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Article

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THE EQUILIBRIUM AND SOCIALLY EFFECTIVE NUMBER OF FIRMS AT OLIGOPOLY MARKETS: THEORY AND EMPRIRICS

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Abstract

The paper considers impact of entry barriers on the social welfare. Despite the common opinion that entry barriers are always bad, the excessive number of firms' means, all pros aside, duplicated fixed costs. It is shown that the socially effective number of firms is smaller than the equilibrium one for the wide specter of demand and cost functions, and also for different strategies of companies' behavior. This proposition is satisfied for the homogeneous product markets where output of each company decreases when the number of firms increases, and competition gets stronger. But there is the considerable danger of the increasing probability of collusion in a situation of number of firms' limitation. We show that collusion is less dangerous than duplicated fixed costs if the gap between the choke price and marginal costs is less than a certain critical value connected with the ratio of fixed and variable costs. We back up our findings by the empirical research on the base of the financial statistics of the biggest world corporations.

Keywords: oligopoly, strategic interaction, firm concentration, entry barriers, collusion, Nash equilibrium, social welfare, market regulation, corporate statistics

JEL classification: D21, L13, L22

Introduction

The equilibrium state in economy is often socially ineffective. One can remember different examples of the prisoner's dilemma, tragedy of commons, insufficient financing of public good, or such situations studied in the contracts theory as negative selection and moral hazard. In all of them we need a special market design helps to decrease inefficiency. But we always should compare the market inefficiency and the inefficiency of regulation taking into account the possible risks of the behavior change of the economic agents.

In the paper we will concentrate on the problems of the industrial market design and particularly market concentration. Using theoretical models and empirical data we will answer the following two questions: is there excessive or insufficient number of firms at a market in equilibrium, and should we regulate it?

Most of the industrial markets in a modern economy are the imperfect competition markets where every producer is a price-maker. The most interesting for exploring market structure is the oligopoly where we can observe the wide specter of participants' behavior strategies from the price war to the collusion. A lot of books and papers are devoted to the different aspects of oligopolistic behavior. Among them we would emphasize monographs (Tirole, 1994; MasColell et al., 1995; Shy, 1995; (Carlton and Perloff, 2000; Belleflamme and Peitz, 2010). We also made a survey (Eisenberg and Filatov, 2012) of different oligopoly models.

The main feature of oligopoly is a small number of strategic firms maximizing their profits depending on the competitors' behavior. But there is a significant difference between duopoly and oligopoly with ten firms. So the best strategies, equilibrium and social welfare are strongly dependent on the firm concentration at a market, and entry barriers created by the incumbent firms (on the base of absolute cost advantages, increased returns to scale, and access to resources and technologies limitation) and government (through the system of licenses and permissions for doing business).

There is a common opinion that entry barriers are always bad for society, because they decrease the number of firms, weaken competition, raise prices and reduce quantities. However it shouldn't be forgotten that a lot of firms mean, all pros aside, duplicated fixed costs. Thus, free entry can lead to the both situations: excessive or unsufficient number of firms in equilibrium. And the correct conclusion depends on the market structure, types of demand and cost functions, and features of the strategic interaction between companies presented at a market.

Particularly (Spence, 1976) and (Dixit and Stiglitz, 1977) showed insufficient number of firms in equilibrium under monopolistic competition. It means that entry barriers at these markets are always bad. Among other reasons it is connected with increasing number of varieties of offered products in the situation of new firms' entrance and increasing competition. The opposite situation arises at the market of homogeneous product, often having oligopoly structure. About 30 years ago (Von Weizacker, 1980) and (Perry, 1984) expressed reasons for the desired limitation of excessive competition. (Mankiw, Whinston, 1986) formulated the conditions (usually, though not always satisfied) under which this reduction would lead to the social welfare maximization.

At the same time even many empirical papers – (Berry and Waldfogel, 1999) for radio broadcasting; (Hsei and Morretti, 2003) for real-estate sector; (Hortacsu and Syverson, 2004) for investment foundations; (Davis, 2006) for the cinema industry – didn't convince society, that entry barriers and reducing the number of firms at a market may be useful.

This is partly connected with misconceptions, initiated by the basic models of perfect competition, in which zero fixed costs lead to a definite conclusion «more firms is always better». Partly – with the really existing risks of possible modification of companies' behavior or welfare redistribution within society, that can be unfavorable for the majority even when the total welfare increases. Let us consider some of these problems in the paper.

The example with linear demand

Let us assume that n oligopolists with linear cost functions $TC_i\,(q_i) = cq_i + f$ interact at the homogeneous product market with inverse demand $p = a - bQ$. Each firm maximizes profit taking into account the competitors quantities as in the (Cournot, 1838) model:

$$\pi_i(q_i, q_{-i}) = pq_i - TC_i(q_i) = \left(a - bq_i - b\sum_{j\neq i} q_j\right)q_i - cq_i - f \to \max_{q_i} \cdot$$

Taking into account symmetry we can obtain equilibrium quantities and prices:

$$q^* = \frac{1}{n+1}\frac{a-c}{b}, \quad Q^* = \frac{n}{n+1}\frac{a-c}{b}, \quad p^* = \frac{1}{n+1}a + \frac{n}{n+1}c\,.$$

The firms profit then is equal to

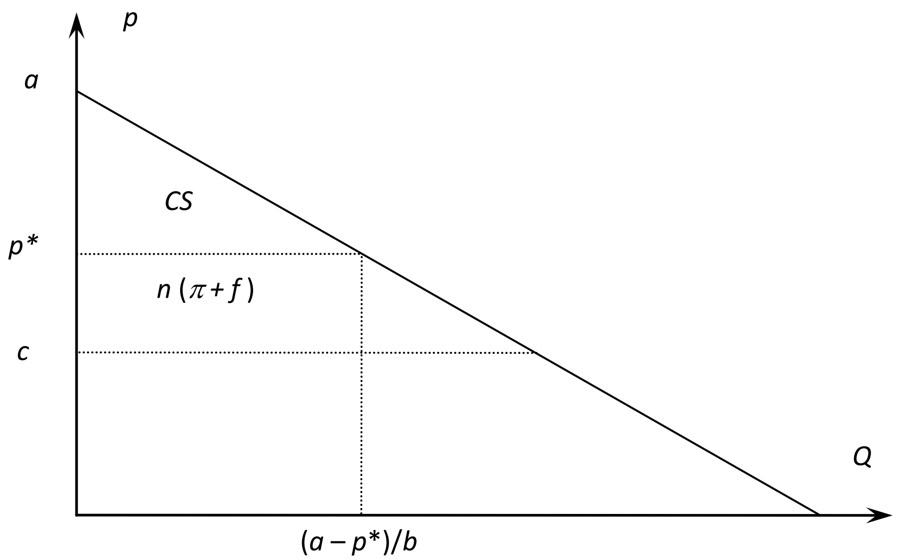
$$\pi^* = p^* q^* - cq^* - f = \frac{(a-c)^2}{(n+1)^2 b} - f \cdot$$

The number of firms is defined from the zero profit condition. Let's note that it's not just a theoretical fact. (Bresnahan and Reiss, 1991) on the basis of numerous data of the US food markets with fluctuating demand showed, that the entry and competition really happens under such conditions. So let's find the equilibrium number of firms at a market n_1:

$$\pi^* = 0, \quad \frac{(a-c)^2}{(n+1)^2} = bf, \quad n_1 = \sqrt{\frac{(a-c)^2}{bf}} - 1 \cdot$$

Let us then compare the equilibrium number of firms n_1 with the socially effective one n_2. The social welfare function is equal to the sum (Figure 1) of consumer surplus *CS* and total profit of all firms $n\pi$.

Figure 1: Consumer surplus, total profit and social welfare



Source: Own results

Let us maximize the social welfare function:

$$SW = CS + n\pi^* = \frac{1}{2}(a - p^*)nq^* + n\pi^* =$$

$$= \left(\frac{n}{n+1}\right)^2 \frac{(a-c)^2}{2b} + \frac{n(a-c)^2}{(n+1)^2 b} - nf = \frac{(a-c)^2}{2b}\left(1 - \frac{1}{(n+1)^2}\right) - nf \to \max_n .$$

After equating derivative of social welfare function to zero we can find the socially effective number of firms at a market n_2:

$$SW' = \frac{(a-c)^2}{b(n+1)^3} - f = 0, \quad (n+1)^3 = \frac{(a-c)^2}{bf}, \quad n_2 = \sqrt[3]{\frac{(a-c)^2}{bf}} - 1 \cdot$$

From the last obtained expression we will see that with any parameters of demand and cost functions the effective number of firms is smaller than equilibrium:

$$n_2 = \sqrt[3]{\frac{(a-c)^2}{bf}} - 1 < \sqrt{\frac{(a-c)^2}{bf}} - 1 = n_1 \cdot$$

The same result is also obtained for quadratic cost functions.

Generalization of the model and counterexample

Let us consider the homogeneous product market. We assume that there is monotonically decreasing inverse demand function $p = D^{-1}(Q)$. The cost functions of n identical oligopolists are the following: $TC(q) = f + VC(q)$. Taking into account the number of firms and their interaction strategies we can find quantities $q(n)$ and the market price $p(n) = D^{-1}(nq(n))$.
The social welfare function consists of consumer surplus (integrated spread between the maximum willingness to pay given in the form of the inverse demand function, and the current market price), and the total profit of firms:

$$\begin{aligned} SW = CS + n\pi(n) &= \int_0^{nq(n)} \left(D^{-1}(q) - p(n)\right)dq + n\left(p(n)q(n) - f - VC(q(n))\right) = \\ &= \int_0^{nq(n)} D^{-1}(q)dq - n\left(f + VC(q(n))\right) \end{aligned}$$

If there are no entry barriers at a market, the equilibrium number of firms can be obtained from the zero profit condition:

$$\pi(n_1) = p(n_1)q(n_1) - f - VC(q(n_1)) = 0.$$

It is possible to estimate how the number of firms impacts the social welfare:

$$\begin{aligned} \frac{\partial(SW)}{\partial n} &= \frac{\partial\left(\int_0^{nq(n)} D^{-1}(q)dq\right)}{\partial n} - f - \frac{\partial(nVC(q(n)))}{\partial n} = \\ &= p(n)\left(q(n) + n\frac{\partial q(n)}{\partial n}\right) - f - VC(q(n)) - nMC(q(n))\frac{\partial q(n)}{\partial n} = \\ &= p(n)q(n) - f - VC(q(n)) + n\left(p(n) - MC(q(n))\right)\frac{\partial q(n)}{\partial n} = \\ &= \pi(n) + n\left(p(n) - MC(q(n))\right)\frac{\partial q(n)}{\partial n}. \end{aligned}$$

As noted above, the first term in this equation is equal to zero in equilibrium:

$$\pi(n_1) = 0.$$

Let us also assume that the firm quantities decrease in situation of number of firms growth (business-stealing effect is present):

$$\frac{\partial q(n)}{\partial n} < 0, \tag{1}$$

and the market price exceeds marginal costs of production:

$$p(n) - MC(q(n)) > 0, \tag{2}$$

Then the second term and the whole derivative of social welfare at the equilibrium number of firms are negative:

$$\frac{\partial(SW)}{\partial n} < 0$$

It means that for social welfare maximization the social planner should decrease the number of firms with respect to their equilibrium quantity.
For most demand and cost functions, and strategies of firms' behavior the inequalities (1)-(2) are satisfied. But it's difficult to check them (especially the first one) even when we know everything about the market. For example assumption (1) is not satisfied for inverse proportionality demand function and the linear costs:

$$p = \frac{a}{Q} = \frac{a}{q_1 + \ldots + q_n}, \quad TC_i(q_i) = cq_i + f.$$

Let each producer operate as a Cournot competitor maximizing profit:

$$\pi_i = pq_i - cq_i - f = \frac{aq_i}{q_1 + \ldots + q_n} - cq_i - f \to \max.$$

Solving this problem for all symmetric firms we can find equilibrium prices and quantities:

$$q^* = \frac{a(n-1)}{n^2 c}, \quad Q^* = \frac{a(n-1)}{nc}, \quad p^* = \frac{n}{n-1}c \cdot$$

Firms' profits will be the following:

$$\pi^* = \frac{an}{n^2} - \frac{a(n-1)}{n^2} - f$$

The equilibrium number of firms can be found from the zero profit condition:

$$\pi^* = 0, \quad \frac{an}{n^2} - \frac{a(n-1)}{n^2} = f, \quad n_1 = \sqrt{\frac{a}{f}}$$

The social welfare function will be written as follows:

$$SW = \int_0^Q \frac{a}{q} - cQ - nf = a \ln \frac{a(n-1)}{nc} - \frac{a(n-1)}{n} - nf \cdot$$

Let us obtain the derivative of social welfare and estimate its sign at $n_1 = \sqrt{a/f}$:

$$SW' = \frac{\partial(SW)}{\partial n} = \frac{a}{n^2(n-1)} - f \cdot$$

$$SW'(n_1) = SW'\left(\sqrt{\frac{a}{f}}\right) = \frac{a}{\frac{a}{f}\left(\sqrt{\frac{a}{f}} - 1\right)} - f = \frac{f}{n_1 - 1} - f = f \cdot \frac{2 - n_1}{n_1 - 1}.$$

Thence, when $n_1 \in (1; 2)$ $SW'(n_1) > 0$, and the number of firms growth can increase the social welfare, which means insufficient number of firms in equilibrium. We can face this situation if $f > 0.25\alpha$, which means a very high level of fixed costs, that doesn't allow more than two firms enter the market.

Generally we can say that it's rather the exception than the rule. It's similar to the anti-competitive markets (Zhelobodko et al., 2012) where firms with market power increase prices during demand reduction. They are rare, but can be. And there are also several more questions:

1. We said that it is always necessary to decrease the number of firms from the equilibrium level. But can we state that the globally best for society number of firms is always less than the equilibrium one?
2. What is happening if we face the real situation with heterogeneous firms, for example with firms having different cost functions?
3. How the possible changes of firms' behavior, for example possible collusion, impact the market situation and social welfare?
4. How are the results connected with shares of fixed and variable costs, and what can we say about real markets on the base of empirical data?

The answer for the first question was given by (Mankiw and Whinston, 1986). They proposed one more assumption:

$$\frac{\partial Q(n)}{\partial n} > 0, \quad \lim_{n \to \infty} Q(n) < \infty. \tag{3}$$

The assumption (3) means that equilibrium market output rises with the number of firms entering the industry and approaches some finite bound. It provides the monotonic social welfare growth in situation when number of firms falls from the equilibrium to the optimum level, but it's also difficult to identify if it's satisfied.

The second research direction is connected with firms' heterogeneity. In reality producers are very different even within one country. Moreover, contrary to a popular opinion that some industries (for example, oil and gas) live well and obtain high profits, and the other (for example, agriculture) are on the edge of survival, interindustry distinctions in the firms' productivity are much less essential, than distinctions inside the industry. Particularly it was shown (Golikova et al, 2008) that the gap between the best 20% and the worst 20% Russian enterprises is equal to 9–24 times for different industries. So we should take it into account.

The theoretical models for heterogeneous firms are much more complicated. Instead of number of firms we should use Herfindahl-Hirschman Index as a measure of market concentration. But first preliminary results show the similar conclusions: there are too many firms in equilibrium. Of course we have to assume that when some firms should exit the market it would be the worst ones, the most effective firms would stay on. Otherwise everything is possible. Nevertheless, we will not focus on heterogeneity. Let us consider in detail the last two questions: by-effects and possible risks of the concentration growth, and empirical evidence.

Collusion and social welfare

The by-effect of reducing the number of firms at a market could be connected with the possible change of their strategies, particularly with increasing probability of collusion. Let's estimate the consequences it can lead to.

In situation of collusion firms maximize their total profit by establishing monopolistic price and quantities and then divide profits among them. For linear case it follows:

$$\pi = (a - bnq)q - cq - f \to \max, \quad a - 2bnq - c = 0,$$
$$q^* = \frac{a-c}{2bn}, \quad Q^* = \frac{a-c}{2b}, \quad p^* = \frac{a+c}{2}, \quad \pi^* = \frac{(a-c)^2}{4bn} - f.$$

The social welfare function will be:

$$SW = \frac{1}{2}\left(a - (a+c)/2\right)\frac{(a-c)}{2b} + \frac{(a-c)^2}{4bn}n - nf = \frac{3}{8}\frac{(a-c)^2}{b} - nf.$$

It should be noted that consumer surplus, total revenue and variable costs are independent from the number of firms, because prices and quantities coincide the monopolistic ones. So increasing number of firms in situation of collusion just duplicates fixed cost and influences negatively on social effectiveness.

Let us consider the numerical example with demand $p = 55 - Q$ and total cost function $TC(q) = 25+15q$. As it's followed from the obtained above formulas, the equilibrium number of firms will be seven, but at the same time for social welfare maximization it should be three firms.

In Table 1 we will show the individual and summarized market quantities, prices, profits, consumer surplus and social welfare for cases of equilibrium and socially effective number of firms, and also of monopoly. In the table 2 there is a similar information describing the market of cooperating firms

Table 1: Quantities, prices and social welfare in the model without collusion

n	***Q***	***Q***	***p***	***Π***	***CS***	***nπ***	***SW***
7	5	35	20	0	613	0	**613**
3	10	30	25	75	450	225	**675**
1	20	20	35	375	200	375	575

Source: Own results

Table 2: Quantities, prices and social welfare in the model with collusion

n	***Q***	***Q***	***p***	***Π***	***CS***	***nπ***	***SW***
7	2,86	20	35	32	200	225	425
3	6,67	20	35	108	200	325	**525**
1	20	20	35	375	200	375	575

Source: Own results

It is seen from the tables that after the number of firms decrease from seven to three social welfare increases from 613 to 675 (despite rising of prices and reduction of consumer surplus, firms' profits decrease at the greater extent). However, if the collusion is possible, the cooperated firms by increasing prices and decreasing quantities to the level of monopoly will reduce the social welfare function to the 525 which is worse not only than socially

effective value 675, but than initial equilibrium state 613. Further let us answer the question, whether the risk of collusion will always dominate the factor of fixed cost reduction.
Let us compare the social welfare in initial situation of equilibrium number of firms with no collusion and in possible under regulation situation of effective number of firms with collusion:

$$SW_{wo/col}(n_1) = \frac{1}{2}\frac{(a-c)^2}{b} - \frac{1}{2}\frac{(a-c)^2}{(n_1+1)^2 b} - n_1 f = \frac{1}{2}\frac{(a-c)^2}{b} + \frac{1}{2} f - \sqrt{\frac{(a-c)^2 f}{b}}$$

,

$$SW_{col}(n_2) = \frac{3}{8}\frac{(a-c)^2}{b} - n_2 f = \frac{3}{8}\frac{(a-c)^2}{b} + f - \sqrt[3]{\frac{(a-c)^2}{bf}} f .$$

Let us estimate under what range of parameters the new situation will be better than initial one, i.e. the inequality $SW_{col}(n_2) - SW_{wo/col}(n_1) > 0$ is satisfied. By defining $x = (a-c)^2 / b > 0$ we will get:

$$SW_{col}(n_2) - SW_{wo/col}(n_1) = -\frac{1}{8}x + \frac{1}{2} f + \sqrt{xf} - \sqrt[3]{xf^2}$$

Then let us consider the function $g(y)$, where $y = f/x = fb/(a-c)^2 < 1$:

$$g(y) = \frac{SW_{col}(n_2) - SW_{wo/col}(n_1)}{x} = -\frac{1}{8} + \frac{1}{2} y + \sqrt{y} - \sqrt[3]{y^2}$$

The positivity of function *g*(*y*) means that collusion is less dangerous than duplication of fixed cost which we can face in equilibrium. Derivative of function *g*(*y*):

$$g'(y) = \frac{1}{2} + \frac{1}{2\sqrt{y}} - \frac{2}{3\sqrt[3]{y}}$$

is always positive, it means that *g*(*y*) is increasing monotonously. Taking into account that:

$$g(0) = -\frac{1}{8} < 0, \quad g(1) = \frac{3}{8} > 0,$$

we can state that the only root of function *g*(*y*) lies in the interval of [0; 1]. By solving numerically the equation $g(y) = 0$ we can find that y*≈0.064. Going back to the initial variables we obtain, that $SW_{col}(n_2) - SW_{wo/col}(n_1) > 0$ when the following inequality is satisfied:

$$f > \frac{(a-c)^2}{2b} 2y^* \approx 0.128 \frac{(a-c)^2}{2b} . \qquad (4)$$

It should be noted that if to forget about fixed cost the expression $(a-c)^2/2b$ means the consumer surplus CS_{PC} in situation of perfect competition, i.e. when goods are on sale at the price equal to marginal cost. Thus, in situation of high fixed cost that exceeds 12.8% of CS_{PC} even the inevitable collusion of socially effective number of firms is preferable than competition of equilibrium number of firms.

The obtained boundary level of fixed cost is extremely high and is carried out quite seldom. But if it is known that the collusion is inevitable the lesser of two evils will be the transition from competition of excessive equilibrium number of firms to monopoly. In case of monopoly social welfare is determined by the following formula:

$$SW_{mon} = \frac{3}{8}\frac{(a-c)^2}{b} - f \,.$$

We will now estimate the values of model parameters, when the difference:

$$SW_{mon} - SW_{wo/col}(n_1) = -\frac{1}{8}\frac{(a-c)^2}{b} - \frac{3}{2}f + \sqrt{\frac{(a-c)^2 f}{b}}$$

is positive. Let's define $z = (a-c)/\sqrt{bf}$ and explore the function:

$$g(z) = \frac{SW_{mon} - SW_{wo/col}(n_1)}{f} = -\frac{1}{8}z^2 - \frac{3}{2} + z \,.$$

If $g(z)$ is positive, monopoly is the lesser of two evils. By solving the inequality:

$$-\frac{1}{8}z^2 + z - \frac{3}{2} > 0$$

We will get that $z \in (2; 6)$, which means that the inequality:

$$\frac{(a-c)^2}{bf} < 36$$

should be satisfied.

Thus, the transition to monopoly is better than competition of excessive equilibrium number of firms when:

$$f > \frac{1}{18} * \frac{(a-c)^2}{2b} = \frac{1}{18} * CS_{PC} \approx 0.056 * CS_{PC} \,,$$

i.e. when fixed cost exceeds 5.6% of consumer surplus in situation of perfect competition.

Thus, with a high share of the fixed component in the costs we are able not to be afraid of reducing the number of firms to the social effective level, despite increasing the collusion threat. Let us find out how the danger of collusion related to the share of fixed costs and the characteristics of the demand function. Let the equilibrium ratio of fixed and variable costs be the following:

$$\alpha = \frac{FC}{VC} = \frac{f}{cq} \cdot \tag{5}$$

Let us suppose also that we know how many times the «choke price» (the maximum price that the consumer is willing to pay for the product) exceeds the marginal cost:

$$\gamma = \frac{a}{c} \ . \tag{6}$$

Under linear demand and costs the optimal quantity of production is calculated by the formula

$$q^* = \frac{1}{n+1} \cdot \frac{a-c}{b},$$

and the equilibrium number of firms is equal to

$$n_1 = \sqrt{\frac{(a-c)^2}{bf}} - 1,$$

So the expression (5) can be rewritten as follows:

$$f = \alpha \cdot cq = \alpha \cdot c \frac{1}{n+1} \cdot \frac{a-c}{b} = \alpha c \frac{\sqrt{bf}}{a-c} \cdot \frac{a-c}{b} = \alpha c \sqrt{\frac{f}{b}},$$

$$f = \frac{\alpha^2 c^2}{b} \cdot$$

As it follows from (4) and (6), the collusion of social effective number of firms is the lesser of evil compared to the excessive equilibrium number of firms when

$$f > 0.064 \frac{(a-c)^2}{b} = 0.064 \frac{(\gamma - 1)^2 \cdot c^2}{b} \cdot$$

Using (6), we obtain the inequality

$$\frac{\alpha^2 \cdot c^2}{b} > 0.064 \frac{(\gamma-1)^2 \cdot c^2}{b}, \quad \alpha > 0.253(\gamma - 1), \quad \gamma < \bar{\gamma} = \frac{\alpha}{0.253} + 1 \approx 3.9\alpha + 1 \cdot$$

Consequently, the risk of collusion is not critically dangerous if the difference between «choke price» and marginal costs does not exceed a certain critical value associated with the ratio of fixed and variable costs.

An empirical investigation

As shown above, the positive or negative relationship between concentration and social efficiency is connected with the ratio of fixed and variable costs. It's possible to estimate this ratio for the largest world corporations on the base of statistics presented at the Bloomberg terminal. Let's see for example the «Digital» industry in the 1998-2012 years. Converting original currencies into US dollars (table 3) and taking into account inflation (table 4) let's use aggregate corporate data on total revenue (*TR*, table 5), variable costs (*VC*, table 6), and profits (π, table 7) to calculate the share of fixed costs (*FC*/*TC*, table 8) by the following formula:

$$\bar{\alpha} = \frac{FC}{TC} = 1 - \frac{VC}{TC} = 1 - \frac{VC}{TR - \pi} \cdot$$

Table 3: The nominal dollar exchange rate against euro and yen in 1998-2012

	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Euro	1.322	1.295	1.330	1.432	1.398	1.460	1.319	1.214	1.356	1.259	1.041	0.877	0.925	1.000	1.176
Yen	0.012	0.012	0.011	0.010	0.009	0.008	0.008	0.009	0.009	0.008	0.008	0.008	0.009	0.008	0.007

Source: Own results

Table 4: Consumer price index in USA in 1998-2012 (2012 = 1)

	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Price index	1	0.979	0.949	0.934	0.938	0.904	0.879	0.852	0.824	0.802	0.784	0.772	0.751	0.726	0.710

Source: http://www.usinflationcalculator.com (2015)

Table 5: Indexed variable costs of the «Digital» companies in 1998-2012, bln $

***VC*, bln $**	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Apple	87.8	65.8	41.7	27.5	25.9	18.2	15.6	11.6	7.3	5.6	5.3	5.3	7.7	6.1	6.3
HP	92.4	99.5	101.1	93.7	95.6	87.3	79.0	78.0	73.8	66.9	53.0	43.1	46.7	40.9	39.1
Dell	44.8	49.3	52.8	46.7	53.5	54.7	54.5	53.9	48.8	42.3	37.1	33.3	33.9	27.6	19.9
Fujitsu	39.8	41.4	39.3	39.3	36.0	37.2	37.0	37.6	39.4	37.2	33.9	39.8	48.7	46.0	40.6
Lenovo	29.8	26.7	20.3	15.9	14.0	15.4	13.8	13.4	3.1	3.2	2.8	2.9	4.1	2.7	1.8
IBM	54.2	58.0	56.7	55.6	61.8	63.1	60.4	64.1	73.7	70.0	64.9	66.3	74.6	76.6	71.5
Yahoo	1.6	1.6	2.8	3.1	3.2	3.1	3.0	2.5	1.6	0.4	0.2	0.2	0.2	0.1	0.1
WD	11.0	9.0	8.2	8.0	6.5	7.0	5.2	4.1	3.7	3.2	2.9	2.4	2.3	2.7	3.9
Microsoft	20.2	17.9	16.4	13.3	13.0	12.8	12.2	9.0	7.5	8.4	7.7	6.7	4.6	4.1	4.0
Oracle	7.1	8.0	8.8	6.1	5.1	5.5	4.8	3.8	3.2	2.9	3.0	3.1	3.9	4.1	4.3
Adobe	0.5	0.4	0.4	0.3	0.4	0.4	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Intel	20.2	20.7	15.9	16.7	17.9	20.4	19.5	18.5	17.6	16.3	17.2	17.5	16.9	16.3	17.1
Cisco	17.9	17.0	15.2	13.9	15.0	13.9	11.1	9.5	8.4	7.0	8.8	14.5	9.0	5.9	4.1
Panasonic	67.9	75.1	76.7	61.0	58.4	59.9	62.6	65.6	69.3	57.1	54.2	56.6	67.7	62.9	57.5
Sony	66.9	65.6	66.1	63.6	64.0	64.1	62.9	61.4	56.1	54.4	50.7	55.9	62.4	55.7	49.8

Source: Own results

Table 6: Indexed total revenue of the «Digital» companies in 1998-2012, bln $

***TR*, bln $**	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Apple	156.5	110.5	68.7	45.9	40.0	27.2	22.0	16.4	10.1	7.7	7.3	7.0	10.6	8.4	8.4
HP	120.4	129.9	132.8	122.6	126.2	115.4	104.3	101.8	97.0	91.1	72.2	58.6	65.1	58.4	55.5
Dell	56.9	63.4	64.8	56.6	65.1	67.7	65.3	65.5	59.7	51.7	45.2	40.4	42.5	34.8	25.7
Fujitsu	54.9	57.2	54.4	53.5	48.4	50.1	49.9	51.1	53.5	51.3	47.0	53.4	67.8	63.7	56.4
Lenovo	33.9	30.2	22.8	17.8	15.9	18.1	15.9	15.6	3.5	3.7	3.3	3.5	4.7	3.1	2.1
IBM	104.5	109.2	105.2	102.5	110.5	109.3	104.0	107.0	116.9	111.1	103.6	107.7	117.8	120.6	115.0
Yahoo	5.0	5.1	6.7	6.9	7.7	7.7	7.3	6.2	4.3	2.0	1.2	0.9	1.5	0.8	0.3
WD	15.4	12.7	10.0	10.5	7.9	8.9	6.2	5.1	4.4	3.8	3.5	2.8	2.6	2.7	3.9
Microsoft	77.8	75.3	73.7	66.9	62.3	66.9	58.2	52.0	48.3	45.9	41.1	36.8	33.7	31.6	27.8
Oracle	37.2	37.9	37.5	28.7	24.8	24.8	20.5	16.9	14.3	12.7	12.1	12.5	14.6	14.0	12.4
Adobe	4.4	4.3	4.0	3.2	3.8	3.5	2.9	2.3	2.0	1.6	1.5	1.6	1.7	1.4	1.3
Intel	53.3	55.1	46.0	37.6	40.1	42.4	40.3	45.6	41.5	37.6	34.1	34.4	44.9	40.5	37.0
Cisco	46.1	44.1	42.2	38.7	42.2	38.7	32.4	29.1	26.8	23.5	24.1	28.9	25.2	16.8	11.9
Panasonic	91.5	100.5	104.3	84.8	80.1	85.2	89.1	94.8	97.8	80.4	75.4	75.4	94.9	88.4	82.1
Sony	85.2	83.2	86.2	82.4	79.7	83.4	81.1	80.1	80.4	80.6	76.1	80.8	90.4	81.0	73.1

Source: Own results

Table 7: Indexed profit of the «Digital» companies in 1998-2012, bln $

π, bln. $	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Apple	41.7	26.5	14.8	8.8	6.5	3.9	2.3	1.6	0.3	0.1	0.1	0.0	1.0	0.8	0.4
HP	-12.7	7.2	9.2	8.2	8.9	8.0	7.1	2.8	4.2	3.2	-1.2	0.5	4.9	4.8	4.1
Dell	2.4	3.6	2.8	1.5	2.6	3.3	2.9	4.2	3.7	3.3	2.7	1.6	2.9	2.3	2.1
Fujitsu	-0.9	0.5	0.7	1.1	-1.2	0.5	1.0	0.7	0.4	0.5	-1.2	-4.1	0.1	0.5	-0.1
Lenovo	0.6	0.5	0.3	0.1	-0.2	0.5	0.2	0.0	0.2	0.2	0.2	0.2	0.0	0.1	0.1
IBM	16.6	16.2	15.6	14.4	13.2	11.5	10.8	9.3	9.1	9.5	4.6	10.0	10.8	10.6	8.9

Yahoo	0.9	1.1	1.3	0.6	0.4	0.7	0.9	2.2	1.0	0.3	0.1	-0.1	0.1	0.1	0.0
WD	1.0	1.6	0.8	1.5	0.5	1.0	0.6	0.5	0.2	0.2	0.2	0.1	-0.1	-0.3	-0.7
Microsoft	21.9	17.3	24.4	20.1	15.5	19.6	16.0	14.8	14.9	10.2	9.6	10.1	9.8	13.0	11.0
Oracle	10.9	10.2	9.0	6.6	6.0	6.1	4.9	4.0	3.5	3.3	2.9	2.9	3.4	3.7	1.8
Adobe	0.8	0.9	0.8	0.4	0.9	0.8	0.6	0.7	0.5	0.3	0.2	0.3	0.4	0.3	0.1
Intel	11.0	13.2	12.1	4.7	5.6	7.7	5.7	10.2	9.1	7.0	4.0	1.7	14.0	10.1	8.5
Cisco	8.0	6.6	8.2	6.6	8.6	8.1	6.3	6.7	5.3	4.5	2.4	-1.3	3.6	2.8	1.9
Panasonic	-9.4	-9.9	0.9	-1.2	-3.9	2.6	2.1	1.6	0.7	0.5	-0.2	-4.6	0.5	1.2	0.1
Sony	0.5	-5.9	-3.1	-0.5	-1.0	3.5	1.2	1.3	1.8	1.0	1.2	0.2	0.2	1.5	1.9

Source: Own results

Table 8: The share of fixed costs in the «Digital» companies in 1998-2012

FC/TC	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**	**1999**	**1998**
Apple	0.23	0.22	0.23	0.26	0.23	0.22	0.21	0.22	0.25	0.27	0.27	0.23	0.19	0.20	0.21
HP	0.31	0.19	0.18	0.18	0.18	0.19	0.19	0.21	0.20	0.24	0.28	0.26	0.22	0.24	0.24
Dell	0.18	0.18	0.15	0.15	0.14	0.15	0.13	0.12	0.13	0.13	0.13	0.14	0.14	0.15	0.16
Fujitsu	0.29	0.27	0.27	0.25	0.27	0.25	0.24	0.25	0.26	0.27	0.30	0.31	0.28	0.27	0.28
Lenovo	0.10	0.10	0.10	0.10	0.13	0.12	0.12	0.14	0.08	0.11	0.11	0.12	0.12	0.10	0.12
IBM	0.38	0.38	0.37	0.37	0.37	0.35	0.35	0.34	0.32	0.31	0.34	0.32	0.30	0.30	0.33
Yahoo	0.56	0.60	0.48	0.51	0.55	0.55	0.53	0.38	0.53	0.74	0.82	0.81	0.85	0.81	0.80
WD	0.24	0.19	0.12	0.12	0.12	0.12	0.07	0.11	0.11	0.11	0.10	0.10	0.15	0.09	0.15
Microsoft	0.64	0.69	0.67	0.72	0.72	0.73	0.71	0.76	0.77	0.77	0.75	0.75	0.81	0.78	0.76
Oracle	0.73	0.71	0.69	0.72	0.73	0.71	0.69	0.71	0.70	0.69	0.67	0.68	0.66	0.63	0.59
Adobe	0.86	0.87	0.87	0.88	0.87	0.85	0.86	0.92	0.91	0.91	0.89	0.92	0.91	0.88	0.86
Intel	0.52	0.51	0.53	0.49	0.48	0.41	0.43	0.48	0.46	0.47	0.43	0.47	0.45	0.46	0.40
Cisco	0.53	0.55	0.55	0.57	0.55	0.54	0.57	0.57	0.61	0.63	0.59	0.52	0.59	0.58	0.59
Panasonic	0.33	0.32	0.26	0.29	0.30	0.27	0.28	0.30	0.29	0.29	0.28	0.29	0.28	0.28	0.30
Sony	0.21	0.26	0.26	0.23	0.21	0.20	0.21	0.22	0.29	0.32	0.32	0.31	0.31	0.30	0.30

Source: Own results

Although total revenue, total costs, and especially profit have high volatility, the share of fixed costs is almost constant from year to year for all firms. Let's find the critical ratio between the choke price and the marginal costs for several companies of the «Digital» industry and estimate for them the risk of possible collusion connected with transition from the equilibrium number of firms to the socially effective one (Table 9).

Table 9: Risk of possible collusion depending on the share of the fixed costs

$\bar{\alpha}$	α	**Typical Company**	γ	**Risk**
0,1	0,11	Lenovo	1,4	Very high risk
0,25	0,33	Sony, Apple	2,3	High risk
0,5	1	Intel	5	Medium risk
0,75	3	Microsoft	13	Low risk
0,9	9	Adobe	37	No risk

Source: Own results

One can see that the costs of the collusion for companies engaged in the production of computers and digital technologies (such as «Lenovo», «Sony», «Apple») are quite serious in the situation of limited competition. Therefore, the regulation of these markets is impractical. Moreover, the social planner should restrict the possible increasing of market power caused by the companies presented at the market.

On the other hand, for the companies engaged in software development («Microsoft», «Adobe», etc.) the high share of R&D fixed costs leads to the fact that the restriction of competition may be socially efficient, despite the increased risk of collusion.

Conclusion and policy implications

The first result presented in the paper is that socially effective number of firms is smaller than the equilibrium one for the wide specter of demand and cost functions, and also for different strategies of companies' behavior. This proposition is satisfied for the markets where output of each company decreases when the number of firms increases, and the competition gets stronger.

Thus, the entry barriers, constructed by incumbent companies, do not always decrease social welfare. In some cases it's even good for government not to stimulate excessive competition but on the contrary to restrict the entry of new companies to the market.

At the same time there is the considerable danger of the increasing probability of collusion in a situation of number of firms limitation. We showed that the collusion is not very dangerous if the gap between the choke price and marginal costs is less than the certain critical value connected with ratio of fixed and variable costs.

When the entry barriers system is organized through licenses and permissions it's very important to restrict corruption which is highly probable, especially if the licenses distribution is carried out by officials, but not via auction. Also, as the entry barriers lead to social welfare redistribution (consumer surplus reduces with the simultaneous increase of firms' profits) it's very important to design the effective tax mechanisms of withdrawal of rent, gained because of higher level of monopoly power.

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