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MARKET POWER AND THE ADJUSTED CONCENTRATION INDEX

Dr. Can BEKAROĞLU[1]

ABSTRACT

This study aims to define an alternative index to measure market power and concentration ratio, similar to the Herfindahl, Hall & Tideman and the Dominance Indices in terms of ease, as a simple and scalable but more consistent scalar number carrying all the desired properties from such an index, which should be negatively correlated with the number of firms and positively correlated with the variance of firm market shares. In addition to examples from the US industries, based on the alternative index, we also formulate the impact of market concentration on welfare. The impact of technological progress and demand elasticity on market power however is not addressed in this study.

Keywords: Market Power, Concentration Ratio, Hirschman-Herfindahl Index

JEL Classification: D40, D43, D61

PİYASA GÜCÜ VE UYARLANMIŞ KONSANTRASYON ENDEKSİ

ÖZET

Bu çalışma, piyasa gücü ve konsantrasyon oranını ölçmek amacıyla, Herfindahl, Hall & Tideman ve Dominans Endekslerine benzer fakat hem basit ve ölçeklenebilir hem de böyle bir endeksten beklenen tüm istenen özellikleri üzerinde taşıyan bir endeks tanımlamayı amaçlamaktadır. Endeksin, firma sayısı ile negatif, firmaların piyasa paylarının varyansıyla pozitif orantılı olması gerekmektedir. Amerikan endüstrisinden alınan örneklere ek olarak, alternatif endeksimizden yola çıkarak, piyasa paylarının servet üzerindeki etkilerini formülize etmekteyiz. Diğer yandan, teknolojik gelişmeler ve talep esnekliği, bu çalışmanın kapsamının dışında kalmaktadır.

Anahtar Kelimeler: Piyasa Gücü, Konsantrasyon Oranı, Hirschman-Herfindahl Endeksi

JEL Sınıflandırması: D40, D43, D61

1- Dr. Can Bekaroğlu, Çanakkale Onsekiz Mart University, Faculty of Political Sciences, Department of Economics, orcid: 0000-0002-4033-1897

1. INTRODUCTION

Market Power, in simple terms, is defined as "the ability of a firm to change or affect the market price to maximize its profits" (Scherer, F., 1980). The emphasis here lies on the "price". In monopolies, the price is "set" by the firm, while in competition; the firms hardly have any effect on the prices, with zero effective market power.

From this picture alone, it can be seen that the "number" of firms in the market is a major element in determining the market price, which, in return, yields some sort of market power to the existing firms. However, in most markets, those individual firms are not identical, along with their influence on the market price, and the associated market power proportional to their market shares.

We can also talk about a collective market power for the whole industry. In extreme cases, this will be 100% for a monopoly while a perfect competition will have a market power close to zero for the whole industry as well as each of the individual firms. This market power is usually reversely proportional to the price level. In other words, an industry with a higher market power, ceteris paribus, yields a higher price level, which is a bad signal for the welfare of the society.

On the other hand, a high level of market power will also lead to higher profits to the firms and will most likely improve the production technology, and will wind up with lower prices in the future. Whether or not it will benefit the society in the long run also depends on other factors such as the profitability of the industry, fixed costs and other barriers to the market, technological progress in the industry, and most importantly the demand elasticity.

2. MARKET POWER AND CONCENTRATION

As we have established that the market power is highly dependent on the number of firms in the market, which incites competition, two variables, market power and competition seem like the two facets of the coin from opposite angles. We will now proceed to talk about three major components in the market that affect the market power.

2.1 Technological Progress

The Industries which have high technological progress and innovation tend to be competitive regardless of the number of firms (except for the monopoly case). The loss of "*status quo*" is the greatest threat to the dominant/large firms, with

a relatively high market power, and constant technological progress provides a constant threat to the status quo (Scherer, F, 1980). Thus advantageous firms have to build and invest on their own capacity to protect the status quo by improving their technology; or they will lose a significant portion of their market share, and profits, which, in turn, keeps the market power and profits low, and the competition and social welfare high, due to lower prices and improving productivity.

2.2 Demand Elasticity

Prices tend to be lower even in monopolies when demand elasticity is high, and consumers can substitute away from the product. However, when the price elasticity is low, and the technological progress is relatively low as in healthcare industry, the competition ceases to exist, the price levels skyrocket, yielding very high amounts of market power and profits to the existing firms, at the expense of social welfare.

Although a decrease in demand elasticity increases the market power for the industry, at the end of the day, it is the "competition" that determines the prices, which is usually driven by the technological progress or innovation.

2.3 Concentration Ratio

Apart from the two aforementioned elements, the number of firms alone, ceteris paribus, is not sufficient in explaining the market power, although it provides some useful insight in similar industries where the market structures are similar and known (Wolframalpha, Merger Guidelines). Let us try to understand why...

The concentration ratio is calculated by summing up the cumulative market shares of the top firms in an industry, and two of the most commonly used methods are the 4 and 8-firm concentration ratios. For example, The US concentration ratios for utility firms (United States Census Bureau, 2011, Concentration Ratios);

Table 1	Top 4 firms	Top 8 firms	Top 20 firms
Utilities	12.5%	22.1%	44.5%
Electric Power	21.1%	36.0%	60.1%
Hydroelectric Power	47%	70.2%	90.4%
Nuclear Power	2.9%	76.4%	99.5%

As it is clear from the example above, the concentration ratio increases from Electric to Nuclear Power Generation, and we can conclude that the Nuclear Power industry clearly has a higher market power, by solely looking at the market concentration data, which is consistent within the same industry or across similar industries. However, comparing structurally different markets is fundamentally flawed since the composition of the cumulative market shares may highly vary. For example, let us assume an equal 4-firm concentration ratio at 80% for two different markets, with the following market shares for each firm:

Example 1:

Market 1: Firm 1 (20%), Firm 2 (20%), Firm 3 (20%), Firm 4 (20%)

Market 2: Firm 1 (65%), Firm 2 (5%), Firm 3 (5%), Firm 4 (5%)

The market 1 will likely end up with a good level of competition since all firms are the same size and similar in other aspects; market 2, on the other hand is dominated with one large firm (dominant firm) and surrounded by small fringe firms. The price will be mostly set by the dominant firm in a somewhat monopolistic fashion, affecting the fringe firms acting as price-takers. Those two markets are vastly different, and so are their outcomes and effects on social welfare.

Another point is the number of firms specified for the concentration, which is mostly selected arbitrarily for industry-specific convenience. There is no universal approach for that, and a 4-firm number concentration ratio might be ideal for one industry while we may need a 20-firm ratio for another, which makes the comparison quite useless.

3. MEASURING THE CONCENTRATION RATIO

3.1 Desired Properties

A better way to measure the concentration ratio should have those four desired properties (Hall & Tideman, 1967):

a) The Concentration ratio should be measured with one single scalar number, independent of the market structure, number of firms, or their individual market shares, within the predetermined and scalable range, and comparable to other similar measures.

b) There should be a negative and consistent correlation between the number

of firms and the concentration ratio. In other words, when the number of firms increases, the concentration ratio should decrease.

c) There should be a positive correlation between the variance of the market shares of the firms in question. To put it differently, a market consisting of similar firms will have a lower concentration ratio compared to a case where there is a dominant firm with other fringe firms.

d) The Concentration ratio must be scalable to the percentage range of the market share we desire, and the results must be consistent and comparable to different market shares. For instance, comparing the 90% market share concentration across industries versus comparing 100% share should be comparable and consistent.

3.2 The Hirschman-Herfindahl Index (HI)

Also known as the Herfindahl Index, HI provides a more elaborate way to define the concentration ratio, by including each individual firm market share to the measurement, effectively restoring the lost data in simple n-firm concentration rate measures (Agiobenebo & Jones, 2004; Lijesen, Mark, (2004)). The construction here is simple and as follows:

HI = $\sum x_i^2$ where x is the market share of each firm (x100) lined up in a descending order, and HI ranging between 21, where the "n" is the number of firms (Nauenberg et al., 1997 & 2004).

HI is usually a better measurement for concentration as it accounts for the individual firm sizes (rather than simply summing them up), and the market share variances. Let us take the previous example with the two markets with equal 4-firm concentration ratios:

Example 2:

Market 1: Firm 1 (20%), Firm 2 (20%), Firm 3 (20%), Firm 4 (20%) => $HI_1 = 1600$

Market 2: Firm 1 (65%), Firm 2 (5%), Firm 3 (5%), Firm 4 (5%) => $HI_2 = 4300$

As expected, HI is much higher for market 2 as the variance between firms is so much larger, creating relatively a much larger market power. However, one major problem with this index is that it ranges from 1/n to 1, while "n" is a variable and subject to change, so the range is moving with the number of firms.

Another problem is the over-sensitivity to the number of firms. For instance, let us imagine a market with 2 firms, with 60% and 40% market shares. Now,

if another firm enters the market and steals half of the market share from the smaller firm, ending up in a 60%-20%-20% division, this is good news according to HI, as it decreases from 5200 to 4400. But does it really imply a "decrease" in concentration and the market power of the larger firm (and the industry as a whole)? The common sense would tell us that the dominant firm can now more easily dictate the price against two smaller competing firms, compared to one larger rival.

3.3 The Normalized Herfindahl Index (NHI)

The Normalized Herfindahl Index, NHI, aims to correct the two aforementioned problems with measurement of the concentration ratio; namely, the moving range, and the over-sensitivity to the number of firms. The formula is simply given as:

$$NHI = \frac{1 + \frac{H - 1}{1 - 1/n}}{}$$ where HI is the Herfindahl Index and n is the number of firms. If closely examined, it can be understood that this is a very cleverly manipulated formula to keep the HI within the predetermined range of 0 to 1, and emphasize the variance between firms, which will help mask the over-sensitivity of HI to the number of firms. When we run our previous example, the two markets will have the following NHI values:

Example 3:

Market 1: Firm 1 (60%), Firm 2 (40%) => $HI_1 = 5200$, $NHI_1 = 400$

Market 2: Firm 1 (60%), Firm 2 (20%), Firm 3 (20%)=> $HI_2 = 4400$, $NHI_2 = 1600$

Unlike the HI, which tells us that market 2 is less concentrated (because of its over-sensitive nature to the number of firms), the NHI yields a larger figure, implying a more concentrated market due to the dominant market position of firm 1.

There are two major flaws with the NHI. The first one is the more obvious one, the over-sensitivity to the variance of firm market shares, which was used to mask the over-sensitivity to the number of firms, and included a trade-off. This major flaw implies, regardless of the number of firms, when the firms are identical in market shares, the NHI will yield zero values, or equal (zero) concentration ratios, which violates our basic assumption that the number of firms must be negatively correlated with the concentration ratio.

Another flaw is less obvious and arguably less harmful. When the number of firms

increases, the clever formulation above can no longer mask the over-sensitivity to the number of firms. Let us take the following example:

Example 4:

Market 1: Firm 1 (40%), Firm 2 (30%), Firm 3 (30%) => $NHI_1 = 100$

Market 2: Firm 1 (30%), Firm 2 (30%), Firm 3 (20%), Firm 4 (20%) => $NHI_2 = 133$

The common sense here would dictate that market 1 is the more concentrated one with fewer firms and similar variance compared to market 2. However, the over-sensitivity to variance on NHI wins over, and yields a larger value (133 versus 100).

3.4 The Adjusted Concentration Index (ACI)

Despite alternative indices in the literature to measure market concentration such as the Dominance Index used by the Mexican Government (Ruiz-Porras et al., 2010), studies by Hall and Tideman (1967), Adelman (1969), and Horvath (1970) represent modest variations on the basic Herfindahl index. Based on the two major flaws of the NHI, the best solution seems to address the flaws directly. The formulation above already takes care of the over-sensitivity to the number of firms, but fails to properly emphasize the variance, by over-emphasizing it to the degree that the number of firms does not matter anymore.

Our simple and elegant solution, Adjusted Concentration Index (ACI) is based on the NHI, but substitutes the HI component with the Adjusted HI (AHI):

AHI = $\sum x_i^k$ where 1<k<2, and in this paper, taken as k=1.5 (k: impact coefficient), which then yields ACI = $1 + \frac{AHI - 1}{1 - 1/n}$.

Now let us recalculate our previous example with the both new and old formulas:

Example 5:

Market 1: Firm 1 (40%), Firm 2 (30%), Firm 3 (30%) => $NHI_1 = 100$, $ACI_1 = 3724$

Market 2: Firm1 (30%), Firm 2 (30%), Firm 3 (20%), Firm 4 (20%) => $NHI_2 = 133$, $ACI_2 = 3434$

As we will recall, NHI suggests an increase in concentration (from 100 to 133) in contrast to ACI, our new formula, which actually suggests a decrease in concentration (from 3724 to 3434) as desired. Let us just remember to focus on the "changes" using the same formula, since the absolute values here, does not

make much sense (so comparing 100 with 3724 is meaningless).

Furthermore, ACI is not over-sensitive to variance of market shares either, and even if all firms are identical, ACI will still yield positive values. For instance,

Example 6:

Market 1: Firm 1 (50%), Firm 2 (50%) $\Rightarrow NHI_1 = 100, ACI_1 = 4142$

Market 2: Firm 1 (25%), Firm 2 (25%), Firm 3 (25%), Firm 4 (25%) $\Rightarrow NHI_2 = 0, ACI_2 = 3333$

As expected, the concentration ratio decreases with ACI but still positive although NHI values are stuck at zero due to identical firms (and over-sensitivity to variance).

The ACI is also scalable to different market share concentration ratios, but needs to be rescaled with respect to the whole market share. So, for example, 80% market share concentration ratios might be compared instead of the whole market share.

3.5 Industry Examples

Hypothetical market situations are one way to test the feasibility of the ACI. It is, however, extremely important to test its applicability in real world scenarios. As the normalized Herfindahl index (NHI) is currently the most widely used measurement for market concentration, it will be used as a base-line comparison for the ACI in two specific markets.

Firm-level data for the United State's oil refining industry were taken from the Energy Information Administration, while data for large commercial banks were taken from the Federal Reserve. For each market it is necessary to specify a measure of output. Given available data, crude oil distillation capacity in barrels per day was chosen for the refining industry and consolidated assets for banking. The table 2 below shows market share for the top 15 firms in each industry:

It is important to notice the perceived differences between the two markets. While the commercial bank market is obviously more concentrated, it is not significantly so. The top 4 firms control 42% of the oil refining market, while the respective figure for the commercial bank market is 62% (Table 2).

From earlier discussion, we know it is necessary for an index measuring market concentration to properly represent these differences. Table 3 below shows a comparison between the NHI and ACI for US oil refining and large commercial

banks:

Table 2

Oil Refinery *	Market Share	Bank **	Market Share
Valero	11.90%	JPMORGAN CHASE	19.99%
Exxon	11.11%	BANK OF AMERICA	16.23%
Conocoph.	10.63%	CITIBANK	13.57%
BP PLC	8.11%	WELLS FARGO	12.33%
Chevron	6.15%	US	3.46%
Marathon	6.04%	PNC	2.84%
Sunoco	5.37%	BANK OF NY MELLON	2.64%
Koch Ind.	4.63%	HSBC	2.18%
PDV America	4.52%	FIA	2.09%
Motiva	4.50%	STATE STREET	2.07%
Tesoro	3.95%	TD	2.01%
WRB Refining	2.69%	SUNTRUST	1.85%
Royal-Shell	2.63%	BRANCH	1.71%
Deer Park	1.96%	CAPITAL ONE	1.42%
Access	1.61%	REGIONS	1.41%

Table 3	NHI	ACI
U.S. Oil Refining *	338	2169
Large Commercial Banks **	760	2736

Sources
* US Energy Information Administration, 2009, Refinery Capacity Report
** Federal Reserve Statistical Release, 2011, Large Commercial Banks

According to the NHI, market concentration of the large commercial bank industry is more than twice that of US oil refining. This does not fit with the data above. Commercial banking is indeed a more concentrated market, but not to the extreme the NHI represents. However, the ACI correctly accounts for the different variances and gives a more digestible figure when compared with industry market shares. Using Census data, further comparisons are made between the NHI and ACI for several US industries:

Table 3 ***	NHI	ACI
Passenger Air Transport	590	2735
Automobile Manufacturing	745	2917
Tire Dealers	936	3191
Breakfast Cereal Manufacturing	1302	3629
Soybean Processing	1385	3730

Sources
*** United States Census Bureau, 2011, Concentration Ratios

Inter-industry comparison shows relative differences between the two indices. If focus is on the NHI, it would appear that soybean processing is significantly more concentrated than passenger air transport. The ACI, however, provides evidence that this may not be the case.

Market concentration ratios are used for a variety of purposes. For instance, the Department of Justice takes them into consideration when analysing corporate mergers and antitrust suits. It is necessary then that the measure be as accurate and "well behaved" as possible. The above discussion is exemplary in that it clearly shows the short comings of the commonly used NHI and how corrections can be made using the ACI.

Overall, ACI seems to be an ideal measure for concentration rate. However, it only explains part of the market power, which is also related to the demand elasticity, and technological change among other variables. Developing an elaborate measure for market power is beyond the scope of this paper; however we will try to integrate our ACI measure with the methods in the literature and find out the implications for the welfare.

3.6 Measuring the Impact of Market Power on Welfare

The welfare performance of a market is directly related to the ability of the firms within that market to price above marginal cost. This ability to price above marginal cost is derived from market power. As market power rises, it can be expected that the welfare performance of a market will fall.

Previous works have utilized the elasticity of demand and concentration ratio components of market power in order to quantify the welfare performance of a market (Adelman, 1969; Dansby and Willig, 1979; Kelly, 1981). For the purposes of this study, we adopt a performance gradient model similar to that derived by Kelly (1981) within the framework of the Herfindahl Index:

$$\Phi = \left(\frac{11}{ee}\right)\sqrt{((N-1)HI+1)/N}\sqrt{((N-1)HI+1)/N} \quad (1)$$

where e is the elasticity of demand, N is the number of firms within the market, and HI is the Herfindahl Index.

Manipulation of the Normalized Herfindahl Index reveals that this performance gradient is equivalent to:

$$\Phi = \left(\frac{11}{ee}\right)\sqrt{NHI}\sqrt{NHI} \quad (2)$$

where NHI is the Normalized Herfindahl Index.

Substituting our ACI for the NHI creates a performance gradient that can be used to measure the relative effectiveness of the ACI in consistently representing a measure of welfare compared to the NHI:

$$\Phi = \left(\frac{11}{ee}\right)\sqrt{ACI}\sqrt{ACI} \quad (3)$$

It is important to note that the performance gradient is inversely related to welfare performance. Hence, any increase in Φ is representative of a decrease in welfare and vice versa. Consequently, equations (2) and (3) show that any variation in the elasticity of substitution (e) has a positive relationship with the welfare performance of a market. Additionally, it can also be seen that any change in the NHI from equation (2) or the ACI from equation (3) will have a negative relationship with the welfare performance of a market.

As was demonstrated in examples 3 and 5, the over-sensitivity of the NHI to the variance of market shares can yield results that are negatively related to market power. Specifically, a decrease in market power may be incorrectly represented by an increase in the NHI. On the other hand, the ACI has been shown to correct this flaw. Any decrease (increase) in market power will be represented by a decrease (increase) in the ACI.

4. CONCLUSION

The ACI (Adjusted Concentration Ratio) satisfies all four properties desired for a concentration ratio to properly measure market power:

- It provides a simple, consistent scalar measure within the predetermined range.
- There is a negative correlation between the number of firms and ACI.
- There is a positive correlation with the variance of firm market shares and ACI.
- ACI is scalable to different market share concentration rates

Thus, the ability of the ACI to more consistently indicate the true level of firms' power to affect the price within a market shows that it provides a better representation of the welfare performance of a market. However, part of the market power, related to the demand elasticity and technological change among others, remains unexplained and beyond the scope of this paper.

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