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Innovation as a decisive factor of organizations in emerging countries

La innovación como factor decisivo de las organizaciones en países emergentes

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Abstract

Any field that requires renewal must enter into processes that contain innovation, this factor is vital for productivity, competitiveness and obtaining social welfare. The research was based on the question: what factors determine organizational innovation in an emerging economy? The objective was to develop a model that explains innovation as a dependent variable of a system of variables or independent categories for emerging economies, using a model of multiple linear regression. For the application of the methodology, a pertinent and measurable categorical system consisting of nine independent variables is extracted bibliographically. The information was obtained from 40 organizations in the metropolitan area of Medellín and 65 records with Likert scale questions. The data sampled for the different variables are moderately homogeneous. There is a linear relationship between the innovation variable and the subset of independent variables. The model indicated that the independent variables that most influence innovation are physical infrastructure, adaptability to change, and research and technological progress.

JEL Code: L67, O30, L29
Keywords: innovation; innovation variables; innovation in organizations

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Resumen

Cualquier campo que requiera renovación debe incursionar en procesos que contengan innovación. La investigación tuvo como partida la pregunta ¿qué factores determinan la innovación organizacional en una economía emergente?, el objetivo fue desarrollar un modelo que explique la innovación como variable dependiente de un sistema de variables o categorías independientes para economías emergentes, utilizando un modelo de regresión lineal múltiple. Para la aplicación de la metodología se extrae bibliográficamente un sistema categorial pertinente y medible conformado por nueve variables independientes. La información se obtuvo en 40 organizaciones del área metropolitana de Medellín y 65 registros con preguntas tipo escala Likert. Los datos muestreados para las distintas variables se encuentran moderadamente homogéneos. Hay una relación lineal entre la variable innovación y el subconjunto de variables independientes. El modelo indicó que las variables independientes que más influyen en la innovación es infraestructura física, articulación de políticas, adaptabilidad al cambio, e investigación y avance tecnológico.

Código JEL: L67, O30, L29
Palabras clave: innovación; variables de innovación; innovación en organizaciones

Introduction

Innovation plays an increasingly important role; it is a core component in productivity and competitiveness, which every organizational and social framework must seek to achieve levels of development. According to the Oslo OECD manual (2018), innovation is a new or improved product or process at the organization's service to best satisfy the market. Robledo (2019) indicates that innovation is an important social phenomenon since it generates real change associated with socioeconomic dynamics that brings wealth, welfare, and human development. "Innovation is also recognized as the key factor that ensures the sustainable competitive capacity of organizations and territories, compared to codified knowledge and material resources, which are more readily available" (Kohler & Gonzalez, 2014).

The concept of innovation can be explained as an eminently mercantile relationship, or an exclusive subject of productive organizations, as it has characteristics that affect the entire social structure and changes and power relations established among all social agents (social innovation). Innovation brings about changes and thus modifies all the daily occurrences and the framework of every socioeconomic structure. Nonetheless, to narrow down the present research, the analysis presented here will be on organizational innovation, based on the question: what factors determine organizational innovation for a network in emerging economies? The aim was to develop a model that explains innovation as a dependent variable of a system of independent variables or categories for emerging economies using a multiple linear regression model.

A literature search was carried out to obtain the independent variables or categorical system that support innovation as a dependent variable, which is also supported theoretically by Galeano (2003), who stated that for the analysis of research, it is pertinent to obtain variables or categories that are sufficiently representative to be evaluated. The categorical system variables were obtained in the following order: 1. Social Aspects (AS), 2. Wage Remuneration (RS), 3. Physical Infrastructure (IEF), 4. Policy Coordination and Government Support (AP), 5. Motivation (M), 6. Personnel Training (FP), 7. Adaptability to Change (AC), 8. Research and Technological Progress (IAT), 9. Labor Aspects (AL).

The selected variables were analyzed methodologically using a multiple linear regression model, specifying Innovation as a dependent variable with respect to 9 independent variables, as shown in Equation 1:

$$Y = \beta_0 + \sum_{i=1}^{9} \beta_i X_i + \varepsilon. \quad (1)$$

The technique for collecting information was through a survey sent to 40 different organizations located in the metropolitan area of Medellín, obtaining 65 records through Likert scale questions. In addition, the information was complemented with a bibliographic search of the organization.

Theoretical framework

Howells (2005), quoted by Cai, Normann, Pinheiro, and Sotarauta (2018), indicates that an innovation policy can be defined as a means governments use to establish priorities and approaches to promote innovation and economic growth. Nevertheless, each regional context will have different characteristics depending on the economic model, political order, organizational framework, and other social and cultural aspects. Guimon (2018) emphasizes that an innovation policy in emerging countries requires decentralization, supported by three complementary features: finding the correct division of the levels of responsibility in government, coordination mechanisms between the country and the regions, and an innovation policy that closes the income gap between regions.

The dichotomy between developed (USA - Western Europe) and emerging (China and India, particularly) countries in terms of innovation—notably analyzed in the work of Crescenzi and Rodriguez (2017)—and the economic dynamism of the BRICS countries (especially China and India, based on endogenous innovation) has generated a new geography of innovation: “the pace of change currently experienced by emerging countries is virtually unparalleled in history” (Henderson, 2010). The indicators of this increase in innovation are the levels of patenting, qualified human capital, researchers, and

publications, among others. Another noteworthy aspect is that innovative areas are not homogeneous throughout a territory, i.e., there are regions where progress is much higher in contrast to others.

Innovation is a key factor of productivity, according to the World Intellectual Property Organization (WIPO, 2018), and is a central determinant of the welfare of humanity (Baker, 2007). For the case of emerging countries such as Colombia, the "Green Book 2030" Colciencias, government of Colombia (2018) of the national science and innovation policy indicated that the State needed to increase scientific, technological, and innovation capacity to generate wealth, income, equity, and social welfare. Torres, Polanco, and Tinoco (2014) demonstrate that the Mexican states that produced more innovations achieved greater economic growth. Zhu, Chen, and Lian (2018) emphasize that in the case of China as an emerging economy, a successful innovation strategy is temporary clusters (trade fairs, exhibitions, conventions, congresses), which achieve rapid dissemination of knowledge as cyclical or temporary organizational groupings.

WIPO (2018) annually measures the Global Innovation Index. The 2018 report on the innovation performance of 126 countries, using 80 indicators—by Cornell University and INSEAD Business School—identified Switzerland as the most innovative country in the world, followed by the Netherlands and Sweden. Latin American countries include Chile (47th), Costa Rica (54th), and Mexico (56th). The report for the Government of Colombia, received by National Planning (DNP, 2018), confirms Colombia (65) as the fifth country in the region. To measure the indicator, the methodology used by WIPO included two sub-indexes: inputs, composed of five elements(institutions, human capital and research, infrastructure, market sophistication, and business sophistication), and results, with two elements (production of knowledge and technology, and creative production).

The research focuses on organizational innovation as a foundation for business growth in emerging countries: "The concept of innovation is born mainly as an action derived from economic aspects, which motivates creativity as a generator of new processes that drive economic growth" (Colpas, Taron, & Fuentes, 2019). Innovation as a business action arises from organizations' needs, as satisfiers of highly volatile markets, and consumers who want to obtain the highest levels of benefits in the act of purchase or consumption. "... innovation today depends largely on the interaction between the external environment and economic, political, and governmental conditions, as well as the internal configuration, resources, capabilities, and financial support of businesses" (Zapata & Gonzalez, 2021).

Velásquez, Pino, Restrepo, and Viana (2018) indicate that there are four ways for organizations to innovate: new or improved products; new processes or production methods or application of new technologies; marketing in terms of commercialization methods; and organizational, where management is improved. Organizational innovation is essential to achieve levels of growth and development. The organizations addressed in this research are located in the metropolitan area of Medellín (Colombia), in

the secondary and tertiary economic sectors (transformer and services). The World Economic Forum 2019 held in Medellin included a portfolio for emerging economies: smart commerce, artificial intelligence, aerospace of the future, precision medicine, data policy, and autonomous and urban mobility. Medellín won the City of The Year contest, organized by the Wall Street Journal and Citi Group, as an innovative world city.

Variables that determine innovation

The bibliography highlights the following variables that determine innovation for emerging economies, on which this research is based. Kim, Seo, Booranabanyat, and Kim (2021) indicate that organizations in these economies tend to possess relatively limited knowledge. Therefore, they have a greater need to transfer knowledge from developed economies, albeit with real implications for performance. Bodolica and Spraggon (2021) describe the importance of creating innovation centers that can be adopted by higher education institutions (HEIs). This contributes to an entrepreneurial mindset that encourages future innovative leaders and complements the importance of HEIs in research. Fumasoline and Rossi (2021) indicate that in the European Union transnational networks are formed to promote innovation.

1. Social Aspects (AS): the main characteristic of emerging and underdeveloped countries is the multiple unsatisfied needs of the population. It is important to highlight that "it is more likely that innovations will be generated in a context of scarcity and lack of economic opportunity" (Instituto Nacional de Tecnologías Agropecuarias, 2015). However, why is innovation not taking place? According to ECLAC (2018), there is no real public spending in Latin America that drives investment in research and development and other innovation policies to strengthen competitiveness. Therefore, governments should be a guarantor in the financing of innovation. Of how much interest will it be? Innovation should be a State policy and not a government policy; it should remain in the medium and long term until it is embedded in the collective thinking, in the soul of society. "Social innovations and changes in educational systems are the pillars of success in emerging countries" (Maldonado, 2020)

Another aspect highlighted by Caravaca, González, Méndez, and Silva (2002) is the importance of culture in innovative processes. What is the importance of culture in making a social context innovative? As emerging countries have multiple unsatisfied needs, the severe scarcity problem would be an opportunity for innovation; nonetheless, the cultural aspect plays a decisive role in innovation.

2. Wage Remuneration (RS): "Wages are an important factor for workers. They enable them to acquire the goods and services they require for their well-being and that of their families; for entrepreneurs, they represent a production cost" (Castro, Restrepo, & Gómez, 2019). In this situation, the wage is a basic income for employees hired by States or organizations interested in developing activities

that generate innovation. Katovich and Maia (2018) indicate that productivity should be significantly associated with salary levels; nevertheless, market and institutional factors dictate the wage conditions established. Therefore, an optimal salary that generates quality of life is crucial for employees with a high level of knowledge, who are developers of innovation processes.

3. Physical Infrastructure (IEF): the model of Baierle, Benítez, Benítez Schaefer, and Sellitto (2020) concerning SMEs in Brazil indicates how the competitiveness most influenced by innovation are the internal aspects of the organization or physical infrastructure. Diaz (2019) states that infrastructure is the hard element of logistics that guarantees innovation (transportation, airports, telecommunications, warehouses). Uribe Gomez (2021) states that logistics performance is one of the key elements of the Global Innovation Index for a country like Colombia. In addition, there are the soft elements, which will be the procedures and processes of innovative management. Organizations must have research departments (R&D&I, research+development+innovation) that lead and drive innovation processes. According to Juliao and Pineda (2019)—Dane (2015, 2016)—Colombia only invests on average less than 0.3% of GDP in R&D. There is no State policy to promote investment that encourages innovation. "Comparing the gross domestic product in R&D of the countries that are in the first places of competitiveness of the WEF, it was observed that they allocate between 1.7% and 3.5% of GDP to R&D" (Sarmiento, Nava, Carro, & Hernández, 2018). The differences that emerging economies such as Colombia and Mexico have in R&D (0.55% of GDP) are evident (Sarmiento et al. 2018).

4. Policy Coordination and Government Support (AP): Zapata and González (2021) indicate that most Latin American countries have implemented policies and strategies in the construction of innovation systems: Argentina, Brazil, Costa Rica, Colombia (Ministries of Science, Technology and Innovation), Uruguay (Ministerial Cabinet of Innovation), Chile (aquaculture and wine), Argentina (communication and food), and Costa Rica (tourism and forest conservation). Even so, the Latin American region contributes only marginally to innovation in the world. In addition, Uribe Gómez (2021) highlighted that for Colombia, this variable grouped in obtaining credit, investment, and strategic alliances is an influential variable within innovation metrics and in its global index.

The support of the State through a policy that benefits innovation is of utmost importance to establish a long-term vision of growth in such a way that it stimulates innovation and provides a great opportunity to ensure well-being. Institutional weakness is typical of Latin America with respect to the lag in innovation. There is no State policy but rather a government policy, i.e., everything depends on the government in power. There are low budget allocations, where the State is expected to develop innovation processes (State dependence), as opposed to developed countries where the private sector is at the forefront. The ECLAC report (2014) indicates that it is necessary to modernize Colombia in terms of

innovation policy: public policy models and instruments, governance models, and strengthening of institutional capacities at the technical level.

5. Motivation (M): Latham (2007), cited by López, Vélez, and Franco (2017), states that motivation is a term that covers a diverse series of desires, needs, impulses, longings, and internal forces, which originate in the cultural environment. From this perspective, what degree of motivation does a person need to undertake activities that lead to innovation in a cultural environment? Studies specify that there are intrinsic motivation factors (internal) and extrinsic factors (external) that are the triggers for the degree of motivation that a person may have to undertake any activity (Zarauz & Ruiz, 2015) (López, Vélez, & Franco, 2017). People must have a high degree of intrinsic motivation, such as a vocation, and a favorable external environment, such as salary and infrastructure, to carry out innovative processes. "When a person lacks motivation, neither the information nor the advice given from outside is useful" (Rubio, Medina, & Cembranos, 2000). Li et al. (2021) emphasize that employees' self-determination within the organization is the main motivator to achieve innovation. Motivation is the basis on which any process or human activity is based, especially those that require effort and permanent dedication, such as research activities that will bring innovation.

6. Personnel Training (FP): the innovation processes of organizations need to have well-trained intellectual capital, especially in those involved in knowledge management, in terms of human, structural, and relational capital (Bueno et al., 2011). Human capital includes the skills, capabilities, aptitudes, and attitudes that every employee has acquired throughout the training and learning process prior to recruitment by the organization. For its part, relational capital is the explicit knowledge that supports the dissemination and communication of scientific and technical knowledge owned by the organization and is composed of organizational and technological elements (Ramirez, 2013). Relational capital enables integration with the internal and external environment. Finally, as it contains high levels of specialization, innovation must establish work networks in high-performance teams. For a socioeconomic structure with innovation criteria, it is crucial to have educational organizations committed to this dynamic. "The economic growth of a territory depends on the presence of institutions, such as universities or innovation centers, whose systematic operation produces innovation" (Abeledo et al., 2016). It is necessary to have knowledge workers: "a necessary but not sufficient condition for innovation; it is necessary that teaching from basic levels focus on creative thinking" (Díaz, 2019). The research of Li et al. (2021)—carried out in the SMEs of Pakistan in the cities of Lahore and Karachi—shows the importance of training personnel to achieve innovation as an organizational culture, recognizing human talent as the main factor of organizational innovation, especially due to lack of hard technology in that place.

7. Adaptability to Change (AC): Managing change or innovation is considered a constant in history and is becoming increasingly prominent. Organizations must constantly reinvent themselves, adjusting products, processes, human talent, and relations with all environments. Organizations that are unable to change do not have much chance of success.

"To survive in an increasingly hostile and competitive environment, organizations must adapt and change the products and services they offer to the market" (Hidalgo, Vizán, & Torres, 2008). Peter Drucker (1986), quoted by Hidalgo et al. (2008), noted that "innovation is influenced by changes in demographics, perceptions, and culture, and new scientific and empirical knowledge." Organizations are compelled to adopt a culture of change, which is almost unavoidable or imperative. Current dynamics lead to change, and if they are not adopted, any organization is condemned to disappear. In addition, Uribe Gómez (2021) highlights factors represented by knowledge workers and knowledge absorption for Colombia, which are grouped in this variable as influential factors in the calculation of the global innovation index.

8. Research and Technological Progress (IAT): the Global Innovation Index cited by Zapata and González (2021) considers that education and research are the pillars of innovation, and human capital and research are influential factors within the index (Uribe Gómez, 2021). Multiple examples demonstrate that research is the path to reach innovation: Sanchez and Martin (2011) demonstrate it in sports; Golubev, Sekerin, Gorokhova, and Gayduk (2018) indicate that nanotechnology is a key sector for the economy where innovation is of the utmost importance. In administrative processes, Cheng, Yang, and Sheu (2014), cited by Pineda (2019), indicate that managers must develop effective innovation programs for optimal business performance. In the case of Innovation Marketing, which seeks to position cities as tourist destinations, Lesmes and Callejas (2018) emphasize that developing strategies through research is essential to enable cities to be innovative and in this way attract significant levels of tourism. Many examples indicate that the way to achieve innovation is through research. "Consideration of the scale, structure, and dynamics of research and development (R&D) implementation are the tools to evaluate the development of the innovation process" (Krosova, 2019). "Research and development (R&D) are the creative elements of innovation" (Mateo, 2006).

9. Labor Aspects (AL): the market must have "knowledge workers," as stated by Peter Drucker, quoted by Falco (2003): "Unlike the manual worker, the knowledge worker is the owner of their means of production. They identify themselves with their area of specialization and not with their employer. The organization is a resource for them, a space where they can apply their knowledge." In these circumstances, the labor market must have workers with high standards of training and continuous education in order to develop innovative products.

The labor market for a developer of innovative products is eminently specialized, with knowledge being the basis of all innovative production. "The impact of knowledge is determinant in all activities, no matter how simple and straightforward they may seem." (Mateo, 2006).

Methodology

To develop the model that explains the most significant variables that affect innovation within the organizational environment of emerging economies, the methodology devised by Devore (2018) will be followed using multiple linear regression. This methodology investigates the relation between multiple associated variables in a nondeterministic way, that is, with a fixed value of the variables (X), where the response of the dependent variable (Y) is uncertain.

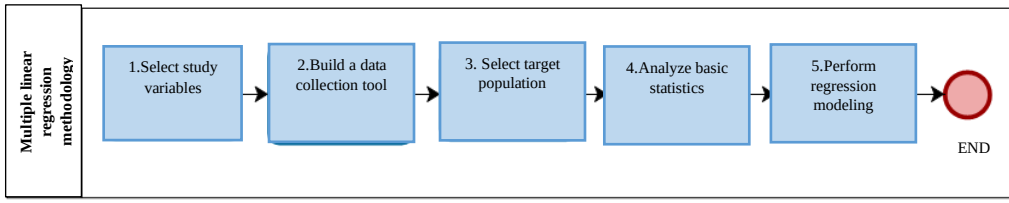
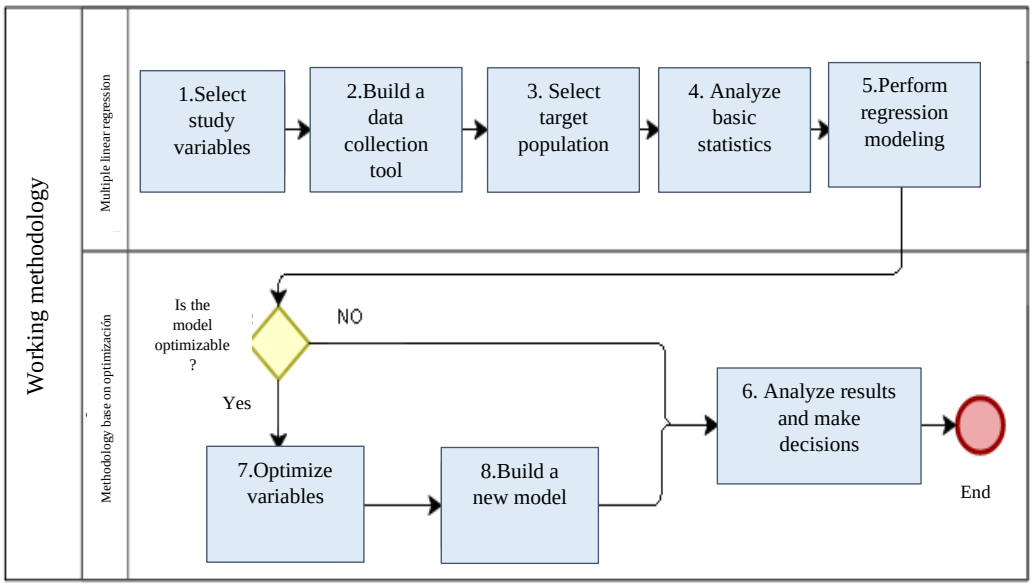


Figure 1. Representation of the multiple linear regression methodology
Source: created by the authors

Including different types of methodologies in the object of study obtains improved models; this is how multivariate statistics and regression models integrate multiobjective optimization methodologies, allowing a better assessment of the models represented. In this aspect, Martínez, González, Garza, and Hernández (2018) recognize the usefulness of multi-attribute techniques. Nonetheless, it is often necessary to determine the optimal combination of controllable or independent factors or variables, having to decide it by optimization methods. In this case, regression models are integrated with optimization to find the best-fit polynomial that characterizes the situation. Figure 2 proposes a working method that shows the formation of a multiple regression problem with the application of optimization to obtain the best combination of variables that satisfies the criteria proposed.



Methodological steps used:

1. Selecting the study variables: in this step, the variables to be studied are characterized, and the independent and dependent variables are defined.

2. Building a data collection tool: the survey to be applied, including the study variables and hypotheses, is created using the MS EXCEL 2016 platform.

3. The hypotheses for the regression model are constituted as follows: Null hypothesis (H_0) consists of statistically demonstrating that all the independent variables of the study are equal and have no effect on the dependent variable and on the regression model. The alternative hypothesis (H_1) states that at least one independent variable has an effect on the regression model.

4. Selecting the target population: the sample of the population to be studied was estimated using GPower software version 3.1.

5. Conducting statistical analysis using Statgraphics, Centurion, and IBM Spss software

6. Developing the regression model with the selected data and variables using the software mentioned.

If the model cannot be optimized or the delivered solution is considered to meet the criteria, step 6 can be established.

7. Analyzing results and making decisions: using the multiple regression equation that describes the statistical relation will allow estimations and predictions to be made.

If the model allows for optimizing the variables found in the relations, steps 7 and 8 can be established.

8. Optimizing variables: the multiple regression equation is formed, and through optimization, the most suitable variables are selected and evaluated according to the interest of the chosen sample.

9. Building a new model: the regression equation is defined, selecting the best combination of variables.

Calculation of the required sample

GPower software version 3.1 was used to calculate the sample for the multiple linear regression model. In this case, the number of surveys required was 65, calculated with a random error of 19% and 9 predictor variables within the model. Table 1 shows the method of sample size calculation.

Table 1
Sample size calculation

T-test: Multiple linear regression: fixed model, fixed regression coefficient		
A priori: Calculation of required sample size		
Inputs	α error probability	0.19
	Strength (1-β error probability)	0.95
	Number of predictors	9
Outputs	Non-centrality parameter δ	2.5495
	critical t	0.8850
	Degrees of freedom error	55
	Total sample size	65
	Current strength	0.9518

Source: Faul, Erdfelder, Lang, and Buchner (2007)

Table 2 presents the question associated with each variable to measure innovation in every organization. The table responds to each item listed in the section variables affecting innovation.

Table 2
Questions asked associated with the measurement variable

Variable	Questions asked in the survey
Social Aspects (AS)	Is the social environment in which the organization is located secure?
Wage Remuneration (RS)	The wages paid by the organization to its employees and workers are...?
Physical Infrastructure (IEF)	Does the organization have the appropriate physical infrastructure to carry out its activities?
Policy Coordination and Government Support (AP)	Does the organization have governmental support to develop innovation?
Motivation (M)	Do employees feel motivated by the work environment? Are there incentives from the company when the employee undergoes training?
Adaptability to Change (AC)	Do you consider that the organization has been able to adjust to the changes that have occurred?
Personnel Training (FP)	When employees arrive for the first time, do they undergo an induction process? Are there training processes from the organization for its workers?
Research and Technological Progress (IAT)	Do you think the products manufactured by the organization are innovative in the market?
Labor Aspects (AL)	Does the organization ensure job stability for its workers, especially when they are innovators?

Source: created by the authors

Table 3 provides a brief description of the organizations providing information located in the metropolitan area of Medellín (Colombia).

Table 3
Types of organizations surveyed in the metropolitan area of Medellín

Number of Organizations	Type of activity	Number of Organizations	Type of activity
2	Bakers	2	Public Transportation Organizations
1	Household products trading company	2	Medical products distributors
1	Social Foundations	2	Textile industries
1	Non-alcoholic beverage industry	1	Purchase and sale of construction equipment
1	Public event coordinator	3	Financial Cooperatives
3	Lithographs	2	Teachers' Employees Fund
2	Automotive lubrication service	2	Motorcycle assemblers
2	Cosmetics laboratories	1	Insurance organization
2	Outlet of original brand clothing	1	Biomedical equipment developer
1	Ophthalmological examination laboratory	1	Paint Manufacturer and Distributor
1	Health care institution	2	Hotel Management
2	Higher Education Institutions	2	Security organizations

Source: created by the authors

Findings

Based on the data obtained in the surveys of the 40 organizations, where 65 records were obtained, Table 4 shows the results of the basic statistics for the non-grouped data. These results include the minimum values, maximum values, averages, standard deviations, and coefficient of variation for each variable. It is important to emphasize that this last statistic is an important measure that represents the measure of dispersion of the behavior of the data collected. The results show that the independent variables Social Aspects, Motivation, Personnel Training, Adaptability to Change, and Research and Technological Progress have a value greater than 0.2 (20%), as does the dependent variable Innovation. This means that the data are highly dispersed, and as a general rule, high dispersion is found in values greater than 21% (Uribe Gómez, 2021). Lower values in this coefficient indicate that the data sampled for the different variables are moderately homogeneous (Rustom, 2012) around their mean.

Table 4
Basic statistics of the independent and dependent variables

Variable	#	Minimum	Maximum	Mean	Deviation	Variation coefficient
Social Aspects (AS)	65	2.00	5.00	4.09	0.87	0.21
Wage Remuneration (RS)	65	2.00	5.00	3.98	0.78	0.19
Physical Infrastructure (IEF)	65	2.00	5.00	4.30	0.86	0.20
Policy Coordination and Government Support (AP)	65	3.00	5.00	4.29	0.70	0.16
Motivation (M)	65	1.00	5.00	3.96	0.99	0.25
Personnel Training (FP)	65	1.00	5.00	3.67	1.39	0.37
Adaptability to Change (AC)	65	1.00	5.00	4.00	1.13	0.28
Research and Technological Progress (IAT)	65	2.00	5.00	3.95	0.94	0.23
Labor Aspects (AL)	65	2.00	5.00	4.58	0.65	0.14
Innovation (I)	65	0.00	5.00	4.15	1.13	0.27

Source: created by the authors

Multiple linear regression model

The model with n-independent variables will form a multiple linear regression model, and it will be estimated according to Equation 2:

$$\hat{Y} = \beta_0 + \sum_{i=1}^{n} \beta_i X_i \quad (2)$$

Where:

$\hat{Y} =$ Estimate of the dependent variable

$\beta_0 =$ Continuous coefficient representing the intercept

$\sum_{i=1}^{n} \beta_i =$ Constant coefficients representing slopes. It indicates units of change

$X =$ Independent variables or predictors of Y

This multiple regression model enables the evaluation of the relation that exists between a set of independent variables (X) and a dependent variable (Y) to study the impact of the independent variables on the dependent variable or to predict the values of the independent variable (Y) (Véliz, 2017). According to the general equation, the multiple linear regression model proposed for the phenomenon is the one presented in Equation 3:

$$I = \beta_0 + \beta_1 AS + \beta_2 RS + \beta_3 IEF + \beta_4 AP + \beta_5 M + \beta_6 FP + \beta_7 AC + \beta_8 IAT + \beta_9 AL \quad (3)$$

Table 5 shows the estimated values for each of the coefficients that include the study variables of the phenomenon. In this case, the P values for each of the variables can be seen, indicating that with a significance level equal to 0.05, since the P value is greater than the significance level, the null hypothesis, which indicates the significance of the variables on the model, is not rejected.

Table 5
Multiple linear regression model

Variable	Estimated Value	P-value
Constant	1.40	0.2717
Social Aspects (AS)	0.045	0.7729
Wage Remuneration (RS)	-0.052	0.7685
Physical Infrastructure (IEF)	0.176	0.2578
Policy Coordination and Government Support (AP)	-0.193	0.3649
Motivation (M)	0.179	0.3439
Personnel Training (FP)	0.0613	0.5562
Adaptability to Change (AC)	0.340	0.0623
Research and Technological Progress (IAT)	0.268	0.1059
Labor Aspects (AL)	-0.112	0.5732

Source: created by the authors

By estimating these coefficients, the statistical model representing the relation between innovation and the independent variables is constructed, as shown in Equation 4:

$$I = 1.40 + 0.045AS - 0.052RS + 0.176IEF - 0.193AP + 0.179M + 0.0613FP + 0.34AC + 0.268IAT - 0.112AL \quad (4)$$

In the generation of the model, the analysis yielded the P-values (test statistic) for each variable. Removing the variable Social Aspects (SA) from the model is recommended as it has the highest P-value and is not significant.

Adequacy of the model

To ensure the best possible fit of the model, it is tested whether at least some of the independent variables serve to explain the dependent variable (Y) (Véliz, 2017). In this case, the null and alternate hypotheses presented in Equations 5 and 6 are used. These hypotheses involve finding whether the variables in the regression model have a linear relation between the innovation variable and the subset of independent variables:

$$H_0: \beta_1 = \beta_2 = \beta_3 \ldots = \beta_9 = 0; \quad (5)$$

$$H_1: \beta_j \neq 0, \text{at least for a j} \quad (6)$$

Table 6 shows the analysis of variance (ANOVA). Rejection of the null hypothesis will indicate that at least one of the independent variables in the model contributes significantly to the explanation of the innovation variable.

Table 6
Analysis of variance for the multiple linear regression model

Source of variation	Sum of squares	Degrees of freedom	Root mean square	F calculated	P-Value
Model	31.9702	9	3.55225	3.87	0.0008
Residuals	50.4913	55	0.918024		
Total (Corr.)	82.4615	64			

Source: created by the authors

The results obtained in Table 4, according to the calculated p-value, indicate a linear relation between the innovation variable and the subset of independent variables. This value is less than 0.05,

accepting the alternative hypothesis and rejecting the null hypothesis. Likewise, using the data analysis obtained through the software, the adjusted coefficient of determination is calculated with a result of 28.75%. This means that the percentage of variability explained in the independent variable considers the relation between the sample size and the number of independent variables in the regression model (Groebner, Shannon, & Fry, 2018).

Regression model optimization

Once the adequacy of the model has been established, there are several options to form alternative models with the best variables (Véliz, 2017). Thus, it is possible to have similar effects and significance on the response variable, helping to reduce the number of independent variables in the regression model. For this purpose, the independent variables have been listed with the following classification: A= Social Aspects (AS); B= Wage Remuneration (RS); C= Infrastructure (IEF); D= Policy Coordination and Government Support (AP); E= Motivation (M); F= Personnel Training (FP); G=Adaptability to Change (AC); H= Research and Technological Progress (IAT); I= Labor Aspects (AL).

The analysis performed using the Statgraphics software yielded 512 optimized model combinations. Table 7 shows the selection of the first 5 models, corresponding to a higher adjusted R^2 coefficient of determination. The higher the values, the lower the mean squared error; therefore, the best model contains 4 variables to be highlighted.

Table 7
Sample of optimal models for innovation

MSE	R-Squared	Adjusted R-squared	Cp	Included variables
0.863701	37.1561	32.9665	1.44959	CDGH
0.864714	36.0338	32.8879	0.457732	CGH
0.869596	37.7817	32.509	2.88764	CDEGH
0.871077	36.6194	32.3941	1.93165	CFGH
0.873942	36.4109	32.1716	2.11894	CEGH

Source: created by the authors

The optimal linear model to represent the linear relation is constituted as presented in Equation 7, whose selected variables are Infrastructure, Policy Coordination and Government Support, Adaptability to Change, and Research and Technological Progress:

$$I = 1.104 + 0.219IEF - 0.20AP + 0.471AC + 0.272IAT \quad (7)$$

The analysis of variance performed for the selected CDGH model is presented in Table 8, which shows a significant relation between the response variable Innovation and the independent variables selected for the optimized model since the p-value is much less than 0.05.

Table 8
Analysis of variance for the optimized model

Source of variation	Sum of squares	Degrees of freedom	Root mean square	F calculated	P-Value
Model	30.6395	4	7.65987	8.87	0
Residuals	51.8221	60	0.863701		
Total (Corr.)	82.4615	64			

Conclusions

Based on the findings presented, it can be concluded that the model that best explains the relation between innovation and the independent variables is the one that directly includes Physical Infrastructure, Policy Coordination and Government Support, Adaptability to Change, and Research and Technological Progress. Each of these contributes positively to improving innovation, as represented by the statistical indicators in the model. It is important to note that the surveyed organizations are heterogeneous, as they belong to the service and manufacturing sectors. Even so, they share similar results in the selection of the determining variables for innovation.

Initially, the model had 9 independent variables that were used to explain the relation with innovation in each of the sampled organizations. However, a relatively low determination coefficient was found and based on this result, it was decided to look for better combinations of independent variables in order to optimize these relations and increase the statistical indicators of the model —in this case, to increase the reliability of the coefficient of determination. However, this coefficient can be improved in different ways; some involve taking a larger amount of data for the independent variables to make the results more homogeneous and increase the number of samples that contribute to strengthening the results.

Within the multiple linear regression model, it was found that variables such as Wage Remuneration, Policy Coordination and Government Support, and Labor Aspects have an inverse incidence on the dependent variable Innovation, indicating that economic revenue, policy coordination, or labor stability do not necessarily favor innovation, but rather that it is a mixture of favorable factors.

When contrasting the resulting variables for the regression model with the theoretical framework that explains how innovation emerges in different organizations—which can be extrapolated to emerging

country contexts—it should be noted that the four (4) independent variables show a relation with innovation. In other words, the physical infrastructure has been able to explain how Brazil has managed to enhance its innovation policy. On the other hand, innovation systems take advantage of the coordination of government policies to promote innovation; such is the case of China, which has a strong central government that promotes science, technology, and innovation policies. Although less evident, Adaptability to Change is also a necessary variable in innovation to promote the management of change in processes, resources, human talent, knowledge, and policies. Finally, the Research and Technological Progress variable is a variable that drives innovation since representative innovation processes can be achieved through applied basic research, the generation of R&D models, and the management of ideas.

Based on the variables that determine the innovation model for emerging countries—Physical Infrastructure and Research and Technological Progress—it is essential for organizations to promote adequate spaces: to have an R&D center and to replicate it throughout the organization as part of the culture. On the part of the State, it is necessary to allocate, as a policy for public spending on social investment, a large budget to guarantee adequate resources in research for logistics and training of human talent. Regarding the variable Adaptability to Change, it is a premise that change has always existed; it is only that, at present, a more vertiginous pace of change is evident since the current era is increasingly complex. In this regard, only through a policy of permanent innovation will it be possible to maintain cutting-edge organizations in the market and economies with adequate quality of life for their citizens.

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