Measurement of Competitiveness in the Colombian Mobile Telecommunications Market based on the Linda Index

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Abstract— **The mobile telecommunications services market has great relevance in the socioeconomic growth of a country and the reduction of the digital divide. However, the high demand for these mobile telecommunications services has produced a high concentration in this market, which can lead to an oligopoly or even a market monopoly. In order to prevent this, the state must generate adequate policies for the measurement and monitoring of market concentration levels. This article aims to measure concentration in the Colombian mobile telecommunications market. To achieve the above, the databases of mobile internet revenues, traffic, and accesses of the telecommunications companies operating in Colombia from 2012 to 2022, both for postpaid (fixed charge) and prepaid (on demand), provided by the Communications Regulatory Commission, were used, and through the Linda index, the corresponding measurement of the concentration indexes was made. In terms of the overall revenue (prepaid plus postpaid) of the telecommunications companies, the main result was that, in the case of the Colombian mobile telecommunications services market, there is a moderate concentration.**

Keywords-competition; linda's index; market concentration; measurement; mobile internet; revenue; telecommunications market.

I. INTRODUCTION

The mobile telecommunication services market is moving in increasingly flexible and adaptable environments to the customers' needs. In addition, there is a bandwidth increase due to the emergence of various services and applications on mobile internet, increasing the volume of data sales and becoming a solid source of income for Internet Service Providers (ISPs). As a result, competition among ISPs to maintain and attract new customers to their businesses is increasing significantly, and they are forced to analyze the quality of service and experience to improve interaction with their customers. However, the providers' interest lies in keeping these customers and increasing the volume of consumption of their services [1][2].

Studies have been carried out to analyze the current state of the mobile telecommunications market in Latin American countries and show the need for elements such as adequate spectrum management and alignment with established policies on telecommunications services. As a result of these studies, the concentration analysis in these markets is identified as a central point of study to improve competitiveness and reduce the digital divide, facilitating regional development and identifying potential investments. It is determined that countries that allocate greater bandwidth and achieve more competitive market structures obtain a greater amount of demonstrable social benefits. Countries such as Mexico have initiated this task, and the analysis of the spectrum, its allocation, and management is included among the essential variables as a relevant topic of study, appropriating the lessons of more mature markets [3][4].

Globally, it is clear that Information and Communications Technologies (ICTs) are a relevant factor leading to socioeconomic development and growth in a competitive environment that enables countries, companies, and individuals to reap the benefits. It has proven to have a great impact in areas such as commerce, health, and education, provides new job opportunities, and can help people and companies to remain competitive by running their processes more efficiently. For example, in Europe, its relevance can be seen with the creation of a digital agenda in the Europe 2020 Strategy that seeks to achieve sustainable and inclusive growth for the European economy, which aims to develop a digital economy based on knowledge and innovation [5]-[7].

A competitive market has various benefits, among which good quality, more and better options for goods and services, and low prices stand out in favor of the consumer; in favor of companies the increase in production, giving a boost to the economy in general. According to the Organization for Economic Cooperation and Development (OECD) Economic Outlook published in June 2020, global activity is projected to fall by 6% this year. Likewise, global unemployment rose from 5.4% in 2019 to 9.2% in 2020, all this under the assumption that there is no additional crisis due to the COVID-19 contagions. On the other hand, the World Economic Forum estimates that foreign direct investment will fall between 30% and 40% globally.

This article aims to measure the concentration in the Colombian mobile telecommunications market. To achieve this, we used the databases of mobile internet revenues, traffic, and accesses of the telecommunications companies operating in Colombia from 2012 to 2022, both for postpaid (fixed charge) and prepaid (on demand), provided by the Communications Regulation Commission (CRC), and through Linda's index we measured the corresponding concentration indexes.

The structure of this paper is as follows: section II provides a description of mobile telecommunications services market in Colombia. Section III presents the Linda index. Section IV describes the methodology used. Section V presents the

results of the measuring concentration in the mobile telecommunications services market in Colombia. Section VI presents the results analysis. Finally, section VII presents the conclusions.

II. Mobile Telecommunications Services Market in Colombia

Based on figures presented during the third quarter of 2022 by the Ministry of Information and Communication Technologies (MinTIC), the total number of mobile Internet accesses in Colombia reached 39.1 million, 3.4 million more than those registered in the same quarter of the previous year, as shown in Figure 1 [8].

Until September 2022, the provider with the largest number of mobile Internet accesses was Claro (20.6 million), followed by Movistar (8.9 million), TIGO (6.8 million), and WOM (1.7 million), as shown in Figure 2 [8].
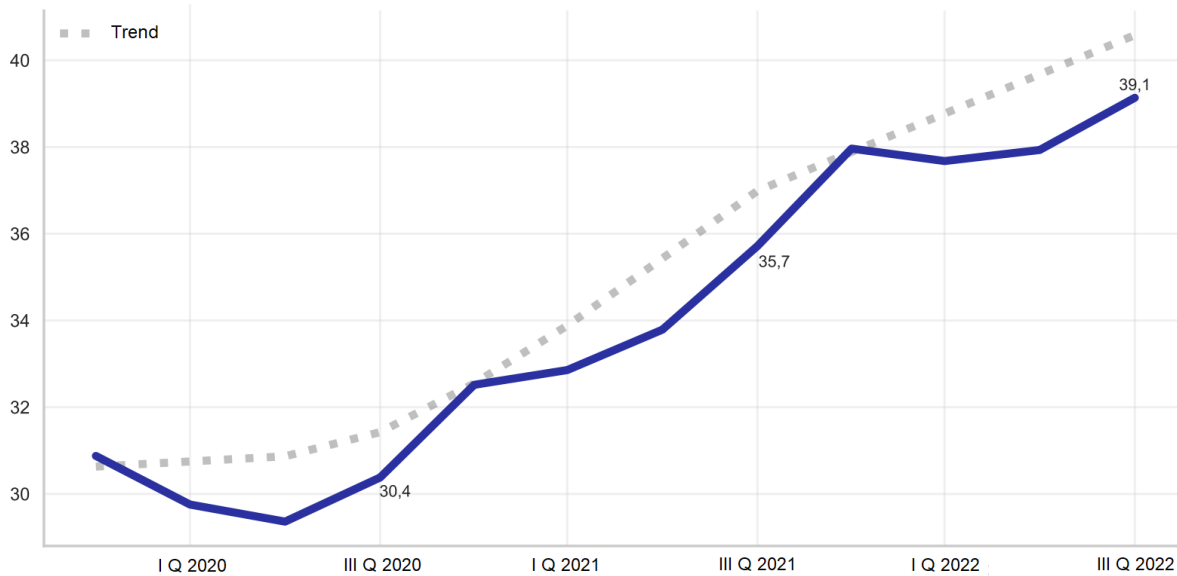

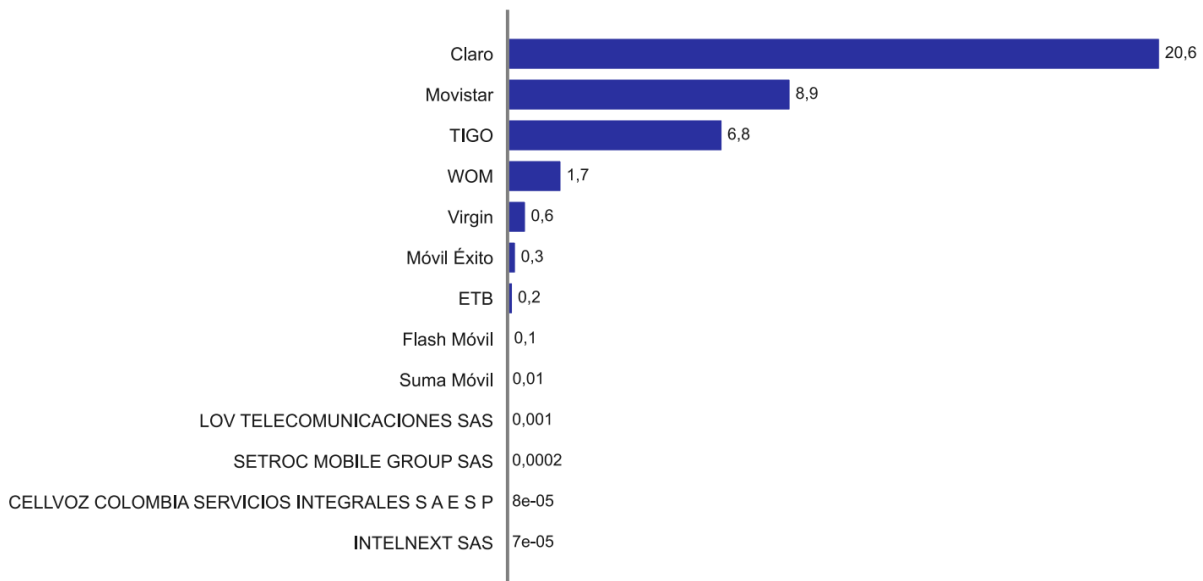Figure 1. Accesos a internet móvil en millones [8]

Figure 2. The number of mobile providers accessed by providers [8]

At the end of the third quarter of 2023, the principal mobile internet access technology in subscription mode was 4G, with 32.9 million accesses, while, with a downward trend, 3G technology has 5.4 million and 2G registers 0.9 million accesses, as shown in Figure 3 [8]. In Figure 3, a greater tendency to use the 4G technology network can be observed, largely due to the advantages that better technology brings.

During the third quarter of 2022, operating revenues in Colombian pesos for prepaid and postpaid modality, excluding taxes, produced by the provision of mobile telephony service were close to $ 400 billion for postpaid and $ 163 billion for prepaid, as shown in Figure 4 [8]. Figure 4 shows a higher level of income from the postpaid modality than from the prepaid modality; this is because the prepaid modality works on demand and it is generally people with low economic resources who take this modality.
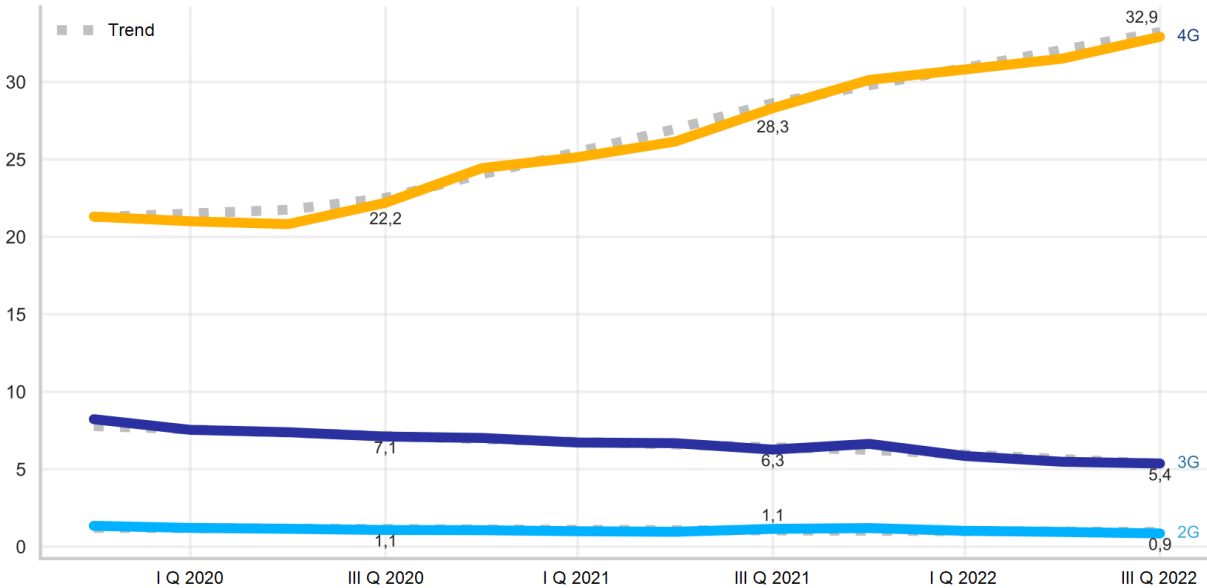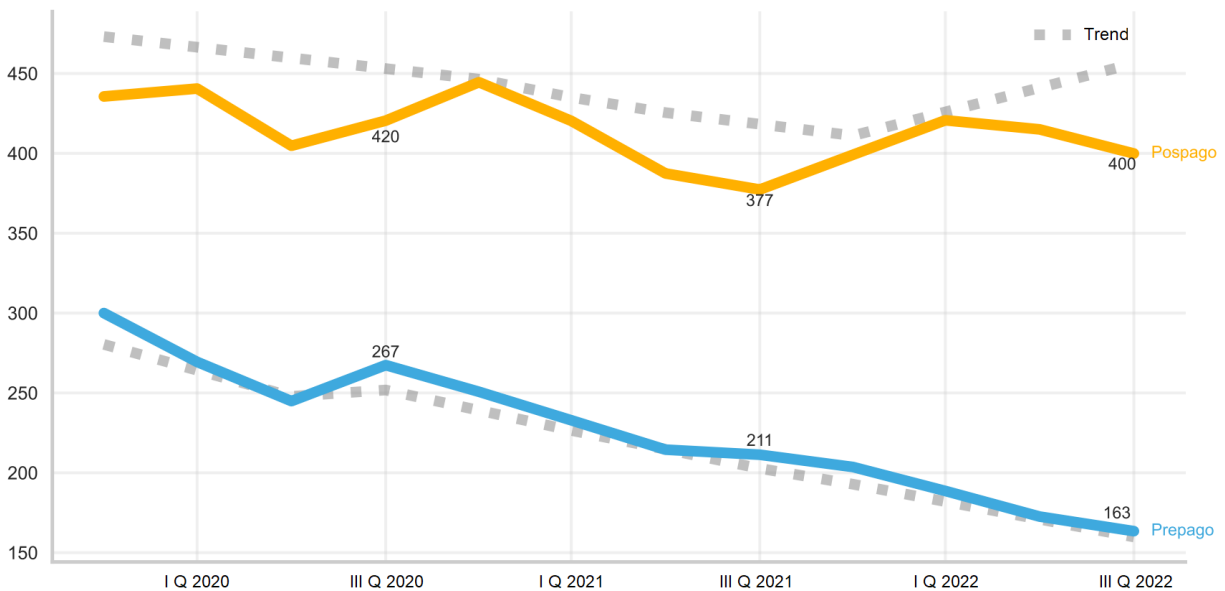

Figure 3. Mobile Internet access by technology [8]

Figure 4. Operating revenues in billions of pesos [8]

III. CONCENTRATION INDEX

The concentration index of a market shows the number of participants and their position in it. In effect, the concentration index will be higher the smaller the number of participants in said market and the more unequal their participations are.

Concentration was measured using three of the most widely used indexes in the global telecommunications market: the Stenbacka dominance index, the Herfindahl-Hirschman index (HHI), and the Linda index. The results obtained with the Linda index are described in this paper.

A. Linda Index

This indicator is usually used to measure the possible existence of oligopoly and inequality between different market shares. Moreover, similar to the concentration ratio, it is calculated for a number n of leading companies in the

market so that their joint relative incidence can be calculated about the rest of the participants at that end of the market (supply or demand); mathematically, this indicator can be defined as shown in (1) [9][10].

$$L = \frac{1}{N(N-1)} \sum_{i=1}^{N-1} \frac{\bar{X}_i}{\bar{X}_{N-i}} \qquad (1)$$

Where $\bar{X}_i$ is the average market share of the first i firms, and $\bar{X}_{N-i}$ is the average market share of the remaining firms. This indicator presents values between zero and infinity, where values close to zero are obtained for markets with low concentration, and higher values (greater than one) represent highly concentrated markets (see Table I) [9][10].

TABLE I. LINDA'S INDEX INTERPRETATION [9][10]

Concentration	Range
Low	<0,2
Moderade	0.2 a 0.5
High	0.5 a 1
Very High	>1

Low concentration implies high market competitiveness; high concentration implies low competitiveness; and a very high concentration implies the presence of a monopoly or oligopoly.

B. Stenbacka Dominance Index

The Stenbacka index is defined as a dominance threshold based on the shares of the two hugest companies in the market. The value of the Stenbacka index estimates a threshold above which the leading firm could have market power; equation (2) calculates this threshold.

$$S^D = \frac{1}{2}[1 - \gamma(S_1^2 - S_2^2)] \qquad (2)$$

Where:
S1 and S2 correspond to the market share of the two market largest companies, with $0 \leq S_i \leq 1$.
$\gamma \geq 0$ is a given parameter obtained from the particular characteristics of each market, such as entry barriers and regulations to motivate competition.

C. Herfindahl-Hirschman Index (IHH)

The HHI is represented by the sum of the squares of the shares of the companies in the market, as described in equation (3).

$$IHH = \sum_{i=1}^{N} S_i^2 \qquad (3)$$

Where:
N is the number of companies in the market.

Si is the market share of the company i in percentage terms.

IV. METHODOLOGY

Initially, data corresponding to the analysis variables were obtained, such as traffic, revenue, and accesses, for prepaid and postpaid, corresponding to each telecommunications company that operated in Colombia from 2012 to September 2022 (inclusive). This information was obtained from the post-data database of the Communications Regulation Commission [11]. Subsequently, an organization of the data was performed in Excel to create a database with the information of interest organized chronologically. In the end, nine databases were obtained: (1) fixed charge mobile internet demand traffic (postpaid); (2) fixed charge mobile internet demand revenues (postpaid); (3) fixed charge mobile internet demand accesses (postpaid); (4) on-demand mobile internet demand traffic (prepaid); (5) on-demand mobile internet demand revenues (prepaid); (6) on-demand mobile internet demand accesses (prepaid); (7) global mobile internet demand traffic (postpaid + prepaid); (8) global mobile internet demand revenues (postpaid + prepaid); and (9) global mobile internet demand accesses (postpaid + prepaid).

In a subsequent phase, Linda's index was constructed for each of the nine databases mentioned above. It was decided to calculate this index monthly to obtain more data that would allow a future forecast and projection of the concentration behavior in the Colombian mobile telecommunications market [12]. According to the procedure required to calculate Linda's index, it was necessary that for each period (month), the telecommunications companies were ordered from highest to lowest according to the value of the variable to be analyzed (traffic, revenues, or subscribers).

During the construction of the Linda index, it became evident that when any of the companies had a zero value in the variable of interest, the Linda index was indeterminate, and if it was very close to zero, it increased exponentially. Due to the above, it was decided to eliminate the data equal to zero since the interpretation of these data is fundamental that the company did not operate in that period. Additionally, it was decided to eliminate all data less than 50,000 in the traffic and revenue databases, both in postpaid and prepaid, and overall, since these data produce inconsistent values of the index; the amount of data deleted was 36 in total, which gives approximately a value of less than 0.4% of the total database.

The Linda index determines the level of concentration by groups of companies from 2 to N-1; for example, if there are 3 companies, there is only one Linda, since it compares the group composed of company 1 and 2, against 3. For the months in which more than three companies were operating, more than one Linda index was obtained since this index compares groups of companies. The first Linda obtained is if at least three companies are competing in the market and would correspond to Linda 2 (L2); if there are four companies, L2 and L3 would be obtained, and so on. In other words, the last Linda corresponds to N-2, where N is the number of companies competing in the market. Since there are periods where up to 14 companies operate simultaneously, Linda indexes of up to L12 are obtained, mapping each of them up

would mean an extension of this document. Therefore, it was decided to present the L2 Linda index graph for the case of the global revenue (prepaid + postpaid) of each telecommunications company, together with a table showing the rest of the Linda index values for the corresponding scenario.

V. MEASURING CONCENTRATION IN THE MOBILE TELECOMMUNICATIONS SERVICES MARKET IN COLOMBIA

Figure 5 describes the behavior of Linda's index 2 for the case of the overall (prepaid + postpaid) mobile internet revenue of each Colombian telecommunications company

from 2012 to 2022. Table II shows the other Linda 2 index values for the corresponding scenario.

According to Figure 5, the first two values of Linda's index are very high compared to the rest, which show an almost uniform trend of low value. The above can be explained by the entry into the market of several telecommunications companies.
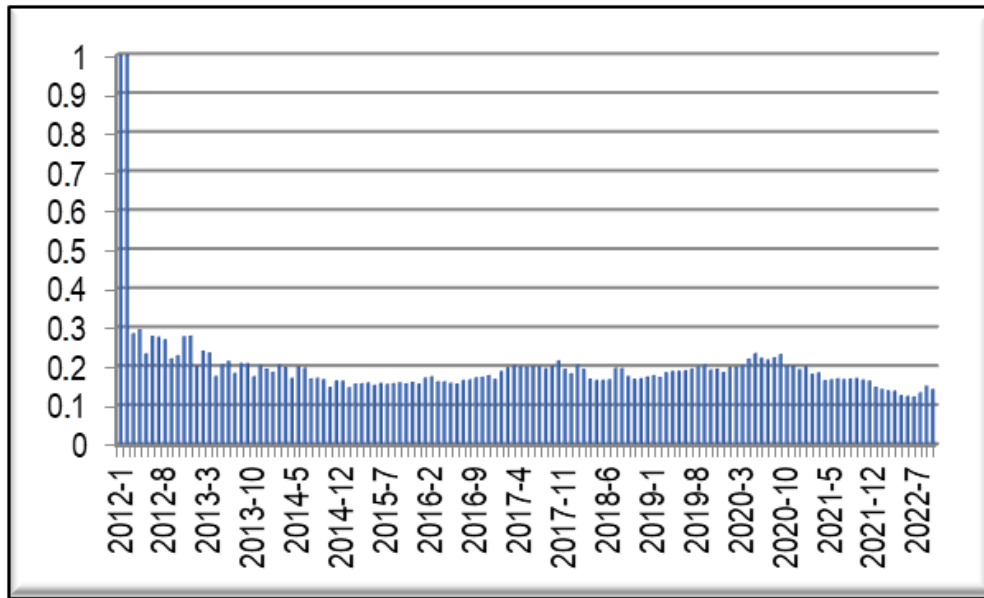

Figure 5. Linda 2 index for the overall mobile internet revenue of Colombian telecommunication companies.

TABLE II. LINDA INDEX FOR THE OVERALL MOBILE INTERNET REVENUE OF COLOMBIAN TELECOMMUNICATION COMPANIES.

Date	Linda Value										
	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
2012-1	2.24	7.32	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN
2012-2	21.10	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN
2012-3	0.28	8.34	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN
2012-4	0.29	8.42	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN
2012-5	0.23	1.24	3.65	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN
…	…	…	…	…	…	…	…	…	…	…	…
2022-1	0.14	0.57	0.86	1.15	1.26	1.80	3.33	136.41	214.11	310.71	NAN
2022-2	0.13	0.56	0.88	1.17	1.30	2.01	3.61	60.93	99.46	220.28	NAN
2022-3	0.13	0.53	0.86	1.15	1.33	2.20	3.37	48.89	83.44	179.01	NAN
2022-4	0.12	0.47	0.91	1.24	1.46	2.42	3.62	27.76	67.01	84.20	182.91
2022-5	0.12	0.46	0.94	1.30	1.65	2.85	4.32	36.35	64.65	137.44	358.08
…	…	…	…	…	…	…	…	…	…	…	…

VI. RESULTS ANALYSIS

The highest value of Linda 2 is given for the global mobile internet demand (postpaid + prepaid) revenue with a value of 21.11 and a standard deviation of 1.85 and for the number of subscribers of the global mobile internet demand (postpaid + prepaid) with a value of 20.72 and a standard deviation of 2.49. On the other hand, the lowest value of Linda is given for global traffic with a value of 0.067 and a standard deviation of 0.0499 and for prepaid traffic with a value of 0.073 and a standard deviation of 0.111.

For postpaid mobile Internet demand (fixed charge), the Linda index values, on average, are between 0.23 and 0.32, so there is a moderate concentration. In the case of prepaid (on-demand) mobile Internet demand, the Linda index values, on average, have differences for the traffic of 0.15, low concentration, revenues of 0.26, moderate concentration, and the number of subscribers of 0.41, moderate concentration. In the overall mobile Internet demand, the Linda index values, on average, have higher differences for traffic 0.14, low concentration, revenue 0.36, moderate concentration, and number of subscribers 0.53, high concentration. However, for the case of global revenue, if the first two periods (2012-1 and 2012-2) are not bearing in mind, the average drops to 0.18, which would give a low concentration.

It is important to emphasize that the Linda 2 index compares the group of the two companies with the highest value of the variable of interest (traffic, revenues, or subscribers) concerning the group of the other companies. In some cases, it is possible to present a higher concentration, evidenced by the group of the 3 or 4 most dominant companies in the market.

VII. CONCLUSIONS

The measurement of concentration in the Colombian mobile telecommunications market was carried out using the Linda index using as input variables the income, traffic and mobile internet access of the telecommunications companies operating in Colombia from 2012 to 2022, both for postpaid (fixed charge) and prepaid (on demand).

Linda's values for the global revenue of mobile internet demand evidence a high concentration in the first two months, but then drops low for the rest of the periods, indicating a high competition in this market. In the telecommunications market, the problem of concentration is an issue that usually affects many countries. However, several countries have addressed this problem by increasing the availability of radio spectrum and reallocating portions of it; even beyond this, the spectrum distribution among mobile operators plays a significant role in achieving the goal of a freely competitive market. It has been empirically demonstrated that the accumulation of spectrum by an operator leads to less competition in the mobile voice market, so spectrum management strategies should aim to avoid unnecessary spectrum accumulation, seeking to achieve balance in the market power of telecommunication services.

As future work, it is planned to propose a new concentration measurement index based on the characteristics of the Linda, Stenbacka and Herfindahl-Hirschman indices.

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