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The diversity of the local economic structure and its relation with occupational demand and poverty rates in Mexico's metropolitan areas

La diversidad de la estructura económica local y su relación con la demanda ocupacional y los índices de pobreza en las zonas metropolitanas de México

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Abstract

This research explores how the diversity of the economic structure in metropolitan areas is related to occupational demand and to moderate and extreme poverty rates. Data from a sample of 29 metropolitan areas in Mexico were analyzed. The variables Simpson Diversity Index (IDS), Informality Rate, State GDP Variation and Years of Schooling were incorporated into the analysis as predictors of employment and poverty. Descriptive and inferential statistics were used as analysis tools, and linear regression and PLS models were formulated. As a relevant result, it was found that there is a significant positive correlation between the IDS and the number of Permanent Insured; as well as significant negative correlations between the IDS and the percentage of the population in a situation of moderate poverty and extreme poverty

JEL Code: C29, 017, R12
Keywords: Simpson diversity index, metropolitan zones, employment predictors, poverty predictors

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Resumen

Esta investigación explora la forma en que la diversidad de la estrucura económica en las zonas metropolitanas se relaciona con la demanda ocupacional y con los índices de pobreza moderada y extrema. Se analizaron datos de una muestra de 29 zonas metropolitanas de México. Al análisis se incorporaron las variables Índice de Diversidad de Simpson (IDS), Tasa de Informalidad, Variación del PIB Estatal y Años de Escolaridad como predictores de empleo y pobreza. Como herramientas de análisis se utilizó estadística descriptiva e inferencial y se formularon modelos de regresión lineal y PLS. Como resultado relevante se encontró que existe una correlación significativa de signo positivo entre el IDS y el número de Asegurados Permanentes; así como correlaciones significativas de signo negativo entre el IDS y el porcentaje de población en situación de pobreza moderada y pobreza extrema

Código JEL: C29, O17, R12
Palabras clave: índice de diversidad de Simpson; zonas metropolitanas; predictores de empleo; predictores de pobreza

Introduction

It is difficult to imagine that a company can emerge and remain in the market without being part of a business ecosystem or outside its influence. Aspects such as the manufacturing specialization of a city or region, the local and national business environment, the number of companies participating in the different economic sectors and subsectors, the interdependence of sectors and subsectors, the formation of supply chains, and the size of the market seem to be related to the emergence and closure of businesses, and therefore to companies' life expectancy.

Metropolitan areas are complex ecosystems with high concentrations of businesses. Nevertheless, each metropolitan area possesses characteristics that differentiate it from its peers. The question that gives rise to this research is whether and to what extent the characteristics of metropolitan areas, understood as business ecosystems, exert any influence on variables associated with social and business development, such as poverty and employment.

Literature review

According to the National Institute of Geography and Statistics (Spanish: Instituto Nacional de Geografía y Estadística, INEGI) (2014), there are 59 metropolitan areas in Mexico where 73% of the population resides and 77% of the GDP is produced. A metropolitan area is formed when a city "exceeds its political-administrative territorial limit to form an urban area located in two or more municipalities" (Sobrino, 2003). The formation of metropolitan areas is a socio-spatial process whose dynamics are influenced by economic and social phenomena such as the social and spatial division of labor, the integration of regions into the flow of local and global economic value, supply chains, and globalization or selective specialization of local economies (Bernardes and Castillo, 2007).

Different authors (Santos, 1977; Sanchez, 1991; Bernardes and Castillo, 2007) agree that these are complex places, composed of different subspaces, whose administration is subject to the variability of public policies and private investment decisions. There is also the perception that, although each metropolitan area has unique characteristics, in countries such as Mexico and Brazil—still located on the "periphery" of the economic giants—their development faces major limitations in the absence of long-term territorial planning.

Iracheta (2010) considers that metropolitan areas concentrate location advantages (economies) for social and economic actors that are superior to most neighboring cities, and offer better living conditions, provision of services, and equipment. He also notes that the disadvantages of metropolitan areas are a tendency toward disorganized and unsustainable growth, unequal provision of services—especially for poor social sectors—, lack of resources to address social needs, weak institutions, and lack of a framework for intergovernmental coordination.

Following Iracheta's (2010) rationale, the locational advantages offered by metropolitan agglomerations—derived from productive, sectoral, and spatial concentration processes, as pointed out by Garza and Schteingart (2010)—would presumably exert some kind of influence on phenomena such as poverty and economic informality. Lezama (2014) mentions that these are socially constructed spaces where social relations evolve, but inequality and inequity do so as well.

One of the ways in which the complexity of urban entrepreneurial ecosystems seems to relate to the phenomenon of poverty is how the configuration of labor markets means that access to employment would be one of the determinants for the population to improve their quality of life progressively, but that they can also quickly fall into poverty in situations of economic contraction, given their dependence on income from work (Aguilar-Zurita, Martínez and Armenta, 2018).

A key variable for understanding the interactions between the economic and social subsystems is the phenomenon of informality. According to Robles, Sánchez, and Beltrán (2019), it is the result, on the one hand, of the low development and productivity of an economy, and on the other, of the heavy demographic concentration in urban areas. Income inequality, lack of social security, and deficient tax collection would be among its consequences.

Robles et al. (2019) state that the population increase in urban areas has a positive relation with informality. Consequently, a priority of public policies in these areas should be the generation of employment and not only mobility, public services and housing, which are the predominant concerns of metropolitan administrations.

The Sustainable Development Goals (SDGs) defined by the UN in 2015 are the framework of a new development agenda whose objectives are eradicating poverty, protecting the planet, and ensuring prosperity for all. In Mexico, the 2030 Agenda for Sustainable Development was adopted, and the Sustainable Cities Index, in which the original 17 goals were translated into 107 indicators, was established (Citibanamex-Centro de Investigación y Docencia Económica [CIDE] 2018).

The reason why the monitoring of the SDGs in Mexico has an emphasis on metropolitan administration is the degree of population concentration in urban spaces, coupled with the processes and imbalances that generate chronic problems of poverty, vulnerability, inequality, and environmental impact (Citibanamex-CIDE, 2018).

Terraza, Rubio, and Vera (2016) note that in urban growth processes, both the need for capital and the means of production converge, as well as the need to meet the aspirations of society that would otherwise be unrealizable. In this respect, they point out that if fairer growth prospects are sought, it is necessary to resort to new planning methodologies and, above all, to think about urban economies from other perspectives that are simultaneously open to local and global aspects. This way, the urban space favors the interaction of nano and micro enterprises with large companies, which could be achieved through managing and strengthening business ecosystems.

The metropolitan area as a business ecosystem

Each metropolitan area has ecosystemic characteristics and pressures that simultaneously drive business creation and closure. It follows that one way to explain the growing specialization and improved efficiency of companies in metropolitan environments is by using a biological metaphor, comparing organizations to biological beings, which are part of ecosystems, focusing on survival and seeking a balance between their subsystems and the environment (Montoya et al., 2012).

The integration of economic units into business ecosystems is a topic that has been widely explored. Authors such as Williamson (1975) state that reducing transaction costs is one of the main motivations for companies to integrate, which also leads to improved productivity since collectivity allows companies to improve their efficiency (Montoya et al., 2012) by favoring their degree of specialization. Among the business groupings that have been widely studied are clusters (Kothandaraman and Wilson, 2001) and productive agglomerations (Teixeira and Ferraro, 2009).

Along these lines, Moore (2005) proposes the notion of organizational ecology to characterize the economic communities in which leading producers, suppliers, customers, and competitors interact. By developing specialized functions, they carry out co-evolutionary processes; that is, they help beneficial relations between two species to evolve.

Montoya et al. (2012) point out that in this type of ecosystem the agents, i.e., the companies, are related by competition, cooperation, or mutualism, and that in general, there is an intention to access markets, solve problems, or access technology that motivates companies to integrate.

Duranton and Puga (2000) point out several key aspects of diversification and specialization in cities, including the fact that both characteristics coexist. To calculate the degree of specialization, they propose a Specialization Index that quantifies a sector's share in local employment. For diversification, they propose the inverse of the Hirshman-Herfindal index, which consists of the sum of the squares of firms' market shares in a given sector.

Regarding highly specialized cities, Duranton and Puga (2000: 534) point out that behind their economic structure lies a strong dependence on natural resources. They also note that large cities tend to be more diversified, while cities with similar levels of specialization have similar sizes, and that the growth of a city is related to specialization and diversification.

In another paper, Duranton and Puga (2019: 43) propose a model of how cities and urbanization interact with aggregate income and economic growth. They identify patterns in which residents of less productive localities are incentivized to move to more productive localities; however, this trend is constrained because city residents impose regulations limiting the arrival of new residents. Thus, when modeling the heterogeneity of localities, they propose considering both agglomeration economies and urban costs, and warn that limiting the size of cities also limits the benefits o agglomeration.

Associating industrial composition with diversity, Park (2020) warns that industrial diversity tends to increase in technology-intensive industries but decreases in traditional ones. He also found that vertical markets are strongly correlated with diversity in building space and that high land prices hinder agglomeration and may have a negative association with diversity.

Analyzing the formation of clusters of knowledge-intensive companies, Pérez-Campuzano (2021) finds that variables such as educational level influence the location of companies but not necessarily the number of companies. In contrast, the presence of other companies and the transportation and mobility variables influence the number of companies that are set up in these clusters.

Another factor related to economic diversity and poverty levels is the rate of entrepreneurship. In this regard, Lee and Rodríguez-Pose (2020) warn that the effect of entrepreneurship on poverty levels in cities depends on the sectors in which it operates. For example, when it is concentrated in tradable sectors with other cities or regions, it can generate positive multiplier effects and impact poverty levels, while if it is focused on non-tradable sectors, it can saturate local markets, neutralizing its effects on poverty.

Socio-ecological systems and structural coupling

A perspective that can also be used to explain the behavior and survival capacity of organizations is that of socio-ecological systems and structural coupling. This theoretical approach proposes that there is a web of relations around the resources that are necessary for human life where social and environmental variables interact (Ostrom, 2009). Accordingly, interactions do not only occur in the social sphere but are also related to physical space.

Among the concepts incorporated into the socio-ecological system approach are self-organization, which designates mechanisms that respond to the preconditions of the system from which its structure can be modified, and attractors or states of self-organized stability (Gunderson and Holling, 2002; Urquiza and Cadenas, 2015).

Another concept that can help understand a social-ecological system is resilience, which in its general form is understood as the capacity of a system to adapt to changing conditions in its environment and to resist or recover from impacts without losing its integrity. In the case of a social-ecological system, it seems to be related to the diversity of the elements that make it up, in such a way that a greater variety of elements is a major advantage in stressful and risky situations (Urquiza and Cadenas, 2015).

In this context, reviewing the concepts and metrics used to estimate the specific diversity of communities is relevant. It is important to note that, although the subject has been widely debated and has also led to semantic and conceptual problems (Hurblert, 1971), specific diversity is considered an emerging property that is related to the variety of communities and is derived from two components: the variety or richness of species and equitability, which is the distribution of abundance among the number of species.

The Margalef (1956) index expresses the specific abundance, that is, the relation between the number of species (S) and the total number of individuals observed (n).

The Shannon-Wiener (H) and Simpson (D) indices measure diversity, incorporating specific richness and equitability in a single value. The Shannon-Wiener index derives from information theory and measures the information content per individual in samples obtained at random from an extensive community, so that diversity is understood as the degree of uncertainty in predicting to which species an individual taken at random from a sample of S species and N individuals corresponds (Pla, 2006).

Simpson's diversity index indicates the probability of finding two individuals of different species in two successive random extractions without replacement (Bouza, 2005). It is expressed in the following equation:

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$$Si = 1 - \sum_{i=1}^{S} pi^2 \tag{1}$$

where pi is the proportional abundance of the ith species and represents the probability that an individual of species i is present in a sample, so the sum of pi equals 1. Therefore,

$$pi = \frac{ni}{N} \tag{2}$$

Values close to 0 in Simpson's Diversity Index would indicate the dominance of a few species, while values close to 1 would indicate greater diversity, less dominance of certain species, and greater ecosystem stability.

Methodology

The research was quantitative, correlational in scope, and cross-sectional in design.

The research questions are:

- Is there any statistically significant relation between Simpson's Diversity Index and moderate and extreme poverty rates in metropolitan areas?"
- Is there any statistically significant relation between Simpson's Diversity Index and job generation in metropolitan areas?"

The research aim is to determine whether the diversity of lines of business in a metropolitan area influences poverty levels and the capacity to generate or retain jobs.

For this research, the subsectors of economic activity will be considered as the equivalent of the species of an ecosystem, and the number of economic units of each subsector per metropolitan area will be the equivalent of the number of individuals of each species per ecosystem. The basis for determining the subsectors (or species) was the Industrial Classification System for North America (Spanish: Sistema de Clasificación Industrial para América del Norte, SCIAN 2018), and the data on the number of units or individuals were taken from INEGI's National Directory of Economic Units (DENUE).

The research consisted of collecting data and calculating and correlating the variables mentioned in the research questions, as shown in Table 1.

Table 1
Operationalization of variables

Variable	Calculation method	Source of data
Specific wealth of the business ecosystem	Number of different subsectors registered in a metropolitan area.	National Directory of Economic Units (DENUE). INEGI, 2018
Simpson's diversity index	$\mathrm{Si} = 1 - \sum_{i=1}^{S} \mathrm{pi}^2$	National Directory of Economic Units (DENUE). INEGI, 2018
Population living in extreme poverty by metropolitan area	Number of people per metropolitan area living with an income insufficient to purchase a basic food basket and lacking at least three of the following basic needs: food, health services, social security, education, basic housing services and housing quality, and total population of the metropolitan area.	CONEVAL, Poverty Module at Municipality Level 2010 and 2015
Population in moderate poverty by metropolitan area	Number of people living with an income insufficient to satisfy their basic needs and suffering at least one of the following deprivations: food, health services, social security, education, basic housing services and housing quality, and total population of the metropolitan area.	CONEVAL, Poverty Module at Municipality Level 2010 and 2015
Variation in the number of people permanently affiliated to the IMSS (Mexican Institute of Social Security)	(Number of people permanently affiliated to the IMSS as of December 31 of year t-Number of permanently affiliated people to the IMSS as of December 31 of year t-1)/Number of permanently affiliated people in year t-1	IMSS-Affiliated Workers by State (IMSS-STPS 2020)
Labor informality rate	Labor informality rate 1(TIL1)= (Informal employment/Population employed)100	Robles, Sánchez and Beltrán (2019) based on the Socioeconomic Conditions Module of INEGI (2014)

Source: created by the authors

Data analysis

First, a sample of 29 of the 59 metropolitan areas identified by INEGI in Mexico was defined (see Table 4). The main criterion for selecting the ZMs (metropolitan areas) was their demographic importance since they are home to 76.31% of the metropolitan areas' population and 48.5% of Mexico's total population.

Next, using INEGI's National Directory of Economic Units (DENUE), data were extracted corresponding to the number of companies or establishments existing in each metropolitan area for each of the 93 subsectors of economic activity considered in the North American Industrial Classification System (SCIAN) catalog used by INEGI (2018).

Using Microsoft Excel: Mac 2011 software, the Specific Wealth and Simpson indices were calculated for each metropolitan area. The results are shown in Table 2.

Table 2
Demographic characterization and productive diversity of the metropolitan areas

Metropolitan area	Population 2015 (1)	Percentage that represents the ZM with respect to the state population	Informality rate in the ZM (2)	Specific Wealth (Number of sub-sectors with activity in the ZM) (3)	Simpson's Index (4)
Aguascalientes	1 056 265	80.47%	0.384933973	86	0.933843611
Tijuana	1 860 704	56.12%	0.393296447	83	0.93985469
Tuxtla Gutiérrez	829 387	15.90%	0.56499469	82	0.906411577
Chihuahua	925 200	26.01%	0.317617044	86	0.944490822
Saltillo	915 536	30.98%	0.337479946	81	0.93624918
Colima	368 270	51.78%	0.465633067	81	0.9332005
Valle de México	21 275 109	84.74%	0.511379701	91	0.916044921
La Laguna	1 374 909	78.35%	0.393296447	84	0.930002072
León	1 773 158	30.29%	0.503896857	85	0.931602144
Acapulco	901 368	25.51%	0.707107578	78	0.904233269
Pachuca	561 422	19.64%	0.585806666	80	0.926231842
Guadalajara	4 943 520	63.02%	0.467748781	89	0.930885656
Toluca	2 207 581	13.64%	0.579309775	87	0.916511249
Morelia	914 644	19.95%	0.520546409	83	0.933495914
Cuernavaca	1 003 174	52.69%	0.61159498	81	0.921543874
Tepic	470 695	39.85%	0.430290702	79	0.924041532
Monterrey	4 749 513	92.77%	0.35357351	87	0.940081264
Oaxaca	667 716	16.83%	0.672828404	84	0.918531184
Puebla-Tlaxcala	2 994 147	48.54%	0.595826714	87	0.917153386
Querétaro	1 334 231	65.46%	0.496654103	88	0.938889391
Cancún	763 310	50.83%	0.464400055	83	0.936386029
SLP	1 164 798	42.86%	0.394783397	84	0.93459691
Guaymas	218 258	7.66%	0.335983197	81	0.927144579
Villahermosa	827 692	34.56%	0.55691054	86	0.930932296
Tampico	936 004	27.20%	0.46106418	89	0.928060424
Tlaxcala Apizaco	552 620	43.42%	0.709054623	80	0.916367174
Veracruz	910 399	11.22%	0.488289091	89	0.923277428
Mérida	1 158 935	55.26%	0.4524553	87	0.933666528
Zacatecas	374 329	23.70%	0.453933947	78	0.936132763

Source: (1) CONAPO (2015)
(2) Created by the authors based on Robles, Sánchez and Beltrán (2019).
(3) Created by the authors based on the National Directory of Economic Units-INEGI (2015).
(4) Created by the authors with data from DENUE_INEGI (2015).

Subsequently, using the Poverty at Municipality Level 2010 and 2015 module of the National Council for the Evaluation of Social Development Policy (CONEVAL, 2015), Table 3 was constructed, which shows the variation of extreme poverty and moderate poverty indicators in the metropolitan areas considered in the sample. As can be seen, in 28 of the 29 Metropolitan Areas, the extreme poverty indicator decreased, while in 17, the moderate poverty indicator decreased.

Table 3
Evolution of the percentages of extreme and moderate poverty in metropolitan areas during the period 2010-2015

Metropolitan area	Extreme Poverty 2010 (1)	Moderate Poverty 2010 (2)	Extreme poverty 2015 (3)	Moderate poverty 2015 (4)	Variation in extreme poverty	Variation in moderate poverty	Years of schooling (5)
Acapulco	2.2	28.1	1.6	24.5	-0.6	-3.6	10.07
Aguascalientes	3.5	27.6	1.8	27.6	-1.7	0	9.68
Cancún	8.9	37.8	6.7	35.2	-2.2	-2.6	10.11
Chihuahua	2	23.8	0.6	19	-1.4	-4.8	10.78
Colima	2	18.8	1.3	16.2	-0.7	-2.6	10.43
Cuernavaca	1	29.2	1.8	25.8	0.8	-3.4	10.36
Guadalajara	1.6	29.6	1.1	27.2	-0.5	-2.4	10.34
Guaymas	5.9	38.3	0.8	29.7	-5.1	-8.6	9.97
La Laguna	4	32.8	2.2	29.3	-1.8	-3.5	9.09
León	13.2	36	12.1	44.5	-1.1	8.5	9.15
Mérida	3.5	28.3	1.9	28.2	-1.6	-0.1	10.55
Monterrey	2.2	23.6	1.4	24	-0.8	0.4	10.01
Morelia	5.9	32.1	6.1	31.4	0.2	-0.7	9.69
Oaxaca	6.8	31.3	5.9	35.8	-0.9	4.5	10.03
Pachuca	2	24.2	3.7	28.2	1.7	4	9.87
Puebla-Tlaxcala	2.5	22.8	1.9	22.3	-0.6	-0.5	10.66
Querétaro	1.6	19.4	1	15.6	-0.6	-3.8	10.53
Saltillo	4.6	30.3	3.5	35.4	-1.1	5.1	10.43
SLP	5.7	31.5	3.8	36.9	-1.9	5.4	10.01
Tampico	3	25.3	1.5	21.5	-1.5	-3.8	10.37
Tepic	3.7	23.2	2.6	25.1	-1.1	1.9	9.97
Tijuana	3	25.7	1.9	22.1	-1.1	-3.6	10.48
Tlaxcala Apizaco	5.4	24	4.3	26.4	-1.1	2.4	9.58
Toluca	7.9	42.6	5.6	30.5	-2.3	-12.1	10.69
Tuxtla Gutiérrez	2.4	25.5	1.8	26.9	-0.6	1.4	10.02
Valle de México	3.4	31.7	1.5	32.1	-1.9	0.4	10.22
Veracruz	4.5	26.8	3.6	29.7	-0.9	2.9	10
Villahermosa	2.7	24.3	1.8	21.1	-0.9	-3.2	10.29
Zacatecas	2.4	28.8	1.8	24.1	-0.6	-4.7	11.05

Source: (1) (2) (3) (4) CONEVAL, Poverty Module at Municipality level; (5) Sustainable Cities Index, 2018.

Access was also gained to the consultation module of workers permanently affiliated to the Mexican Social Security Institute [IMSS] by state (Ministry of Labor and Social Security, Spanish: Secretaría del Trabajo y Previsión Social [STPS], 2020), and the data corresponding to December 31, 2010, and December 31, 2015, were extracted. They were compared to determine the net variation of affiliated workers during that period, which corresponds to the period of comparison of poverty indicators provided by CONEVAL.

Table 4
Variation in the number of permanently affiliated workers by state

State	Permanent workers with the IMSS 2010	Permanent workers with the IMSS 2015	Variation in permanent workers 2010-2015
Aguascalientes	186 894	246 114	0.317
Baja California	557 218	694 849	0.247
Chiapas	175 140	194 949	0.113
Chihuahua	588 412	729 766	0.240
Coahuila	494 461	613 955	0.242
Colima	88 411	96 325	0.090
Distrito Federal	2 239 625	2 727 787	0.218
Durango	162 509	199 879	0.230
Guanajuato	560 289	727 292	0.298
Guerrero	116 567	123 225	0.057
Hidalgo	135 696	156 294	0.152
Jalisco	1 123 635	1 335 131	0.188
México	994 753	1 169 621	0.176
Michoacán	286 732	314 761	0.098
Morelos	153 411	173 345	0.130
Nayarit	91 184	102 366	0.123
Nuevo León	1 050 359	1 282 413	0.221
Oaxaca	145 194	172 008	0.185
Puebla	379 947	456 609	0.202
Querétaro	279 316	380 249	0.361
Quintana Roo	215 671	260 446	0.208
San Luis Potosí	255 445	312 647	0.224
Sonora	405 258	474 292	0.170
Tabasco	134 116	156 958	0.170
Tamaulipas	480 704	536 105	0.115
Tlaxcala	56 838	65 528	0.153
Veracruz	572 400	619 226	0.082
Yucatán	253 866	300 288	0.183
Zacatecas	112 111	138 137	0.232

Source: created by the authors based on STPS (2020). Workers affiliated to the IMSS by federal state

As the first step in the statistical analysis, using XLSAT 2016 software, Pearson correlation coefficients were determined between Simpson's Diversity Index and the variables Informality Rate, Variation of Permanent Workers 2010-2015, and Net Variation of GDP 2010-2015. As can be seen in Table 5, all correlations are significant at a level of 0.05%.

Table 5
Correlation matrix / Simpson's Index / Variation permanently affiliated people

Variables	Simpson's Index	Informality Rate	Variation in permanent workers 2010-2015	Net change in GDP 2010-2015
Simpson's Index	1	-0.753	0.557	0.547
Informality Rate	-0.753	1	-0.426	-0.496
Variation in permanent workers 2010-2015	0.557	-0.426	1	0.636
Net change in GDP 2010-2015	0.547	-0.496	0.636	1

Values in bold are different from 0, with a significance level of alpha=0.05.
Source: created by the authors

Table 6
Normality tests of variables

Variable / Test	Shapiro-Wilk	Jarque-Bera
Simpson's Index	0.162	0.341
Variation in permanent workers 2010-2015	0.786	0.758
Average annual GDP growth 2010-2015	0.417	0.642
Change in GDP 2016	0.080	0.088
Variation in extreme poverty	0.002	<0.0001
Variation in moderate poverty	0.566	0.882
Years of schooling	0.478	0.557
% Informal employment	0.381	0.580

Interpretation of the test:
H0: The variable from which the sample was drawn follows a Normal Distribution.
Ha: The variable from which the sample was drawn does not follow a Normal Distribution.
Since the calculated p-value is greater than the significance level alpha=0.05, the null hypothesis H0 cannot be rejected for the variables Simpson's Index, Change in Permanent Workers, Average Annual GDP Growth, Change in GDP 2016, Change in Moderate Poverty, Years of Schooling, and Informal Employment.

Based on the above, a linear regression model was formulated using the variables already correlated in order to obtain an equation to estimate the variation in the number of permanently affiliated workers based on the variations that could be registered by the Simpson's Index, the Informality Rate in the ZM, and the Variation of the GDP in the Period. It should be noted that the variation in GDP could only be obtained with a disaggregation level by State, so for the formulation of the model, the percentage of population represented by the ZM with respect to the state population was used as a weighting variable. The model parameters are shown in Table 6, and the goodness-of-fit statistics are in Table 7.

Table 7
Parameters of the linear regression model (permanently affiliated variation):

Source	Value	Standard error	t	Pr > |t|	Lower limit (95%)	Upper limit (95%)
Interception	-0.952	0.500	-1.902	0.069	-1.982	0.079
Simpson's Index	0.981	0.518	1.893	0.070	-0.087	2.049
Informality Rate	0.121	0.051	2.369	0.026	0.016	0.227
Change in GDP in the period	0.719	0.133	5.412	< 0.0001	0.446	0.993

Source: created by the authors

Table 8
Goodness-of-fit statistics of the linear regression model for the Permanently Affiliated Workers variable.

Remarks	29.000
Sum of weights	29.000
GL	25.000
R²	0.560
Adjusted R²	0.507
MEC	0.000
RMSE	0.018
MAPE	41.466
DW	2.162
Cp	2.300
AIC	-229.301
SBC	-223.832
PC	0.581

Source: created by the authors

The model equation is:

$$\Delta Ap = -0.951 + 0.9811(Si) + 0.121(Til) + 0.719\ (\Delta Pib) \quad (3)$$

Where

ΔAp = Variation in permanently affiliated,

Si = Simpson's Diversity Index,

Ti = Informality Rate, and

ΔPib is change in Gross State Domestic Product

In order to find a better fit, another model was formulated using the partial least squares (PLS) regression method. This technique reduces the number of predictors, generating a small set of uncorrelated components on which a least squares regression is performed, from which a model with greater solvency in the face of measurement uncertainty is constructed.

In this case, a model with the same number of components (t) as predictors (variables) was obtained. Table 7 shows the correlations between variables and components, while Table 8 shows the goodness-of-fit statistics.

Table 9
Correlations between factors and predictors according to the PLS model

Variable	t1	t2	t3
Simpson's Index	0.545	-0.714	0.439
% Informal employment	-0.691	0.685	0.232
Change in GDP 2016	0.901	0.426	-0.088
Variation permanently affiliated 2015/2016.	0.589	0.277	0.209

Source: created by the authors

Table 10
Goodness-of-fit statistics of PLS model fit

Remarks	29.000
Sum of weights	12.093
GL	25.000
R^2	0.468
Standard deviation	0.018
MEC	0.000
RMSE	0.017

Source: created by the authors

Table 11
Normality and non-correlation tests of residuals

Test for normality of residuals (Shapiro-Wilk) (1)		Durbin-Watson statistic (no correlation of residuals) (2)	
W	0.959	D	2.62965
p-value (bilateral)	0.307	Du	1. 64987
alfa	0.050		

(1) Interpretation of the test:
H0: Residuals follow a Normal distribution
Ha: Residuals do not follow a Normal distribution
Since the calculated p-value is greater than the significance level alpha=0.05, the null hypothesis H0 cannot be rejected.
(2) Test interpretation: As D > 1.64987 (Du for a sample of 29 units with 4 terms), it is concluded that there is no autocorrelation.

The model equation is :

$$\Delta Ap = -0.979 + 1.031(Si) + 0.091(Til) + 0.611(\Delta Pib) \tag{4}$$

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When comparing the statistics of both models, a better goodness of fit was found for the linear regression model since the R^2 coefficient, which is the variability explained by the selected predictors, is higher in the first model than in the PLS regression.

Subsequently, the predictors mentioned above were correlated with the Moderate Poverty and Extreme Poverty variables, to which the variable Average Years of Schooling was added. The results are shown in Table 10, where it can be seen that both variables have significant correlations with the selected predictors.

Table 12
Correlation matrix Simpson's Index / Moderate Poverty and Extreme Poverty

Variables	Simpson's Index	Informality rate	Variation in permanent workers 2010-2015	Net change in GDP 2010-2015	Extreme poverty 2015	Moderate poverty 2015
Simpson's Index	1	-0.753	0.557	0.547	-0.651	-0.762
Informality rate	-0.753	1	-0.426	-0.496	0.563	0.781
Variation in permanent workers 2010-2015	0.557	-0.426	1	0.636	-0.550	-0.498
Net change in GDP 2010-2015	0.547	-0.496	0.636	1	-0.392	-0.434
Extreme poverty 2015	-0.651	0.563	-0.550	-0.392	1	0.767
Moderate poverty 2015	-0.762	0.781	-0.498	-0.434	0.767	1
Years of schooling	0.365	-0.236	0.120	-0.099	-0.480	-0.514

Values in bold are different from 0 with a significance level of alpha=0.05.

Source: created by the authors

Subsequently, a linear regression model was developed to estimate the determinants of extreme poverty, using the predictors shown in Table 9. It was found that the predictors Simpson's Diversity Index and Years of Schooling are significant at a level of 0.05%, and that, according to the goodness-of-fit statistic (R^2), they explain 0.557 of the variability of Extreme Poverty.

Table 13
Model parameters (Population in extreme poverty)

Source	Value	Standard error	t	Pr > |t|	Lower limit (95%)	Upper limit (95%)
Interception	104.687	36.129	2.898	0.008	30.278	179.097
Simpson's Index	-89.119	41.829	-2.131	0.043	-175.267	-2.972
Informality rate	0.000	0.000				
Variation in permanent workers 2010-2015	-10.510	5.493	-1.913	0.067	-21.823	0.804
Net change in GDP 2010-2015	0.000	0.000				
Years of schooling	-1.682	0.784	-2.146	0.042	-3.296	-0.067

Source: created by the authors

Table 14
Goodness-of-fit statistics of the model fit (Extreme poverty)

Remarks	29.000
Sum of weights	29.000
GL	25.000
R^2	0.557
Adjusted R^2	0.503
MEC	2.951
RMSE	1.718
MAPE	60.886
DW	1.837
Cp	2.869
AIC	35.083
SBC	40.552
PC	0.585

Source: created by the authors

Table 15
Normality and non-correlation tests of residuals

Test on the normality of the residuals (Shapiro-Wilk) (1).		Durbin-Watson statistic (no correlation of residuals) (2)	
W	0.960	D	2.08977
p-value (bilateral)	0.334	Du	1.64987
alfa	0.050		

(1) Interpretation of the test:
H0: Residuals follow a Normal distribution
Ha: Residuals do not follow a Normal distribution
Since the calculated p-value is greater than the significance level alpha=0.05, the null hypothesis H0 cannot be rejected.
(2) As D > 1.64987 (Du for a sample of 29 units with 4 terms), it is concluded that there is no autocorrelation.

The model equation is

$$Pe = 104.68 - 89.11(Si) - 10.5(\Delta Ap) - 1.68(Es) \quad (5)$$

Where

Pe= Extreme poverty

ΔAp = Variation in permanently affiliated,

Si = Simpson's Diversity Index,

Es= Years of schooling

Finally, a linear regression model was formulated with the predictors mentioned above and the Moderate Poverty variable, revealing that informal employment and years of schooling are the determinants whose relation is statistically significant at 0.05%. Table 14 also shows the goodness-of-fit statistics, in which the R^2 coefficient indicates that the selected predictors explain 76% of the variability of Moderate Poverty.

Table 16
Model parameters (Population in moderate poverty)

Source	Value	Standard error	t	Pr > |t|	Lower limit (95%)	Upper limit (95%)
Interception	174.168	99.927	1.743	0.094	-32.070	380.407
Simpson's Index	-123.319	109.200	-1.129	0.270	-348.696	102.059
Informality rate	29.875	8.864	3.370	0.003	11.580	48.170
Variation in permanent workers 2010-2015	-12.350	10.632	-1.162	0.257	-34.294	9.593
Net change in GDP 2010-2015	0.000	0.000				
Years of schooling	-4.394	1.520	-2.891	0.008	-7.531	-1.257

Source: created by the authors

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Table 17
Goodness-of-fit statistic for the model
Population in moderate poverty

Remarks	29.000
Sum of weights	29.000
GL	24.000
R^2	0.768
Adjusted R^2	0.730
MEC	11.057
RMSE	3.325
MAPE	9.882
DW	2.225
Cp	4.092
AIC	74.200
SBC	81.037
PC	0.328

Source: created by the authors

Table 18
Normality and non-correlation tests of residuals

Test on the normality of the residuals (Shapiro-Wilk) (1).		Durbin-Watson statistic (no correlation of residuals) (2)	
W	0.978	D	1.88488
p-value (bilateral)	0.795	Du	1.64987
alfa	0.050		

(1) Interpretation of the test:
H0: Residuals follow a Normal distribution
Ha: Residuals do not follow a Normal distribution
Since the calculated p-value is greater than the significance level alpha=0.05, the null hypothesis H0 cannot be rejected.
(2) As D > 1.64987 (Du for a sample of 29 units with 4 terms), it is concluded that there is no autocorrelation.

The model equation is:

$$Pm = 174.16 - 123.31(Si) + 29.87(Til) - 12.35\ (\Delta Ap) - 4.393(Es) \tag{6}$$

Where

Pm= Moderate poverty

ΔAp = Variation in permanently affiliated,

Si = Simpson's Diversity Index,

Til = Informality Rate, and

Es= Years of schooling

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Discussion

Fontenla (2018) describes ecosystems as ensembles where diversity can be seen as an emergent phenomenon derived from complexity. In this sense, diversity can be understood as a measure of the complexity of ecosystems and vice versa (Morin, 2008). Now, if diversity is an epiphenomenon of complexity, this suggests that a system where species richness and abundance are combined also represents a greater number of interactions among themselves and with the environment. This is consistent with the notion that the greater the diversity, the better the conditions for maintaining the system's integrity, even if its behavior is difficult to predict (Levin, 1998; Marion et al. 2015).

If this analogy is transferred to the economic field, diversity could be interpreted as a property that allows business ecosystems to maintain their integrity in the face of external shocks, such as economic recessions. In this regard, a more diverse business ecosystem can be more effective in limiting job losses and business closures since strong interdependence allows companies to survive thanks to their integrated production processes.

In this research, Simpson's Diversity Index has been used to evaluate how the productive diversity of metropolitan areas affects their capacity to generate jobs and reduce poverty.

The correlations found between variables such as Diversity, Employment Supply, Moderate Poverty, and Extreme Poverty seem to be consistent with Iracheta (2010) and Garza and Schteingart (2010), in the sense that productive and spatial concentration translates into good economies and, therefore, advantages for economic actors. This is also consistent with the thesis of Moore (2005), who states that in business concentrations, there is a co-evolution derived from mutually beneficial relations between businesses. An interesting finding would be that diversity impacts not only the generation of wealth but also the progressive reduction of income inequality by being positively related to poverty reduction.

On the other hand, according to the modeling of variables performed, when Simpson's Diversity Index is high, the effect of GDP variations on employment, moderate poverty, and extreme poverty variables is lower than when diversity is low. This is consistent with what Urquiza and Cárdenas (2015) proposed, in the sense that diversity is related to the system's resilience.

The Informality Rate variable requires a separate mention. A finding of the present research is that it has a significant statistic relation of negative sign with Simpson's Diversity Index, which indicates that the less diverse the business ecosystem, the greater the tendency of the population to resort to precarious livelihood options. This is consistent with Robles, Sánchez, and Beltrán (2018), who found heterogeneous features according to the geographic region.

Conclusions

The analysis of the information collected implies the following answers to the research questions:

Simpson's Diversity Index has a significant positive correlation (0.557) with the variation in the number of workers permanently affiliated to the IMSS in the metropolitan areas studied and a significant but negative correlation (-0.753) with the Informality Rate. This indicates that diverse business ecosystems are more effective in creating jobs and reducing informality. It is worth mentioning that the size of a metropolitan area has no relation to diversity or the informality rate, as no significant coefficients are found when correlating these variables.

Simpson's Diversity Index also has a significant negative correlation with the Extreme Poverty Index (-0.651) and the Moderate Poverty Index (-0.762). This shows that diversity is a property of business ecosystems that influences the reduction of inequality in income.

Using Simpson's Diversity Index, Informality Rate, State GDP Variation, and Years of Schooling as predictors, it is possible to model the capacity of a metropolitan area to generate employment and reduce moderate and extreme poverty rates over a certain period. The parameters of the developed models show that the selected predictors explain most of the variability of the mentioned results.

The possible uses of the information gathered in this article can be classified into two parts: those related to public policies and those related to specific investment decisions. In the case of public policies, it is important to highlight the importance of creating government programs that promote integrated production, the diversification of lines of business, the lengthening of local supply chains and, in general, the development of capabilities for entrepreneurs to enter niches that allow them to increase the diversity of business ecosystems. Valuable input for decision-making would be the creation of information systems showing the least developed subsectors in a business ecosystem and the capabilities or competencies that need to be developed to enter them.

Concerning specific investment decisions, entrepreneurs need to have access to information on the lines of business where there are opportunities for entry and access to the training required to venture into these areas.

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