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Research Article

Productivity and Firm Size in the Construction Sector in Ecuador: A Discriminant Analysis

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Abstract

The research addresses the relationship between the business size of the construction sector in Ecuador and productivity indicators, seeking to identify the group with the greatest influence on productive growth. The methodology employed begins with a descriptive-explanatory analysis, using the Discriminant Analysis Technique (ADM). The results reveal that small companies have suffered more impact during the health crisis. In addition, Wilks' Lambda test was applied, confirming that the size of organizations is linked to productive performance, highlighting specific factors. These findings offer valuable insights for improving efficiency in the sector.

Keywords: Productivity Indicators, Business Size, Discriminant Analysis, Construction Sector

1. Introduction

Considering the construction sector as one of the most dynamic industries of the world economy and Latin America being part of this dynamic, this and the other economic sectors had great losses because the health crisis caused a great blow to their business progress, causing losses in the production generated by the construction sector and generating one of the largest economic contractions of this one: despite that, its average growth for 2021 was focused on 5.2% in Latin America as a result of the previous problems mentioned (ECLAC, 2021). In spite of being a greater focus than the others described, it is important to take into account that the difficulties presented in

Latin America are the set of problems presented in each of the countries that belong to it, which is why getting to the core of these is to help all of them in a general way.

From 2019 to 2021 this construction sector denotes a decline, due to 2 important factors: the first is based on the total expenditure of the state of Ecuador that has reduced over time and the second is the continuing problem that has led the COVID 19 for years, that is, the construction sector has remained with three years of negative levels and it is until the previous year that since its second quarter has noticed a growth of 0.1% in two consecutive quarters (CBE, 2022). The impact of the war conflict between Ukraine and Russia has not been taken into account, from the export of products to investments with Europe are interrupted and stopped at every moment. Finally, in spite of having a mediatic advance, the construction sector is on the list of the 14 sectors with the highest figures in Ecuador.

The series of processes involving the construction sector present a high level of relevance in the Ecuadorian economy, reflecting approximately 10% of Ecuador's GDP in 2019, with a growing trend. The reason is attributed to the extensive relationship that the sector has with different productive axes, in addition to the potential capacity to produce employment (CBE, 2023). The growth of the sector is credited to the increase in per capita consumption supplied by the other productive branches linked to the sector (Díaz et al., 2023). In short, despite the conflictive stages, for the following years it denotes a productive increase due to the housing need on the part of society, therefore, the evident increase in constructions and buildings.

The current research focuses on fulfilling the objective of analyzing the incidence that business size has on the productivity and its indicators of companies in the construction sector of Ecuador in the period 2019 - 2021, through a quantitative analysis. In summary, it is supported by two methodologies of descriptive and explanatory level, the first one is treated with the definition of the productivity indicators of the companies of the construction sector of Ecuador and finally for the following two methodologies the Discriminant Analysis will be applied to classify the productivity indicators according to the business size of the construction sector.

For this reason, this paper begins with a first section, which mentions the literature review of the construction sector. This is followed by the methodology used to establish the productivity indicators and their classification according to the business size of the sector. In third instance, it details the results and interpretations, obtained by the Discriminant Analysis model and its contribution with the variables of study already mentioned. Finally, the last section presents the conclusions of the objective of this research.

2. Background

2.1 Construction sector in Latin America

In the case of the construction sector in Latin America, its main consequence after the pandemic is centered on the millions of dollars lost due to the interruption of each of the construction projects due to lack of funds as measures adopted to focus on other priorities, which at that time was to avoid the spread of the virus and therefore the health of those who worked. This made it very difficult for companies that wanted to stay in the market to continue with their projects and maintain production levels (Raoufi & Fayek, 2021). According to Gadino et al., (2022), In the case of South America, a privatizing and excluding development model is observed, which as part of its planning is known as an obstacle to generate growth, so that by absorbing natural resources it causes an increase in the value of land prices, that is to say, it influences the economy and culture of the countries.

2.2 Construction sector in Ecuador

For Backes et al., (2023), this industry causes economic activities to spread, so each production process that the construction industry entails will cause more related branches to intervene in the

production chain. For (Mejía et al., 2019), construction shows in certain occasions a great difference between the entities and the production they can offer, that is, in Ecuador there is the dilemma where it is known that it is a strongly vulnerable country before a crisis, and is that the reality of the country is that there are aspects that submit the national economy, one of the most important is the extensive dependence that has generated by oil, since oil revenues in Ecuador have been of great support (Panaia, 2021). On the other hand, the other aspect is the great help provided by dollarization to better negotiate in the international market (Mejía et al., 2019). Another important detail focuses on GDP, since its increase goes hand in hand with that of the economic sectors and construction (Dong et al., 2023).

Ecuador and the economy of its industries depend a lot on what can happen to each of them, meaning that in this case what affects the construction area will influence the other sectors, and not because it is the most important but rather because it produces economic movement in the others (Wilkinson et al., 2016). Currently Ecuador is going through the consequence of different factors that affect its economic areas, one of these factors starts with the devaluation of non-oil exports, devaluation of the currencies of neighboring countries and therefore the reduction that it causes in prices, outflow of the Ecuadorian currency due to the forced imports (Díaz et al., 2023). Finally, this causes more sources of financing to be sought. In addition, as already mentioned, the pandemic affected the world and Ecuador is one of the countries whose economy is most affected by the link that depends on the export of oil and therefore the commercial connection with China, Europe and the USA.

It was found that this sector produces an effect that multiplies economic activities. That is, for every job that is done in the sector, there will be two more jobs to pay for it, and in this way a circular economy is formed that starts from the raw material until it is used for its continuity (Robles & Velázquez, 2013). In other words, the builders of a restaurant will sooner or later be fed by the production exerted by the investment in that restaurant (Gómez & Velandia, 2016). In addition to that, this sector is subjected to certain external aspects that can be economic, social and even political, aspects that harm according to some first-hand to the industry, but the problems in the environment do not mean that the production of the sector should be affected (Camacho et al., 2020).In summary, despite the circumstances in which the country finds itself, the investor's focus must be on the fact that the population increase and the demand for housing should not be affected by the moment the national economy is going through, in other words, construction should not stop if the country's economy does.

Productivity is an indicator from which information can be obtained based on the resources used in order to meet company objectives. According to this, according to Fontalvo et al., (2017)), productivity remains connected to two terms: efficiency and effectiveness, which are considered determinants that contribute to evaluating the ability of companies to achieve their purpose, based on a better optimization and utilization of the resources necessary for the manufacturing chain. These factors mean a connection between the B/S and the matter available for production (Ramírez et al., 2022). In the same way, for Jaimes et al., (2018), companies in the construction sector that have understood this concept have opened up to a larger market at the national level. In summary, companies that effectively use their resources are the important axis for the country to be recognized for its performance and to extend its work in the Ecuadorian market.

3. Methodology

To work on this research, a quantitative approach was taken into account, which begins with the statistical analysis of the data obtained from secondary sources, to continue with the application of a Discriminant Analysis model that aims to classify the indicators that generate productivity according to the business size of the companies in the construction sector in Ecuador in the period 2019 - 2021.

3.1 Data

The population under study in this case is made up of all the companies that carry out construction activities in Ecuador. This industry is found within category F of the International Standard Industrial Classification (ISIC), which is a group of approximately 2,412 active companies. The activities that these companies are part of in the construction sector are characterized by 3 particularities that are differentiated by the homogeneity of the work that is done in each of them, first of all, F41, which is the construction of buildings, F42 civil engineering works. and finally F43 that represent specialized construction activities (INEGI, 2008). Since the size of the population is accessible, it is not necessary to estimate a representative sample, which makes the methodological procedure proposed in the research possible. The main source of information from which the corresponding data is extracted is the Superintendency of Corporations, which publishes the statements of financial situation and results (Supercias, 2021). These data are available to the public. In addition, the institution makes available the directory of companies, which is freely accessible and contains information on each company resident in Ecuador, as well as the sector in which they perform their productive activities.

Statistical information sources are available to estimate the different indicators that will quantify the variables under study, in this case the productivity indicators and business size. The first variable mentioned consists of 6 indicators, among which are the value added index (VAI), which awards the service a higher commercial value, generating a unique piece of differentiation for the company compared to the competition, the capital participation index (CPI) that represents a share contribution that is granted to the company for a productive purpose and that, for the shareholder partner, represents a financial benefit, the Contribution of personnel cost (CPC) corresponds to the economic expenses incurred by maintaining employees in the company and that being used efficiently the company will achieve great profitability, capital productivity (CP) assesses the efficiency to produce based on the use of assets and business capital, the equipment utilization index (EU) measures the productive capacity with the available resources and inputs, finally the labor productivity (LP) which refers to the performance of the productive process through which the work team generates the service. The main source of information from which secondary sources are extracted and the most relevant articles belong to authors such as Mejía et al. (2019), Fontalvo et al. (2017) and Haro, (2021)

Table 1. Codification of the productivity indicators of the construction sector in Ecuador

	Indicators	Formula
VAI	Value added index	= Value added/operating revenues
CPI	Capital participation index	= Profit for the period/Value added
CPC	Contribution of personnel cost to value added	= Value added/personnel cost
LP	Labor productivity	= Personnel cost/Value added
CP	Productivity of capital in equipment and machinery	= Value added/Tangible fixed assets
EUI	Equipment utilization index	= Total income/Tangible fixed assets

3.2 Variables - Model description

To study the different variables proposed as a function of business size, the present research used Discriminant Analysis. As its name is a model where discriminant functions are applied and thus being able to have a discriminant group according to the proposed variable (Mendoza et al., 2017). Judging by the financial statements, the sales of the entities of the construction sector and dedicated to civil engineering works were considered to distribute them by their business size, under the direction of the Andean Community (CAN, 2009), where it is established whether the entity is a micro, small, medium or large company. In order to be part of the descriptive analysis together with the productivity indicators described above. Therefore, the following methodology is described.

This process contributes to a better estimation of the productivity indicators and therefore to

their evaluation as groups with significant dissimilarities in the three years considered. Thus, the verification of the assumptions given by the discriminant analysis was obtained, given by the discriminant function (T. Fontalvo, 2014).Simply put, it aims to establish the indicators that best discriminate in order to be able to evaluate the productivity of the construction sector in Ecuador.

The assumptions of Discriminant Analysis are the following:
- The independent variables must conform to a multivariate normal distribution.
- The covariance matrices must be equal in all groups.

It is taken into consideration that the Normal Distribution of a model is an assumption that in most econometric models. Its function in great magnitude is in the approximation where a situation is linked to the value of a random variable (Rodríguez et al., 2016).In other words, it allows establishing the probability of obtaining that the value of said variable is greater or less than a certain value (Luna & Armada, 2022). That said, many models require that this statistic be met in order to continue with their estimates, but the ADM does not.

In the case of Box's M or test of variances and covariances, it is understood as a test that assumes that the variance and covariance matrices in each of the population groups are equal to each other. Additionally, this test is perceptible to the lack of normality (Rendón et al., 2016). In other words, the lack of normality would cause matrices that are equal to be significantly different according to the test (Mendoza et al., 2017) .In addition, if the sample number is large, the validity and effectiveness of the model is affected or in turn disappears. However, because the ADM is a robust method, it is not influenced in the event that any of the assumptions are not met (De la Hoz et al., 2014). From this, we began by considering n individuals based on a number p of variables that, therefore, are grouped because they have one of these variables in common, and with 2 or more categories so that each of the individuals acquires a series of valuations that show the group to which it corresponds (Carvajal et al., 2004). In other words, it is a process similar to factor analysis, because it seeks a linear function in such a way as to increase the variability between each set, and thus, to be able to discriminate them in a better way.

An equation called discriminant function is the one acquired when developing the ADM as a result that denotes the linear combination expressed by the variables, better known as canonical variables. It is important to consider, that the peak amount of discriminant functions that are reached, is equal to the minimum that occurs between q groups that are less than 1 (q - 1) and the number of variables (Arias et al., 2016).The linear combination that occurs between the predictive variables results in an unobserved variable (y), except that such a quantitative variable cannot be estimated as the explained section of a criterion variable, in the same way as in the multiple regression analysis (López et al., 2017). The discriminant coefficients aj, are expressed as the weighting of the variables that are predictive, same that express the contribution of such variables based on the discriminant function (Mendoza et al., 2017). Similarly, in the result of these, the degree of covariation that are original of the predictive variables is of great relevance.

Based on all that has been said, the ADM formula is expressed as follows:

$Y = a0 + (a1 * x1) + (a2 * x2) + \cdots + (ap * xp)$

Where:

X = the independent variables

a0 = the constant

ap = discrimination coefficients

The discriminant equation that will be obtained will be correct as long as it proposes a classification rule that decreases the errors, and as long as it analyzes and explains a large portion of the variability between groups.

3.3 Obtaining the discriminating variables

The process of determining discriminant variables tends to connect. Firstly, the definition of fundamental variables that apply to theoretical models that are already assessed by previous research

and, secondly, the implementation of statistical tests (R. Pérez, 2014). These two paths are considered complementary. In such a way, the statistical determination is given in function of the connection of a descriptive calculation, meaning, measurement of the means and other descriptive statistics values, relationship of the data and, finally, the most important dissimilarities given between the data sets (García et al., 2015). For the verification of the correlation between the groups, the Mahalanobis distance according to Wilks' λ is used.

3.4 Mahalanobis distance:

This process is given because it is a measure based on the squared Euclidean distance, which adapts to different variances. The selection method was given because its purpose is in maximizing the Mahalanobis distance D^2 (Torrado & Berlanga, 2016). Being its equation between groups i and j, defined as follows:

$$D_{ij}^2(x) = (n - m) \sum_{i=1}^{p} \sum_{j=1}^{p} H_{ij}(X_i^{(i)} - X_i^{(j)})(X_j^{(i)} - X_j^{(j)}) \ (1)$$

Where:
n: number of valid cases
k: number of groups
$X\_i^{\wedge}((i))$: measurement of group i
$X\_i^{\wedge}((j))$: measurement of group j
$X\_{ij}^{\wedge}((-1))$: inverse of the matrix of variances and covariances of the groups

3.5 Selection of the coefficients of the discriminant function:

The coefficients of the discriminant function are determined according to the previous process and the linear connection of these is considered as a factor or variable. It is relevant to understand that more than one discriminant function can be determined, however, only one of these will have the power to make predictions of the most convenient future classifications (Torrado & Berlanga, 2016). This selection process involves an auto value coefficient as much as the standardized one, but depending on, if the absolute value of the estimate (a_{ij}) is high, the association between the indicators (X_j) and their size function (Z_i), will be large (F. Pérez & Támara, 2012). In summary, the selection of such coefficients depends on the path taken by the Mahalanobis distance in its process.

3.6 Prediction of membership groups - Classification of subjects or objects:

Finally, with this technique, a subject is assigned to a group in order to outline a decision path. In such a way that, once it is applied, a result will be obtained in percentage value of the successes that have been predicted according to the classification of the subjects (Torrado & Berlanga, 2016). In order to obtain a classification table with the summary of the membership groups (Morales & Masis, 2014). That said, this process is one of the most important in the model because of its ability to resolve.

3.7 Lambda of Wilks Contrast:

The discriminant analysis statistic is considered as a contrast that allows determining the part of the total variability that is not influenced by the dissimilarities between the groups of study. That is, it provides the contrast of the null hypothesis that ensures the relationship between the multivariate means (Mora, 2022). It is important to mention that the autovalue does not have a maximum, which makes it difficult to have an auto-interpretation by itself, due to this is the importance of using the Lambda de Wilks contrast, because of its relation with the autovalues (Mendoza et al., 2017). That is, the autovalue of the discriminant function is considered as a proportion of the variability of the group

of points that is projected based on the functions. In summary, if the value is high, the function discriminates better.

4. Results

In order to respond to the purpose of this research, a descriptive analysis of both business size and productivity indicators is shown below.

4.1 Business size of construction companies in Ecuador

In order to analyze the business size according to their sales of the companies in the construction sector in Ecuador along with their years of analysis, in Figure N°11 it is determined that in the three years the largest number of companies are the "small" ones, being 2019 the year with the largest manifestation, with 18.82%. In the same way, it is established that the least number of companies that are expressed are the large ones, being 2020 the year with the lowest amount with 2.36%. In total, the percentage with the highest representation is 36% corresponding to the year 2019. In addition to the above, the data of the "large companies" are similar to the study conducted by the National Finance Corporation (NFC, 2022), where it defines that these companies are the ones that show the lowest number, however, its explanation is attributed to not requiring a greater number of companies for them to be the largest producers in the market, meaning that they have a much greater capacity to produce employment than all the others.
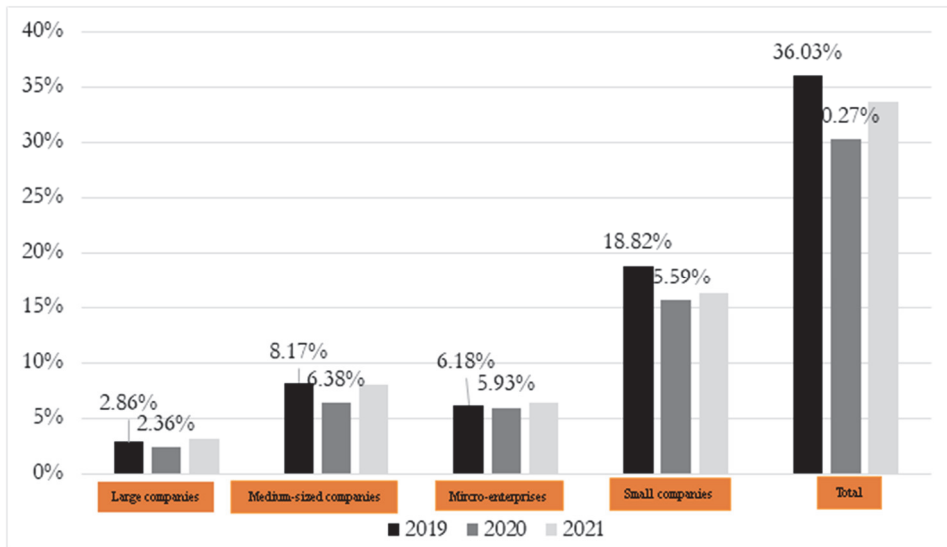

Figure 1. Percentage distribution of construction companies in Ecuador in the period 2019-202

4.2 Productivity indicators for Ecuador's construction sector

The analysis of the means of the productivity indicators, a statistic that allows obtaining a value without taking into account the outliers that were presented in each of the cases, was carried out thanks to the application of the exponential of the logarithm of the available data, in order to acquire more information and knowledge regarding the trend and proceeding of the sector of productivity indicators of the construction sector of Ecuador. Therefore, to determine particularities that maintain

and improve the quality of the industry, these are instruments that, when applied jointly, will support a more efficient and effective productivity. Therefore, it will allow the construction sector to establish strategic decisions that will improve its performance.

Table 2. Productivity indicators for Ecuador's construction sector

Means of indicators with Exp (Ln)					
Year	VAI_Exp	CPI_Exp	CPC_Exp	CP_Exp	EUI_Exp	LP_Exp
2019	2,75%	0,15%	13,72%	7,83%	10,05%	0,62%
2020	2,70%	0,16%	13,72%	5,56%	7,10%	0,62%
2021	2,71%	0,15%	15,48%	6,88%	9,25%	0,55%
Mean	8,16%	0,46%	42,92%	20,27%	26,40%	1,79%

*Note: Authors' calculation based on (Supercias, 2021).

The productivity indicators of Ecuador's construction sector from 2412 companies in the construction sector, data that were consolidated according to their mean to achieve an overall analysis for the period 2019-2021. As it was determined in Chart N°2, each of the indicators present a little increasing trend in their majority. In spite of this, focusing on the highest manifestation in the whole sector, it is obtained to the contribution of the personnel cost with 42.92% referring to this value as the celerity with which it produces added value to the company, that is to say, that all the expenses in salaries, fees and worker's rights attributed to the use of labor have produced a great contribution to productivity. On the contrary, the indicator with the lowest contribution to productivity is the capital participation index with 0.47%, which reflects a lower level of capital generation by the hands of value added, in other words, the low connection between employee organization and management. This refers to the low distribution of value added with respect to its own capital.

4.3 Discriminant analysis of Ecuador's construction sector

4.3.1 Discriminant analysis assumptions

Normality test of productivity indicators

Table 3 shows the results of normality of each of the productivity indicators of the construction sector in Ecuador, expressed by the Shapiro Wilk and Kolmogorov-Smimov normality tests, giving importance to the second test mentioned, because it is recommended to use it when the data exceeds 50 units. In the present investigation, 2412 companies were established, therefore, emphasis has been placed on this test, however, both tests were taken into account in order to have an assertion of the results obtained. The test establishes the significance of the test by using the confidence level used for the mean, so that the data generated in the significance of the test are analyzed according to the 0.05, to be determined as non-normal data. In addition to this, the assumptions for this test are considered as follows.

Table 3. Normality Test

Normality Test							
Indicators	Year	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	Gl	Statistic	Gl	Statistic	Gl
VAI Exp (Ln)	2019	0,487	869	0	0,019	869	0
	2020	0,343	730	0	0,388	730	0
	2021	0,317	813	0	0,407	813	0
CPI Exp (Ln)	2019	0,443	869	0	0,058	869	0
	2020	0,478	730	0	0,04	730	0
	2021	0,483	813	0	0,038	813	0

Normality Test							
Indicators	Year	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	Gl	Statistic	Gl	Statistic	Gl
CPC Exp (Ln)	2019	0,43	869	0	0,103	869	0
	2020	0,444	730	0	0,082	730	0
	2021	0,459	813	0	0,047	813	0
CP Exp (Ln)	2019	0,432	869	0	0,127	869	0
	2020	0,422	730	0	0,152	730	0
	2021	0,471	813	0	0,022	813	0
EUI Exp (Ln)	2019	0,429	869	0	0,152	869	0
	2020	0,427	730	0	0,145	730	0
	2021	0,48	813	0	0,021	813	0
LP Exp (Ln)	2019	0,454	869	0	0,07	869	0
	2020	0,468	730	0	0,041	730	0
	2021	0,465	813	0	0,063	813	0

*Note: Authors' calculation from R Studio software

Table 3 shows the results of the normality tests of the productivity indicators of the construction sector in Ecuador during the 3 years of analysis of this research work, 2019-2021, where the results are less than 0.05 in all indicators, so the null hypothesis is rejected and the alternative is accepted, thus determining that they do not follow a normal distribution. Despite the above, it is important to clarify that the Discriminant Analysis is not susceptible to normal or non-normal data, in other words, the method is not affected by the distribution of the variables under study.

4.4 Homogeneity test for variance and covariance matrices

Although discriminant analysis is a classification technique considered strong, that is, it is not highly influenced by the non-fulfillment of one of its assumptions. However, it is important to apply Box's M. test, which will consider the second assumption proposed in this research project. This test is defined according to the calculation of the covariance determinants focused on each group and it is based on the conjecture that the variance and covariance matrices are equal. In this case the approximate result to chi-sq is obtained in order to test the established premises, that is, table N°4 shows the results obtained from the Box's M. test for the productivity indicators of the construction sector in Ecuador according to its business size, where the primary focus of the results shown is in the p-value that, has a value of < 2. 2e-16, an estimate that indicates that the null hypothesis is not accepted, which establishes the equality of covariances given between the discriminated groups, in other words, the ability to explain the separation given between the groups is good.

Table 4. Box's M Test

Box's M test for homogeneity of covariance matrices		
Chi-Sq	Aprox.	48201,
	Df	63
	Sig	< 2.2e-16

*Note: Authors' calculation from R Studio software

4.5 Obtaining the variables with the highest discrimination

4.5.1 Mahalanobis Distance

To establish the discriminant variables, the Mahalanobis distance D^2 was used, because its contribution defines the difference or similarity between the groups of productivity indicators, in

other words, it discriminates the groups with the greatest contribution to productivity, taking into consideration a correlation between each group and, therefore, establishing the groups with the greatest variation. That is, to establish the discriminating variables of the data of the construction sector, the Mahalanobis distance is considered for each of the years, which is considered a criterion for selecting the discriminating groups, its form of calculation is given in terms of matrices, and its purpose is to determine from each of the productivity indicators which business size has a variation with greater magnitude. Overall, the results obtained from this criterion yield the discriminant coefficients described in table 5.

According to the previous information, the criterion used is the Mahalanobis distance, a criterion for which the productivity indicators calculated according to table N°5 were determined for the analysis of the size of their companies, considering all the years of research. that is, 2019-2021. From this process, the best discrimination coefficients are obtained and the discriminant function is formed, expressed in equation (2).

Table 5. Coefficients of the discrimination function of the productivity indicators

Indicator	Size
VAI Exp (Ln)	-0,0232
CPI Exp (Ln)	-0,0099
CPC Exp (Ln)	-0,0003
CP Exp (Ln)	-0,0017
EUI Exp (Ln)	0,0016
LP Exp (Ln)	0,0608

*Note: Authors' calculation from R Studio software

The values obtained in the coefficients of the discriminant equation are explained as indicators of relevance for the variable of this function, in this case size. Thus, they are analyzed in the first instance according to their absolute value, in order to then consider their highest estimate. Therefore, it is explained by considering the following: if the absolute value of the estimate (a_ij) is high, the association between the indicators (X_j) and their size function (Z_i) will be large. In this case, it is established that labor productivity (LP) is the indicator that represents the greatest relevance when determining the membership group. Unlike the other indicators, which even present negative values in their coefficients.

$$Z_{size} = VAI(-0,0232) + CPI(-0,0099) + CPC(-0,0003) + CP(0,0017) + EUI(0,0016) + LP(0,0608) - K \quad (2)$$

4.6 Business size classification of Ecuador's construction sector

In accordance with the discriminant function obtained, the analysis of a summary chart is available from which the groups of belonging of the subjects are established according to the application of this function. In table N°6, in the construction sector, it is observed that "micro-company" expresses 100% of correctly classified companies, while for "small companies" a value of 50.92% has been determined. It is important to clarify that in this case it is also considered that in the construction sector there are business sizes that do not present any discrimination, these are the "large company" and "medium company". In short, the total number of groups shows a classification effectiveness of 51.11%.

Table 6. Predicting membership groups as a function of company size

		Predicted membership group Remarks				
Predictions		Big company	Medium company	Microcompany	Small company	Total
Remarks	Big company	0	0	0	0	0
	Medium company	0	0	0	0	0
	Microcompany	0	0	10	0	10
	Small company	201	543	435	1223	2402
Percentage	Big company	0	0	0	0	0
	Mediaum company	0	0	0	0	0
	Microcompany	0	0	100	0	100
	Small company	8,37	22,61	18,11	50,92	100

*Note: Authors' calculation from R Studio software

4.7 Analysis of productivity indicators in Ecuador's construction sector

For the evaluation of productivity, the following indicators have been considered: value added index (VAI), capital participation index (CPI), personnel cost contribution (CPC), capital productivity (CP), equipment utilization index (EUI) and labor productivity (LP), which have been considered according to the business size of the companies in the construction sector in Ecuador, being these "Micro company", "Small company", "Medium company" and " Big company".

For example, Argentina, Brazil, and Colombia show relatively high fertility rates. This phenomenon is attributed to various factors such as limited accessibility to sexual education and contraceptives, lower educational levels, and a significant percentage of unplanned pregnancies.

4.8 Evaluation of productivity indicators of construction companies in Ecuador

In the first place, the difference presented according to the means of each indicator will be taken into account, with respect to the discriminated groups, both "Micro Company" and "Small Company", in other words, in the case that the means of each group are similar, it would mean that in this case the function does not discriminate the groups. In addition to this, the relevance of the indicator for the productivity of the construction sector will be considered, looking at the largest and at the same time its increase from one company size to another.

Therefore, table N°7 shows that all indicators have shown a significant change from one company size to another, being labor productivity (LP) the value that changes negatively because it has a lower manifestation in the "small company", however, the other indicators have shown that in this group is where they have greater discrimination, being the contribution of personnel cost the highest value, followed by capital productivity, equipment utilization index and value-added index.

According to the results obtained, it can be highlighted that the indicators with the most relevant behavior are the contribution of personnel cost (CPC) and capital productivity (CP), the first being an indicator that reflects that an efficient way in the use of personnel contributes to the chain of production processes of the construction service being profitable for the sector, that is, the optimization or, in turn, good use of employees' work time are factors that put companies in a link that, Despite their size, micro and small businesses can have a fairly favorable productive increase to cover their demand, hand in hand, capital productivity represents that the level of productive efficiency based on the good use of assets and available capital is due a logistical factor correctly directed, starting from professional work on plans, supplier management, time supervision, use of specialized labor, and joint work with productive sectors that are part of the production process and that in turn They also benefit.

Table 7. Productivity indicators as a function of their discriminating business sizes

Group 1	Microcompany	Small company
VAI_Exp (Ln)	0,536948	0,777738
CPC_ Exp (Ln)	0,013425	5,911213
CP_ Exp (Ln)	0,018662	2,473983
EU_ Exp (Ln)	0,027892	3,256108
LP_ Exp (Ln)	74,48837	0,16917

*Note: Authors' calculation from R Studio software

4.9 Lambda of Wilks Contrast

Lambda of Wilks is considered a statistic that calculates the discriminating power of a group of variables, in this case productivity indicators.

Table 8. Lambda of Wilks contrast as a function of company size in the construction sector in Ecuador

Category	Df	Wilks	Approx F	Num Df	Den Df	Pr(>F)	
Size	1	0,14463	2370.5	6	2405	2,20E-16	***
Residuals	2410						

*Note: Authors' calculation from R Studio software

The results in table 8 show the existence of significant differences in the productivity indicators addressed between micro and small companies, which were the categories of the size variable that recorded observations and were predicted by the model derived from the discriminant analysis. This is considered by registering a value of Lambda of Wilks close to zero, which was 0.1446, indicating that the mean of the variables measured differ between the levels of the categorical variable 'Size', that is, the groups of companies classified according to their size are very different. This is considered by registering a p-value of the Lambda of Wilks coefficient statistic significant at 1%, which was 2.20E-16, thus rejecting the null hypothesis and determining that "Productivity is significantly related to the business size of companies in the construction sector in Ecuador in the period 2019 - 2021". For such reason, the existence of an association between the mentioned variables indicates that the size that organizations have is associable with their productive performance due to different factors, as argued by Camino et al., (2018) and Van Stel et al., (2019) such as the trajectory of the companies in the market or the formation of economies of scale.

5. Conclusions

The construction sector is considered as one of the most influential in the economy of Ecuador due to its great capacity to accommodate other sectors, therefore, it is an indicator of the country's economy; despite that it is considered as an industry with quite sensitivity, especially to the large amount of labor and investment it requires. However, by virtue of the results of the Lambda Wilks test, the incidence that exists between productivity and business size of companies in the construction sector in Ecuador in the period 2019-2021 is verified, therefore, the alliance between these variables shows that the size of the companies is related to their productive function due to factors such as the establishment of economies of scale and the experience of the construction entities in the market.

Small construction companies are the ones that have the largest number compared to the others, however, they are the ones that were most affected in the period 2019 - 2021. It was determined that they have a lower sales capacity therefore their operating costs are lower, a factor

that lowers financial costs and raises their productive capacity, but those same benefits are what allowed them to have a strong solvency in the face of external problems and markets contracted from the health crisis. On the contrary, in spite of having a smaller quantity, large companies are the ones that have considerable capital and inputs, factors that require a great organization and control, adding that the use of infrastructure, labor and production process increases the supply with which this type of companies are managed, therefore, from an international market point of view, they have more profitability and sales capacity.

The productivity of the construction sector in Ecuador can be determined based on its indicators, where its analysis is distributed individually by mean of the statistical calculation of the median of each one of them, considering that their results have a different purpose than the others, however, the group of indicators has had a great contribution to the productivity of the construction sector and therefore to the country's GDP. In such a way that, it was obtained that the highest percentage in the median value is the contribution of the personnel cost, being this a sensitive indicator in process companies, which are dependent on a great number of processes to reach the final product, from raw material, elaboration and production, reason for which it requires a strong sum of investment in infrastructure, personnel and machineries. In spite of this, the PCC is an index that has demonstrated a great speed with which it produces added value in the production process, thanks to its great capacity for investment in fixed assets.

It was determined that the use of the analysis allowed discriminating among the indicators, those that have greater relevance according to the business size of the companies in the construction sector of Ecuador in the period 2019-2021 for the permanence of these companies in the market. The accuracy of the model is given by an average classification effectiveness of 51.11% of all groups presented by business size, which expresses an intermediate reliability of the model to predict the behavior of the productivity indicators of the construction sector, with small companies having a higher group membership than the others with 51.11%. Similarly, the discrimination function was obtained in view of the size, emphasizing that only the "Small companies" and "Micro companies" groups are correctly predicted. Obtaining a significant change on the part of the productivity indicators in the two groups, however, it is analyzed that the remaining business sizes do not fit or behave within their size categorization, which demonstrate their need to be accommodated beyond their productive capacity.

Finally, it is important to highlight the relevance of this research taking into account that Discriminant Analysis through values, in this case productivity indicators, can find the level or size to which the companies correspond. At the same time, the results provide a favorable evaluation of the state of the indicators and how their behavior will allow micro and small businesses to make decisions that are more accurate to the situation in which they find themselves individually, thus they will be able to choose for the improvement in its quality standards, efficiency in the use of its human resources, optimization of its inputs, development of the logistics and organizational system, and finally the strengthening of commercial agreements with other support sectors. According to the latter, it would be favorable for a complete future study if the discriminant analysis could focus on the other productive sectors of the country, which are related and largely support the circular flow of the economy.

6. Acknowledgment

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