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The Antitrust Regulation Harms Consumers

When you don't compete with stronger players, you stop developing (c)

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Abstract

This article examines the effects of antitrust regulation. It is always assumed that this regulation has the purpose and function of protecting the interests of consumers. The other function of regulation is to protect competition, and it is assumed that this also indirectly protects consumer interests, because the dogma ‚the more competition the better' is accepted without reservation.

We will demonstrate that antitrust regulation can harm consumer interests and will consistently prove the following theses in general:

Antitrust regulation leads to a new, forced market equilibrium from which no participant has an interest in deviating.

Regulation results in an equilibrium that is less profitable for consumers but more profitable for players that are not subject to antitrust regulation.

In maximising their profit, players will offer quantities to the market such that the price on the market will increase and the total quantity offered will decrease.

The efficiency of production decreases as a result of regulation.

Although anti-monopoly regulation leads to a redistribution of market shares and profits, it generally leads to an increase in the equilibrium price for consumers and thus harms their interests.

Keywords: antitrust regulation, protection of competition, consumer protection, Nash equilibrium

JEL: D42, D43, L4, L13

Initial notations and assumptions

It is assumed that there is a state authority that regulates competition and enforces the relevant antitrust legislation governing such markets. For brevity, we will refer to this public authority as the "Regulator". The Regulator fixes a market share cap applicable to each of the market participants, above which the sanctions provided for in the case of a monopoly situation on the market are applicable. A monopoly position should not be understood as a classical monopoly having 100% market share, but as a "quasi-monopoly" having a market share higher than that fixed in the Regulator's norms.

We will consider a market situation that we will model in the general case. As a starting

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point, we will take an unregulated situation in which there is a Cournot-Nash Equilibrium in the market (referred to and denoted hereafter for brevity by CNE) in which one of the participants has a market share higher than the maximum allowed by the Regulator. This requires the intervention of the Regulator to limit the market share of the offending participant and to protect competition. For the alleged role of the Regulator in protecting competition in the EU see (Tanushev, 2022) p. 395.

In a given market there are three competing firms, which we will refer to hereafter as "players", in line with the terminology adopted in Game Theory. For brevity, we will refer to the three players as P_1, P_2 and P_3 respectively.

Throughout, we will consider that the first player, P_1, is the one with the highest market share and that it is the one that may come under the Regulator's action if its market share exceeds the Regulator's fixed maximum allowable share. Otherwise, neither it nor other market participants are subject to any sanctions.

We will use the following notation:

M – a maximum allowable market share fixed by the Regulator so that no player is considered to have a monopoly position. The value of M cannot exceed 1 (or 100%) because then this limit becomes meaningless as no player can have a market share above 100%;

n – number of players on the market, in the present case - three;

a, b – positive numbers, market parameters describing the relationship between quantity offered and price;

Q – total quantity offered on the market;

P – a price corresponding to the total quantity offered on the market;

c_i,– positive numbers, unit costs of each player, generally different;

q_i – positive numbers, quantities offered by each of the players, generally different;

q_i^* – positive numbers, the optimal quantities for each of the players at which they maximize their profits, generally different. They may be optimal in the equilibrium reached or they may be optimal responses to the actions of the other players;

U_i – profits of each of the players, generally different;

u_i – profits per physical unit of product of each of the players, generally different;

S_i – positive numbers, market shares of each player, generally different;

The following dependencies are valid

$$P = a - b.Q \tag{1}$$

For every quantity offered on the market there is a price at which it is sold in its entirety and vice versa - for every price there is a quantity that will be sold at that price. In cases where an equilibrium exists, we will speak of an equilibrium quantity and an equilibrium price.

$$Q = \sum_{i=1}^{n} q_i \tag{2}$$

The quantity offered on the market is the sum of the quantities offered by the players.

$$u_i = P - c_i \tag{3}$$

The profit per unit of each player is equal to the difference between the market price P and the unit cost c_i.

$$U_i = u_i q_i = (P - c_i).q_i \tag{4}$$

Each player's profit is formed by the profit per unit multiplied by the quantity q_i offered by the player. In what follows, we will always express profits in one of these two ways.

$$S_i = \frac{q_i}{Q} \quad (5)$$

The market share of each player is calculated as the ratio between the quantity offered by that player and the total quantity offered on the market.

$$c_i < a \quad (6)$$

The unit costs of all players are strictly smaller than the parameter *a* characterising the response of the price *P* to the marketed quantity *Q*.

In our case it will also be true that:

$$c_1 < c_2 < c_3 < a \quad (7)$$

Player P_3 will have the highest cost per unit and player P_1 the lowest.

A Cournot-Nash Equilibrium will be established on the market.

The Cournot-Nash Equilibrium is characterised briefly by the following assumptions (Cournot A., 1838), (Dusouchet, 2006):

The price and quantity are related linearly.

For every quantity offered on the market, there is a single price at which that quantity can be sold and vice versa - for every price on the market there is a quantity that will be offered and sold.

Players offer homogeneous goods on the market that are substitutable and are poorly differentiated for the consumer. Players therefore compete through the volumes of output offered.

Players can freely and quickly increase or decrease the volume of their output. This is an important assumption allowing players to react to emerging market opportunities.

Each of the players maximises its profit.

Players do not enter into coalitions with each other and act rationally in accordance with their profit maximisation objective.

Constraints on the production capacities of the players are either absent or inactive (redundant) when the equilibrium is reached, i.e. the equilibrium is not constrained by the production capacities of the players.

In the case of CNE, the following well-known formulas are true, whose derivation we will not do here. They are generally available for those wishing to learn how they are derived.

Formula 1. Optimal quantity offered by each player in the CNE

$$q_i^* = \frac{a - n.c_i + \sum_{j \neq i}^{n} c_j}{(n+1).b} = \frac{a - c_i + n.(c_i - \bar{c})}{(n+1).b} \quad (8)$$

Formula 2. Optimal (equilibrium) total marketed quantity in the CNE

$$Q^* = \sum_{i=1}^{n} q_i^* = \frac{n.a - \sum_j^n c_j}{(n+1).b} = \frac{n.(a - \bar{c})}{(n+1).b} \quad (9)$$

Formula 3. Optimal (equilibrium) market price in the CNE

$$P^* = a - b.Q^* = \frac{a + \sum_j^n c_j}{(n+1)} = \frac{a + n.\bar{c}}{(n+1)} \quad (10)$$

These formulas will hereafter be used without proofs.

Research methodology

The research methodology is the mathematical proof of statements in the general case. Therefore, the proofs are valid for any values satisfying the conditions derived by the author. Proven statements are generalisable to more players and their truth does not depend on this number.

The chosen methodology does not need any data. The methodology used does not require working hypotheses because it deals with proofs of statements.

Although numerical example is used in the paper, all the proofs are done not with specific numbers but with parameters in the general case. The numerical example is only illustrative and serves only to show what results are obtained by applying given formulas that are known or obtained by the author. The numerical example was created by the author. Any coincidence of numerical values with those of actually existing economic entities is coincidental.

Numerical example

There are three players, P_1, P_2 and P_3 in the game.

The market is characterised by the following relationship between price (*P*) and quantity supplied (*Q*):

$$P = 400 - 2.Q \tag{11}$$

Each of the three players has different unit production costs:

$c_1 = 40$, $c_2 = 120$, $c_3 = 140$

There is a CNE on the market.

In the equilibrium, the three players offer the following quantities respectively:

$q_1 = 67.5$, $q_2 = 27.5$, $q_3 = 17.5$

In our example, the quantities are assumed to be non-integer, i.e. there is a divisibility of the product quantity - e.g. tonnes, kilograms, grams and their possible cuts. The requirement of integer-valuedness adds constraints not inherent in CNE, which, however, do not change the statement of the problem of finding equilibrium.

The equilibrium quantity is

$$Q = q_1 + q_2 + q_3 = 112.5 \tag{12}$$

The equilibrium price is

$$P = 400 - 2.Q = 175 \tag{13}$$

The following table summarises the important characteristics of the three CNE players:

Table 1. Characteristics of the players in CNE

Player	Quantities offered q_i	Market shares S_i	Profits U_i
P_1	67.5	60.0%	9112.5
P_2	27.5	24.4%	1512.5
P_3	17.5	15.6%	612.5
Total	112.5	100,0%	11237.5

We will introduce as an indicator of the efficiency of the part of the economy that offers the given product the ratio between the aggregate costs of all players and the quantity offered (the weighted average cost per unit of quantity offered):

$$\frac{\sum c_i q_i^*}{Q^*} = 75.11 \tag{14}$$

The individual unit cost weights are precisely the market shares of the players. The larger this average cost, the less efficient is the production (and supply) in that market.

Everybody should be happy, but someone of the players P_2 and P_3 (or both) is displeased with the too high (in their opinion) market share of P_1, which in our example reaches 60%. The dissatisfied player complains to the Regulator.

The formal ground is present because P_1 has a market share of 60% and the maximum market share allowed by the Regulator and the current regulations is 50% (in our example). Soon we will look into the world of law to see how this share is determined in different countries.

Accordingly, P_1 is **forced** to reduce its market share to the 50% allowed, which means that it has to reduce the quantity it offers as it cannot influence other players to offer additional quantities and thus increase their market shares. Moreover, the Regulator also cannot influence other players to increase their quantity offered. These players will offer such quantities that maximise their profits.

This is an important point in the logic of the study because, in principle, no one impedes the other players from increasing their own offer and thus their market shares. However, there is no rule that can force one of them to increase its offer, which means that there is freedom of decision and no interventions in the decisions of the players as long as they do not violate antitrust rules.

But the CNE is what it is according to the characteristics of the market and the players participating in it. Under it, each player has maximised its profit, which means that it is unprofitable for players P_2 and P_3 to increase their offer, as this would lead to a reduction in the equilibrium price and therefore to a reduction in their profits.

By complying with the Regulator‘s requirements, P_1 reduces its offer to such a quantity that its market share is equal to the maximum allowable, and the other two players divide the market freed by it according to their profit maximisation objectives.

A new CNE is established on the market where one of the players, P_1, is artificially (legally) constrained in increasing its offer. For this reason, this CNE can be called a “forced Cournot-Nash Equilibrium”, considering only the player that is subject to the regulatory rules. Hereafter, we will refer to this CNE as the „forced CNE“ resulting from the Regulator‘s intervention and distinguish it from the unregulated CNE that occurs without regulatory intervention. The remaining players can modify their offers as consistent with maximising their profit.

What will be the result in the forced CNE?

The following table shows the quantities, market shares and profits of the three players in the forced equilibrium:

Table 2. Characteristics of players in the forced CNE

Player	Quantities offered q_i	Market shares S_i	Market share changes	Profits U_i	Profit changes
P_1	54	50.0%	-10.0%	7776.0	-1336.5
P_2	32	29.6%	+5.2%	2048.0	+535.5
P_3	22	20.4%	+4.8%	968.0	+355.5
Total	108	100.0%	0.0%	10792.0	-445.5

The new equilibrium quantity is

$$Q = q_1 + q_2 + q_3 = 108.0 \tag{15}$$

The new equilibrium price is

$$P = 400 - 2.Q = 184 \tag{16}$$

The new average unit cost is 84.07

We will highlight that efficiency has deteriorated. It cannot be otherwise, since the player with the lowest unit costs has been forced by the Regulator to reduce its market share.

The Regulator‘s actions have produced the desired results:

1. P_1‘s market share has been reduced to the acceptable level;
2. The market shares of the other two players have increased;
3. P_1‘s profit has decreased;
4. The profits of the other two players have increased.

Competition is protected, most importantly, the two players P_2 and P_3 have increased their profits **without any effort** to increase their competitiveness because the market is artificially freed for their production. They cannot be dissatisfied with the result.

We have to assume that consumers will also be satisfied with the result, namely a reduction in the supply of this product on the market and an increase of its price.

Since this is doubtful, we will examine the effects of imposing restrictions aiming to protect competition. The other name for these actions is fighting the monopolistic position of one of the players. In our example, this fixed maximum allowable market share was 50%, but in reality it depends on the imagination of those writing the regulatory rules and their perceptions of the wonderful.

From the point of view of law, this market position of the first player should be called „dominant" and the Regulator should investigate precisely abuse of dominant position. Different countries have different views on the conditions under which the conditions for dominance exist, which shows once again that there is no single value that is generally accepted in theory and practice.

For example, the Federal Law of 26.07.2006 N 135-FZ (rev. 29.12.2022) "On Protection of Competition" considers a share of 50% or more to be dominant on the market of a particular good, but immediately follows stipulations, including that a share of less than 50% may also mean a dominant position if it is established by the antimonopoly authority. The same law states that a market share below 35% cannot be considered dominant, and exceptions immediately follow.

The analogous Law of the Republic of Azerbaijan On Antimonopoly activity" states that "An economic entity with a market share of more than 35% or more than the other limit established by law is considered to have a dominant position." Therefore, the limit is established by law, as we have mentioned - according to the legislator's understandings.

But in the analogue LAW OF UKRAINE ON THE PROTECTION OF ECONOMIC COMPETITION, already in Article 1. Terms Defined an equivalence is drawn between a dominant and a monopolistic position in the text defining the basic concept of monopolisation: "monopolisation denoting the acquisition of a monopoly (dominant) position on the product market, the maintenance or strengthening of that sort of position;" And this is further confirmed in Article 12. Monopoly (Dominant) Position of an Economic Entity in the text" 2. The position of an economic entity shall be considered as a monopoly (dominant) position if its share in the product market exceeds 35% unless the economic entity proves that it is exposed to substantial competition."

We may also mention the practice of the Chinese regulator in a separate (acquisition) case (Mitsubishi/Lucite), which concluded that „64 per cent to consider that the transaction was capable of restricting competition".

And, to conclude the excursion into the fascinating world of legislation, which is not the subject of our article, we can point out that in EU law the definitions are so vague that the dominant position remains the exclusive decision of the relevant Regulator. Citation: "The Commission's view is that the higher the market share, and the longer the period of time over which it is held, the more likely it is to be a preliminary indication of dominance. If a company has a market share of less than 40%, it is unlikely to be dominant." How much is "less than 40%" and how much is "more likely" remains a secret until the Regulator decides. By how much does the probability of dominance increase after crossing the 40% red line, say by 0.1%?

In economic studies, however, we can encounter different interpretations of monopoly position based on practical studies of different markets rather than on legal texts.

In “DEVELOPING A METHODOLOGY FOR DETERMINING THE PERIODICITY OF TAXI VEHICLE MAINTENANCE IN VIETNAM CONDITIONS”, Dissertation for the Degree of Ph.D. in Engineering, 2023, the author Thay Hiu Chyong states (p. 18) “Currently, the monopoly market share of passenger transportation services by taxi technology is more than 23.8%.”

In “Economic mechanism of functioning of marketing environment of agro-industrial complex”, Fomenko, Ekaterina Aleksandrovna, PhD in economics, 1999 draws the conclusion: “The main representative of the regional market is the open joint-stock company “Karavay”. It owns a monopoly share of the market (42%).”

Different countries, different markets, different times. Can there then be a single norm that is valid for at least one country for a certain period of time, but - for all possible markets in that country? The question is rhetorical.

For example, the liquidity crisis at one of the largest banks, Credit Suisse, showed that the maximum allowable shareholder stake of 10% prevented the main shareholder, Saudi National Bank with its 9.8%, from increasing its stake in the bank. Breaching the 10% limit threatens “regulations” both at national and European level. External credit to the bank is possible, but in full accordance with the numerical example just seen, is more expensive and less effective because of the additional risk component in the interest rate of the credit. For more details see “Top shareholder says won‘t raise stake above 10% threshold” (*https://www.bloomberg.com/news/articles/2023-03-15/credit-suisse-top-shareholder-rules-out-more-assistance-to-bank)*. The story has a continuation from 19.03.2023, apparently the rescue of the bank cannot wait until Monday. Credit Suisse‘s big competitor, UBS, has offered to buy the bank‘s shares at CHF 0.25 (final price 0.76) per share, which is 13.5% of the closing price on 17.03.2023. In doing so, the authorities (and the Regulator included) have urgently revised the country‘s legislation to be able to circumvent the consent of Credit Suisse and UBS shareholders. Ultimately, the takeover took place, not without the help of the Swiss National Bank, which provided “liquidity assistance” of CHF 100 billion. And bypassing the regulator‘s restrictions!

In order for P_1‘s market share in the unregulated CNE to exceed that allowed by the Regulator, a certain important condition must be met, which we will refer to as “**key condition**” here. It will be used repeatedly in proving certain propositions, so in these cases we will simply use the term “key condition”.

The following condition for the market share S_1 of P_1 must be satisfied in the unregulated CNE:

$$S_1 = \frac{q_1^*}{Q^*} > M \tag{17}$$

(the optimal quantity of P_1 offered in the CNE as a share of the total quantity *Q* offered on the market must exceed the maximum allowed share *M* set by the Regulator).

Given that in a CNE with three players (see Formula 1 Optimal quantity offered by each player in the CNE)

$$q_1^* = \frac{a-3.c_1+c_2+c_3}{4.b} \tag{18}$$

and (see Formula 2 Optimal (equilibrium) total marketed quantity in the CNE)

$$Q^* = \frac{3a-c_1-c_2-c_3}{4.b} \tag{19}$$

the key condition takes the form

$$\frac{\frac{a-3.c_1+c_2+c_3}{4.b}}{\frac{3.a-c_1-c_2-c_3}{4.b}} > M \tag{20}$$

or, after rearranging the expression the formula that will be used later is obtained:

Formula 4. Basic formula of the key condition

$$(1-3M)a+(1+M)c_2+ \\ +(1+M)c_3 > (3-M)c_1 \tag{21}$$

In the case of a game with *n* players, this condition has the form

$$(1-nM)a+\sum_{j=2}^{n}(1+M)c_j > (n-M)c_1 \tag{22}$$

Obviously, the high market share of P_1 in CNE is not just a matter of desire or ambition, but a matter of ratios between market parameters and the unit costs of players. These may be met, and then a "monopoly" will inevitably emerge in the CNE, or they may not be met, and then regulation is unnecessary, or more accurately put, inactive.

In our example, the condition was satisfied because the unit costs of P_2 and P_3 are high enough for the left-hand side of the inequality to be a positive number, since the right-hand side will **always** be positive. There is no value of M < 1 such that the right-hand side of the inequality in the Formula 4 Basic formula of the key condition can have a negative value

Statement: ***For every quantity q_1 offered by P_1, under regulation or not, there exist optimal responses of P_2 and P_3, which are their quantities, such that their profits are maximised. The set of these quantities is also a CNE, given the P_1's quantity q_1.***

Proof:

Suppose that P_1 offers some quantity q_1 Then, P_2 and P_3 maximise their profits in solving the following system of equations - first derivatives of the profits with respect to the quantities offered by the players:

$$\begin{cases} U_2' = 0 \\ U_3' = 0 \end{cases} \tag{23}$$

Solving such systems is the generally accepted way of finding the optimal quantities of players in equilibria.

We write down the detailed expressions for the profits of the two players:

$$\begin{cases} U_2 = [a-b(q_1+q_2+q_3)-c_2]q_2 \\ U_3 = [a-b(q_1+q_2+q_3)-c_3]q_3 \end{cases} \tag{24}$$

The derivatives of these prifits at a **fixed** quantity of P_1 are as follows:

$$\begin{cases} U_2' = a-c_2-bq_1-2bq_2-bq_3 = 0 \\ U_3' = a-c_3-bq_1-q_2-2bq_3 = 0 \end{cases} \tag{25}$$

The second derivatives of the above expressions are the negative numbers *-2b* and hence the second condition of maximising profits is also satisfied.

The solution of this system for the quantities of the two players P_2 and P_3 is their optimal response to the change (reduction for the regulated player) of the quantity offered by P_1:

Formula 5. Optimal responses of P_2 and P_3

$$q_2^* = \frac{a-bq_1-2c_2+c_3}{3b} \\ q_3^* = \frac{a-bq_1+c_2-2c_3}{3b} \tag{26}$$

The total quantity offered and the equilibrium price will be:

$$Q = q_1+q_2^*+q_3^* = \frac{2a+bq_1-c_2-c_3}{3b} \tag{27}$$

$$P = a-bQ = \frac{a-bq_1+c_2+c_3}{3} \tag{28}$$

Those readers, familiar with CNE will easily recognise two-player versions of CNE in these formulas. If P_1 does not exist or is forced to offer zero quantity, the above formulas reduce to CNE with two players or the standard duopoly, Cournot equilibrium.

The quantity offered by P_1 occurs in each of the above expressions. Under regulation, a constraint will be imposed on P_1's actions, but this does not change the fact that other players will seek to maximise their profits.

Our case of interest is one in which P_1 offers a quantity strictly less than the optimal in the unregulated CNE $q_1 < q_1^*$. We cannot expect that a rational P_1 will offer a larger quantity and want to come under sanctions for its monopoly position and for maliciously violating regulatory norms.

The statement is easily proven that none of the players P_2 and P_3 can increase his profit if he offers a quantity greater or less than his optimal quantity and the other player sticks to his optimal quantities. This is typical of CNE.

So, for every quantity offered by P_1 the other two players will have their optimal responses that maximise their profits. Clearly, if P_1 offers less than his optimal quantity, under fear of sanctions from the Regulator, the other two players **will increase** their quantity offered. This can be seen from the formulas derived for their optimal response. In the numerators of both fractions, P_1's quantity participates in the expression with a negative sign, and so when it decreases, the numerators will increase, and so will the quantities of the two players.

The important question is - what will be the offer of P_1? It will be the result of the maximum allowable market share and the offer of the other players. The maximum quantity that P_1 can offer is such that its market share is exactly equal to the maximum allowable market share *M* set by the Regulator.

We will consider next the following model of the behaviour of the players on the market and prove that in this model the outcome in terms of quantities and equilibrium price is CNE, disadvantageous for consumers but advantageous for unregulated players.

"Big predator - scavenger" behaviour model

This is a model of behaviour common in nature. There is a big predator and small predators or scavengers. The small predators recognise the leadership of the big predator and when it kills an animal, they wait for it to eat, move away from its prey and then they proceed to the remains. In economics, similar behaviour is observed when there is a recognised leader in a market and some number of small competitors. They recognise his leadership and adapt their actions on the market after the leader (the large predator) decides on its market share (eats its share of the prey). In turn, the leader has the freedom to determine his market share (how much of the prey to eat), but he does not forget that there are competitors, and if he frees up the market (eats less), they will necessarily take advantage of this and increase their market shares.

Of course, the given model of behaviour is only an analogy, the participants have no rational behaviour. Having a Regulator prevents the "big predator" from being too big and protects the interests of the "small predators" and thus maintains some equilibrium in this "ecosystem" where the "small predators" will not starve to death.

Technically, the procedure for analytically finding the quantity of P_1 (optimal for him) is analogous to that used in finding the optimal quantities of the player-leader in von Stackelberg's equilibrium.

In the new, forced CNE, the quantity offered by P_1 will be determined as follows:

$$\frac{q_1}{Q^*} = M \qquad (29)$$

The total quantity offered will be the sum of the quantities of the three players:

$$Q^* = q_1 + q_2^* + q_3^* =$$
$$= q_1 + \frac{a - bq_1 - 2c_2 + c_3}{3b} + \frac{a - bq_1 + c_2 - 2c_3}{3b} =$$
$$= \frac{2a + bq_1 - c_2 - c_3}{3b} \tag{30}$$

From this expression, in which the only unknown is the quantity offered by P_1, we obtain that quantity which would correspond to a market share equal to *M*:

$$\frac{q_1}{\left(\frac{2a + bq_1 - c_2 - c_3}{3b}\right)} = M \tag{31}$$

$$q_1 = M\left(\frac{2a + bq_1 - c_2 - c_3}{3b}\right) \tag{32}$$

Solving the expression for q_1, we get the following expression:

$$(3 - M)bq_1 = M(2a - c_2 - c_3) \tag{33}$$

Or, ultimately

Formula 6. Optimal quantity offered by the regulated player in the forced equilibrium

$$q_1^* = \frac{M(2a - c_2 - c_3)}{(3 - M)b} \tag{34}$$

The meaning of this way of finding the optimal quantity for P_1 is as follows:

Knowing that for every quantity he offers, the other two players, P_2 and P_3, have their own optimal responses, P_1 will choose a quantity such that, taking into account the optimal responses of the opponents, a total quantity will be offered to the market such that **his** share will be exactly equal to the maximum allowed by the Regulator.

This quantity determines both the optimal quantities for the other two players and the total quantity in the forced CNE. The optimal quantities of P_2 and P_3 are:

Formula 7. Optimal quantity for P_2 in the forced equilibrium

$$q_2^* = \frac{(1 - M)a - (2 - M)c_2 + c_3}{(3 - M)b} \tag{35}$$

Formula 8. Optimal quantity for P_3 in the forced equilibrium

$$q_3^* = \frac{(1 - M)a + c_2 - (2 - M)c_3}{(3 - M)b} \tag{36}$$

The total quantity offered will be:

Formula 9. Optimal market offer in the forced equilibrium

$$Q^* = \frac{2a - c_2 - c_3}{(3 - M)b} \tag{37}$$

The new price in the forced CNE will be:

Formula 10. Equilibrium price in the forced equilibrium

$$P^* = a - bQ^* = \frac{(1 - M)a + c_2 + c_3}{(3 - M)} \tag{38}$$

If the Regulator follows a discriminatory approach to P_1 and the parameter M specifically for it is reduced to zero, which means that this player is not allowed in the given market at all, then all formulas for P_2, P_3, *Q* and *P* become the corresponding formulas for an unregulated CNE with two players (duopoly).

Before proceeding to analyse the outcomes and consequences of regulation, we must first demonstrate that there is a new, forced CNE in the market at these quantities. The author has proved (see Appendix A Proof of the existence of an CNE under regulation) that with the quantities for the three players so determined, a CNE does indeed result. Hence, no player can increase its profit by unilaterally changing (decreasing or increasing) its quantity offered if the other players stick to their equilibrium quantities.

As can be seen from all the expressions, both for the equilibrium price, for the total quantity offered, and for the quantities offered by the other players, the unit cost of P_1 no longer appears in any of them. Players P_2 and P_3 no longer have to consider how large the regulated competitor‘s costs are. The growth of their quantities and profits depends only on their profit maximisation because they are guaranteed by the Regulator, not on how able they are to compete with P_1 on production costs.

Conclusion: *the regulation for the purpose of monopoly protection blocks an important signal of the competitiveness of unregulated players, which is the unit cost of the regulated player. This information is excluded from the set of factors influencing their decisions. Going forward, they have no interest in making efforts to lower their costs to the level of P_1 and improve their competitiveness. Their profits are guaranteed by the Regulator. It can be concluded that the actions of the Regulator distort the actual unit cost ratios of the players and extinguish the incentive to lower costs as an instrument of competitive struggle*.

A series of statements about forced equilibrium that characterise it are consistently proved.

First of all, the important statement that after the intervention of the Regulator the optimal total quantity is strictly less than the optimal total quantity offered in the unregulated market in the unregulated CNE is proved.

Statement: ***The equilibrium quantity offered on the market after the intervention of the Regulator is strictly less than that in the unregulated CNE, ie:***

$$\frac{2a-c_2-c_3}{(3-M)b} < \frac{3a-c_1-c_2-c_3}{4.b} \qquad (39)$$

Proof:

After discarding the common multiplier *b* and the denominators we get the expression

$$8a-4c_2-4c_3 < \\ < (3-M)(3a-c_1-c_2-c_3) \qquad (40)$$

$$(3-M)c_1 < (1-3M)a + \\ + (1+M)c_2 + (1+M)c_3 \qquad (41)$$

This expression is entirely consistent with the key condition we derived, which was a condition for P_1 to have a market share greater than that permitted by the regulator in the first place. See Formula 4 Basic formula of the key condition.

Statement: ***The derivative of the total quantity offered Q with respect to the maximum allowable market share M is positive.***

Proof:

For the quantity offered Q we have the following expression (see Formula 9 Optimal market offer in the forced equilibrium):

$$Q = \frac{2a-c_2-c_3}{(3-M)b} \qquad (42)$$

The derivative of this expression with respect to the parameter *M* is positive in sign:

$$\frac{dQ}{dM} = \frac{b(2a-c_2-c_3)}{(3-M)^2b^2} > 0 \qquad (43)$$

We have shown that as *M* increases this quantity (*Q*) will increase and therefore the converse also will be true - as *M* decreases it will decrease. This dependence of the quantity marketed is only true up to a certain threshold value of *M*. We already know that when P_1 is not constrained by the regulator‘s norm at its optimal offer, the market supply *Q* reaches its maximum.

Conclusion*: as regulation tightens, which consists in reducing the maximum allowable market share M, the total quantity supplied on the market will decrease.*

Another important consequence is that the price in the new forced equilibrium will be higher than in the unregulated market.

Statement: ***The price in the forced CNE is higher than in the unregulated CNE***.

$$\frac{(1-M)a+c_2+c_3}{(3-M)} > \frac{a+c_1+c_2+c_3}{4} \quad (44)$$

See also Formula 3 Optimal (equilibrium) market price in the CNE.

Proof:

After obvious transformations we obtain:

$$4(1-M)a+4c_2+4c_3 > \\ > (3-M)(a+c_1+c_2) \quad (45)$$

And, in a “canonical” form

$$(1-3\mathrm{M})a+(1+\mathrm{M})c_2+ \\ +(1+\mathrm{M})c_3>(3-\mathrm{M})c_1 \quad (46)$$

Which also satisfies the key condition.

A separate comment is required on the new equilibrium price, which is higher.

On the surface, the unit cost of P_1 has disappeared in the numerator, which means that it has decreased and potentially this should lead to a lower price. Also, instead of the parameter *a* in the numerator, the expression *(1-M)a* appears, which is also smaller and should also lead to a smaller numerator. This is all true for the numerator, but the denominator is also smaller and this leads to a higher equilibrium price.

Conclusion*: with tightening regulation, which consists in reducing the maximum allowable market share, the equilibrium price on the market will increase.*

Similarly, by verifying that the key condition is fulfilled, the following propositions are proved:

Statement: ***The quantities offered by P_2 and P_3 are larger than in the unregulated CNE.***

Proof:

The following inequalities have to be proved:

$$\frac{(1-M)a-c_2(2-M)+c_3}{(3-M)b} > \frac{a+c_1-3c_2+c_3}{4.b} \quad (47)$$

$$\frac{(1-M)a-c_3(2-M)+c_2}{(3-M)b} > \frac{a+c_1+c_2-3c_3}{4.b} \quad (48)$$

After processing these expressions, the key condition is also satisfied (see Formula 4 Basic formula of the key condition).

Since the total quantity offered in the forced CNE is less than in the unregulated CNE, and the quantities offered by P_2 and P_3 are larger, it logically follows that P_1 offers less quantity than before regulation.

Statement: ***In the forced CNE, the profits of P_2 and P_3 are larger than in the unregulated CNE*.**

Proof:

The profit of P_2 in the new equilibrium will be:

$$U_2=(P-c_2)q_2^*=\frac{[(1-M)a-(2-M)c_2+c_3]^2}{(3-M)^2b} \quad (49)$$

We compare this profit to the profit in the unregulated CNE and prove the statement that the new profit is larger.

$$\frac{[(1-M)a-(2-M)c_2+c_3]^2}{(3-M)^2b} > \frac{(a+c_1-3c_2+c_3)^2}{4^2b} \quad (50)$$

After truncation of the multiplier *b* and taking the positive root of the above expressions, we obtain the familiar expression for the quantities of P_2 in the two equilibria (regulated and unregulated). For these, we already know that in the forced CNE the quantity of P_2 is larger and therefore it is also true that the profit of P_2 is larger. Similarly, the statement is proved for the profit of P_3.

Statement: ***The difference between P_1‘s quantity in the forced and unregulated equilibrium is a negative number (the regulated player‘s quantity offered will decrease)*.**

This statement is logically understandable, since we have proved that the total quantity decreases and the offers of P_2 and P_3 increase, but we will obtain a mathematical expression for this difference as well.

Proof:

$$q_1 - q_1^* = \Delta q_1 = \frac{M(2a-c_2-c_3)}{(3-M)b} - \frac{(a-3c_1+c_2+c_3)}{4b} = 3\frac{(3M-1)a+(3-M)c_1-(1+M)c_2-(1+M)c_3}{4(3-M)b} \quad (51)$$

Compared to the key condition, the expression in the numerator is the same condition but with a negative sign. We can also consider as formally proved the statement that in the new equilibrium the quantity offered by P_1 is less.

It is also proved (see Appendix B Proof that the profit of P_1 in the regulated CNE decreases) that the profit of P_1 in the new CNE has decreased.

***Conclusion**: through regulation, a redistribution of market quantities, and of the mass of profit between players is achieved, but this comes at the expense of a reduction in quantity supplied and an increase of the price for consumers.*

Instead of a conclusion

Recently, the EU decided to "sanction" Chinese manufacturers in the field of green technologies. The reason for this is that these manufacturers have 65% of the European market and win a "disproportionate" number of tenders. What is remarkable is that Chinese manufacturers are not considered as individual players in a game with many players, but as a single one subject to regulation.

We can predict what will happen on this market once the main supplier is artificially restricted or eliminated. The offer of equipment will diminish, prices will rise, and green projects will be delayed or rendered ineffective by higher prices. Also, "grey schemes" cannot be excluded, where local manufacturers will simply import items from Chinese suppliers, but assemble and sell them under their own brand, effectively just changing the labels.

Regardless of the methods used to restrict the strongest players - through prohibitions, quotas, confiscation of their assets or sudden underwater explosions, the result is predictable and is what we are seeing.

Disclaimer: The author accepts no responsibility if the reading of this article has resulted in injury to anyone's feelings, beliefs or convictions. Any such occurrence is completely coincidental and unintentional.

Appendix A. Proof of the existence of an CNE under regulation

We have to prove that no player can increase his profit if he unilaterally deviates from his optimal quantity and the other players do not. For P_2 and P_3, this proof holds for either player and therefore, it suffices to prove it for one of the two players. We will do it for P_2 using the formulas already obtained for the quantities of the three players. Let P_1 and P_3 maintain their quantities, as we have already derived:

$$q_1^* = \frac{M(2a-c_2-c_3)}{(3-M)b} \quad (52)$$

$$q_3^* = \frac{(1-M)a+c_2-c_3(2-M)}{(3-M)b} \quad (53)$$

We will prove that the quantity at which P_2 maximises its profit coincides with the one already derived (Formula 6 Optimal quantity offered by the regulated player in the forced equilibrium, Formula 7 Optimal quantity for P_2 in the forced equilibrium, Formula 8 Optimal quantity for P_3 in the forced equilibrium).

$$U_2 = [a - b\,(q_1^* + q_2 + q_3^*) - c_2]q_2 =$$
$$= \left\{a - b\left[\frac{M(2a - c_2 - c_3)}{(3-M)b} + \frac{(1-M)a + c_2 - c_3(2-M)}{(3-M)b} + q_2\right] - c_2\right\}q_2 =$$
$$= \left[a - \frac{a(1+M) + c_2(1-M) - 2c_3}{(3-M)} - c_2 - bq_2\right]q_2 =$$
$$= \left[\frac{2a(1-M) - 2(2-M)c_2 + 2c_3}{(3-M)} - bq_2\right]q_2 \quad (54)$$

From this expression, we obtain the first and second derivatives of the profit with respect to the quantity of P_2 and the profit maximisation conditions.

$$U_2' = \frac{2a(1-M) - 2(2-M)c_2 + 2c_3}{(3-M)} - 2bq_2 = 0 \quad (55)$$

$$U_2'' = -2b < 0 \quad (56)$$

$$q_2^* = \frac{2a(1-M) - 2(2-M)c_2 + 2c_3}{2b(3-M)} =$$
$$= \frac{a(1-M) - (2-M)c_2 + c_3}{b(3-M)} \quad (57)$$

The resulting expression for the optimal quantity for P_2 does not differ from the previous one (see Formula 7 Optimal quantity for P_2 in the forced equilibrium). This proved the statement that P_2 cannot improve its profit if P_1 and P_3 maintain their quantities.

Similarly, it is also proved that any change in the quantity of P_3 cannot improve its profit, but can only worsen it.

For the complete proof of CNE existence, we need to prove the same for P_1. But there are two special points.

The first one is that P_1 cannot increase its quantity without violating the constraint imposed by the Regulator, since the expression for its quantity was derived after limiting P_1's share by the maximum allowable *M*. Hence, for him, the only possibility to be examined is whether or not he can increase his profit **by reducin**g his proposed quantity relative to the maximum allowed by complying with the Regulator's requirements. Therefore, a CNE can (and will) be established on the market with the feature that the first player can increase its profit only if he violates the maximum market share constraint.

The second (technical), is the expression for the offer of P_1, which differs from the expressions for P_2 and P_3 and which does not lead to expressions that are so suitable for transformation.

Without changing the quantity for P_1, its profit would be expressed as follows (here we use the expressions already derived in Formula 10 Equilibrium price in the forced equilibrium and Formula 6 Optimal quantity offered by the regulated player in the forced equilibrium):

$$U_1^* = \left[\frac{(1-M)a + c_2 + c_3}{(3-M)} - c_1\right]\left[\frac{M(2a - c_2 - c_3)}{(3-M)b}\right] =$$
$$= \left[\frac{(1-M)a - (3-M)c_1 + c_2 + c_3}{(3-M)}\right]\left[\frac{M(2a - c_2 - c_3)}{(3-M)b}\right] \quad (58)$$

With this expression we will compare the profit of P_1 after reducing its quantity offered.

Suppose that P_1 reduces his quantity offered by some value *d*. Then the total quantity offered will become

$$Q^* - d = \frac{2a - c_2 - c_3}{(3-M)b} - d = \frac{2a - c_2 - c_3 - d(3-M)b}{(3-M)b} \quad (59)$$

This reduced quantity will reflect to an increase in the market price:

$$P^+ = a - b(Q^* - d) =$$
$$= a - b.\frac{2a - c_2 - c_3 - d(3-M)b}{(3-M)b} =$$
$$= \frac{(1-M)a + c_2 + c_3 + d(3-M)b}{(3-M)} \quad (60)$$

The profit of P_1 after reducing its quantity will be as follows:

$$U_1 = (P^+ - c_1).(q_1^* - d) = \left[\frac{(1-M)a+c_2+c_3+d(3-M)b}{(3-M)} - c_1\right]\left[\frac{M(2a-c_2-c_3)}{(3-M)b} - d\right] =$$
$$= \left[\frac{(1-M)a-(3-M)c_1+c_2+c_3+d(3-M)b}{(3-M)}\right]\left[\frac{M(2a-c_2-c_3)-d(3-M)b}{(3-M)b}\right] \quad (61)$$

This expression can be written as the sum of four addends, the first of which is exactly equal to the profit of P_1 before the reduction of its quantity:

$$U_1 = \left[\frac{(1-M)a-(3-M)c_1+c_2+c_3}{(3-M)}\right]\left[\frac{M(2a-c_2-c_3)}{(3-M)b}\right] - $$
$$-\frac{1}{b}\left[\frac{d(3-M)b}{(3-M)}\right]^2 + \left[\frac{d(3-M)b}{(3-M)}\right]\left[\frac{M(2a-c_2-c_3)}{(3-M)b}\right] -$$
$$-\left[\frac{d(3-M)b}{(3-M)b}\right]\left[\frac{(1-M)a-(3-M)c_1+c_2+c_3}{(3-M)}\right] \quad (62)$$

Our statement is that the profit before quantity reduction is strictly larger than the profit after quantity reduction, so we can write down:

$$U_1^* > U_1, \text{ i.e.}$$
$$\left[\frac{(1-M)a-(3-M)c_1+c_2+c_3}{(3-M)}\right]\left[\frac{M(2a-c_2-c_3)}{(3-M)b}\right] >$$
$$> \left[\frac{(1-M)a-(3-M)c_1+c_2+c_3}{(3-M)}\right]\left[\frac{M(2a-c_2-c_3)}{(3-M)b}\right] -$$
$$-\frac{1}{b}\left[\frac{d(3-M)b}{(3-M)}\right]^2 + \left[\frac{d(3-M)b}{(3-M)}\right]\left[\frac{M(2a-c_2-c_3)}{(3-M)b}\right] -$$
$$-\left[\frac{d(3-M)b}{(3-M)b}\right]\left[\frac{(1-M)a-(3-M)c_1+c_2+c_3}{(3-M)}\right] \quad (63)$$

The first additive on the right hand side of the inequality is equal to the profit on the left hand side of the inequality. The inequality simplifies to

$$0 > -\frac{1}{b}\left[\frac{d(3-M)b}{(3-M)}\right]^2 +$$
$$+\left[\frac{d(3-M)b}{(3-M)}\right]\left[\frac{M(2a-c_2-c_3)}{(3-M)b}\right] -$$
$$-\left[\frac{d(3-M)b}{(3-M)}\right]\left[\frac{(1-M)a-(3-M)c_1+c_2+c_3}{(3-M)b}\right] \quad (64)$$

The additive $-\frac{1}{b}\left[\frac{d(3-M)b}{(3-M)}\right]^2$ is a negative number. We will prove that the sum of the second and third addends is also a negative number and we end up with the sum of negative numbers on the right hand side of the inequality.

We group the second and third addends of the inequality and export the common multiplier $\frac{d(3-M)b}{(3-M)(3-M)b}$:

$$\left[\frac{d(3-M)b}{(3-M)}\right]\left[\frac{M(2a-c_2-c_3)}{(3-M)b} - \frac{(1-M)a-(3-M)c_1+c_2+c_3}{(3-M)b}\right] =$$
$$= \left[\frac{d(3-M)b}{(3-M)(3-M)b}\right][(3M-1)a - (1+M)c_2 -$$
$$-(1+M)c_3 + (3-M)c_1] \quad (65)$$

From the key condition (see Formula 4 Basic formula of the key condition) it follows

$$(3M-1)a - (1+M)c_2 - (1+M)c_3 +$$
$$+ (3-M)c_1 < 0 \quad (66)$$

which implies that the whole expression $\left[\frac{d(3-M)b}{(3-M)(3-M)b}\right][(3M-1)a - (1+M)c_2 - (1+M)c_3 + (3-M)c_1]$ is a negative number.

With this we proved the inequality and the statement that P_1 cannot increase his profit if he decreases his quantity offered. This was the missing piece of proof that given the new quantities there is a new, forced CNE in which the first player is required to offer a quantity at which its market share is exactly equal to the maximum allowed by the Regulator.

Appendix B. Proof that the profit of P$_1$ in the regulated CNE decreases

We know that in the forced equilibrium the quantity offered by P$_1$ decreases, but since the price and hence the profit per unit increases, we cannot directly and without proof argue that the profit of P$_1$ is necessarily lower.

Since the profit expressions in the unregulated and forced CNE are not so convenient to compare, we will have to prove the statement not by directly comparing the two profits in the two equilibria, but to prove that the difference between the profit U_1 in the forced equilibrium and the profit U_1^* in the equilibrium without regulation is a **negative** number.

We will decompose the difference between the two profits into expressions convenient to transform and simplify further.

$$U_1^* - U_1 = u_1^* q_1^* - (q_1^* + \Delta q_1)(u_1^* + \Delta u_1) = \\ = u_1^* q_1^* - u_1^* q_1^* - u_1^* \Delta q_1 - \\ - q_1^* \Delta u_1 - \Delta q_1 \Delta u_1 \quad (67)$$

We will prove that the following expression is a positive number:

$$-q_1^* \Delta u_1 - u_1^* \Delta q_1 - \Delta q_1 \Delta u_1 > 0 \quad (68)$$

The difference between the two per-unit profits is a positive number:

$$u_1 - u_1^* = \Delta u_1 = \frac{(1-M)a - (3-M)c_1 + c_2 + c_3}{(3-M)} - \\ - \frac{(a - 3c_1 + c_2 + c_3)}{4}$$

$$\Delta u_1 = \frac{(1-3M)a-(3-M)c_1+(1+M)c_2+(1+M)c_3}{4(3-M)} \quad (69)$$

The expression in the numerator is positive due to the fulfilment of the key condition and therefore the entire difference between the profits of P$_1$ is positive.

For Δq_1 we have

$$\Delta q_1 = 3\frac{(3M-1)a+(3-M)c_1-(1+M)c_2-(1+M)c_3}{4(3-M)b} = \\ = -3\frac{(1-3M)a-(3-M)c_1+(1+M)c_2+(1+M)c_3}{4(3-M)b} \quad (70)$$

and can now record the different addends in the inequality:

$$-q_1^* \Delta u_1 = -\frac{(a-3c_1+c_2+c_3)}{4b} \cdot \\ \cdot \frac{(1-3M)a-(3-M)c_1+(1+M)c_2+(1+M)c_3}{4(3-M)} \quad (71)$$

$$-u_1^* \Delta q_1 = -\frac{(a-3c_1+c_2+c_3)}{4} \cdot \\ \cdot \left[-3\frac{(1-3M)a-(3-M)c_1+(1+M)c_2+(1+M)c_3}{4(3-M)b}\right] = \\ 3.\frac{(a-3c_1+c_2+c_3)}{4} \cdot \\ \cdot \left[\frac{(1-3M)a-(3-M)c_1+(1+M)c_2+(1+M)c_3}{4(3-M)b}\right] \quad (72)$$

$$-\Delta q_1 \Delta u_1 = \\ = \left[-3\frac{(1-3M)a-(3-M)c_1+(1+M)c_2+(1+M)c_3}{4(3-M)b}\right] \cdot \\ \left[-\frac{(1-3M)a-(3-M)c_1+(1+M)c_2+(1+M)c_3}{4(3-M)}\right] = \\ = 3\frac{[(1-3M)a-(3-M)c_1+(1+M)c_2+(1+M)c_3]^2}{[4(3-M)]^2 b} \quad (73)$$

Each expression contains the key condition, which in our case is transformed as follows $(1-3M)a-(3-M)c_1+(1+M)c_2+(1+M)c_3 > 0$ and the denominator $4(3-M)b > 0$. Therefore, the above expressions can be simplified before summing and comparing the sum to 0. Our statement was that, the difference between the profits is a positive number and therefore, after truncation:

$$-\frac{(a-3c_1+c_2+c_3)}{4} + 3\frac{(a-3c_1+c_2+c_3)}{4} + \\ +3\frac{(1-3M)a-(3-M)c_1+(1+M)c_2+(1+M)c_3}{4(3-M)} = \\ = 2.\frac{(a-3c_1+c_2+c_3)}{4} + 3\frac{(1-3M)a-(3-M)c_1+(1+M)c_2+(1+M)c_3}{4(3-M)} > 0 \quad (74)$$

In this final expression, the two addends are both positive numbers, which implies that the difference between the profits in the two equilibria is also positive. Remember that the first additive is simply twice the profit per unit of P$_1$ in the unregulated equilibrium, and the numerator of the second additive is also a positive number because the key condition is satisfied. With this, we proved that the regulated player will **always** have lower profit in the forced CNE than in the unregulated CNE.

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