Possibilities of Application of the Index Concentration of Linda in Small Economy: Example of Serbian Food Industries

Bukvić, Rajko and Pavlović, Radica and Gajić, lksndr M.

Geographical Institute "Jovan Cvijić" SASA, Megatrend University - Faculty for Management in Zajecar, Higher School of Professional Business Studies

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POSSIBILITIES OF APPLICATION OF THE INDEX CONCENTRATION OF LINDA IN SMALL ECONOMY: EXAMPLE OF SERBIAN FOOD INDUSTRIES

Rajko M. BUKVIĆ[1], Radica Ž. PAVLOVIĆ[2], Aleksandar M. GAJIĆ[3]

[1] Institure of Geography" Jovan Cvijić, SASA, Belgrade, E-mail: r.bukvic@mail.ru
[2] Faculty of management, Zaječar, E-mail: m.pavlovic1985@yahoo.com
[3] Higher business school of professional studies „Prof. dr Radomir Bojković", Kruševac, E-mail: aleksandarm.gajic@open.telekom.rs

Abstract **—** The aim of this paper is to show the possibility and importance of using the index of concentration of Linda in the analysis of market structure in small economies, and thus, to examine the possibility of its involvement in the practice of anti-monopoly state authorities in those countries. Results of application of the mentioned (system) index are proved in comparison with the results of previously conducted cluster analysis in the food industry, one of the most competitive branch in the economy of Serbia. The study showed the solidity and excellent opportunities of using the index of Linda even in relatively small economy, in which predominate oligopolistic and other imperfectly-competitive structures.

Keywords **—** competition, concentration, indices of Linda, oligopolies.

I. INTRODUCTION

Competition is one of the fundamental economic concepts, which is located in the center of economists vitually from the very beginning of economic science. During the development of science there has been developed and changed the perception of competition. Today, it is defined as a dynamic selection process, during which competitors (manufacturers, companies) have the same goals (to sell the goods, thereby making it possible at higher price), and buyers, consumers make decision about who and at what extent will accomplish it through themselves [Bazeler et al., 2000, pp. 208-209]. In accordance with most theoretical understanding, the competition provides the greatest benefit to the individual market actors, and the whole economy: it gives market participants the fundamental economic rights and freedoms (of entrepreneurial activity, consumption choices, choices of workplace), and provides an optimal allocation (deployment) resources, as well as and other benefits.

It was long thought that in order to acquire these benefits is necessary to create and support the conditions of complete (perfect) competition, in which in each market (market of each products) exist and operate many sellers and many buyers. With the passage of time the full competition was shown as more obvious abstraction, which has nothing in common with the existing markets, on the other hand its basic assumption (more participants - more competition) proved to be unrealistic. Therefore, such a structural approach to the study of market structure gradually has been replaced by a functionalist, which have begun to take into account other criteria: the size of the participants, the nature of the goods, the conditions of entry to the market and others. Since the beginning of the 1960s as an ideal of competitive policy an increasing recognition gets the so-called effective competition, in which the emphasis is placed not so much on the shape of the market as to its effectiveness.

II. DEFINITION AND MEASUREMENT OF THE CONCENTRATION

One of the main criteria of differentiation and classification of market structure in the concept of effective competition is the degree of concentration bid of the given manufacture. This concentration can be measured in many ways. If the measurement is performed at the level of specific products, then the degree of concentration is expressed by an indicator which takes into account share of each particular manufacturers (companies) in the total production of the product in the relevant market, which does not necessarily coincide, and often does not coincide with a national market:

[1] $$s_i = \frac{Q_i}{Q}$$

where: s_i – is share of the producer (company) i in the production of a given product, Q_i – total production of the producer i for that product, and $Q = \Sigma Q_i$ – total production of that product in the relevant market.

As an acceptable alternative in [1] can be used data based on other criteria, such as the number of employees, on values of asset or capital, on corporate income of enterprise and corresponding branches. Although such obtained results are not so accurate, they are still suitable for the solution of the tasks that are in question here. In the letter case, the share of the enterprise in the branch is calculated as the ratio of the company's revenue and total revenue of the given branch. In that case, in [1] does not appear the problem of the unit of measure, the data can be used at a higher level of aggregation, specifically for analysis of concentration in the branches, at the same time regardless of whether in [1] figuring incomes, assets, capital or employees. Exactly, in this way are carried out analysis in the majority of cases in Serbia/Yugoslavia.

According to the [1] there may be constructed many indices. In the research of market structures the greatest popularity gained the concentration index of CRn, that indicates share of the largest n manufacturers in a given production:

[2] $$CRn = s_1 + s_2 + \cdots + s_n = \sum_{i=1}^{n} s_i$$

and coefficient (index) of Herfindahl-Hirschman concentration, which is defined as a sum of squares of the share of all manufacturers (all enterprises in the branch)

[3] $$I_{HH} = \sum_{i=1}^{m} (s_i)^2$$

where the number of the manufacturers of the given product (i.e. the number of the enterprises in the branch) is equal to m. Both indices [2] and [3] are calculated quite simply (especially in modern terms) and have a simple explanation. The limits of their values are between n/m and 1 for CRn and 1/m and 1 for I_{HH}. If shares s_i are expressed as indices, then the aggregate values of the indices CRn, i.e. of the index I_{HH}, are also expressed as a percentage. The limits of their values for each product, or for each branch (each production) then will be ranging within the frameworks from $(n/m)\times100$ to 100 for the index CRn, and from $(1/m)\times100^2$, i.e. practically from 0 (zero) if m is large enough, i.e. m→∞, to 10.000 for the index I_{HH}.

The concentration indices of CRn have a long tradition of use, both in research of economists, associated with market structures, as well as on the part of state authorities. The use of Herfindahl's index is a relatively new approach either in practical works of anti-monopoly authorities, or in theoretical studies of these problems. The use of Herfindahl's index particularly was increased in relation with its application in practice of the anti-monopoly legislation in the USA.

One can easily see the great advantages of the Herfindahl's index compared with any form of concentration indices in [2], even if one would use a coefficient that indicates the share of a greater number of companies, for example CR8. Indices CRn, on the one hand, "cut off" the so-called periphery of the market, which in many cases proves to be quite large, and, on the other hand, the value of the index (regardless of whether it is CR4, CR8 or some other index) can not to show the distribution of participation within these values, which may be very different. Herfindahl's index takes into account the share of all companies within the branch and, of course, is much more sensitive than the index CRn on the real state of the market.

TABLE 1. CLASSIFICATION OF BRANCH MARKETS ACCORDING TO THE DEGREE OF CONCENTRATION ON THE VALUES OF COEFFICIENTS CRN IN PRACTICE OF SERBIA/YUGOSLAVIA

Degree of concentration	Value of coefficient CRn (%)
Very high concentrations	100
High concentration	75–99
Middle concentration	50–74
Low concentration	25–49
Very low concentration	do 25

Regardless of the choice of coefficient, after its computation there is a need for the classification of

branches (production) to the value of the coefficient. In the case of the application of the coefficient [2], one of the acceptable ways, which is many times used in Serbian/Yugoslavian practice, is presented in Table 1. All branches are divided into four main groups, depending on what the value has coefficient CRn in those branches.

But, this method of determining the degree of concentration, except for simplicity of calculation and explanation, does not possess other advantages. On the contrary, it has many disadvantages. Particularly, there should be noted the fact that this coefficient does not differ market conditions in the first group, where you can find: branches with only one manufacturer (pure monopoly), then branches with two producers (the same power - a classic duopoly, or asymmetric power - the situation closely monopoly) even a state in which there may be (all) four manufacturers (if they are of equal power, each can share in a given production with only 25%). Another big disadvantage consists in the division of the market according to a priori of a given criterion, as seen in Table 1, also in the following Tables. These (and other) disadvantages significantly reduce the usefulness of a given approach to the analysis of the degree of concentration. In countries with strong traditions in the anti-monopoly regulation (for example, in the US), it is used an alternative approach.

In Russian anti-monopoly practice, by the Federal Anti-monopoly Service (FAS) is used coefficient CR3, and classification of market branches according to the level of market concentration is based on this coefficient and the coefficient of Herfindahl (see Table 2).

TABLE 2. CLASSIFICATION OF BRANCH MARKET ACCORDING TO A DEGREE OF CONCENTRATION, WHICH USES THE FAS OF THE RUSSIAN FEDERATION

Classification of branch market	Value of concentration index CR3	Index value of Herfindahl (I_{HH})
Low concentrated	CR3≤45%	I_{HH}≤1000
Moderately concentrated	45%<CR3<70%	1000<I_{HH}<2000
Highly concentrated	CR3>70%	I_{HH}>2000

In the anti-monopoly practice of the USA was accepted the following division of the market (in an appropriate production, i.e. branch) based on the degree of concentration, expressed as an index I_{HH} (see Table 3). Since1982, the index of Herfindahl became the main landmark of anti-monopoly policy of the USA in the assessment of the admissibility of various types of mergers. It is used for classification of merger into three main groups depending on the values of I_{HH} merger, where the limits are taken as the size of the index of 1,000 and 1,800, and in the new guide of 1,500 and 2,500. In the anti-monopoly practice of the European Union is also used the index of Herfindahl, but there's another limit value used for delineation of high concentration set to 2,000.

TABLE 3. THE CONCENTRATION DEGREE OF ECONOMY BRANCHES BY VALUES OF INDEX I_{HH} (IN ANTIMONOPOLY PRACTICE OF USA AND EU)

	Index value of I_{HH}		
Degree of concentration	USA earlier	USA since 2010.	European Union
High	More than 1,800	More than 2,500	More than 2,000
Middle	From1,000 to 1,800	From 1,500 to 2,500	From 1,000 to 2,000
Low	Less than 1,000	Less than 1,500	Less than 1,000

If we take into account the peculiarities of Serbian economy (much less the general market, lesser manufacturers in each production, etc.), then such division of market is shown as inadequate to real conditions (almost in every production values of I_{HH} would be located in the second group). Therefore, as possible is shown a desirable modification of the conditions presented in Table 3. Such an attempt has been made in the monograph [Begović et al., 2002] (see Table 4).

TABLE 4. THE CONCENTRATION DEGREE IN ECONOMY BRANCHES ACCORDING TO VALUE OF INDEX I_{HH} IN SERBIA/YUGOSLAVIA (MODIFIEDDIVISION)

Degree of concentration	Index value of I_{HH}
Absolutaly concentrated	10,000
Extra concentrated	From 2,600 to 10,000
Highly concentrated	From 1,800 to 2,600
Moderately concentrated	From 1,000 to 1,800
Non-concentrated	Less than 1,000

As can be concluded, there are no clear rules for classification of the market: Tables 2-4 shows different solutions. On one hand, it testifies about taking into account the specific conditions of each country of the author (or state authorities), but also speaks of the absence of a desire to delve too essentially problems that may occur.

All this has long been more than enough reason to search for new paths in the analysis of market conditions.

III. LINDA INDEX AS INDICATOR OF MARKET CONCENTRATION

In further exposure we shall review the index (more precisely, the system of indices) of concentrations proposed by the EU Commission staff in Brussels Remo Linda (Linda index, L). This index, as well as the index of concentration CRn, is calculated only for a few (m) largest companies and, therefore, also does not take into account the situation on the "periphery" of the market. However, unlike the considered indices of CRn concentrations, it is focused on taking into account the difference in the "core" of the market. While in the calculation of indices CRn the number of considered companies is predetermined (in most cases n = 4) and in addition to these nothing is to calculate, the index Linda Lm assumes calculation and consideration of all values of the index (Li, i = 2, ..., m), since it only makes possible to analyze the situation in the "core" of the market. The use of index CRn in the past was caused by the simplicity of its calculation (and explanation) compared with the index of Herfindahl, which previously had no little importance, but in modern conditions in the use of computers it has become irrelevant. Somewhat, the situation is different with an index of Linda.

Linda index (L) is calculated according to the following general formula [Linda, 1976, p. 19]

$$[4] \quad L_m = \frac{1}{m(m-1)} \sum_{i=1}^{m-1} \frac{m-i}{i} \times \frac{CRi}{CRm-CRi}$$

where: m – is number of firms for which the index is calculated, CRi – concentration coefficient for the first i firms (i = 1, … , m–1).

Unlike the concentration index of CRn, which is steadily growing in size for each firm (CR1 <... <CRN), Linda indices graphically represent the broken curve. Let us consider a typical example of the concentration indices and Linda indices in one of the manufacture in the economy of Serbia (clear fruit juice from domestic fruit), which would later be further examined (Fig. 1). In the picture is displayed, in addition to the two indices, and the curve of "perfect equilibrium" PE (of perfect competition), which is characterized by the equality of all companies within the given manufacture, why and their market shares are for each n equal to (1/n). This also defines the minimum values of the Linda index (Lmin$_n$ = 1/n).
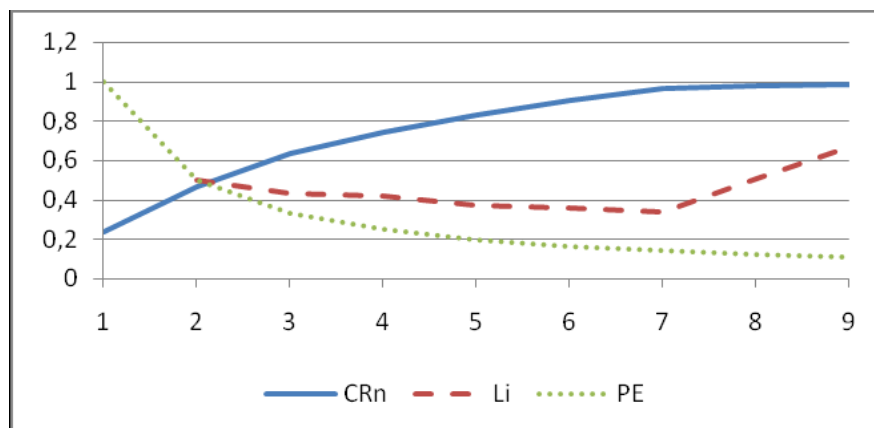

Figure 1: Concentration indices, Linda index and the curve of „perfect equilibrium" for production of clear fruit juice from continental fruits.
Source: [Bukvić, 2002] and calculations of the authors on the basis of the data in that paper.

As can be seen, the Linda indices in this example are initially declining, and after reaching a minimum (for L7, i.e, for seven companies) they're beginning to increase. Just reaching the minimum represents a special

interest. The surface between the curves of L and PE is referred to as "oligopolistic arena" and even visually shows the difference of the real position of perfect competition situation.

From relation [4] is obtained that the index L_2 directly depends on the ratio of participation of the two largest producers, so that its value which is set up in case of their equality ($L_2 = 0.5$) is obtained as the ratio of their participation multiplied by 2. The values of the other indices depend not only on the ratio of share of enterprises, but also on the size of the "oligopolistic arena", determined by reaching the (first) minimum index of L_m.

IV. APPLICATION POSSIBILITIES OF THE LINDA INDEX: AN EXAMPLE

While the concentration indices of CRn and I_{HH} are often enough used, examples of application of the Linda index is poor. In EU countries it is used, since the 1970s, for the analysis of market structure and as a control indicator for regulatory state authorities in the event of a firm desire for merger. Regulators can provide the appropriate permission on condition that the Linda index is within certain limits (as a rule, within the limits of 120% < L <200%). Linda index is also used as an indicator of the oligopoly "limit" as follows: L is calculated for m = 2, m = 3 and so on until the moment when $L_{m+1} > L_m$, i.e. until a first distortion of the continuity of indicators L decline. „Limit" is considered to be established when reaching the value of L_m less in comparison with the value of the index L_{m+1}. Of course, the application possibilities of these indices is than not exhaustive.

In Serbia, there are no examples of the Linda index application. The last, and the most exhaustive, research (referring to former Federal Republic of Yugoslavia) [Begović et al., 2002], has used the indices of Herfindahl. As a participant of this research, one of the authors of this study felt an inadequacy of such an approach, especially taking into account the size and structure of the analyzed economy. Therefore, in his next paper ([Bukvić, 2002], also [Bukvić, 2012]) applied cluster analysis, which is expected to reveal further characteristics of the considered markets. The analysis is limited to the food industry and involved all of its products (218 products). Since the food industry is one of the most competitive branch, the author expected an occurrence of different types (clusters) of the market, or their greater number than as presented in Tables I- IV, or in other studies (see [2, 3]). For analysis were calculated shares of the six largest manufacturers, which have formed a series of <s1, ..., s6> and therefore <CR1, ..., CR6> for each product.

The expectations were justified. Cluster analysis based on Euclidean distance, gave 11 clusters (see Fig. 2), grouped into four major groups:
1) *monopoly (C1, 31 products);*
2) *duopoly and quasy-oligopoly:*
   a) *quasy-monopoly, i.e. quasy-duopoly (C2, 23);*
   b) *classical duopoly (C7, 20);*
   c) *oligopoly in transition to a quasy-monopoly (C6, 22);*
   d) *oligopoly with a dominant leading of (C3, 37);*
3) *oligopoly:*
   a) *oligopoly (C11, 21);*
   b) *oligopoly (C8, 14);*
   c) *oligopoly (C4, 15)*
   d) *oligopoly, or oligopoly in the transition to competition (C10, 15);*
4) *competition;*
   a) *competition (C9, 15);*
   b) *full competition (C5, 5).*

These interesting results we could compare with the data obtained by calculating the index of Linda. These indices can be used for different goals, but we're here, in order to not disseminate the subject of analysis, we will be focused only on one aspects. Let's try to pay attention to the clusters in which the previous analysis identified the existence of oligopolies: what is new when using the index of Linda? In theory of the oligopoly, if 2-3 companies predominate on the market such a situation is referred to as "sturdy" oligopoly, if 6-7 companies occupy 70-80% of the market then it's "loose" oligopoly. It is obvious that the previous calculation of the concentration coefficients of CR1 to CR6 for such analysis is shown as insufficient. Therefore, the series of the coefficients for each product are supplemented with the coefficients CR7-CR9, and also are calculated the indices of Linda L1, ..., L9.
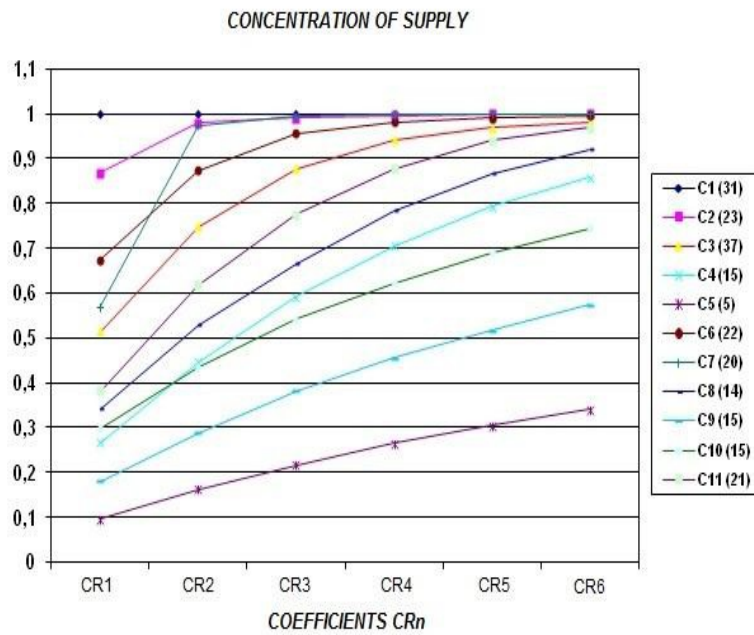
Fig. 2.- Clusters of 218 products of the food industry

Seriously should be noted the limitation of further analysis: the vast production majority the number of manufacturers is less than 10, which excludes the possibility of the existence of real competition. Thus, in the production of 122 products (56%) the number of producers was from 1 to 7, which by definition creates the possibility of a monopoly existence (as was the case in the manufacture of 31 products, or 14.2%), duopoly or an oligopoly vision. The distribution of the number of manufacturers in this branch of the Serbian industry is shown in Fig. 3. Immediately is visible its asymmetry, and a high density (in addition to 1 and 2 of the manufacturer) in the range of 3 to 8 (or 10) units. As shown in Fig. 3, it would be very interesting to investigate what happens in markets with a small number of producers – whether there exist, and if yes, what is the competition? This problem and possibilities of Linda index in its analysis deserves particular research.
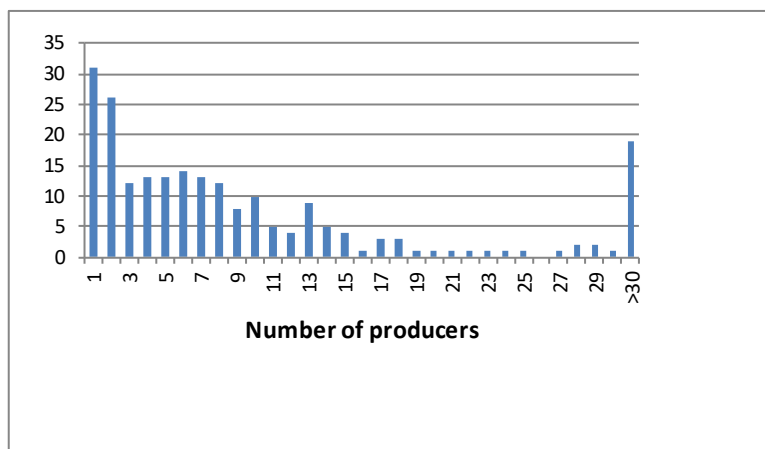

Fig. 3. Frequencies of the number of producers in the food industry

Although competition may exist among a small number of market participants, not less interesting (and important) is an oligopoly in the case of a large number of participants. Precisely, finding this situation, among other things, is intended the use of Linda indices. And the existence of oligopolies shows, as already pointed out, reaching first minimum of curve of the Linda index (see Fig. 1.).
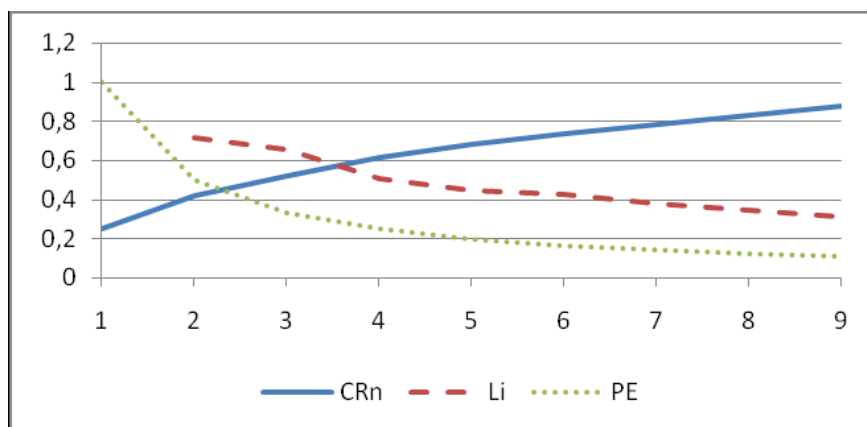
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Fig. 4.- Indices of concentrations, indices of Linda and a curve of „perfect equilibrium" for the production of the fermented tobacco.

For the purpose of these objectives we'll pay attention to the production of more than 10 manufacturers. Such was the 66 (or 30.3% of total). Cluster analysis among them in 46 cases identified some form of oligopoly. Indices of Linda almost completely confirmed it: only one of these 46 productions, the indices of Linda classify as competitive - production of fermented tobacco, which is ranked by a cluster analysis in the type of "oligopoly on the transition to competition" (i.e. already close to competition, which was confirmed by Herfindahl's value of index – 1,281). The values of concentration, especially Linda index (see Fig. 4) suggests that this production is located on the limit between competitive and oligopolistic structure, fixing this ambiguous situation [Linda, 1976, p. 23].investigate what happens in markets with a small number of producers – whether there exist, and if yes, what is the competition? This problem and possibilities of Linda index in its analysis deserves particular research.
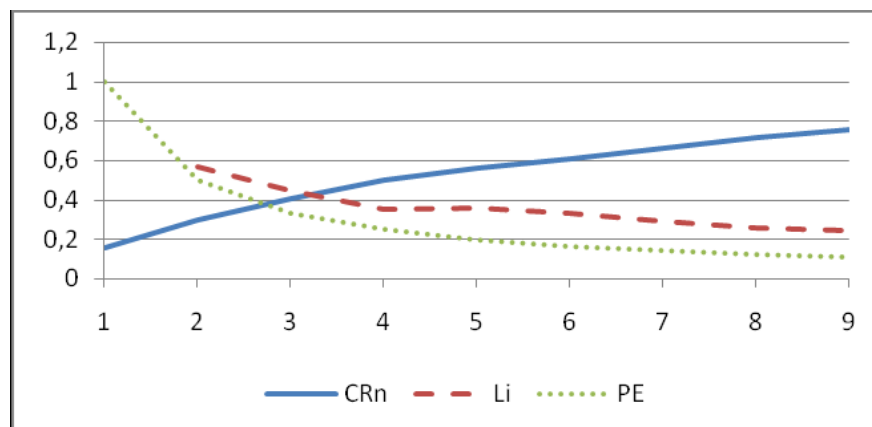

Fig. 5.- Indices of concentrations, indices of Linda and a curve of „perfect equilibrium" for production of complete feed mixture for poultry

Of course, one should consider and the opposite situation, where the cluster analysis showed competition. Among 20 such production, indices of Linda showed disagreement with previously defined clusters in only two cases. Index of Linda in one case pointed to an oligopoly of six manufacturers (minimum is reached for L_6), which does not constitute an inconsistency since the cluster analysis was conducted for a set of <CR1, ..., CR6>. Interest, therefore, represents only one case (see Fig. 5), where the indices of Linda "reveal" oligopoly of four manufacturers. But even the visual comparison of the two images (Figs. 4 and 5) warns that one should not interprete mechanically the specified values of index. In fact CRn, and the curve Li shows more competition in the production of complex feed mixtures for poultry than in the production of fermented tobacco. This confirms the value of the index of Herfindahl, which is lower in the second (827) than in the first of these manufacturing (1,281).

Let us also consider the production of ten companies. The number of such production (of ten manufacturers) also is 10, and they make up a considerable part of the food industry of Serbia (4.6% of the entire

set of products). Cluster analysis conducted in all cases indicated the presence of some form of oligopoly (in particular, were found clusters C3, C4, C6, C10 and C11), and Linda indices basically confirmed it. Therefore, again was repeated the same situation - discriminatory power of the two methods basically coincide (see Table 5).

In the third column of this table is shown reaching the first minimum index of Linda for ten products. There are confirm the different characteristics in their markets, even more than what was revealed by cluster analysis - oligopolies include 2, 4, 5, 6, 7 and 8 manufacturers. The fifth column are listed the corresponding values of the index of Herfindahl.

TABLE 5. RESULTS OF CLUSTER ANALYSIS, INDICES OF LINDA AND HERFINDAHL FOR PRODUCTION OF TEN PRODUCERS

Product	Cluster	L_{min}	L_2	I_{HH}
1	C6	L7	3.24	0.5180
2	C10	L8	1.09	0.1499
3	C11	L2	0.64	0.2588
4	C4	L8	0.86	0.1576
5	C4	L5	0.53	0.1378
6	C4	L4	0.75	0.1625
7	C4	L2	0.55	0.1605
8	C11	L6	1.26	0.2424
9	C3	L5	2.15	0.3614
10	C11	L4	1.33	0.2942

As we can see, no matter which criteria is applied (see Tables 2, 3 and 4), the products have been deployed alike - five products both in the medium and high market group concentration. This, of course, confirms the inadequacy of such division. Finally, in the fourth column are given the values of L_2, representing special interests. Since the minimum values of the index L_n defined as 1/n, to L_2 it means ½. Relationships of shares of the two largest companies in [4] are determined by the expression

[5]
$$L_2^* = \frac{k}{2}$$

and indicate that the first enterprise is k times greater than the second. In Table 5 we see it, in the production of the first product share of the first manufacturer is 6.48 times greater than the second, and so on. But it shows great differences among the ten products. And further values of the index of Linda should only clearer to present these differences.

V. CONCLUSION

The analysis that we have done allows to formulate a few remarks and conclusions. Linda indices are presented as an acceptable instrument for analyzing the concentration (in market conditions and market structure) in the production of a large number of manufacturers. Great consent of obtained (using the index of Linda) results with previously obtained results of cluster analysis stress out the need for joint use of these methodologies, which properly complement each other. Of course, we should not forget other methods, primarily indices of Herfindahl.

It should be taken into consideration that the practical application of the index of Linda to a greater extent is suitable for formalization than the application of cluster analysis. This, however, has a greater significance for anti-monopoly authorities than for researchers.

Possibilities of application of the index of Linda in the production of a small number of manufacturers in this analysis were not checked in all aspects, it remains one of the tasks of research. Special interest and importance of such research must have a relatively small economy, which include Serbia, where there are so many such branches due to the fact that the issue of work is related to the changes in the approach to the analysis of concentration compared to previous approaches. An additional reason is that such application is not grounded in domestic practice and practically is not present even in our.

In general, we can say that our experience of using the system of Linda index proved soundness of their

application in the analysis of market conditions as well as their involvement in the development of anti-monopoly policy.

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