: geographic location, local provisioning, and supply chain integration. After analyzing the literature, the construct of proximity will be defined in this study in one hand as the set of structural firm information about its geographic location, such as size and local resources of the company, as well as the physical closeness between cluster members; and on the other hand the implications and advantages that sourcing locally has on the firm's costs and relations.
As seen in Table X1, diverse authors analyze the variable proximity, and mention these six factors within it, as follows:

2.3 Social Capital

The second variable that will be studied is Social Capital. Social capital is viewed as a multidimensional concept (Rocha, C. et al., 2009). It refers to the characteristics of the social organization, such as trust, norms and networks, which can improve the efficiency of society by facilitating coordinated actions (Putnam, 1993).

When addressing new opportunities through collaboration within a cluster, companies usually form alliances between them (Freije, 2015). This section will discuss the different aspects within the construct of Social Capital such as

Networking, Teamwork and Collaboration, and access to Specialized Information in a cluster, and their positive effect on each firm's productivity.

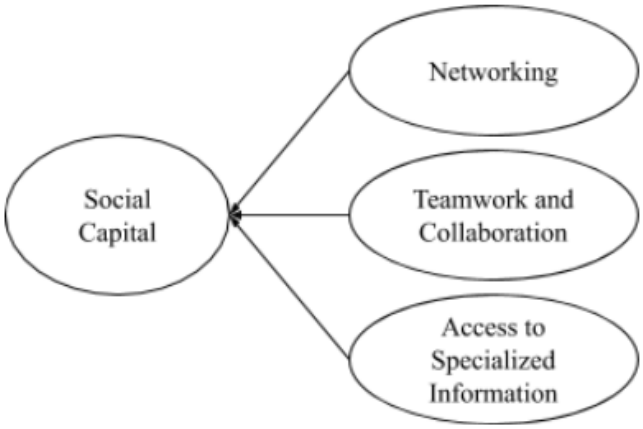

Figure 2: Social Capital Construct and its Observable Variables

2.3.1 Networking

According to the United Nations Industrial Development Organization (UNIDO), networks are alliances of firms that work together towards an economic goal (UNIDO, 2019). They can be constituted by different cluster stakeholders such as suppliers, customers, competitors and related firms (Carvalho, 2016). Interconnected industries and supporting institutions should be included in the networking activities, since its existence provides a positive impact on productivity of cluster members (Hervas-Oliver et al., 2007).

Participation in the networking activities organized by clusters is proven to have a positive impact on the productivity of firms belonging to a cluster (Bakarić, 2017). These types of networking activities can provide the possibility for enterprises to take advantage of new market opportunities, obtain market information, learn from the experience of others, and benefit from the synergistic effects of the common resources (Krugman, 1991).

Under previous circumstances, alliances can be established through personal interactions during informal social events organized by the cluster, where plenty of networking between colleagues takes place (Schiele, 2008).

2.3.2 Teamwork and collaboration

The act of clustering firms can consequently help in the formation of business alliances inviting them to engage in teamwork and collaboration activities (Hui-lin, et al., 2019). As a matter of fact, literature studies have indicated that firms that work together within a cluster tend to perceive a higher productivity, because it allows them to exchange information and ideas that can be beneficial to one or the other. (Wiratmadja, et al., 2016)

Furthermore, the coordination of activities across companies helps optimize their collective productivity, by allowing them to rapidly recognize and capture linkages, identify the root of the problems and create simultaneous change, which would not exist in geographically dispersed firms (Porter, 1998). Distinct forms of teamwork and cooperation are possible within a cluster, therefore, systematically searching for partnering opportunities within the cluster and implementing such cooperation agreements should be at the core of a cluster strategy (Schiele, 2008).

2.3.3 Access to specialized information

Porter (1998) states that access to specialized information is the preferential access by cluster members to extensive market, technical, and competitive information that accumulates within a cluster. In addition, personal relationships and community ties foster trust and facilitate the flow of information making information more transferable (Porter,

1998). Cluster membership makes possible direct observation of other firms. in comparison with isolated firm, facing higher costs and steeper impediments to acquiring information and a corresponding increase in the need to devote resources to generating such knowledge internally (Porter, 2017). Working together allows clustered firms to exchange information and ideas related to products, processes, and operations (Wiratmadja, 2016). These types of transactional relations also involve flows of certain kinds of business information or knowledge spillovers (Hui-Lin et al., 2019).

2.4 Innovation

According to Porter (1998) innovation generates a better use of inputs in firms. Therefore, it has been proved that it impacts positively on a firm's productivity. (Wiratmadja et al., 2016) This variable is going to focus on process innovation. (See Figure 3)

Cainelli, G. (2008) defines process innovation as the application of different techniques, new production organization, implementing an immensely improved or new production and / or distribution technique. According to Jayarama et al. (2014) lowering costs and incrementing productivity is one of the main reasons to utilize process innovation.
In addition, process innovation has been considered a key element for the increment in productivity. In fact, it has been the answer for the evolution in some areas. Contributing by making economic power transfers between sectors, to raise productivity of economic activities and create different inventions to generate a differentiator among countries (López 2013).

It has been mentioned in various occasions that firms mainly use process innovation for lowering costs and improving their firm's productivity (Carvalho 2016; Jayarama 2014). Caillois (2008) mentions that process innovation benefits the perception of technical problems. Therefore, a quality improvement is achieved in the production process (Carvalho, 2016).

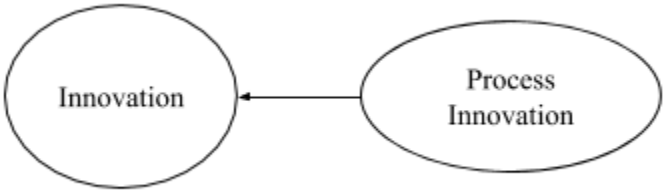

Figure 3: Innovation Construct and its Observable Variable

2.4.1 Process Innovation

Process Innovation makes reference to a new way in which firms can perform an activity, implement new tools and renew processes (Davenport 1993). Cainelli, G. (2008) defines process innovation as the application of different techniques, new production organization, implementing an immensely improved or new production and / or distribution technique. According to Jayarama, J. et al. (2014) it is mainly used for lowering costs and incrementing productivity.

Technological innovation has been considered a key element for the increment in productivity. In fact, it has been the answer for evolution in some areas. Contributing by making economic power transfers between sectors, to raise productivity of economic activities and create different inventions to generate a differentiator among countries López, J. (2013). Furthermore, technological innovation in processes provides economic power between regions and increases productivity for economic activities (López, J., 2013).

The main benefits of process innovation are the impact in the reduction of operating costs (Carvalho, 2016), the renewal of perception of technical problems (Callois, 2008), quality improvement in the production process (Carvalho, 2016), involvement of new procedures in the production organization (Cainelli, G., 2008).

The interaction between firms and cluster managers simplify innovations. Having access and sharing resources generates benefits for firms within the cluster and tend to generate a positive result with regards to their innovation (Delgado et al., 2010).

3. Methods

This study is based on data collected from the Local Home Appliance Cluster of the state of Nuevo Leon, located in Mexico. It was designed an instrument and submitted to a several tests. At the firm level carrying out a total of 4 interviews for instrument content validity that were answered by CEO's, Plant Managers, Operations Managers, Quality/Continuous Improvement Managers and from CLELAC directors. Later, it was collected data of a sample of 48 respondents that were answered by CEO's, Plant Managers, Operations Managers, Quality/Continuous Improvement Engineers, Manufacturing Manager, Supplier Development Manager and Commercial Managers. It was used Cronbach's alpha test for the instrument reliability.

The instrument consists in a survey which contained a total of 58 questions divided in three parts: identification questions, demographics questions and perception questions being the largest part with a Likert Scale from 1-5. The scale used in this survey is sustained by Tristão, H. et al (2013) and Carvalho, L. (2016) whose statistical analysis agree on the use of a perception survey with a Likert scale from 1-5. The recollection of data was carried out between March 2019 and May 2019 to all the firms that participate in the cluster within the universe of fifty-four firms with a total response rate of 72% (39 firms). The response rate for Original Equipment Manufacturer (OEM) was 13%, for Tier 1 firms was 69% and for Tier 2 firms the response rate was 18% of the total of surveys answered. These surveys were distributed via email and answered through QuestionPro.

In order to prove the content of the instrument created, several test were conducted.

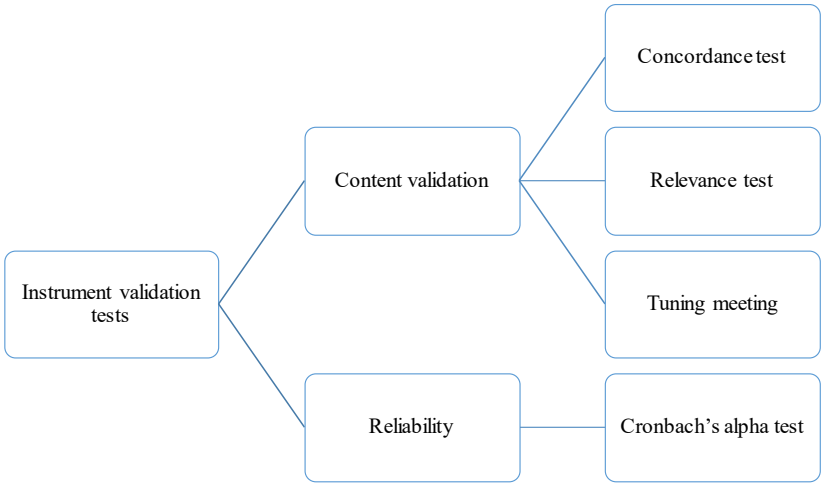

Figure 4: Instrument content validation tests.

In order to estimate the possible relations between some factors of a (geographic proximity, social capital, and innovation) and the dependent variable productivity, as well as the strength and significance of these relations, we decided on following an empirical approach.

For this research, different techniques were used for the validation and analysis of the data. First, the content validation was planned, firstly, by putting the instrument through a concordance and relevance test, which is a method proposed by Mendoza & Garza (2009). The concordance test consists of identifying if each of the items belong to the list of variables of the study. On the other hand, the relevance test evaluates the level of relevance for each of the items, using a score from 1 to 4, being 1 irrelevant, and 4 very relevant.

The final content validation is the tuning meeting, which took place with the participation of home appliance industry directors and executives top management, and directors and staff from CLELAC. There, each item was reviewed and analyzed carefully, until the experts concluded that the content of the measurement instrument was valid, and that it was ready to be applied.

4. Results

The content validation was done in three steps. First, a concordance and relevance tests were done simultaneously, and afterwards, a tuning meeting with the Cluster's executives took place. The concordance test consists of identifying if each of the items belong to the list of variables of the study. On the other hand, the relevance test evaluates the level of relevance for each of the items, using a score from 1 to 4, being 1 irrelevant, and 4 very relevant.
These tests must be filled by experts who are external to the research, with specific characteristics for each test type:
Concordance test respondent profile: Academic experts with a doctoral degree in this knowledge area, who are also researchers or consultants at the present time.

Relevance test respondent profile: Experts in the home appliance industry, such as the cluster's director and coordinators, and plant directors, plant managers, or other managerial level executives from the firms inside CLELAC. These tests led to the elimination of items, the change of some items to another construct, or the redefinition of items. To do a final content validation, the tuning meeting took place. There, each item was reviewed and analyzed carefully, until the experts concluded that the content of the measurement instrument was valid, and that it was ready to be applied.

Once the results were observed as shown in table 1, a comparison was made between the relevance and concordance results of each item. First, those items from the relevance test which showed little or no relevance, were eliminated from the instrument. Then the concordance was analyzed and those items that were not in agreement with their respective construct, were relocated in their corresponding variable or if it is the case, eliminated. In order to concentrate the results, a percentage of items with positive results in the concordance and relevancy test were obtained for each dimension of the respective constructs, this is shown in Table 2.

Table 1. Concordance Test with academic experts and Relevance test with experts from the home appliance industry.

Original Construct	No. of the item in the instrument	Concordance Test				Mean	Relevance Test				Mean
		Geographic Proximity	Social Capital	Innovation	Productivity		*R1	R2	R3	R4	
P	**1**	4	1	0	0	1,2	4	3	4	1	3
P	**2**	0	0	0	5	4	4	2	4	2	3
P	**3**	0	0	0	5	4	1	2	4	1	2
P	**4**	0	0	0	5	4	4	2	4	2	3
P	**5**	0	0	0	5	4	1	1	4	1	1,75
P	**6**	3	2	0	0	1,4	4	3	4	2	3,25
P	**7**	2	0	0	3	2,8	4	3	4	2	3,25
P	**8**	5	0	0	0	1	1	3	3	2	2,25
P	**9**	0	0	0	5	4	1	2	4	1	2
P	**10**	0	0	0	5	4	4	3	4	1	3
PR	**1**	3	2	0	0	1,4	4	3	4	1	3

Original Construct	No. of the item in the instrument	Concordance Test				Mean	Relevance Test				Mean
		Geographic Proximity	Social Capital	Innovation	Productivity		*R1	R2	R3	R4	
PR	**2**	3	1	0	1	1,8	1	2	4	1	2
PR	**3**	1	2	0	2	2,6	1	2	4	1	2
PR	**4**	4	1	0	0	1,2	4	2	3	1	2,5
PR	**5**	0	2	1	2	3	1	2	4	1	2
PR	**6**	5	0	0	0	1	4	3	4	1	3
PR	**7**	4	1	0	0	1,2	1	3	3	2	2,25
PR	**8**	2	1	0	2	2,4	4	2	4	1	2,75
SC	**1**	0	4	0	1	2,4	4	3	4	2	3,25
SC	**2**	1	4	0	0	1,8	4	2	4	1	2,75
SC	**3**	0	5	0	0	2	4	3	4	1	3
SC	**4**	0	4	0	1	2,4	4	2	4	1	2,75
SC	**5**	0	5	0	0	2	4	2	4	1	2,75
SC	**6**	1	4	0	0	1,8	1	3	4	1	2,25
SC	**7**	0	1	1	3	3,4	1	2	3	1	1,75
SC	**8**	0	2	2	1	2,8	2	2	4	2	2,5
SC	**9**	0	1	3	1	3	2	2	3	1	2
IN	**1**	0	1	4	0	2,8	1	1	4	1	1,75
IN	**2**	0	0	5	0	3	1	1	4	1	1,75
IN	**3**	0	0	5	0	3	1	2	3	1	1,75
IN	**4**	0	0	5	0	3	1	1	4	2	2
IN	**5**	0	1	4	0	2,8	1	1	4	1	1,75
IN	**6**	0	0	5	0	3	1	1	4	1	1,75
IN	**7**	0	0	5	0	3	1	1	4	1	1,75
IN	**8**	0	0	4	1	3,2	1	1	4	1	1,75

Note: Code of constructs. Productivity (P), Geographical proximity (PR), Social Capital (SC) an Innovation (IN).
*R1 to R4 represents the respondents whom are experts from home appliance industry.

Table 2. Concordance and Relevance results divided by observable variables.

Construct	**Observable Variables**	**Construct Relevance**	**Relevance**	**Construct Concordance**	**Concordance**
Productivity	Finished goods Output	60%	100%	70%	0,00%
	Labor Costs		50%		100,00%
	Transformation Costs		50%		100,00%
	Capital Costs		100%		0,00%
	Raw Material Costs		100%		100,00%

	Transportation Costs		0%		0,00%
	Cost of Sales		0%		100,00%
	Quality		100%		100,00%
Geographic Proximity	Geographic location	25%	100%	63%	100,00%
	Local Provisioning		14,29%		57,14%
Social Capital	Networking	22%	50,00%	67%	100,00%
	Teamwork		0%		40,00%
Innovation	Process Innovation	0,00%	0,00%	100,00%	100,00%

The last step, the "tuning meeting" was done with de Home Appliance Cluster Director, in order to discuss and bring up concerns regarding the measurement instrument. The following table shows the different matters of importance that were reviewed and put under discussion for future modifications. The results are shown in table 3.

Table 3 :Tuning Meeting's observations

Specify the Committees and activities	**Deletion of unrelated questions**	**Translate questions to industry language**	**Explain Total Factor and Labour Productivity**	**Clarify Terms**	**Reduce length of instructions**
- Competitiveness and Efficiency Committee - Energy Committee - Social Responsibilities Committee - Supply Committee - Financing Committee - Projects - Board Meeting	- 4 items were deleted	- Due to the knowledge gap, many items had to be changed into understandable home appliance industry terms. - A total of 18 items were either modified or considered for elimination	- Consider that the definition of Total Factor Productivity is the relationship between production and the set of inputs used (labor, capital, and other immediate inputs, such as energy, materials and services) for it. - Consider that the definition of labor productivity is the units produced per man hour total productivity	- Output - Quality	The length of the instrument's instructions was reduced in order to make it as brief as possible

Different points were discussed with the CLELAC staff regarding the measurement instrument and a consensus was reached in which the specification of the clusters committees and activities, the deletion of unrelated questions, the translation of questions into the home appliance industry language, total factor and labor productivity explanation within the instrument, clarification of terms such as outputs and quality and the addition of questions regarding client-supplier projects were all discussed and either modified, deleted or added into the instrument.

Afterwards, the data recollection took place. The selected confidence level for the sample was 95% with a confidence interval of 5%. This resulted in a sample of 48 surveys that must get collected for this paper's analysis.
For this research a Cronbach's Alpha Test was done through SPSS, in order to determine the scale reliability. Nunnally (1978, p.245) mentions that for this type tests getting a 0.70 or higher it is suffice. Hernández-Sampieri (2014) a coefficient between 0.70 and 0.90 means that the measurement instrument is reliable. The results are shown in table 4.

Table 4. Reliability test, Cronbach's alpha

Construct	Number of Items	Cronbach's Alpha
Productivity	7	0.866
Proximity	8	0.822
Social Capital	8	0.913
Innovation	5	0.780

These results showed that the model had to be rearranged and items had to be eliminated through the next steps, specifically for social capital construct, in order to get the desired reliability.

5. Conclusions

In order to fill the knowledge gap, found on the literature of the impact of clusters on the home appliance industry and the impact that manufacturing clusters have on their members' productivity, we analyzed the factors of a local home appliance cluster that impact their members' productivity.

This article presents the process to create an instrument to measure the effect of cluster factors on the manufacturing firm's productivity, supported by a comprehensive literature review, which concluded on three variables impacting on it: Geographic Proximity, Social Capital, and Process Innovation. This article aims to create and validate the measurement instrument through a content validation method using two different tests, Concordance and Relevance Tests; these were applied to experts in the field.

Future research will be to make explicative relations between variables in order to find out the impact from each one of them on another. Correlations study and structural equations model could be the best methods for it.

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