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Microeconomics

Lyubov KRYMSKA

THE STUDY OF MARKET CONCENTRATION IN THE TOOL-PRODUCING INDUSTRY

Abstract

The author elucidates the interrelation between the concentration of sellers on the market and the level of monopolistic power, and attempts to determine a true level of concentration of the market for metal-cutting tools.

Key words:

Concentration level and indices, Herfindal-Hirshman index, Lorenz curve, irregularity of market sharing.

1. Introduction

Setting a Problem. A practical transition to market relations demands more focus on the theory and practice of competition. Each economic entity is economically interested in using effective competition techniques in its activities. These methods become an important means of survival under the market conditions. Interrelation between the concentration of sellers on the market and the level of monopolistic power turns out to be among the fundamental issues of the theory of industrial organization. The models of the market structure examined by economic theory assume the mo-

Krymska Lyubov, Candidate of Economic Sciences, Head of Management and Marketing Department at Zaporizzhya National Technical University.

nopolistic power to be based on high concentration of sellers on the market and restrictions to entry (monopoly, oligopoly), and product differentiation (monopolistic competition). **The correlation between the market and the industry** is a difficult question as well. Known is the fact that industry is defined as a total of the firms which produce similar products using analogous resources and technology. At the same time, the market is unified by the need that must be satisfied, which means that the market can include substitute products produced by enterprises of other industries. We will study the sectoral market taking into consideration the enterprises producing substitute products and competing for their sale. The antimonopoly committees of many countries use the Joan Robinson's definition: The market includes a uniform commodity and its substitutes until an abrupt gap in the chain of substitutes is found. The degree of substitution is characterised by price cross-elasticity of demand. As soon as price cross-elasticity falls below a certain level, the gap in the chain of substitute products is found, and this determines the market limit. It should be noted that the industry and the market of metal-cutting tools concur because the metal-cutting tool has no substitutes. In the works of foreign authors (M. Porter, A. Thompson, D. Formby, R. Pindyke at. al.) not a single market research could be conducted prior to thorough examination of competition. Unfortunately, in the post-USSR space only several works of national researches are worthy of allusion, namely the works by S. Avdasheva and N. Rozanova [1]. ***The aim of this research is to apply the methodology of determining the market structure through the level of concentration to the study of tool-producing industry.*** The indicators of concentration are based on the comparison of the firm size and the size of the market on which it is active. The larger is the size of the firm compared to the size of the whole market, the higher is the concentration of producers (sellers) on this market. One of the major indicators, which characterises the size of the firm in proportion to the market size, is the share of the company's sales in the overall market sales volume. In this research, we do not account for other indicators describing the firm's size (personnel, assets, value added). The research proceeds from the assumption that the theory of industrial organization correlates with the theory of the firm and the theory of management, since the concept of market structure creates theoretical foundations for corporate management, helping to understand more clearly the basic patterns of market behaviour and internal organization of the firm.

2. The Nature of the Firm's Market Power

Let us consider the indicators used to describe the market and the market power of the firm.

The **Market Concentration Ratio** is calculated as the sum of market shares of the largest firms on the market:

$$Ck = \sum Y_i, \quad i = 1, 2, ..., k, \tag{1}$$

Y_i = firm size (market share);

k = number of firms in the calculation.

Market concentration ratio is a measure of the sum k – the number of the largest firms on the market. Given the number of the largest firms is equal, then the higher is the concentration index, the further off is the market from perfect competition. The index demonstrates the inequality of companies on the market. Its most widespread version in western studies is the firm's percentage share in the overall volume of industry sales, which is estimated for four (GR4), six (GR6), eight (GR8), or ten leading firms (GR10). However, the information obtained from the concentration ratio is not sufficient to describe the market. The methodology of calculating the concentration ratio presupposes the firms to be rated by market share (from maximal to minimal value) and their shares to be subsequently added by progressive total. The minimal value of the index always coincides with the market share of the largest firm, and on the contrary, it equals 1 for the smallest firm. Even more important than the proper selection of concentration indicator is the accuracy of selecting the market for which the concentration calculation should be conducted. If the market limits are defined too broadly (that is they include the firms which are not real competitors), then the concentration index will be understated; if the market is defined too narrowly (that is, without consideration for significant competitors), the concentration index will be overstated. However, the index does not provide an opportunity to draw conclusions about the level of industry concentration, as it does not supply the information about the size of the firms outside the sample and the relative size of the firms in the sample. More importantly, the information it does deliver is insufficient to characterize the market. Nevertheless, the level of industry concentration is characterised by the **Herfindal-Hirschman Index**, which is calculated as the sum of squared market shares of all firms:

$$HHI = \sum Y_i^2, \quad i = 1, 2, \ldots, n, \tag{2}$$

where HHI = Herfindal-Hirschman index;

Y_i – firm size (market share).

Tables 1 and 2 present the input data for calculation of the world and the Ukrainian market concentration indices. Table 3 represents concentration index for leading companies.

The value of the Herfindal-Hirschman index ranges from 0 in case of perfect competition (there are infinitely many sellers on the market, none of them capable of controlling a significant market share) to 1.0 (only one firm produces 100% of the product).

If market shares were calculated in percentage terms, then the index value would range from 0 to 10 000. The higher is the value of the index, the higher is the concentration of sellers on the market. Since 1982 has the Herfindal-Hirshman index served as the reference-point for the antimonopoly policy in the USA. Its main advantage is the ability to reveal the slightest redistribution of the market shares among the firms.

Table 1.

Concentration of the World Metal-Cutting Tools Market

Firms (in order of decreasing market shares)	Market Shares	Concentration Index
Sundvic	0.29	0.29
Kennametal Hertel	0.16	0.45
ISCAR Group	0.15	0.6
Milacron	0.13	0.73
Other	0.07	0.8
Mitsubishi	0.04	0.84
Toshiba	0.03	0.87
Simitomo	0.03	0.9
Tizit	0.03	0.93
Teledyne	0.03	0.96
Kyocera	0.02	0.98
Walter	0.02	1.00

Table 2.

Concentration of the Ukrainian Metal-Cutting Tools Market

Firms (in order of decreasing market shares)	Market Shares	Concentration Index
Vinnytsya plant	0.28	0.28
Zaporizzhya plant	0.16	0.44
Kharkiv plant	0.14	0.58
Lviv plant	0.13	0.71
Other producers	0.12	0.83
Import	0.1	0.93
Chernihiv plant	0.07	1.00

Table 3.

Concentration of Leading Companies

Market	GR4	GR6	GR8	GR10
World	73	84	90	93
Ukrainian	71	82	–	–

The index of Herfindal-Hirshman for the world market of metal-cutting tools is:

$$HHI = 0.29^2 + 0.16^2 + 0.15^2 + 0.13^2 + 0.07^2 + 0.04^2 + 0.03^2 + \\ + 0.03^2 + 0.03^2 + 0.02^2 + 0.02^2 = 0.16\ (1600).$$

while for the Ukrainian market it equals:

$$HHI = 0.28^2 + 0.16^2 + 0.14^2 + 0.13^2 + 0.12^2 + \\ + 0.1^2 + 0.07^2 = 0.1698 \approx 0.17(1700).$$

Inasmuch as the number of significant competitors on the Ukrainian market is somewhat understated, the concentration index should be considered as overstated. Nevertheless, at both the world (1600) and the national (1700) levels, the market for metal-cutting tools should be recognized as competitive, since the market is considered as non-competitive when *HHI* exceeds 1800.

The HHI value is closely related to the dispersion of the firms' market shares:

$$HHI = n\sigma^2 + \frac{1}{n}, \qquad (3)$$

where σ^2 = dispersion of the firms' market shares;

n = number of firms on the market.

Dispersion of market shares is calculated as:

$$\sigma^2 = \sum \frac{(Yi - \overline{Y})^2}{n}, \qquad (4)$$

where $\overline{Y}$ = average market share of the firm = $\frac{1}{n}$;

Yi = firm size (market share);

n = number of firms on the market.

The above formula allows separating the influence of both the number of firms on the market from the influence of market shares distribution upon the HHI. If all firms occupy equal market shares, dispersion amounts to zero. Given the number of firms on the market is constant, then the more their shares differ, the higher is the value of the index.

Let us calculate the Herfindal-Hirshman indices for the world and the Ukrainian markets of metal-cutting tools according to (3) and (4). For the world market, HHI = 1596~1600, for the Ukrainian market, HHI = 1699~1700. This calculation also allows for an error derived from the inability to determine clearly all small companies that, as a whole, account for 7% of the world market. For the national market, this error is even more significant, since the calculation does not identify small producers controlling 12% of the market, and it does not take

into account the importing companies occupying 10% of the whole market. However, according to F. Sherer and D. Ross [2:68], when market shares are squared, the index will ascribe more weight to the indicators of large firms rather than to those of the small ones. This means that as long as the exact data on the market shares of small firms are not available, the error will not be significant.

The Entropy Index demonstrates the average share of the firms on the market weighted by natural logarithm of its inverse value:

$$E = \sum Yi \cdot ln \cdot \left(\frac{1}{Yi}\right), \quad i = 1, \ldots, n, \tag{5}$$

where E = entropy index;

Yi = firm size (e. g., market share).

Entropy index is opposite to concentration index: the higher is its value, the lower is the concentration of sellers on the market. Entropy assesses the inconsistency of market share distribution among the firms: the higher is the index of entropy, the weaker are the sellers' capabilities of influencing upon the market price. To compare the indicators of entropy on different markets, often used is the relative index of entropy:

$$E' = \frac{1}{n} \sum Yi \cdot ln \cdot \left(\frac{1}{Yi}\right), \quad i = 1, \ldots, n, \tag{6}$$

where E' = relative index of entropy;

n = number of firms on the market;

Yi = firm size (e. g., market share).

Let us calculate the entropy of the world market for metal-cutting tools:

$$E = 0.29 \cdot \ln 3.4483 + 0.16 \cdot \ln 6.25 + 0.15 \cdot \ln 6.6666 + 0.13 \cdot \ln 7.6923 +$$
$$+ 0.07 \cdot \ln 14.2857 + 0.04 \cdot \ln 25 + 0.03 \cdot \ln 33.333 + 0.03 \cdot \ln 33.333 +$$
$$+ 0.03 \cdot \ln 33333 + 0.03 \cdot \ln 33.333 + 0.02 \cdot \ln 50 + 0.02 \cdot \ln 50 =$$
$$= 2.094174504 \approx 2.1$$

$$E' = \frac{1}{12} \cdot 2.094174504 = 0.1744447362 \approx 0.174$$

Let us now calculate the entropy of the Ukrainian market for metal-cutting tools:

$$E = 0.28 \cdot \ln 3.57143 + 0.16 \cdot \ln 6.25 + 0.14 \cdot \ln 7.1429 + 0.13 \cdot \ln 7.6923 +$$
$$+ 0.12 \cdot \ln 8.333 + 0.10 \cdot \ln 10 + 0.07 \cdot \ln 14.28571 = 1.860966267 \approx 1.86$$

$$E' = \frac{1}{7} \cdot 1.860966267 = 0.265852324 \approx 0.267.$$

The entropy indices of the world (2.1) and the Ukrainian (1.8) markets do not differ much because the level of concentration on both markets is almost identical. However, the sellers' ability to influence the market price is weaker on the world market than it is on the Ukrainian market because the inconsistency of market shares distribution is more evident on the former one.

The indicator of variance of the market shares is used for gauging the level of inequality of firm sizes:

$$\sigma^2 = \frac{1}{n}\sum(Yi - \overline{Y})^2, \quad i = 1, \ldots, n, \tag{7}$$

where Yi = market share of the firm;

$\overline{Y}$ = average market share of the firm, which equals $\frac{1}{n}$;

n = number of firms on the market.

For the world market of metal-cutting tools dispersion is:

$$\sigma^2 = 0.083\ \sum(0.29–0.083)^2 + (0.16–0.083)^2 + (0.14–0.083)^2 + (0.13–0.083)^2 +$$
$$+ (0.07–0.083)^2 + (0.0.04–0.083)^2 + (0.03–0.083)^2 + (0.03–0.083)^2 +$$
$$+ (0.03–0.083)^2 + (0.03–0.083)^2 + (0.02–0.083)^2 + (0.02–0.083)^2 =$$
$$= 0.006363 \approx 0.0064.$$

For the Ukrainian market of metal-cutting instruments, dispersion equals:

$$\sigma^2 = 0.143\ \sum\ (0.28–0.143)^2 + (0.16–0.143)^2 + (0.14–0.143)^2 + (0.13–0.143)^2 +$$
$$+ (0.12–0.143)^2 + (0.1–0.143)^2 + (0.07–0.143)^2 = 0.003849 \approx 0.004.$$

In western studies, it is more typical to use the dispersion of market share logarithms:

$$\sigma^2 = \frac{1}{n}\sum(\ln Yi - \ln \overline{Y})^2, \quad i = 1, \ldots, n. \tag{8}$$

Both of these indicators are similar in terms of economic essence, i. e. both of them reflect the inequality of market sharing among the market participants and differ only in value and dimensions. The higher is the inequality of market sharing, the higher is, *ceteris paribus*, the market concentration. However, the dispersion does not describe relative firm size: both for the market with two firms of equal size and the market with one hundred firms of equal size the dispersion will equal zero, but the level of concentration will differ. That is why dispersion can be used only as an auxiliary technique, designed to assess the inequality of the firm size rather than the level of concentration. Other conditions

being equal (i.e. at equal number of firms in the industry and almost identical other seller concentration indices), it can serve as an indirect measure of concentration. This indicator indirectly confirms that the level of concentration of the world market for metal-cutting tools is higher than that of the Ukrainian market (0.06 > 0.04); the same is true for inequality of firms' sizes. Thus, the sizes of the most important enterprises on the Ukrainian market for metal-cutting instruments are approximately equal, in contrast to the leading producers of metal-cutting tools on the world market.

Concentration ratio (Gini coefficient) is a statistical indicator based on the Lorenz curve. The Lorenz curve, which characterises the unevenness of distribution of any indicator, in the case of concentration of sellers on the market shows the interrelation between the percentage of firms on the market and the market share calculated by progressive total (from the smallest to the largest).

Gini coefficient is the ratio of the area limited by factual Lorenz curve and the Lorenz curve for absolutely equal distribution of market shares (so-called «absolute equality curve») to the area of the triangular limited by the Lorenz curve for absolutely equal distribution of market shares, the abscissa axis, and the ordinate axis. Table 4 represents input data and calculation of the figures required to construct the Lorenz curve.

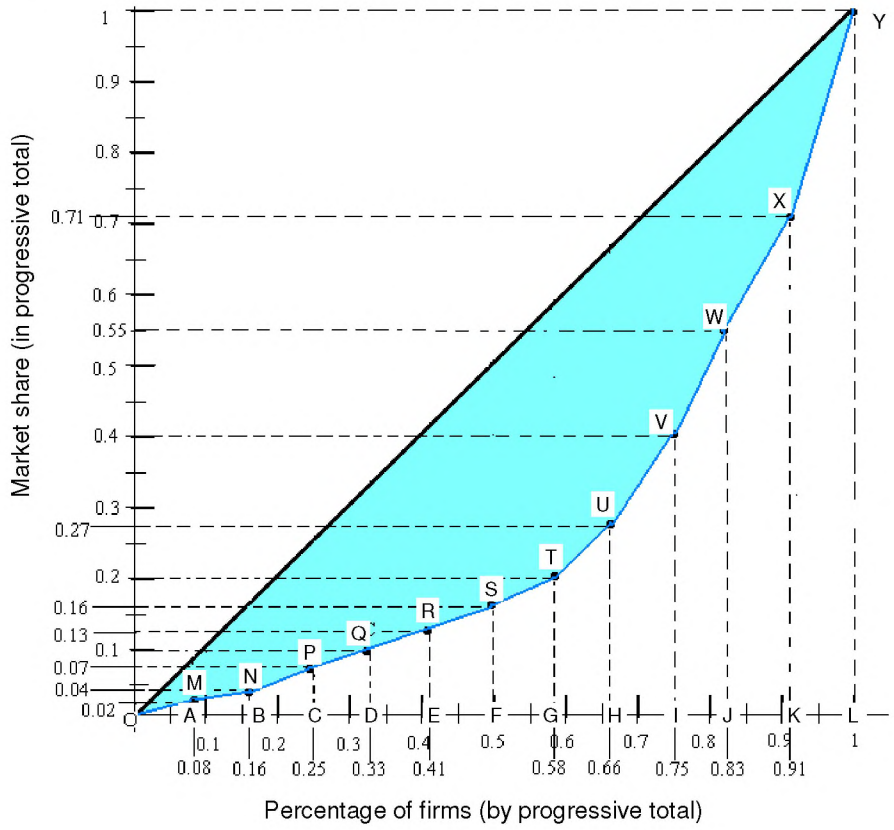
Table 4.

The World Market: Shares Distribution

Companies (by shares in the ascending order)	Market Share	Cumulative Series of Shares (Accumulated Frequencies)	Specific Share of Each Company in Their Total	Cumulative Series
Walter	0.02	0.02	0.08333	0.8333
Kyocera	0.02	0.04	0.08333	0.16667
Teledyne	0.03	0.07	0.08333	0.25
Tizit	0.03	0.1	0.08333	0.33333
Simitomo	0.03	0.13	0.08333	0.41667
Toshiba	0.03	0.16	0.08333	0.5
Mitsubishi	0.04	0.2	0.08333	0.58333
Others	0.07	0.27	0.08333	0.66667
Milacron	0.13	0.4	0.08333	0.75
ISCAR Group	0.15	0.55	0.08333	0.83333
Kennametal Hertel	0.16	0.71	0.08333	0.91667
Sundvic	0.29	1.00	0.08333	1.00
TOTAL	1.00		1.00	

Figure 1.

The Lorenz Curve for the World Market



To construct the Lorenz curve (Figure 1), we must depict the consecutively summed specific weights of the firms (taking into account that the specific weight of each equals 1/12) on the abscissa axis, and the cumulative shares (accumulated frequencies) – on the ordinate axis. The graph we obtain is the Lorenz curve. In order to understand in which way this curve characterises the unevenness of market sharing, we must find out what would be the curve like under the absolute evenness of income. Obviously, in this situation, the share of each firm would amount to 0.833, and we would get a straight line OY at an angle of 45° to the axes. Thus, the unevenness of shares is characterised by the degree of the Lorenz curve deviation from the bisector of the 1st coordinate angle. This deviation can be calculated as a ratio of the area of the figure (S) between the Lorenz curve and OY to the area of the whole triangle OYL. As a result, we obtain the indicator called the concentration coefficient (or the Gini coefficient):

$$G = \text{area } S / \text{area } OYL. \quad (9)$$

Having made certain calculations, we get the Gini coefficient for the world market:

$$G = 0.4956 \approx 0.5.$$

Now, we can calculate the Gini coefficient for the Ukrainian market for metal-cutting tools using the same method (Table 5) and construct the Lorenz curve (Figure 2).

Having made respective calculations, we obtain the Gini coefficient for the Ukrainian market:

$$G = 0.21.$$

When using the Gini coefficient to describe the concentration of the sellers, two aspects should be considered. The first one is linked to the internal drawback of the index. It characterises the level of unevenness of market shares distribution just like the indicator of logarithmic dispersion of market shares. Therefore, if we assume that there are two markets, and one of them is competitive and includes 10 000 firms occupying 10 000 equal shares of it, while the other is duopolistic, with two firms occupying two equal parts of it, the Gini coefficient would be the same for each of them. The second aspect relates to complexity of calculating the Gini coefficient: in order to calculate it, all the information about all firms, including the smallest ones, in the industry is necessary. This turned out to be impossible for us to do within this research.

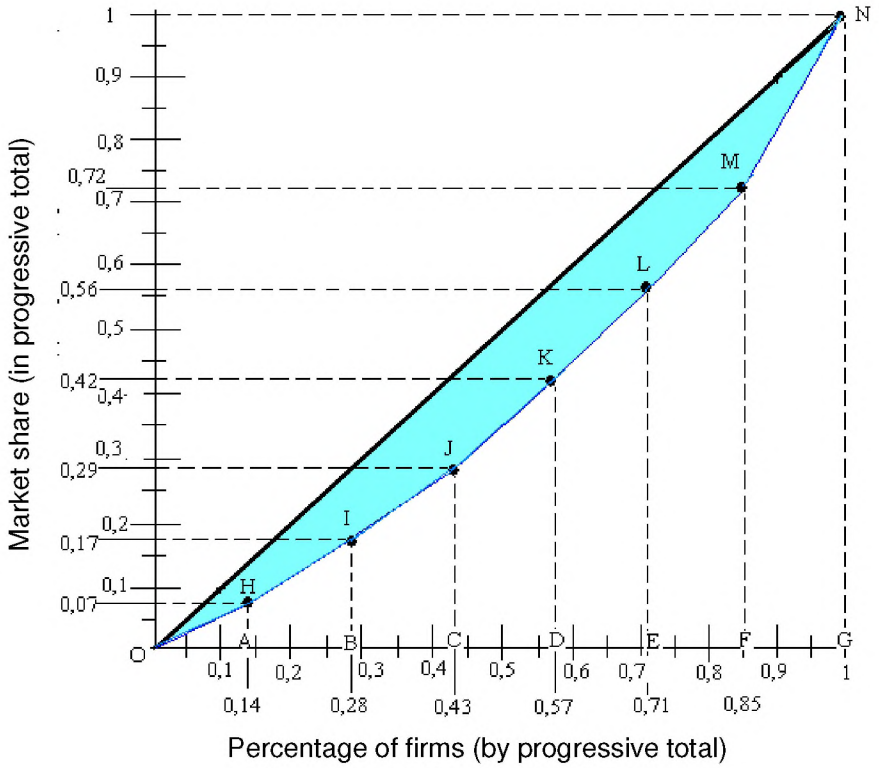
Table 5.

National Market: Distribution of Shares

Companies (by share in ascending order)	Market Share	Cumulative Series of Shares (Accumulated Frequencies)	Specific Share of Each Company in Their Total	Cumulative Series
Chernihiv plant	0.07	0.07	0.142857	0.142857
Imports	0.10	0.17	0.142857	0.285714
Other Producers	0.12	0.29	0.142857	0.428571
Lviv plant	0.13	0.42	0.142857	0.511429
Kharkiv plant	0.14	0.56	0.142857	0.714286
Zaporizzhya plant	0.16	0.72	0.142857	0.857143
Vinnytsya plant	0.28	1.00	0.142857	1.00
TOTAL	1.00		1.00	

Figure 2.

The Lorenz Curve for the Ukrainian Market



3. Conclusions

The concentration of sellers reflects the relative size and the number of firms which function in the industry. The fewer firms are in the industry, the higher is the concentration level. If the number of firms is equal, than the less they are different in size, the lower is the concentration level.

Both the world and the Ukrainian markets of metal-cutting tools exhibit rather high levels of concentration. The sizes of the largest companies by themselves can be the indicator of market concentration. This very criterion serves as a foundation for defining the monopoly situation: if more than 35% of the market is controlled by one firm, it is the sign of monopolism in Ukraine and Russia, while in Britain this figure is 25%. For preserving sound market competition, the

situation on the market with 10 and more firms should meet the following requirements:

- one firm should not occupy more than 31% of the market;
- two firms should not occupy more than 44% of the market;
- three firms should not occupy more than 54% of the market;
- four firms should not occupy more than 63% of the market.

All indicators in the analyzed industry prove that the situation is extreme (Table 3). According to its nature, the tool-producing industry should better be classified as the oligopolistic market with product differentiation rather than the market of monopolistic competition. Although there are many companies on the world and the Ukrainian markets - which approximates the market to monopolistic competition, - their number remains relatively low (Sundvic, Kennametal Hertel, ISCAR Group, Milacron on the world market; Vinnytsya, Zaporizzya, Kharkiv, and Lviv tool-producing plants in Ukraine). This situation is predetermined by the expensive technologies used in the production process and high barriers to entry, on the one hand, and it proves the oligopolistic nature of the market, on the other hand. The amalgamation of two or more competing companies can substantially increase their market share and, as a result, change the concentration level and the market structure.

The number of firms on the world market for metal-cutting tools is rather large. The largest market share of the leading company (Swiss concern Sundvic) is 0.29, while its main rival accounts for 0.16 of the market. The national market has the following structure: Vinnytsya tool-producing plant occupies 0.28 of the market, its main rival – 0.16. The leader occupies twice as much of the market share compared to the next nearest in terms of size enterprise. A rather high concentration on the world and the Ukrainian markets is confirmed by the Herfindal-Hirshman index (0.16 and 0.17 respectively). The coefficient of market share dispersion (0.006 and 0.007 respectively) and the Gini coefficient (0.5 and 0.21 respectively) confirm that the unevenness of market sharing among the sellers on the world market is higher than that on the Ukrainian market. Finally, the Lorenz curves demonstrate that the concentration on the world market is higher than on the Ukrainian market.

The level of concentration influences market behaviour of the companies: the higher it gets, the higher is the firm's dependence. The outcome of the company's independent choice of output volume and product price is determined by the respective competitor reaction. The level of concentration affects the company's inclination either to cooperate or to compete: the fewer firms function on the market, the easier it is to realise their interdependence. This makes the cooperation between them more likely to exist. The higher is the level of concentration, the less competitive is the market. Furthermore, the market situation aggravates every year because of the expanding market limits. In view of this, it is especially important for the Ukrainian companies to evaluate thoroughly the current

economic situation in order to develop effective methods of competition, which would conform to the market situation and its developmental tendencies in Ukraine, as well as to the specificity of production.

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