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Geographic Concentration of Economic Activities in Aburrá Sur in Antioquia (Colombia) — A Reinterpretation of the Industrialisation Coefficients of the Stochastic Independence Approach[1]

In terms of economic geography, spatial and industrial concentration represents an increasingly important input for the design of public policies that foster local economic development and productive transformation of a territory. This analysis aims to identify the geographic concentration indices of different sectors in which the economic activity is distributed in each of the five municipalities that are part of the territorial agglomeration of Aburrá Sur in the department of Antioquia (Colombia). The methodology is based on a reinterpretation of the industrialisation coefficients used in the stochastic independence approach, which explains the divergences between specialisation levels of production and geographical concentration by using entropy indices that consider the reference distribution as uniform distribution, as is the case with maximum dispersion. We start from the hypothesis that in the municipalities belonging to the Aburrá Sur predominates the high concentration in the manufacturing industry, although some of them could have medium and even low concentration because they have different sector indicators. Results show that the manufacturing industry is the most concentrated sector in the territorial agglomeration. The research findings can be used by political and economic actors in the territory for designing strategies and decision-making on sectoral strategic development commitments.

Keywords: local economic development, public policies, business competitiveness, territorial localisation, territorial productivity, Aburrá Sur, economic geography, Stochastic Independence Approach, territorial concentration, smart specialisation

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ИССЛЕДОВАТЕЛЬСКАЯ СТАТЬЯ

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Пространственная концентрация экономической деятельности в Абурра-Сур в Антьокии (Колумбия): пересмотр коэффициентов индустриализации с использованием подхода стохастической независимости

С точки зрения экономической географии в государственной политике большую роль играют факторы пространственной и промышленной концентрации, способствующие экономическому развитию и эффективной трансформации территорий. В этой статье определяются индексы географической концентрации экономической деятельности в каждом из пяти муниципалитетов, входящих в состав территориальной агломерации Абурра Сур в департаменте Антьокия (Колумбия). В ходе исследования дана новая интерпретация коэффициентов индустриализации, используемых при подходе стохастической независимости. Этот подход объясняет расхождения между уровнями специализации производства и пространственной концентрацией с помощью индексов энтропии, в которых в качестве эталонного рассматривается равномерное распределение, как в случае с максимальной дисперсией. Проверена гипотеза о преобладании в муниципалитетах Абурра Сур высокой концентрации обрабатывающей промышленности, несмотря на то, что в некоторых муниципалитетах отмечаются средние и даже низкие показатели концентрации производства (в зависимости от отрасли). Проведенные расчеты показали, что обрабатывающая промышленность является наиболее концентрированным сектором территориальной агломерации. Результаты исследования могут быть использованы руководством государственных органов и промышленных предприятий для разработки стратегий и решений в области отраслевого развития.

Ключевые слова: экономическое развитие территорий, государственная политика, конкурентоспособность бизнеса, территориальная локализация, территориальная производительность, Абурра Сур, экономическая география, подход стохастической независимости, территориальная концентрация, умная специализация

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1. Introduction

Territorial localisation of businesses that are part of a particular economic sector is an aspect related to productivity and business competitiveness, which is further studied in the field of economic geography (Dueñas, Morales, Olmos, 2009). From Marshall (1890) to Romer (1990), several studies have tried to substantiate the benefits of territorial localisation for businesses in a particular sector using the following points in their explanations: (i) ease of recruiting trained and specialised labour in the sector, (ii) ease in accessing necessary and specific information, and (iii) wide availability of specialised providers (Marshall, 1890; Arrow, 1962; Romer, 1990; Krugman, 1991). In this sense, economic literature points to a significant and largely positive net effect of the concentration of businesses and labour on the sectoral and territorial productivity in such a way that the effects of concentration enhance productivity and competitiveness when it is confined to specific economic sectors (Ciccone, Hall, 1996; Ciccone, 2002; Lall, Deichmann, Shalizi, 2004; Bogetic, Sanogo, 2005; Lin, Yun, Hai, 2011).

Since, traditionally, the economy of the municipalities in the analysed territory has been based on a manufacturing industry, this paper will try to confirm whether a high concentration in this industry actually predominates through the Stochastic Independence Approach (SIA). The research aims to identify the economic sectors in each municipality that is part of the Aburrá Sur,

which have a certain level of business concentration. Reinterpretation and calculation of industrialisation indices used to determine the industrial specialisation of territories and geographic concentration of economic activities is based on the methodology developed by Haedo and Mouchart (2018), which will be addressed in the methodology section.

This paper is divided into three sections. The first describes the methodology used to calculate the geographic concentration index (GCIs) of the economic sectors in the municipalities of Aburrá Sur, using as a reference the SIA model, with data aggregated by territory, developed by Haedo and Mouchart (2015) and applied in the configuration of Colombian industrial geography maps (Donato, Haedo, 2019). The second section presents the calculations resulting from measuring the GCIs by sector and the interpretation of results based on the methodological description section. Lastly, the third section establishes some conclusions related to the description and interpretation of the results according to the economic sectors of each municipality, which yielded a certain level of spatial concentration through the proposed methodology.

2. Methodology

The Aburrá Valley is one of the nine sub-regions of the department of Antioquia (Colombia), which covers an area of 1156 km2 (Área Metropolitana del Valle de Aburrá, 2007), with an estimated population of 4,256,997 inhabitants (DANE, 2018). This sub-region comprises the municipality of Medellín as its central axis in addition to neighbouring municipalities to the north (Barbosa, Bello, Copacabana, Girardota) and to the south (Caldas, Envigado, La Estrella, Itagüí and Sabaneta), which according to Law 1625 of 2013[1], form the Metropolitan Area of Aburrá Valley.

The method used to prove the high concentration in the manufactory industry in the municipalities belonging to the south of the Aburrá Valley, consists of reinterpretation of the industrialisation coefficients of the stochastic independence approach applied in the studied territory. The contributions developed by Donato and Haedo (2019) are used as a reference and define the following variables from the SIA model. The methodology developed for this study starts from a finite set AS[2] of I territories, i, for the territorial grouping, which is the subject of study wherein $i : \mathrm{i} \in AS = \{1, \ldots, I\}$, and a finite set J of J sectors, j, of economic activity wherein $j \in J = \{1, \ldots, J\}$. Tags $i \in AS$ and $j \in J$ are not informative given that they are not arbitrary and do not include any information. For each territorial data point $(i, j) \in AS \times J$, there is a number N_{ij} of primary units of analysis, which refer to the number of companies and employees in territory i in sector j. This yields a matrix of $I \times J\, N = [N_{ij}]$ wherein the table rows and columns contain information for a finite set AS in the following manner:

$$N_i = \sum_{j=1}^{J} N_{ij}; \quad N_j = \sum_{i=1}^{I} N_{ij};$$

$$N_{ij} = \sum_{i=1}^{I}\sum_{j=1}^{J} N_{ij} = \sum_{j=1}^{J} N_{.j} = \sum_{i=1}^{I} N_i. \qquad (1)$$

Data is represented by the total number of observations N.., and the relative frequencies[3]:

$$p_{ij} = \frac{N_{ij}}{N_{..}}; p_i = \frac{N_{i.}}{N_{..}}; p_{ij} = \frac{N_{.j}}{N_{..}}; p_{i/j} = \frac{N_{ij}}{N_{i.}}; p_{i/j} = \frac{N_{ij}}{N_{.j}}. \quad (2)$$

The focus of this analysis will be on the geographic concentration of economic sectors based on the classification of all economic activities established by the fourth edition of the International Standard Industrial Classification (ISIC, Rev. 4) of the United Nations[4]. Given the hierarchical structure of information organisation established by ISIC Rev. 4 according to four category levels (sections, divisions, groups, and classes), the category used in this study is the highest category level corresponding to the sections identified through an alphabetical code that subdivides the economic activities of any territory in 21 large groups. These are equivalent to sectors of the economy through the methodology used in Colombia to measure production via GDP by supply (Lora, Prada, 2016). The analysis of the aggregated territorial data by the SIA model is not exempt from discrepancies among territorial data distributions (i, j) (Basseville, 2013). To consider and evaluate the possible effects of these discrepancies on the information, the principle of the estimated Hoover-Balassa index[5] or location quotient (LQ) (Florence, 1939) will be used for each territorial data point (i, j) in the manner proposed by Donato and Haedo (2019):

[1] "Law by which Organic Law 128 of 1994 is repealed and the Regime for Metropolitan Areas in Colombia is enacted."

[2] Understood as Aburrá Sur

[3] Where $N..$ represents the total number of observations.

[4] https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4s.pdf.

[5] The estimated Hoover-Balassa coefficient is commonly recognised in the applications of location theory and New Economic Geography as the Location Quotient.

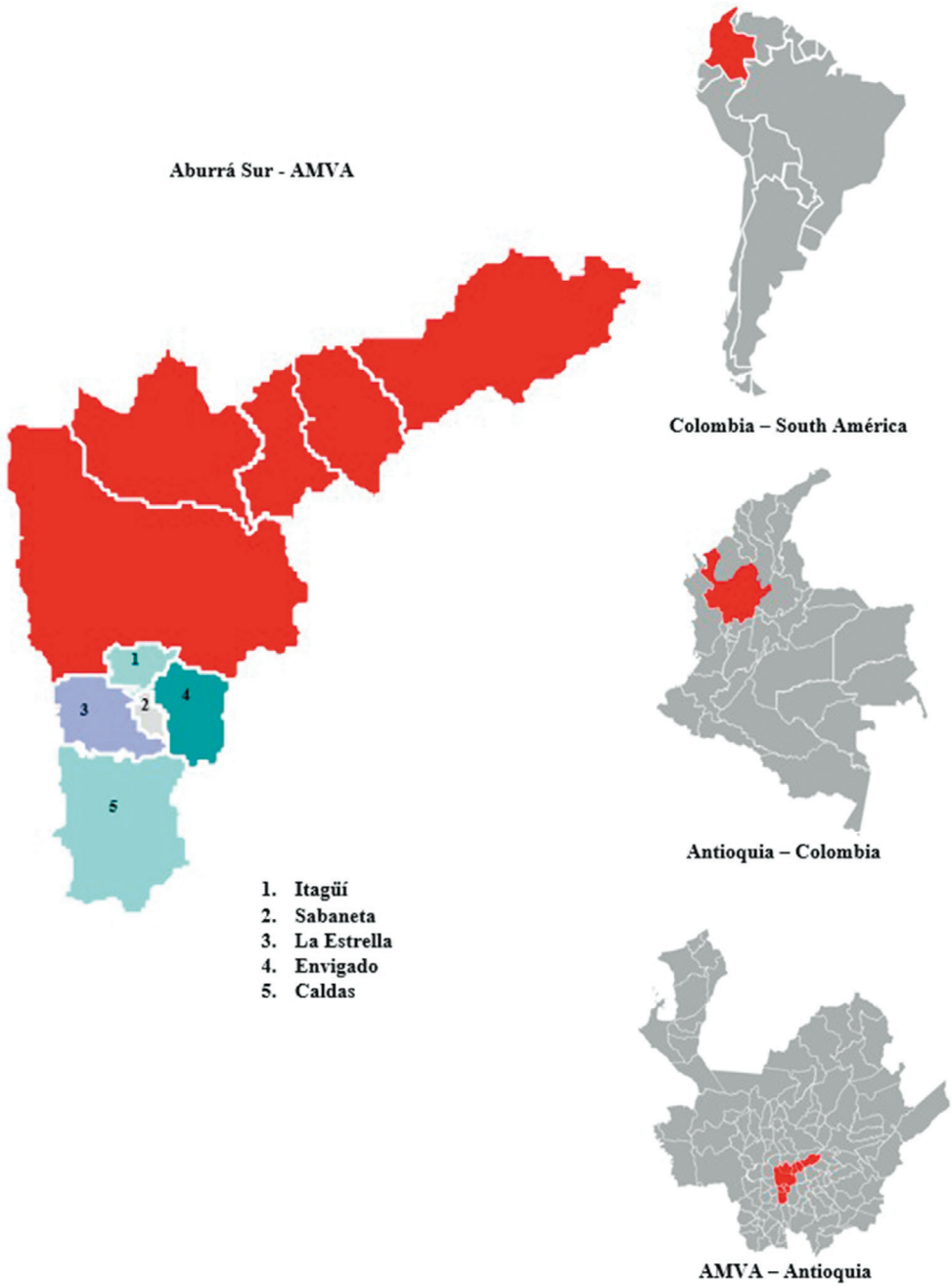

Fig. 1. *Location of Aburrá Sur (AS) (source: Prepared by the authors based on https://sites.google.com/site/seriescol/shapes (Date of access: 20.03.2020))*

$$LQ_{ij} = \frac{N_{ij} / N_{i.}}{N_{.j} / N_{..}} = \frac{N_{ij} / .j}{N_{i.} / N_{..}} = \frac{N_{ij} / N_{..}}{N_{i.} / N_{.j}} = \frac{p_{ij}}{p_{i.} p_{.j}} = \frac{p_{i\,|j}}{p_{.j}} = \frac{p_{i\,|j}}{p_{i.}}. \quad (3)$$

The measurement of the relative territorial concentration $d(p_{\overline{i\,|j}} \mid p_{\overline{i.}})$ is derived from the difference of the distributions that measure the relative and general association between territories *i* and sectors *j* of the finite set of territories *AS*. The methodology employed takes as a reference Aiginger and Davies' approach (2004), which explains the divergences between specialisation levels of production and geographical concentration by using entropy indices that consider the reference distribution as uniform distribution, as is the case with maximum dispersion. In the same methodological line, (Wu, Zhu, 2017) analysed the trend determinants of geographic concentration and industrial specialisation in China between 1999 and 2010 using the reference distribution as the area distribution of territories and taking the Kullback and Leiber divergence model (1951) as a pattern for discrepancies, wherein the relative concentration of sector *j* in territory *i* will be determined by *Relative territorial concentration*

$$d(p_{\bar{i}|j} \mid p_{\bar{i}.}) = \sum_i p_{i|j} \log\left(\frac{p_{i|j}}{p_{i.}}\right) = \\ = \sum_i p_{i.} LQ_{ij} \log\left(LQ_{ij}\right). \quad (4)$$

$$Relative\,territorial\,concentration_{ij} = \\ = p_{ij} \log\left(\frac{p_{ij}}{\bar{p}_i, .\bar{p}_j}\right) \forall j \in J. \quad (5)$$

Thus, the geographic concentration index (*GCI*) by sector can be calculated for Aburrá Sur based on the reinterpretation of the industrialisation coefficient (*INCO*), which is used in economic geography as a measurement of industrial concentration in a territory (Kiely, 1994). This industrialisation coefficient is developed based on the number of employed people, considering the participation of people employed in industry in a territory as a proportion of the total number of employed people in that territory in comparison with the level of industrialisation in the region. The latter is assumed to be the regional average of people employed in industry (Polèse, Rubiera, 2009).

$$INCO_{ij} = \frac{\frac{OI_{ij}}{O_{ij}}}{\frac{\overline{OI_{ij}}}{O_{ij}}}. \quad (6)$$

Reinterpreting (6) based on (4) and (5), the GCI by sector can be obtained through

$$GCI_{ij} = \frac{\frac{O_{ij}}{\sum O_{ij}}}{\frac{\bar{O}_{ij}}{\sum O_{ij}}}. \quad (7)$$

This study reinterprets Donato and Haedo's proposal (2019) on a national scale for the territorial grouping of municipalities that form Aburrá Sur in a manner such that

— when the value of $GCI_{ij} \geq 1.1$ (10 % above the average of Aburrá Sur), the territory is classified as high concentration (*HC*);

— when the value of $0.9 < GCI_{ij} < 1.1$ (+/–10 % above the average of Aburrá Sur), the territory is classified as medium concentration (*MC*);

— when the value of $0.6 \leq GCI_{ij} < 1.1$ (between 10 % — 40 % below the average of Aburrá Sur), the territory is classified as low concentration (*LC*); and

— when the value of $0.6 > GCI$, the territory is classified as no concentration (*NC*).

Indicators Used

The indicators used to represent the information in Tables 2, 3, 4, 5, and 6 are described below:

— Area (km^2) of the municipal *i*: $AREA_{MU_i}$.

— Population (inhabitants) in the municipality *i*: POP_{MU_i}.

— Population density of municipality *i*: Indicator that determines the quantity of inhabitants per km^2 in each municipality MU_i.

$$POPDEN_{MU_i} = \frac{POP_{MU_i}}{AREA_{MU_i}}. \quad (8)$$

— Quantity of businesses in municipality *i* in sector *j*: B_{ij}.

— Quantity of employees in municipality *i* in sector *j*: E_{ij}.

— Availability of business resources in municipality *i* in sector *j*: Indicator that determines the number of businesses in each municipality MU_i of each economic sector *j* per 1,000 inhabitants.

$$AVAILBUS_{MU_{ij}} = \frac{B_{MU_{ij}}}{POP_{MU_i}} \times 1000. \quad (9)$$

— Relative business participation of municipality *i* in sector *j* in %: Indicator that determines the business participation percentage of sector *j* in municipality MU_i with respect to the total number of businesses in municipality MU_i.

$$BUSPART_{Relative_{MU_i}} = \frac{B_{ij}}{\sum B_{MU_i}} \times 100. \quad (10)$$

— Total business participation of municipality *i* in sector *j* in %: Indicator that determines the business participation percentage of sector *j* in municipality *i* MU_i with regard to the total number of businesses in Aburrá Sur MU_{AS}.

$$BUSPART_{Total_{MU_i}} = \frac{B_{ij}}{\sum B_{MU_{AS}}} \times 100. \quad (11)$$

— Relative employee participation of municipality *i* in sector *j* in %: Indicator that determines the percentage of employees in sector *j* in municipality MU_i with regard to the total number of employees in MU_i. This indicator is the result of reinterpreting what economic geography considers as the territorial industrialisation level, which is obtained by calculating the participation of employed people as a proportion of the total amount of employed people (Donato, Haedo, 2019).

$$EMPLPART_{Relative_{MU_i}} = \frac{E_{ij}}{\sum E_{MU_i}} \times 100. \quad (12)$$

— Total employee participation in municipality *i* in sector *j* in %: Indicator that determines the employee participation percentage of sector *j* in

Table 1

General Information about each Municipality of Aburrá Sur

Territory	*AREA*	*POP*	*POPDEN*	*B*	*E*	*AVAILBUS*	*Total BUSPART, %*	*Total EMPLPART, %*	$\overline{O}_{MU_{AS}}$
Caldas	135	80 538	596.5	2 319	7 188	28.8	8.1	3.2	342.2
Envigado	78.8	238 173	3023.2	9 696	68 336	40.7	33.7	30.7	3254.1
Itagüí	21.1	276 936	13 131.1	10 477	84 914	37.8	36.4	38.2	4043.5
La Estrella	35	65 303	1865.8	2 230	19 362	34.1	7.7	8.7	922.0
Sabaneta	15	53 913	3594.2	4 049	42 203	75.1	14.1	19	2009.6
Total in Aburrá Sur	**284.8**	**714 863**	**2509.4**	**28 771**	**222 003**	**40.2**	**100**	**100**	**10 571.4**

Source: Calculated by the authors based on information provided by (CAS-Cámara de Comercio del Aburrá Sur, 2018) and DANE (2018).

municipality MU_i with regard to the total number of employees in MU_{AS}. As with the indicator above, this participation level is obtained by reinterpreting the indicator known as territorial industrialisation level. The difference in this case is that the territorial base is broader and determined by the total number of employees in the Aburrá Sur AS territorial grouping.

$$EMPLPART_{Total_{MU_i}} = \frac{E_{ij}}{\sum E_{MU_{AS}}} \times 100. \quad (13)$$

— Average number of employees in Aburrá Sur *AS* in sector *j*: Indicator that determines the average number of employees for each of the 21 economic sectors according to the ISIC Rev. 4 classification for the municipalities of Aburrá Sur AS.

$$\overline{}_{MU_{AS}} \quad \frac{\sum MU_{AS}}{21}. \quad (14)$$

— Geographic concentration level of municipality *i* in sector *j* in %: The indicator that results from reinterpreting the industrialisation coefficients used in the SIA model, with data aggregated by territory in (4), (5), and (6).

$$GCI_{MU_{ij}} = \frac{E_{MU_{ij}}}{\frac{\sum E_{MU_{ij}}}{\overline{E}_{AS}}} \times 100. \quad (15)$$

3. Results

Results of the calculation of the GCIs for Aburrá Sur's municipalities were developed from the database of the Aburrá Sur business structure as of December 31, 2018 and obtained from the Aburrá Sur Chamber of Commerce (CAS — Cámara de Comercio del Aburrá Sur, 2018). Employment data was gathered by the Public Employment Service through the Statistical Directory of Companies (DEST) by DANE (2018).

Table 1 provides general information about each municipality of the Aburrá Sur based on applied basic indicators related to the area measured in km^2 (*AREA*), population (*POP*), and population density (*POPDEN*). Inventories of the total amount of businesses (*B*) and employees (*E*) are also presented, which enables the calculation of basic indicators related to the availability of business resources (*AVAILBUS*) and levels of business (*BUSPART*) and employment (*EMPLPART*) participation, with regard to the entirety territory and average number of jobs in Aburrá Sur ($\overline{O}_{MU_{AS}}$).

Tables 2, 3, 4, 5 and 6, which are presented below, show the GCIs by sector for each municipality of Aburrá Sur, calculated through the proposed methodology and indicators throughout this research study.

Based on Table 1, the municipality of Caldas presents the lowest level of labour participation, in the same analytical line, in 2018, it had 2,319 registered companies, higher than the municipality of La Estrella in number and business participation and in terms of availability of business resources, the municipality of Caldas has an added value of 28.8, with the lowest indicator in Aburrá Sur.

The calculation of the correlation coefficient p of Pearson (Edwards, 1976) between the indicators of business participation of the different sectors in the municipality ⟦*EMPLPART*⟧*Relative* and the employment participation of each sector in the municipality ⟦*BUSPART*⟧*Relative* shows a low level of correlation with a result of $p = 0.440572$. This can be explained in greater detail by noting that the vehicle sales and repair sector (Section G) has the largest number of related businesses (1,045) but produces only 12.28 % of total municipal employment. On the other hand, the sectors of manufacturing industries (Section C) and transport and storage (Section H) produce 27.43 % and 16.07 %, respectively, of employment in the municipality. However, its participation in the total

Table 2

GCI and Basic Indicators per Economic Sector for the Municipality of Caldas

Economic Sector	*B*	*E*	*AVAILBUS*	*BUSPART Relative, %*	*BUSPART Total, %*	*EMPLPART Relative, %*	*EMPLPART Total, %*	*GCI, %*	*GCI* Categorisation
A. Agriculture, Livestock, Hunting, Forestry, Fishing	35	531	0.4	1.5	0.12	7.39	0.23	0.00	NC
B. Mining & Quarrying	6	213	0.1	0.3	0.02	2.96	0.09	2.01	NC
C. Manufacturing Industries	293	1972	3.6	12.6	1.02	27.49	0.88	18.65	NC
D. Electricity & Gas Supply	3	64	0.0	0.1	0.01	0.89	0.02	0.60	NC
E. Water Distribution & Treatment	13	31	0.2	0.6	0.05	0.43	0.01	0.29	NC
F. Construction	104	517	1.3	4.5	0.36	7.19	0.23	4.89	NC
G. Vehicle Sales & Repair	1045	883	12.8	45.1	3.63	12.28	0.39	8.35	NC
H. Transportation & Storage	97	1155	1.2	4.2	0.34	16.07	0.52	10.92	NC
I. Lodging & Food Services	344	120	4.2	14.8	1.20	1.67	0.05	1.13	NC
J. Information & Communication	25	92	0.3	1.1	0.09	1.28	0.04	0.87	NC
K. Financial & Insurance Related Activities	17	11	0.2	0.7	0.06	0.15	0.00	0.10	NC
L. Real Estate Activities	32	83	0.4	1.4	0.11	1.15	0.03	0.78	NC
M. Professional, Scientific & Technical Activities	65	241	0.8	2.8	0.23	3.35	0.10	2.28	NC
N. Administrative & Support Services Activities	55	31	0.7	2.4	0.19	0.43	0.01	0.29	NC
O. Public Administration	0	122	0.0	0.0	0.00	1.70	0.05	1.15	NC
P. Education	9	483	0.1	0.4	0.03	6.72	0.21	4.56	NC
Q. Human Health Care Activities	21	424	0.3	0.9	0.07	5.90	0.19	4.01	NC
R. Artistic & Recreational Activities	27	9	0.3	1.2	0.09	0.13	0.00	0.08	NC
S. Other Service Activities	128	206	1.6	5.5	0.44	2.87	0.09	1.94	NC
T. Household activities as Employers	0	0	0.0	0.0	0.00	0.00	0.00	0.00	NC
Total	**2319**	**7188**	**28.8**	**100**	**8.06**	**100**	**3.238**		

Source: Calculated by the authors based on the information provided by (CAS-Cámara de Comercio del Aburrá Sur, 2018) and DANE (2018).

employment levels of the five municipalities of Aburrá Sur does not even reach 1 %.

The calculation of the geographic concentration of economic sectors in the municipality through the GCI in 2018 shows that the municipality of Caldas does not have an economic sector with evidence of concentration in its territory. This is because under the classification scale of the territorial sectoral concentration proposed by this research, none of the 21 sectors, in which economic activity and employment are distributed, shows a coefficient higher than 60 %.

The analysis of the data in Table 1 identifies Envigado as the second municipality with the highest business participation and labour participation. In 2018, the municipality produced 33.70 % of companies and 30.78 % of jobs in the territorial grouping, only less than the municipality of Itagüí. Regarding the availability of business resources, the municipality of Envigado had a value of 40.7 in 2018, being, after the municipality of Sabaneta, the territory with the second highest indicator.

The vehicle sales and repair sector (Section G) registered the highest level of business participation in the municipality. The second with the highest relative business participation was the manufacturing industry (Section C).

The calculation of the Pearson correlation coefficient p (Edwards, 1976) between the business participation indicators of the different economic sectors and employment participation yielded the result $p = 0.860120$, establishing a positive impact between the economic sectors that register the largest number of companies and generation of employment in the territory. This situation can be verified by stating that the vehicle sales and repair sector (Section G) is the one with the most registered companies (3,140) and generates the largest number of jobs in the municipality (17,954). Likewise, the manufacturing industry

Table 3

GCI and Basic Indicators per Economic Sector for the Municipality of Envigado

Economic Sector	*B*	*E*	*AVAILBUS*	*BUSPART Relative, %*	*BUSPART Total, %*	*EMPLPART Relative, %*	*EMPLPART Total, %*	*GCI, %*	*GCI Categorisation*
A. Agriculture, Livestock, Hunting, Forestry, Fishing	161	7890	0.68	1.7	0.56	11.55	3.55	74.63	LC
B. Mining & Quarrying	19	851	0.08	0.2	0.07	1.25	0.38	8.05	NC
C. Manufacturing Industries	1168	9716	4.90	12.0	4.06	14.22	4.38	91.90	MC
D. Electricity & Gas Supply	6	5	0.03	0.1	0.02	0.01	0.00	0.04	NC
E. Water Distribution & Treatment	18	455	0.08	0.2	0.06	0.67	0.20	4.30	NC
F. Construction	517	5874	2.17	5.3	1.80	8.60	2.65	55.56	NC
G. Vehicle Sales & Repair	3140	17954	13.18	32.4	10.91	26.27	8.09	169.83	HC
H. Transportation & Storage	228	2460	0.96	2.4	0.79	3.60	1.11	23.27	NC
I. Lodging & Food Services	1061	2617	4.45	10.9	3.69	3.83	1.18	24.75	NC
J. Information & Communication	293	3662	1.23	3.0	1.02	5.36	1.65	34.64	NC
K. Financial & Insurance Related Activities	285	553	1.20	2.9	0.99	0.81	0.25	5.23	NC
L. Real Estate Activities	427	1210	1.79	4.4	1.48	1.77	0.55	11.44	NC
M. Professional, Scientific & Technical Activities	958	3257	4.02	9.9	3.33	4.77	1.47	30.80	NC
N. Administrative & Support Services Activities	464	4220	1.95	4.8	1.61	6.18	1.90	39.91	NC
O. Public Administration	5	1152	0.02	0.1	0.02	1.69	0.52	10.89	NC
P. Education	99	2900	0.42	1.0	0.34	4.24	1.31	27.43	NC
Q. Human Health Care Activities	147	1776	0.62	1.5	0.51	2.60	0.80	16.80	NC
R. Artistic & Recreational Activities	125	410	0.52	1.3	0.43	0.60	0.18	3.87	NC
S. Other Service Activities	575	1374	2.41	5.9	2.00	2.01	0.62	12.99	NC
T. Household activities as Employers	0	0	0.00	0.0	0.00	0.00	0.00	0.00	NC
Total	**9696**	**68336**	**40.71**	**100**	**33.70**	**100.00**	**30.78**		

Source: Calculated by the authors based on the information provided by (CAS-Cámara de Comercio del Aburrá Sur, 2018) and DANE (2018).

(Section C) has the second largest number of businesses (1,168) and job creation (9,716).

Regarding the geographic concentration according to the ICG as of 2018, the municipality of Envigado has three sectors that present levels of territorial concentration based on the scale applied in this research study. In turn, these sectors are the ones that contribute the most in the municipality in terms of labour participation and correspond to the vehicle sales and repair sector with a high territorial concentration categorisation where *ICG* = 169.83 %; the manufacturing industry sector with medium concentration categorisation where *ICG* = 91.90 %; and the agriculture, livestock, hunting, forestry and fishing sector with low concentration where *ICG* = 74.63 %.

Table 1 shows that, in aggregate terms, Itagüí is the municipality of Aburrá Sur characterised by the best performance in terms of business participation and labour participation. It can be established that although it is the territory of Aburrá Sur with the largest population, it has the largest number of registered companies and employees. For this reason, the relationship between the total number of companies and the population of the municipality per 1,000 inhabitants, produces the indicator of availability of business resources that places Itagüí with the third best performance in the region with 37.8.

The calculation of the Pearson correlation coefficient *p* (Edwards, 1976) between the indicators of business participation of the different economic sectors and participation in employment for the municipality showed the results of $p = 0.788980$, establishing an acceptable level of correlation between the economic sectors that register the greater number of companies and generation of employment in the territory. This is verified by analysing that of the five economic sectors with the most businesses registered in the municipality, only the vehicle sales and repair sectors (Section G) and the manufacturing industry (Section C) are among the top five in the municipality in terms of employment.

Table 4

GCI and Basic Indicators per Economic Sector for the Municipality of Itagui

Economic Sector	*B*	*E*	*AVAILBUS*	*BUSPART Relative, %*	*BUSPART Total, %*	*EMPLPART Relative, %*	*EMPLPART Total, %*	*GCI, %*	*GCI* Categorisation
A. Agriculture, Livestock, Hunting, Forestry, Fishing	82	1590	0.30	0.8	0.28	1.87	0.72	15.04	NC
B. Mining & Quarrying	10	310	0.04	0.1	0.03	0.37	0.14	2.93	NC
C. Manufacturing Industries	2027	28458	7.32	19.3	7.04	33.51	12.82	269.19	HC
D. Electricity & Gas Supply	5	25	0.02	0.0	0.01	0.03	0.01	0.23	NC
E. Water Distribution & Treatment	35	283	0.13	0.3	0.12	0.33	0.13	2.67	NC
F. Construction	359	6166	1.30	3.4	1.24	7.26	2.78	58.32	NC
G. Vehicle Sales & Repair	4504	20284	16.26	43.0	15.65	23.89	9.14	191.87	HC
H. Transportation & Storage	400	4699	1.44	3.8	1.39	5.53	2.12	44.44	NC
I. Lodging & Food Services	1211	1233	4.37	11.6	4.20	1.45	0.56	11.66	NC
J. Information & Communication	146	1823	0.53	1.4	0.50	2.15	0.82	17.24	NC
K. Financial & Insurance Related Activities	132	195	0.48	1.3	0.45	0.23	0.09	1.84	NC
L. Real Estate Activities	214	485	0.77	2.0	0.74	0.57	0.22	4.58	NC
M. Professional, Scientific & Technical Activities	327	4195	1.18	3.1	1.13	4.94	1.89	39.68	NC
N. Administrative & Support Services Activities	292	7740	1.05	2.8	1.01	9.12	3.49	73.21	LC
O. Public Administration	2	2097	0.01	0.0	0.00	2.47	0.94	19.83	NC
P. Education	79	732	0.29	0.8	0.27	0.86	0.33	6.92	NC
Q. Human Health Care Activities	78	1999	0.28	0.7	0.27	2.35	0.90	18.90	NC
R. Artistic & Recreational Activities	116	635	0.42	1.1	0.40	0.75	0.29	6.00	NC
S. Other Service Activities	458	1965	1.65	4.4	1.59	2.31	0.89	18.58	NC
T. Household activities as Employers	0	0	0.00	0.0	0.00	0.00	0.00	0.00	NC
Total	**10477**	**84914**	**37.83**	**100.0**	**36.415**	**100.00**	**38.25**		

Source: Calculated by the authors based on the information provided by (CAS-Cámara de Comercio del Aburrá Sur, 2018) and DANE (2018).

Only three economic sectors have some level of territorial concentration according to the proposed methodology. The first sector is the manufacturing industry (Section C) with a high concentration supported by *GCI* = 269.19 %. The second highest is the vehicle sales and repair sector (Section G) with a high concentration according to *GCI* = 191.87 %. The last sector with territorial concentration is that of administrative and support services activities (Section N) with a low level of concentration of *GCI* = 73.21 %.

According to the data in Table 1, La Estrella, after Caldas, has the lowest labour participation. Regarding business participation, in 2018, the municipality of La Estrella registered the least number of companies in Aburrá Sur. Regarding the availability of business resources, the municipality of La Estrella has a value of 34.1, surpassing the municipality of Caldas.

The vehicle sales and repair sector (Section G) had the highest level of business participation. In 2018, the manufacturing industries (Section C) and hospitality and food services (Section I) sectors had the second and third highest participation percentages in the same period with 23.4 % and 10 %, respectively.

The calculation of the Pearson correlation coefficient p (Edwards, 1976) between the business participation indicators of the different sectors of the municipality and the labour participation of each sector in the municipality yields a correlation level of $p = 0.680720$. It is explained in greater detail by highlighting that the vehicle sales and repair sector (Section G), which has the largest number of related businesses (787), generates only 12.90 % of total municipal employment.

The spatial concentration by sectors of the municipality of La Estrella obtained from the GCI for the year 2018 establishes that of the 21 economic sectors, only the manufacturing industries sector (Section C) can be framed within the lev-

Table 5

GCI and Basic Indicators per Economic Sector for the Municipality of La Estrella

Economic Sector	B	E	AVAILBUS	BUSPART Relative, %	BUSPART Total, %	EMPLPART Relative, %	EMPLPART Total, %	GCI, %	*GCI* Categorisation
A. Agriculture, Livestock, Hunting, Forestry, Fishing	32	165	0.49	1.4	0.11	0.85	0.07	1.56	NC
B. Mining & Quarrying	4	199	0.06	0.2	0.01	1.03	0.09	1.88	NC
C. Manufacturing Industries	522	9264	7.99	23.4	1.81	47.85	4.17	87.63	LC
D. Electricity & Gas Supply	2	0	0.03	0.1	0.01	0.00	0.00	0.00	NC
E. Water Distribution & Treatment	19	234	0.29	0.9	0.07	1.21	0.11	2.21	NC
F. Construction	99	1450	1.52	4.4	0.34	7.49	0.65	13.71	NC
G. Vehicle Sales & Repair	787	2498	12.05	35.3	2.74	12.90	1.13	23.62	NC
H. Transportation & Storage	94	1430	1.52	4.2	0.33	7.39	0.64	13.52	NC
I. Lodging & Food Services	222	314	3.40	10.0	0.77	1.62	0.14	2.97	NC
J. Information & Communication	31	272	0.47	1.4	0.11	1.40	0.12	2.57	NC
K. Financial & Insurance Related Activities	26	328	0.40	1.2	0.09	1.69	0.15	3.10	NC
L. Real Estate Activities	71	245	1.09	3.2	0.25	1.27	0.11	2.31	NC
M. Professional, Scientific & Technical Activities	105	521	1.61	4.7	0.36	2.69	0.23	4.92	NC
N. Administrative & Support Services Activities	69	1103	1.06	3.1	0.24	5.70	0.50	10.43	NC
O. Public Administration	1	197	0.02	0.0	0.00	1.02	0.09	1.86	NC
P. Education	21	432	0.32	0.9	0.07	2.23	0.19	4.08	NC
Q. Human Health Care Activities	17	299	0.26	0.8	0.06	1.54	0.13	2.82	NC
R. Artistic & Recreational Activities	21	16	0.32	0.9	0.07	0.08	0.01	0.15	NC
S. Other Service Activities	87	395	1.33	3.9	0.30	2.04	0.18	3.73	NC
T. Household activities as Employers	0	0	0.00	0.0	0.00	0.00	0.00	0.00	NC
Total	**2230**	**19362**	**34.15**	**100.0**	**7.75**	**100.00**	**8.72**		

Source: Calculated by the authors based on the information provided by (CAS-Cámara de Comercio del Aburrá Sur, 2018) and DANE (2018).

els established for territorial concentration conditions with low concentration according to the proposed methodology, which is supported by *GCI* = 87.631 %.

According to the data in Table 1, La Estrella, after Caldas, has the lowest labour participation with 19,362 employed persons, that is, 8.72 % of the total employment generated in the five municipalities, in Aburrá Sur. Regarding business participation, in 2018 the municipality of La Estrella registered 2,230 companies in total, equivalent to 7.75 % of the companies in the region, being the municipality with the least number of companies registered in Aburrá Sur. Regarding the availability of business resources, AVAILBUS, the municipality of La Estrella has a value of 34.1, surpassing the municipality of Caldas as the territory of Aburrá Sur with the lowest indicator in terms of the relationship between the total number of companies and the population of the municipality per 1000 inhabitants.

The vehicle sales and repair sector (Section G of the ISIC Code, Rev. 4) had the highest level of business participation with 35.3 % of the total businesses in the municipality (787), that is, 2.74 % of all businesses in Aburrá Sur. In 2018, the manufacturing industries (Section C) and accommodation and food services (Section I) sectors had the second and third highest participation percentage in the same period with 23.4 % and 10 %, respectively, among the total number of companies registered in the five municipalities that make up the territorial grouping.

The correlation analysis by calculating the Pearson correlation coefficient *p* (Edwards, 1976) between the business participation indicators of the different sectors of the *BUS*⟦*PART*⟧*_Relative* municipality and the labour participation of each

Table 6

GCI and Basic Indicators per Economic Sector for the Municipality of Sabaneta

Economic Sector	*B*	*E*	*AVAILBUS*	*BUSPART Relative, %*	*BUSPART Total, %*	*EMPLPART Relative, %*	*EMPLPART Total, %*	*GCI, %*	*GCI Categorisation*
A. Agriculture, Livestock, Hunting, Forestry, Fishing	40	3247	0.73	1.0	0.13	7.69	1.46	30.71	NC
B. Mining & Quarrying	13	656	0.24	0.3	0.04	1.55	0.30	6.20	NC
C. Manufacturing Industries	591	16654	10.83	14.6	2.05	39.39	7.49	157.25	HC
D. Electricity & Gas Supply	2	5	0.04	0.0	0.00	0.01	0.00	0.02	NC
E. Water Distribution & Treatment	14	39	0.26	0.3	0.04	0.10	0.02	0.38	NC
F. Construction	238	4235	4.36	5.9	0.82	10.03	1.91	40.02	NC
G. Vehicle Sales & Repair	1320	5340	24.19	32.6	4.58	12.69	2.41	50.66	NC
H. Transportation & Storage	149	4210	2.73	3.7	0.51	10.01	1.90	39.97	NC
I. Lodging & Food Services	486	947	8.91	12.0	1.68	2.25	0.43	8.96	NC
J. Information & Communication	115	1992	2.11	2.8	0.40	4.68	0.89	18.70	NC
K. Financial & Insurance Related Activities	86	95	1.58	2.1	0.29	0.33	0.06	1.30	NC
L. Real Estate Activities	166	302	3.04	4.1	0.57	0.71	0.13	2.81	NC
M. Professional, Scientific & Technical Activities	277	1380	5.08	6.8	0.96	3.29	0.63	13.14	NC
N. Administrative & Support Services Activities	167	1252	3.06	4.1	0.58	2.98	0.57	11.90	NC
O. Public Administration	0	289	0.00	0.0	0.00	0.68	0.13	2.73	NC
P. Education	48	775	0.88	1.2	0.16	1.82	0.35	7.28	NC
Q. Human Health Care Activities	58	202	1.06	1.4	0.20	0.48	0.09	1.91	NC
R. Artistic & Recreational Activities	45	32	0.82	1.1	0.15	0.07	0.01	0.28	NC
S. Other Service Activities	234	528	4.29	5.8	0.81	1.23	0.23	4.90	NC
T. Household activities as Employers	0	0	0.00	0.0	0.00	0.00	0.00	0.00	NC
Total	**4049**	**42203**	**74.21**	**100**	**14.073**	**100**	**19.00**		

Source: Calculated by the authors based on the information provided by (CAS-Cámara de Comercio del Aburrá Sur, 2018) and DANE (2018).

sector in the *EMPL*[*PART*]*Relative* yields a correlation level of $p = 0.680720$, which is explained in greater detail by highlighting that the vehicle sales and repair sector (Section G), which has the largest number of related businesses (787), generates only 12.90 % of total municipal employment. Additionally, the manufacturing industries sector (Section C) with 522 companies has 9,264 registered jobs, that is, 47.85 % of municipal employment and 4.17 % of total employment in Aburrá Sur.

The information in Table 1 highlights a set of particularities regarding the business dynamics of the municipality of Sabaneta, since it is the smallest territory in Aburrá Sur. It is the municipality of the territorial group with the best result in terms of availability of business resources (*AVAILBUS*) with a 2018 result of 75.1, surpassing the municipalities of Envigado (40.7) and Itagüí (37.8), which are the territories-leaders in terms of the number of companies and jobs in Aburrá Sur.

The vehicle sales and repair sector (Section G) has the largest number of registered companies and contributes 12.69 % of the employment generated in the territory. The manufacturing industries sector (Section C) exceeds the first in this category of analysis, since it generated 39.39 % of municipal employment

Other sectors with registered companies outside the described ranking but with optimal performance in terms of job creation were the following: construction (Section F) with a 10.03 % share of municipal employment and transport and storage (Section H) with 10.01 %. The correlation analysis of the indicators of business participation and participation in employment for the different economic sectors yielded a result $p = 0.533832$ for the municipality which, after the result registered by the municipality of Caldas, is the lowest value of the five municipalities of Aburrá Sur.

The calculation of the geographic concentration by sector establishes that in the municipal-

Table 7

Primary Results

	CALDAS	ENVIGADO	ITAGÜÍ	LA ESTRELLA	SABANETA
Employment Participation in the Region	3.24 %	30.78 %	38.25 %	8.72 %	19.10 %
	Lower	Second highest	Highest	Fourth highest	Third highest
Business Participation in the Region	2.319	9.696	10.477	2.230	4.049
	8.06 %	33.70 %	36.42 %	7.75 %	14.10 %
Availability of Business Resources (va)	28.8	40.7	37.8	34.1	75.1
Five Main Sectors by Number of Businesses	i. Vehicle Sales and Repair ii. Lodging and Food Services iii. Manufacturing Industries iv. Other Service Activities v. Construction	i. Vehicle Sales and Repair ii. Manufacturing Industries iii. Lodging and Food Services iv. Professional, Scientific, and Technical Activities v. Other Service Activities	i. Vehicle Sales and Repair ii. Manufacturing Industries iii. Lodging and Food Services iv. Other Service Activities v. Transportation & Storage	i. Vehicle Sales and Repair ii. Manufacturing Industries iii. Lodging and Food Services iv. Professional, Scientific, and Technical Activities v. Construction	i. Vehicle Sales and Repair ii. Manufacturing Industries iii. Lodging and Food Services iv. Professional, Scientific, and Technical Activities v. Other Service Activities
Participation of Businesses in the Five Main Sectors in the Municipality, %	82.50	71.30	82.08	77.80	71.8
Pearson Correlation Coefficient (*p*)	0.44	0.86	0.78	0.68	0.533
Geographic Concentration Index	Sectors with no concentration	Three sectors with territorial concentration	Three sectors with territorial concentration	One sector with territorial concentration	One sector with territorial concentration

Source: Calculated by the authors based on the information provided by (CAS-Cámara de Comercio del Aburrá Sur, 2018) and DANE (2018).

ity of Sabaneta, only the manufacturing industries economic sector has a categorisation of territorial concentration, indicated by $ICG = 157.25$ % and showing high concentration.

4. Conclusions

The industrial sector is the economic sector with the highest levels of territorial concentration in Aburrá Sur, given that it has high concentration categorisation in the municipalities of Itagüí and Sabaneta, medium concentration in the municipality of Envigado, and low concentration in the municipality of La Estrella. The results of this study prove the hypothesis that in the municipalities studied predominates the high concentration in the manufacturing industry and provide an important input for local administrations and other development actors in Aburrá Sur to guide their plans and programs for more efficient resource allocation in the region.

When analysing the industrial concentration of each municipality, the municipality of Itagüí has two sectors with high industrial concentration (manufacturing industries and vehicle sales & repair) and one with low concentration (administrative & support services activities). In this sense, it is understood that the focus of public investment should be geared toward the first two, since they have the greatest impact on both economic growth and job creation. The municipality of Envigado has a highly concentrated sector in vehicle sales & repair; a medium concentration sector in the manufacturing industries; and a low concentration sector in agriculture, livestock, hunting, forestry, and fishing.

In the municipalities of Sabaneta and La Estrella, the manufacturing industries sector should receive the highest proportion of public investment, given that it achieved high and low industrial concentration levels, respectively.

There are no industrial concentration sectors in the municipality of Caldas. This could be related to Pearson's low correlation coefficient (p) (see Table 7), as its business participation is one of the lowest in the region; additionally, it has the lowest level of employment participation and the lowest availability of business resources. Notably, the municipal administration should focus its public policy efforts on promoting and generating incentives that increase the creation, growth, and/or consolidation of existing companies among the five main sectors according to the number of companies and incentivise job creation.

Due to economic activities in the territories being concentrated in one space in most cases, the SIA model is useful when analysing this type of data as the prevalence of reported sectors with concentration levels does not depend on one another or among others, since they are different and one sector does not depend on or influence the other. This is supported by the application of this approach in several studies on corporate specialisation and concentration. In terms of public policy, with regard to business decisions and regional interests, it is important to prioritise efforts and resources regarding investment and assertive decisions to increase business productivity and regional development. The sectors with little or no concentration are no less important, as they also contribute to the regions in terms of employment and as potential sectors for business growth and diversification.

This type of analysis is relevant for local authorities, since it enables them to focus business strategies and public resources in a more efficient and accurate manner, in addition to identifying specific needs and opportunities, such as in the municipality of Caldas, where it would be relevant to promote its main sectors through a more structured analysis, thus providing more robust and complete statistical information and analysis.

Sectoral concentration must be addressed by not only businesspersons but also all the competent local authorities that implement an institutional structure necessary to create an environment conducive to territorial development. This will help them become economically self-sustainable, coincide with the economic activities of the regions, and stay updated with the results of analytical studies of the territories.

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