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ANALYSIS OF CONCENTRATION MEASURES APPLIED TO MANUFACTURE INDUSTRY IN A STATE OF BRAZILIAN NORTHEAST

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Abstract — Obtain analytical knowledge of market structures of a given region is useful in managerial decision-making and establishing company pricing strategies and policies. In view of these attributions, this article presents the application and analysis of the concentration level to the industrial sector in a state of northeastern Brazil. For this, three concentration indicators were used: Concentration Ratio (CR_k), Hirschman-Herfindahl (HHI) and Theil's entropy coefficient (TE). The results showed that the increase in the number of employees in all segments over the period 2002 to 2013 allows us to infer a possible economic growth for this region, which can be better seen in future research on the sector.

Keywords— Industrial concentration; Manufacturing industry; Concentration indices; Northeastern Brazil.

I. INTRODUCTION

According to [1], the conduct and performance of firms result from their market structure, where this structure influences the actions to be taken by the firm. The conduct favors the attitudes used by the firms in order to adapt to the market.

Knowing the market structure of a given region is useful in managerial decision-making and, more specifically, in establishing company pricing strategies and policies. For [2], this set of strategies is defined as the conduct of the company, being characterized by virtue of the Structure-Conduct-Performance (SCP) model. The perception of the market structure, combined with the quantification of the structural component in terms of synthetic measures, is strategic in the SCP paradigm, as well as finding broad use in studies on Industrial Economics, for example, [3-8].

The empirical applications of concentration are supported in concentration measurements. These measures have the objective of capturing how economic agents show a "dominant behavior" in a given market. In this sense, the different indicators consider the market share of the agents, for

example, the number of employees of each company for the total employment bonds of the sector (according to different weighting criteria). Industrial concentration measures are useful to indicate, preliminarily, the sectors for which "market power" is expected to be significant [9].

However, some empirical applications often rely on deficient concentration measurements, which has served as motivation for comparative presentations of the main measures used in studies in the area. The results of these motivations have given rise to studies that address different methodological lines with emphasis on industrial concentration, but finding results with a high degree of divergence [10-12].

In the process of regional migration of industries, new industrial agglomerations occur in peripheral regions, inducing research on industrial concentration and contributing to these studies gain more space in academic debate and development promotion agencies and institutions to support micro and small enterprises. This process draws the attention of the research support agencies to the valorization and, consequently, sponsorship to the development of investigations whose objective is the verification and explanation on the phenomenon of industrial concentration.

However, there are positive aspects, a priori, arising from this concentration. An example of this is the fact that high concentration does not reflect in oligopolistic practices, given the need for technological innovations and modernizations [8]. In view of these and other attributions, this article presents the application and analysis of the level of concentration of the industrial sector in a state of northeastern Brazil. For this, three concentration indicators were used: Concentration Ratio (CR_k), Hirschman-Herfindahl (HHI) and Theil's entropy coefficient (TE).

This paper is organized as follows. The mathematical models to measure the level of concentration in section II. The case study in section III. The application and results are presented in section IV. Concluding remarks are given in section V.



II. CONCENTRATION MEASUREMENT

There are two categories of concentration indicators: *partial* or *summary*; which may be *positive* or *normative*. "*partial*" indicators (such as the "*Concentration Ratio*" index) use only a portion of the market, usually the companies with the highest *market share*. In order to measure this index, it is sufficient to use some information from the sector (for example, the total number of firms is not necessary). For the "*summary*" category there is a need to use information from all the firms in the industry that are to be verified. Examples of these indices are "*Hirschman-Herfindahl*" and "*Theil's Entropy Coefficient*".

According to [13], the correlation between concentration indices does not imply a perfect equivalence, in which [14] empirically reproduces the related relationship between concentration indicators, focusing on European industry.

According to [15] no index will always be ideal, whatever the situation, because the use of all of them makes possible a better use of the data and, consequently, more satisfactory results.

A. Concentration Ratio (CR_k) –

The concentration ratio (CR_k) is a positive indicator that evaluates the market share for the k largest companies. Their indicators provide results ranging from 0 to 1, where 0 represents a perfect competitive situation, while 1 indicates a condition of intense concentration, showing greater market power exerted by the k largest firms. The calculation of the CR_k indicator is represented by Equation 1.

$$CR(k) = \sum_{i=1}^k \varphi_i \quad k = \{1, 2, \dots, n\} \quad (1)$$

For this indicator we have the quantity of large companies in the market (k) and the market-share of the company (φ_i). Table 1 indicates the comparative metrics of the results for the CR_k indicator according to [16].

Table 1 – Interpretation metrics of the CR_k index.

CR_4	CR_8	Concentration level
$\geq 75\%$	$\geq 90\%$	Very high
65% - 75%	85% - 90%	high
50% - 65%	70% - 85%	Moderately High
35% - 50%	45% - 70%	Moderately Low
$\leq 35\%$	$\leq 45\%$	low

The Concentration Ratio index provides a connection of the technical concentration of the industry studied with the levels of sales or participation of a specific market. On the other hand, this index presents some negative points: the ranking of the largest companies may vary during the analyzed period, making it impossible for the CR_k index to demonstrate the level of relative concentration among companies [15]. The CR_k indicator also disregards the size of each company

involved in the calculation. Thus, making use of other indicators together may favor more conclusive results [15].

B. Hirschman-Herfindahl Index (HHI) –

The formulation of the HHI indicator presents an implicit weights structure, since, it refers to the sum of the squares of the market share (φ_i) from the n firms. This participation can be analyzed through any variable that may represent it. Equation 2 represents HHI.

$$HHI = \sum_{i=1}^n (\varphi_i)^2 \quad (2)$$

A high HHI value will indicate that the concentration level is higher and the lower the competition. The results of the execution of the HHI index vary between " $1/n$ " and " 1 ", where the minimum value of " $1/n$ " can reach zero (0), in the case of perfect competition, which derives from a convex function defined in Simplex $\varphi_{n-1} = \{\varphi \in [0,1]^n; \sum_{i=1}^n \varphi_i = 1 \text{ to } \varphi_1 = \varphi_2 = \dots = \varphi_n \text{ i.e., for companies of the same size. The maximum value presented by the index is associated with a monopolistic situation in which a single firm retains all market share, thus indicating the upper limit of the HHI index, reaching a value of "1". In this way, the Hirschman-Herfindahl index presents a variation of } 1/n \leq HHI \leq 1. \text{ Table 2 provides the interpretation of the results for this indicator.}$

Table 2 – Interpretation metrics of the HHI index.

HHI	Concentration level
> 0.18	Industry highly concentrated
$0.1 \leq HHI \leq 0.18$	Industry with moderate concentration
< 0.1	Unconcentrated industry

C. Theil's Entropy Coefficient (TE) –

For this indicator proposed by [17], all companies in the market should be considered in their calculation, taking into account the market share value of each company. Thus, the lower the index value, the higher its concentration. Considering Theil's specification for informational content, we obtain Equation 3.

$$TE = \sum_{i=1}^n \varphi_i \ln \left(\frac{1}{\varphi_i} \right) \quad (3)$$

This measure is used to define the degree of uncertainty in a market in which a large number of competing firms leads to greater uncertainty of maintaining a customer (deconcentrating it and providing a higher value of TE). This coefficient corresponds to the opposite of the Concentration Ratio (CR_k), and its value decreases as the degree of concentration of the firms increases. Therefore, a result of value TE equal to zero indicates the maximum concentration of the market, characterizing a monopolistic situation.



III. A CASE STUDY OF A STATE IN THE BRAZILIAN NORTHEAST

The industrial sector of Ceará (northern state of Brazil) is characterized by the presence of the following divisions belonging to the category of use of non-durable consumer goods: food and beverages, textiles, clothing and leather and footwear. In 2010, the industrial sector of Ceará accounted for 23.7% of the state's economy [18].

Regarding the industrial sector structure, the manufacturing activity is the most representative (48.1%), where the Metropolitan Region of Fortaleza (Ceará Capital) concentrates a substantial part of the state industrial park (accounting for 73.3% % of formal jobs and 70.1% of the value added of Industry). Given the spatial distribution of the industry that considered the scarcity of the number of local units within the State [18].

Among the formal jobs in the industry, more than 70% of them are related to manufacturing activities, in which the Textile, Footwear and Food and Beverages segments stand out.

Based on data from the Annual Social Information Report (RAIS) of the Ministry of Labor and Employment (MTE) in Brazil [19], it is possible to verify the number of employment links (variable used in the measurement of concentration indices) by sector of economic activity. Such data are available in Table 3, 4 and 5.

Table 3 – Number of employment relationships in the manufacturing industry in Ceará – Part I

Subsector	2002	2003	2004	2005
Prod. Non Metallic Mineral	7.154	7.109	7.504	7.495
Metallurgical industry	6.321	6.219	7.086	7.601
Mechanical Engineering	2.295	1.935	2.113	2.776
Electrical and Communications	1.487	1.327	1.752	2.049
Transportation Material	1.468	1.526	1.881	2.212
Wood & Furniture	5.009	5.465	5.195	5.619
Paper and Graphs	4.730	5.545	5.806	5.862
Rubber, Smoke, Leather	4.494	4.754	5.313	6.009
Chemical industry	6.586	7.413	8.133	9.284
Textile industry	45.906	46.113	49.911	52.449
Industry Footwear	36.770	41.454	45.982	44.268
Food and drinks	32.587	35.613	36.374	35.641

IV. APPLICATION AND RESULTS

The result of the CR_2 index in Table 6 shows that the textile and footwear subsectors were the ones that most employed labor in the period 2002-2013, evidencing an average level of concentration of 52% ($CR_2 = 0.5225$). However, it lost its concentration over the analyzed period (2002-2013) of 4.27%, ending the year 2013 with a concentration of 51.13% ($CR_2 = 0.5113$).

In the analysis of the four subsectors that most used in this industry (Textiles, Footwear, Food and Beverage and Metallurgy), the CR_4 index identified a concentration of 79% ($CR_4 = 0.7908$) in 2002, with a 3.3% reduction by 2008. Over the study period, 2002-2013, the reduction in concentration level was 1.1%, reaching a CR_4 of 0.7563, or 76% of concentration.

Table 4 – Number of employment relationships in the manufacturing industry in Ceará – Part II

Subsector	2006	2007	2008	2009
Prod. Non Metallic Mineral	8.637	9.323	9.976	10.324
Metallurgical industry	9.139	10.286	11.395	12.774
Mechanical Engineering	3.701	3.981	3.831	3.876
Electrical and Communications	1.737	1.506	2.278	1.976
Transportation Material	2.310	2.505	3.000	3.125
Wood & Furniture	6.308	6.261	6.614	6.918
Paper and Graphs	6.241	6.682	7.004	7.656
Rubber, Smoke, Leather	6.235	6.614	6.626	6.392
Chemical industry	10.520	10.815	11.498	12.061
Textile industry	52.598	58.046	62.706	65.969
Industry Footwear	48.498	52.962	49.832	62.365
Food and drinks	39.364	39.168	40.782	43.415

Table 5 – Number of employment relationships in the manufacturing industry in Ceará – Part III

Subsector	2010	2011	2012	2013
Prod. Non Metallic Mineral	12.041	13.273	14.123	14.900
Metallurgical industry	14.425	14.068	16.419	17.120
Mechanical Engineering	4.683	4.840	5.851	5.540
Electrical and Communications	1.895	2.109	1.834	1.704
Transportation Material	4.193	4.109	3.939	3.807
Wood & Furniture	8.066	8.512	8.532	8.443
Paper and Graphs	8.359	8.715	9.019	8.862
Rubber, Smoke, Leather	7.706	7.389	7.435	7.612
Chemical industry	13.090	12.495	12.899	13.430
Textile industry	71.006	69.299	70.719	71.133
Industry Footwear	63.562	61.843	62.496	63.748
Food and drinks	42.331	45.115	45.708	47.520

For the eight largest subsectors (Textiles, Footwear, Food and Beverage, Metallurgy, Non-Metallic Mineral, Chemical, Paper and Graphic, and Wood and Furniture), there was a concentration level of 94% ($CR_8 = 0.9371$) in 2002. Between 2008-2013, unlike previous indexes (CR_2 and CR_4), CR_8 showed a slight increase of 0.24%. However, similar to the CR_2 and CR_4 indices, CR_8 also lost its concentration throughout the analyzed period of 0.83% ($CR_8 = 0.9293$).

For the measurement of Hirschman Herfindahl index (HHI) inferred that the concentration of the subsectors declined



6.21% between 2002 and 2008, following a further reduction of 4.33% between 2008 and 2013. Analyzing the entire period, the *HHI* index showed a reduction of the concentration of 10.27%. In this way, the *HHI* confirms the result of the indicators CR_2 , CR_4 and CR_8 , namely, a decrease in the degree of concentration of the main subsectors, thus illustrating the absence of a dominant subsector, as well as a better distribution and possible growth of the industry of Ceará.

Table 6 - Results of the concentration indicators

	CR_2	CR_4	CR_8	<i>HHI</i>	<i>TE</i>
2002	0.5341	0.7908	0.9371	0.1975	1.9085
2003	0.5324	0.7940	0.9420	0.1977	1.8989
2004	0.5416	0.7930	0.9382	0.1978	1.9041
2005	0.5336	0.7814	0.9302	0.1917	1.9399
2006	0.5177	0.7731	0.9284	0.1856	1.9612
2007	0.5333	0.7734	0.9315	0.1886	1.9500
2008	0.5221	0.7647	0.9271	0.1852	1.9713
2009	0.5418	0.7791	0.9351	0.1910	1.9400
2010	0.5354	0.7612	0.9265	0.1842	1.9780
2011	0.5209	0.7560	0.9267	0.1805	1.9911
2012	0.5144	0.7543	0.9264	0.1773	2.0022
2013	0.5113	0.7563	0.9293	0.1772	1.9980

The Theil's Entropy Coefficient (*TE*) corroborates the results of the other indices, showing a drop in the concentration level for the analyzed period: 2002 ($TE = 1.9085$) to 2013 ($TE = 2.4965$).

In view of the presented results, it can be seen that the textile and footwear subsectors presented a reasonable level of concentration that tends to decrease in a cyclical way, as illustrated by the concentration measures.

V.CONCLUSION

The main objective of this paper was to measure the concentration level of the manufacturing industry in the state of Ceará for the period 2002-2013, based on the concentration indexes, as evidenced by the economic literature (Concentration Ratio, Hirschman-Herfindahl and the Theil's Entropy Coefficient). The variable used to calculate the indices was the number of employees, extracted from the Annual Report of Social Information from the Ministry of Labor and Employment [19].

The results showed that the Textile and Footwear sectors concentrate more than half the share of employees in the manufacturing sector. However, during the period a trend towards reduction was observed, indicating a possible equilibrium, in terms of concentration. The increase in the number of employees in all segments over the period 2002-2013 allows us to infer a possible economic growth for this region, which can be better seen in future research on the

sector. The mean value of the concentration observed in these sectors was 0.94.

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