

Original Research Article

Similarities and differences between the CR and HHI as an indicator of market concentration and market power

ABSTRACT

Market concentration can be measured in different ways, i.e. by using different indicators. In the broadest use are the concentration ratio (*CR*) and Herfindahl-Hirschman Index (*HHI*). Concentration ratio of market concentration is usually measured as the sum of the market shares of four, eight or twelve largest companies in an industry. Herfindahl-Hirschman index of market concentration is expressed as the sum of squared market shares of all firms in an industry. It is believed that the Herfindahl-Hirschman Index is more precise measure because it takes into account all companies. Research on the example of the US economy shows that there is no difference between the concentration ratio and the Herfindahl-Hirschman index, i.e. it shows that there is a specific mathematical relationship between them. This relationship allows the conversion of a certain value of one indicator in the corresponding value of the other indicator and drawing conclusions as well as on the basis of indicator from which it was derived.

Keywords: market concentration, market power, concentration ratio, Herfindahl-Hirschman index.

1. INTRODUCTION

In a market economy, some companies do not have the ability to affect the price of their products, while other companies have the ability to influence the price of their products. The first group consists of companies that are price takers, while the other group comprises the companies that are price makers. Companies that have the ability to set the price above marginal cost, enjoy a certain market power in relation to companies that have no such possibility. Therefore, in theory and in practice one of the important issues is a question of market power and market concentration as a specific indicator of market power.

The question of measuring market concentration has always attracted attention of scientific and professional community. This question is particularly important in recent years, because the processes of globalization spurred a wave of mergers in many industries. Consequently, the changes in market concentration in many markets, and in many industries have occurred. Theory and practice are seeking the answer to the question of how to measure and how to interpret market concentration, especially in terms of distortion of competition, but also to determine the belonging to a particular type of market, i.e. to define market power of the companies operating in that market.

In theory and practice, different measures of market concentration are known. Some measures are very simple and easy to understand, and therefore in very wide use, while some measures are very complex and shaped to serve in some specific situations. Typical representations of the first group are the concentration ratio (*CR*) and Herfindahl-Hirschman Index (*HHI*), whereas the typical representations of the other group are Lerner Index (*L*) and

36 Gini coefficient (G). In this paper, special attention was paid to the first two measures,
37 focusing particularly on exploring their similarities as well as the differences.

38 Concentration ratio of market concentration is calculated as the sum of the percentage
39 shares of usually four, eight or twelve largest companies in an industry. Concentration ratio
40 is thought to be the simplest and most comprehensible measure and its handicap is
41 considered a fact that it does not take into account all, but only a certain number of
42 companies. It is at this criticism that Herfindahl-Hirschman Index of market concentration
43 was developed, which is calculated as a sum of the squared market shares of all companies
44 in a market or an industry.

45 Depending on the value of the concentration ratio, or Herfindahl-Hirschman index, one can
46 make a conclusion on market power, market concentration and of belonging to the type of
47 market of a particular industry. Depending on their values, we can talk about non-
48 concentrated markets, moderately concentrated markets and highly concentrated markets.
49 For non-concentrated markets, market power is very limited, if any, which is a characteristic
50 of perfect competition as well as of monopolistic competition in the part that has a low
51 degree of product differentiation. Moderately concentrated markets are having a moderate
52 market power, which is a characteristic of monopolistic competition with a high degree of
53 product differentiation and loose oligopoly. Highly concentrated industries, such as tight
54 oligopoly and dominant company, enjoy high market power.

55 In some cases, the classification is based on the values of the concentration ratio, while in
56 some other cases the classification is based on the values of the Herfindahl-Hirschman
57 index. Often, there is no specific mathematical relationship between these values, especially
58 in terms of translation of one value to another value. Consequently, different conclusions on
59 market power and market concentration and type of market it belongs to, depends on the
60 indicator being used. Research conducted on the example of the US economy shows that
61 there is exact mathematical relationship between the values of the observed indicators of
62 market power, i.e. of market concentration and the possible conversion of one to another
63 value.

64 CR as a measure of market concentration

65 The concentration ratio is a widespread measure of market power and market concentration.
66 Its popularity stems from its simplicity, in terms of calculation as well as in terms of user-
67 friendliness. The concentration ratio is calculated as the sum of the percentages of the
68 market share of a number of the largest enterprises in the industry concerned, i. e.

$$69 \quad CR_n = \sum_{i=1}^n S_i$$

70

71 where CR_n stands for n companies in the industry concerned, and S_i stands for the market
72 share of the i-th company in the observed industry.

¹Weinstock DS. Using the Herfindahl Index to Measure Concentration, The Antitrust Bulletin. 1982; 27 (2): 285-301.

73 The value of the concentration ratio can range from nearly 0% to 100%. Depending on the
74 percentage conclusion on market concentration, market power and belonging to the type of
75 market structure can be made.

76 If there is a large number of companies with small market shares and homogeneous product
77 operating in the industry, the concentration ratio of the four largest companies will be close
78 to zero or very low. Companies in such industries do not enjoy any market power, and the
79 market in which they operate is called a market with perfect competition. If it comes to the
80 industry, in which a large number of companies operates but their product is at the same
81 time differentiated, enterprises in such industry enjoy a certain market power. Market power
82 can range from the very low to moderate, depending on the degree of differentiation of the
83 product and the market in which they operate is called market of monopolistic competition.
84 With the increasing level of product differentiation and with the reduction of the number of
85 firms in the industry, the degree of concentration and market power are increasing, which is
86 characteristic of oligopoly and monopoly.

87 The concentration ratio as an indicator of the degree of concentration should be, according
88 to some authors, used with extreme caution, and in some cases, they state that it can only
89 be used as an orientation indicator. There are a few reasons why caution is needed. In the
90 first place this is necessary in relation to:

- 91 • the significance of the local market,
- 92 • the share of imported products on the national market,
- 93 • breadth of the definition of the product and
- 94 • the degree of inequality in market share of the largest companies in the industry.

95 Concentration ratio measures the market power at the national level, however, some
96 products are completely sold on the local market, as, for example, local newspapers or local
97 souvenirs or products that are significantly more sold at the local rather than the national
98 market, as for example, cement or cement products. In contrast to such industries, there are
99 industries, as, for example, automobile industry, whose products are sold on the global
100 market. In these cases the same concentration ratio, although it may indicate affiliation to the
101 same market structure, does not mean at the same time the same monopoly power.
102 Industries whose products are entirely or largely sold on the local market enjoy greater
103 monopoly power than the industries whose products are sold on a national or global market.

104 The significance of the local market varies from industry to industry and from product to
105 product. Neglecting the meaning of local markets may lead to erroneous conclusions
106 regarding the amount of monopoly power. This is what could happen if the monopoly power
107 of the four largest companies in the US automotive and cement industry is observed in
108 relation to the concentration ratio. Although both industries are oligopolistic in their nature,
109 cement producers, because of the importance of the local market, have greater market
110 power than the car manufacturers.

111 Concentration ratio measures the market power of a particular industry or its sub-
112 components. The problem occurs in the examples of industries that sell their products in the
113 markets where the same imported products they are present. Imports may significantly affect
114 the monopoly power of domestic producers, i. e. their market power may be lower than that
115 which could be assumed on the basis of the concentration ratio. If, for example, import of
116 cars from the Asian part of the world to the European or American market is neglected, the

117 finding on the market power of American or European car manufacturers would be
118 overemphasized. Similarly, the market power of, for example, Croatian producers of beer
119 would be overemphasized if we did not take into account the import of beer on the Croatian
120 market. Unlike automobile market or beer markets, imports of cement, which in many
121 countries is almost negligible, in no way diminishes the market power of national cement
122 manufacturers.

123 Product definition can be broader and narrower. The broader the definition of the product the
124 lower the concentration ratio, i. e. the value of the concentration ratio generally is inversely
125 proportional to the degree of aggregation of data from which is being calculated. This is
126 confirmed by numerous examples of concentration ratio for the entire industry and its
127 individual parts. Thus, for example, the concentration ratio of the four largest companies in
128 the food industry in the United States in 2007 amounted to 14.8%, whereas in the sector for
129 animal food, as part of the food production industry, concentration ratio was 31.4%. In the
130 more narrow part of the food industry, production of food for dogs and cats, the
131 concentration ratio was 71.0%. Such a relationship between the whole industry and its parts
132 is the same in the example of beverage and tobacco products, leather and related products,
133 transport equipment and many other industries in the US or in any other economy.

134 Finally, the same concentration ratio in two or more industries does not necessarily refer to
135 the same market power. It is easy to conclude that the lower market power is present in the
136 industry in which the four largest firms have almost equal market shares, than in an industry
137 where one of the four largest companies has high market share and the other three lower
138 market shares. In industries in which firms have equal market shares, market power is
139 generally lower than in the industries in which companies with unequal market shares
140 operate. In addition, the concentration ratio does not take into account the market share of
141 the next largest enterprise that is not covered by calculation, and the conclusion on market
142 power may be somewhat wrong.

143 HHI as a measure of market concentration

144 The key criticism to concentration ratio as a measure of market concentration is referred to
145 in relation to the fact that it does not take into account all of the companies in an industry, but
146 only a certain number of companies. It usually operates with four, eight or twelve companies,
147 and it rightly raises the question regarding the conclusion on market concentration in the
148 case where this is not the final number of companies. This question is particularly important
149 in cases where all companies have an equal market share, but, given that their number is
150 greater than the number of companies for which concentration ratio is calculated, a number
151 of companies have been dropped from consideration.

152 According to many authors,² such a criticism in the most acceptable way is eliminated with
153 the use of HHI, taking into consideration all companies in the industry concerned.
154 Specifically, HHI measures market concentration in the form of sum of the squared market
155 shares of all companies in the industry, which means that it takes into account all
156 companies, whereby, squaring their market shares, growing importance is given to
157 companies with larger market shares. Accordingly, for example, in the two industries with the
158 two companies with unequal market shares HHI value will be greater in the industry in which
159 company with the largest market share operates.

² Hannaford S. Market Domination! The Impact of Industry Consolidation on Competition, Innovation, and Consumer Choice, Praeger Publishers; 2007. p. 10.

Herfindahl-Hirschman Index (HHI) is, therefore, the sum of squares of the market shares of all companies in the industry concerned, i. e.

$$HHI = \sum_{i=1}^n S_i^2$$

where HHI stands for the percentage of the sum of squared market shares of all companies in the industry, and S_i^2 squared market share of the i-th company in the industry.

HHI value ranges from near zero, as in the case of perfect and monopolistic competition, up to ten thousand, as in the case of dominant companies or pure monopoly. Otherwise, it is considered that the industry or market is non-concentrated if the index value is less than 1500, while the market is moderately concentrated market if the value of the index ranges between 1500 and 2500. The value of HHI above 2500 represents a highly concentrated industry, and industry with a very high market power.

2. MATHEMATICAL RELATIONSHIP BETWEEN CR AND HHI

CR and HHI, each in their own way, measures market concentration. The first indicator draws a conclusion on market concentration on the basis of the sum of percentages of the market shares of four, eight or twelve largest companies in the industry. Another indicator draws a conclusion on market concentration on the basis of the sum of the squared market shares of all companies in the industry. The key difference is, therefore, in what HHI takes into account all companies, while CR operates only with a number of companies. Based on these differences it is usually considered HHI to be better measure of market concentration than CR.

At first glance, especially if we take into account the fact that the individual market shares are being squared, and greater importance is given to larger companies, it seems that this could be a definite conclusion. However, the question that arises is the meaning, in mathematical and real terms, of squared market shares of those groups of companies that do not belong to the group on the basis of which is CR, but they are included in calculation by HHI. In other words, is their meaning such that it could be ignored, especially if it is known that with the decline in market share, meaning of squared market shares decreases even more. This is confirmed by the many examples of industries that are characterized by digressively increasing function of the HHI, which is asymptotically approaching a value, which in most cases is far less than the maximum possible value.

In this sense, the answer is sought in the example of the US economy, comparing CR and HHI at four levels of aggregation of data, starting with the highest level of aggregation, one that shows the industry at the level of 3-digits, till the lowest level of aggregation, i. e. the one that shows the industry at the level of 6-digits. The data are from 2007, and the analysis involves calculating the correlation between the CR and HHI. CR shows the sum of percentages of market shares of our largest companies in the industry.

At the level of 3-digits, which includes 21 pairs values of CR and HHI, scatter diagram (Figure 1) shows a very high positive correlation between CR and HHI. The curve that approximates the shown values has digressive growing in relation to the HHI, while it progressively increases in relation to the CR. The regression model that best describes the relationship between HHI and CR takes the following form:

$$CR4 = 1,0405HHI^{0,5747}$$

$$R^2 = 0,9923$$

According to this model, an increase in the *HHI* of 1% will affect the average increase of *CR* by 0.5747%. Regression model explained 99.23% of deviations, which testifies of its high quality.

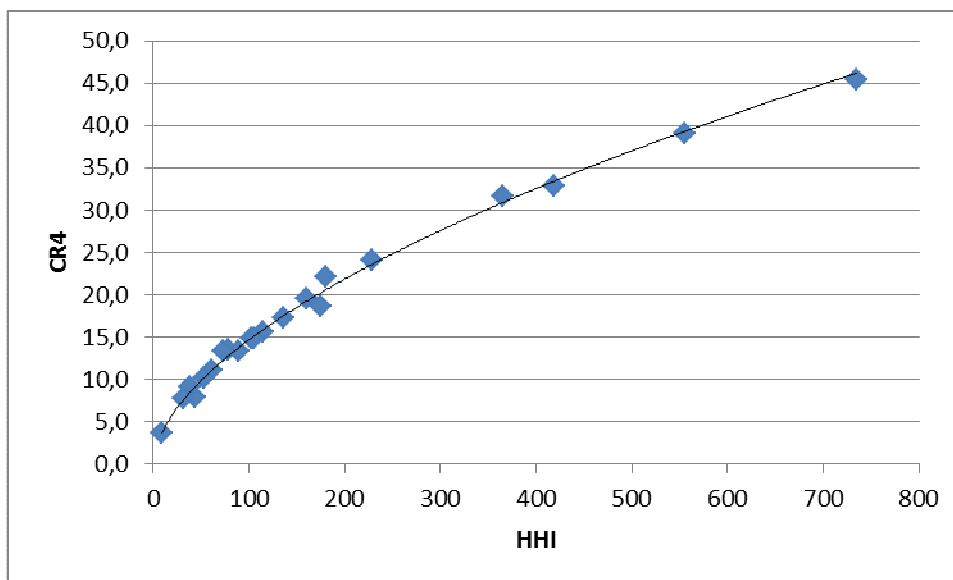


Figure 1. Scatter diagram of CR4 and HHI at the 3-digits level

At the level of aggregation of an industry that is shown at 4-digits level, there are 85 pairs of values of *CR* and *HHI*. Regression model that best describes the relationship between the *HHI* and *CR* in this case is:

$$CR4 = 1,177HHI^{0,5502}$$

$$R^2 = 0,9808$$

According to this model, an increase in the *HHI* of 1% will affect the average increase of *CR4* by 0.5502%. Regression model explained 98.03% of deviation.

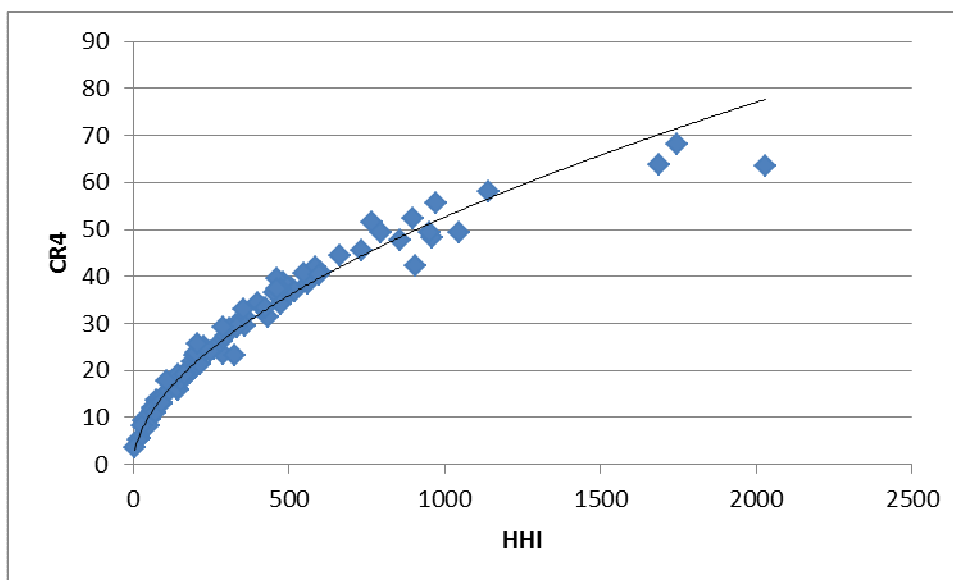


Figure 2. Scatter diagram of CR4 and HHI at the 4-digits level

At the level of aggregation that is displayed at 5-digits level, there are 180 pairs of values of *CR* and *HHI*. The regression model that best describes the relationship between *HHI* and *CR4* at this level of aggregation takes the following form:

$$CR4 = 1,1733HHI^{0,5491}$$

$$R^2 = 0,9793$$

According to this model, an increase in the HHI of 1% will affect the average increase of the concentration ratio CR4 by 0.5491%. The model explained 97.93% of deviation, and therefore this model, similar to previous models, perfectly explains the connection between the variables concerned.

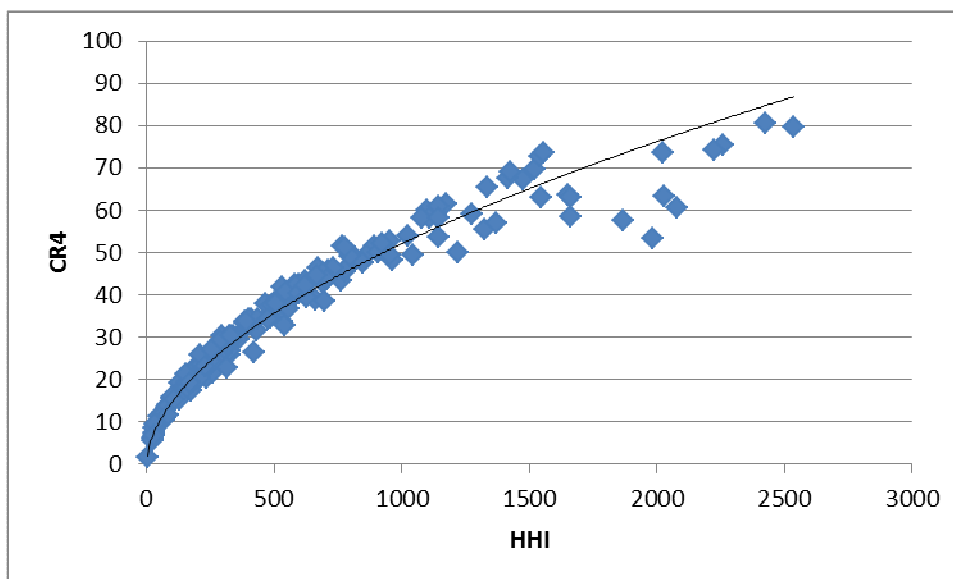


Figure 3. Scatter diagram of CR4 and HHI at the 5-digits level

At a minimum level of aggregation, 6-digits level, a diagram is obtained based on 437 pairs of values of *CR* and *HHI*. The estimated regression equation is in the form:

$$CR4 = 1,2078HHI^{0.5443}$$

$$R^2 = 0,9779$$

The estimated regression equation means that an increase in *HHI* by 1% leads to an increase in the average concentration ratio *CR4* by 0.5443%. Given the fact that the regression model explains 97.79% of deviation, this model can also be considered as excellent.

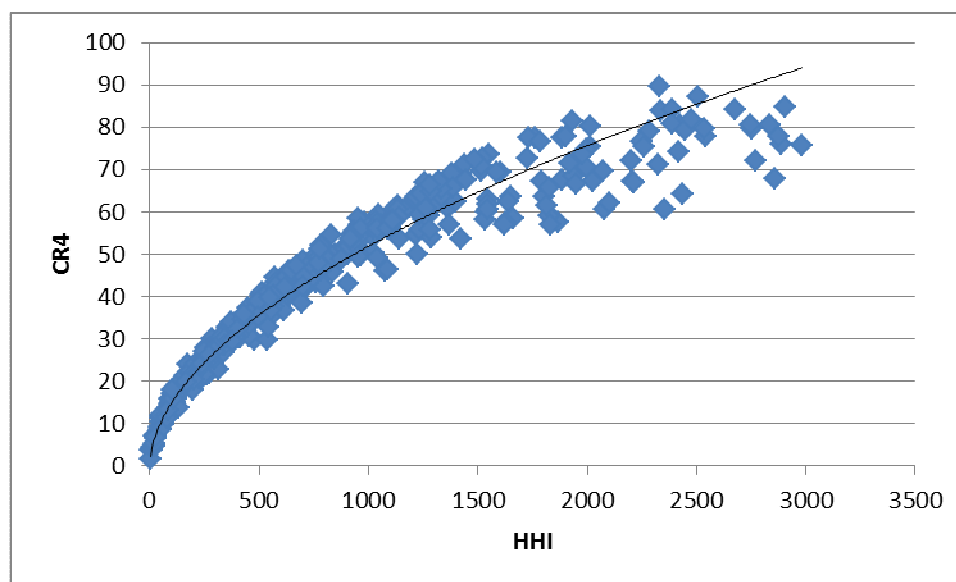


Figure 4. Scatter diagram of CR4 and HHI at the 6digits level

Based on the estimated regression models it is possible to notice certain regularity in the connection between *HHI* and *CR4*. Very similar correlation was obtained even for the values of *CR8* and *CR12*, only with different values of coefficients in the model. It is obvious that with the growth of data, i.e. with the growth of number of industries being analyzed, the values of the coefficients in the regression model are slightly changing. Since at the 6-digit level, the aggregation is at its least, that model includes all US industries to the highest degree of classification, this particular model can be taken as representative according to which it is possible to determine how *HHI* and *CR4* are related.

3. THE RELATION BETWEEN CR AND HHI AT THE LEVEL OF PARTICULAR MARKET CONCENTRATION

Assuming that there is a predetermined mathematical relationship between *CR* and *HHI*, it is possible to define a common domain in terms of the level of market concentration, on the one hand, and the market power and the type of market structure, on the other hand. In this

sense, three levels of market concentration can be defined: (1) non-concentrated market, (2) moderately concentrated market, and (3) a highly concentrated market. Each level of market concentration is characterized by a certain level of market power according to which market structure can be determined. The distinguishing is based on the classification that serves as a guide to mergers adopted by the US Department of Justice and the Federal Trade Commission from 2010.

According to this classification, the term non-concentrated market is considered to be a market in which the measured value of the HHI is less than 1500. Moderately concentrated market is characterized by the value of HHI between 1500 and 2500, while the highly concentrated markets are those in which HHI is greater than 2500. Table 1 contains the corresponding values of CR compared to HHI for each type of market, which are defined on the basis of expression $CR_4 = 1,2078HHI^{0,5443}$.

Table 1.

Level of concentration	Type of market	Market power	HHI ³	CR ₄ ⁴
Non-concentrated market	Efficient competition, part of monopolistic competition	Low, if any	<1500	<45
Moderately concentrated market	Part of monopolistic competition, loose oligopoly	Moderate	1500-2500	45-60
Highly concentrated market	Tight oligopoly, dominant firm	High	>2500	>60

In traditional classification of market structures notion of effective competition refers to the perfect competition and monopolistic competition in part which is characterized by a low degree of differentiation of products. At the same time, moderately concentrated market comprises that portion of monopolistic competition, which is characterized by a high degree of product differentiation, while the notion of a loose oligopoly refers to the oligopoly with more than a few companies of equal market shares. Finally, a highly concentrated market comprises tight oligopoly, a term that implies an oligopoly, or market with a few companies with similar market shares or market with larger number of companies of which a few of them stands out with larger market shares. The dominant company reflects the market in which there are several companies with one that stands out with significantly higher market share than any other company.

4. CONCLUSIONS

Market concentration can be measured in different ways, or by using different indicators. In the broadest use are the concentration ratio (CR) and Herfindahl-Hirschman Index (HHI). It is believed that the Herfindahl-Hirschman Index is more precise measure because it takes

³ Compare: Naldi M, Flamini M. Interval Estimation of the Herfindahl-Hirschman Index Under Incomplete Market Information. 16th International Conference on Computer Modelling and Simulation, UKSim, Cambridge, United Kingdom, March 26-28 2014., p. 320.

⁴ Compare: Naldi M, Flamini M. Interval Estimation of the Herfindahl-Hirschman Index Under Incomplete Market Information. 16th International Conference on Computer Modelling and Simulation, UKSim, Cambridge, United Kingdom, March 26-28 2014., p. 322.

into account all companies. Research, which was conducted on the example of the US economy, shows that there is no difference between the concentration ratio and the Herfindahl-Hirschman index, i. e. that there is a specific mathematical relationship between them. This relationship allows the conversion of a certain value of one indicator in the corresponding value of the other indicator and it allows drawing the same conclusion as on the basis of an indicator from which it was derived. The expression on the basis of which conversion can be done at the level of 6 digits is as follows: $CR4 = 1,2078HHI^{0,5443}$.

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