Joint impact of real and information asymmetries on market equilibrium

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This paper analyzes a duopoly model of sellers, which compete under conditions of the impact of real and information asymmetries. In the paper the equilibrium states of Cournot and Stackelberg are determined and the impact of all asymmetries is explicitly shown. The condition of Cournot superstable equilibrium is obtained, in which competitors can not increase their profits thanks to Stackelberg leadership. It is obtained that asymmetries influence each other in a nontrivial way: real asymmetries can dwindle the effect of information asymmetries, and information asymmetries can change the influence direction of real ones.

Keywords: duopoly, asymmetric information, quality and location asymmetry, Cournot and Stackelberg equilibrium.

Мельников С.В. СУМІСНИЙ ВПЛИВ РЕАЛЬНИХ ТА ІНФОРМАЦІЙНИХ АСИМЕТРІЙ НА РИНКОВУ РІВНОВАГУ

В роботі досліджується модель дуополії продавців, які конкурують в умовах дії реальних та інформаційних асиметрій. У статті визначено стани рівноваги Курно і Штакельберга та в явному вигляді показано вплив усіх асиметрій. Отримано умову надстійкої рівноваги Курно, при якої конкуренти не можуть збільшити свій прибуток за рахунок лідерства за Штакельбергом. Встановлено, що асиметрії впливають одна на одну у нетривіальний спосіб: реальні асиметрії можуть нівелювати дію інформаційних, а інформаційні – змінювати напрям впливу реальних.

Ключові слова: дуополія, асиметрична інформація, асиметрія якості та розташування, рівновага Курно та Штакельберга.

Мельников С.В. СОВМЕСТНОЕ ВЛИЯНИЕ РЕАЛЬНЫХ И ИНФОРМАЦИОННЫХ АСИММЕТРИЙ НА РЫНОЧНОЕ РАВНОВЕСИЕ

В работе исследуется модель дуополии продавцов, конкурирующих в условиях действия реальных и информационных асимметрий. В статье определены состояния равновесия Курно и Штакельберга и в явном виде показано влияние всех асимметрий. Получено условие сверхустойчивого равновесия Курно, при котором конкуренты не могут увеличить свою прибыль за счет лидерства по Штакельбергу. Установлено, что асимметрии влияют друг на друга нетривиальным образом: реальные асимметрии могут нивелировать действие информационных, а информационные – менять направление влияния реальных.

Ключевые слова: дуополия, асимметричная информация, асимметрия качества и местоположения, равновесие Курно и Штакельберга.

Problem setting and its connection with important scientific and practical tasks. The basis of a classical economic theory is the assumption of a completeness and accuracy of information held by the economic agents. On the basis of this assumption, a conclusion is made about the principle possibility of rational behavior of the economic agents and achieving the Pareto efficiency. However, this assumption does not correspond to economic reality and a lot of research in the XX century were devoted to the impact of informational and other types of asymmetry in market processes. The result of this research was the first in the XXI century, the Nobel Prize in economics that was awarded Akerlof, Spence, and Stiglitz for the development of the theory of markets with asymmetric information.

In this paper, we consider a duopoly model of sellers, which compete under conditions of the impact of real and information asymmetries. The equilibrium states of Cournot and Stackelberg are determined and the influence of all asymmetries is explicitly shown.

The article is organized as follows. In Section 2 and 3 we survey briefly some related literature and statement the problem. Section 4 describes the model only at the real asymmetries of quality and location. In section 5 we introduce the Akerlof information asymmetry and analyze how it is impacted on real asymmetries and sellers profits at Cournot equilibrium. In section 6 we introduce the Stackelberg information asymmetry and analyze the impact of all asymmetries. Section 7 is dedicated to comparative analysis

МАТЕМАТИЧНІ МЕТОДИ, МОДЕЛІ ТА ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ В ЕКОНОМІЦІ

of the equilibria. Finally, Section 8 summarizes the results.

Recent research and publications analysis. Akerlof [1] was the first one to describe the impact of asymmetric information on market equilibrium. In his seminal work (1970), Akerlof formalized the adverse selection that occurs in the used car market with the asymmetry of information about car quality between seller and buyer. Vives [2] considers the impact of private information about an uncertain linear demand on Cournot and Bertrand equilibria in the duopoly model. It is shown that if the goods are substitutes (not) to share information is a dominant strategy for each firm in Bertrand (Cournot) competition.

Zanchettin [3] has analyzed the impact of cost asymmetry and demand asymmetry on Bertrand and Cournot equilibria in a differentiated duopoly. The paper has shown that both the efficient firm's and industry profits are higher under Bertrand competition when asymmetry is strong and/or products are weakly differentiated. Wang at el. [4] has proposed an agent-based model to study the impact of asymmetric information on market evolution. The model proposed is able to demonstrate how the asymmetry of information leads to the adverse selection effect. The model also explains the coexistence of low- and high-quality goods in a market with asymmetric information. Ledvina and Sircar [5] have investigated how costs asymmetry impact on entry/exit decisions of firms at Cournot and Bertrand equilibria. The paper shows that due of cost asymmetry the differentiated goods result in more active firms in equilibrium than homogeneous goods.

Nagurney at el. [6] has developed a spatial price equilibrium model with information asymmetry in quality in that the producers at the supply markets are aware of their product quality whereas consumers at the demand markets are only aware of the average quality of the products. In the paper provided qualitative analysis of conditions for existence and uniqueness of equilibria as well as stability analysis for the solutions. Melnikov [7] has investigated Cournot and Stackelberg equilibria in the duopoly model in conditions of asymmetric information of quality. It is found that optimal for both duopolists is a Stackelberg equilibrium when the leader is a manufacturer of high-quality good.

Formulation of research objectives. Based on the analysis of the literature, the following types of the asymmetries impact on market equilibrium can be distinguished.

The first type is the impact of real asymmetries. This is the asymmetry of the values of market indicators. This asymmetry type is natural and always present in the economy. The examples of indicators at the micro level: costs, quality level, prices, activity strategy, production capacities, volumes of activity, location, etc., at the macro level: gross national income, gross regional product, equilibrium state (stability), a degree of monopolization, etc.

The second type is the impact of information asymmetries. This is the asymmetry of completeness, reliability and an availability of information between economic agents about market indicators. For example, asymmetry of Akerlof (asymmetry of information about a quality of goods between a seller and a buyer) and Stackelberg (asymmetry of information about a competitor's strategy between sellers).

The third type is the simultaneous impact of real and information asymmetries. As an example, we can cite the classical model from Akerlof [1], where there are a real asymmetry of quality and asymmetry of information about quality.

In the Melnikov [7] found that the Stackelberg asymmetry does not help the high-quality seller overcome the Akerlof asymmetry and earn more than a competitor. The leadership of a high-quality seller paradoxically increases a profit of the low-quality seller under conditions of the Akerlof asymmetry.

It is of interest to develop the results obtained by Melnikov [7] to the case of a location asymmetry between sellers. The aim of this paper is the analysis of the asymmetry impact on equilibrium states in the duopoly model.

The basic results and their justification. The model. Two sellers sell similar goods in the same markets, $m = 2 \cdot n + 1$, $n \in N$, N − set of natural numbers. Markets are located along a line, the distance between any neighboring markets is l.

One of the sellers sells low-quality goods (index 0), the other – high-quality goods (index 1). The relationship between goods quality levels is described by the quality asymmetry coefficient, $k > 1$. Assume that all unit costs of high-quality goods are higher in k times comparison with low-quality goods.

Transportation delivery costs per unit of the low-quality product per unit distance are equal t. Deliveries are made on a DDP agreement, goods stocks of sellers are unlimited.

Preferences of consumers in each market are described by the Cobb-Douglas utility function. In these conditions, the demand for goods is expressed by isoelastic functions. Consumers

have full information about quality and form a separate demand for low-quality goods: $p_0 = 1/q_0$, and high-quality goods: $p_1 = k/q_1$, where p_0, p_1 – market prices, q_0, q_1 – quantity supplied. Consumers are willing to pay for the same volume of high-quality goods k times greater. In each market, prices and sales volumes are the same.

We introduce into the model the location asymmetry. Location asymmetry arises when one of the sellers has a competitive advantage because of his location. In this model, location asymmetry is measured by the ratio of the total distance of sellers' transportations and depends on their location and the number of markets.

Assume that the low-quality seller is located on the 1-th market, and the high-quality seller is located in the center, on the market with index $(m+1)/2$ (Fig.1).

Obviously, the low-quality seller has a maximum and the high-quality seller has a minimum delivery distance of goods. The total transportation distance of the high-quality seller is: $L = l \cdot (m^2 - 1)/4$, low-quality seller: $d \cdot L$, where $d = 2 \cdot m/(m+1)$ – location asymmetry coefficient, $d \in [1,5; 2)$.

In conditions of complete information about goods quality the sellers are monopolists. Sellers profit functions:

$$F_0^{mono} = q_0 \cdot \left(m \cdot \frac{1}{q_0} - t \cdot d \cdot L \right) \to \max_{q_0},$$

$$F_1^{mono} = q_1 \cdot \left(m \cdot \frac{k}{q_1} - t \cdot k \cdot L \right) \to \max_{q_1}. \tag{1}$$

From (1) we see that for identical volumes of sales, $q_0 = q_1$, a profit of the high-quality seller is always higher than the low-quality seller. The real asymmetries of quality and location "work" in favor of the high-quality seller: $\partial F_0/\partial d < 0$, $\partial F_1/\partial k > 0$.

The impact of Akerlof information asymmetry. Suppose that the low-quality seller began to advertise its product as a quality one.

If consumers can not distinguish a quality of goods, then the Akerlof information asymmetry of arises. In conditions of the Akerlof asymmetry, consumers form the demand for both goods already in the form of a single function: $p = (1 - \alpha) \cdot p_0 + \alpha \cdot p_1 = (k+1)/(q_0 + q_1)$, where $\alpha = q_1/(q_0 + q_1)$ – market share of the high-quality goods, $(1 - \alpha)$ – market share of the low-quality goods.

In conditions of incomplete information about goods quality the sellers are duopolists. Sellers profit functions:

$$F_0^{duo} = q_0 \cdot \left(m \cdot \frac{k+1}{q_0 + q_1} - t \cdot d \cdot L \right) \to \max_{q_0},$$

$$F_1^{duo} = q_1 \cdot \left(m \cdot \frac{k+1}{q_0 + q_1} - t \cdot k \cdot L \right) \to \max_{q_1}.$$

Let's find the Cournot equilibrium and analyze how the Akerlof asymmetry affected the profits of sellers and the impact of real asymmetries. Putting the first derivatives, $\partial F_0^{duo}/\partial q_0 = 0$ and $\partial F_1^{duo}/\partial q_1 = 0$, and solving for q_0, q_1 one obtains:

$$q_0^* = \sqrt{\frac{m \cdot (k+1) \cdot q_1}{t \cdot d \cdot L}} - q_1,$$

$$q_1^* = \sqrt{\frac{m \cdot (k+1) \cdot q_0}{t \cdot k \cdot L}} - q_0, \tag{2}$$

which are the reaction functions.

The second derivatives are negative, $d^2 F_0/dq_0^2 < 0$, $d^2 F_1/dq_1^2 < 0$, what means the profit functions of reach a maximum.

Let's find the following equilibrium indicators (Table 1):

• the range of permissible values of the quality asymmetry coefficient k;
• the sales volumes: q_0^e, q_1^e, $Q^e = q_0^e + q_1^e$;
• the profits: F_0^e, F_1^e;
• the prices under conditions of effect of the Akerlof asymmetry p^e and in its absence p_0^e, p_1^e;
• the market share of high-quality goods α^e;
• the Akerlof point k^e. The Akerlof point corresponds to the value of the quality asymme-
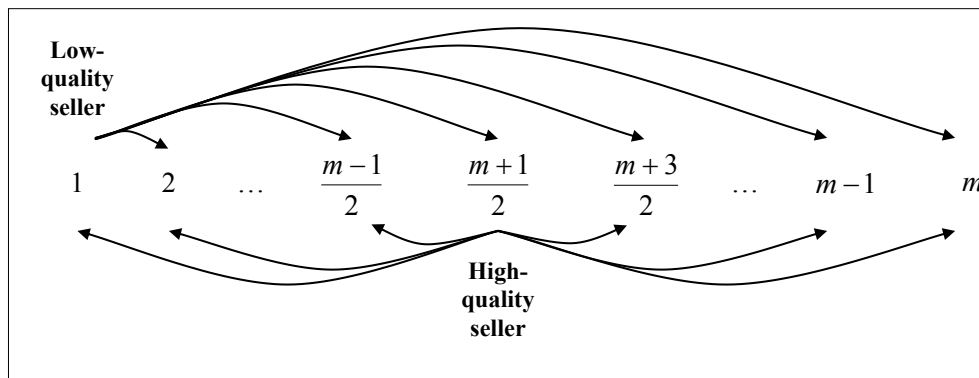

Fig. 1. Location of sellers

try coefficient, in which the duopoly disappears ("market failure"). A sign of the Akerlof point will be considered the absence of sales or profit or loss of equilibrium stability;

- the market share of high-quality goods in the Akerlof point $\alpha^e\left(k^e\right)$.

Let's analyze the results obtained. To analyze the impact of the Akerlof asymmetry on the profit of the low-quality seller, we calculate the coefficient: $A_0 = p^C/p_0^C = k\cdot(k+1)/(k+d)$, where p_0^C – the selling price of the low-quality good in volume q_0^C in the absence of the Akerlof asymmetry. Then the profit of the low-quality seller can be represented in the form:

$$F_0^C = q_0^C \cdot \left(m\cdot A_0 \cdot p_0^C - t\cdot d\cdot L\right). \qquad (3)$$

The impact of the coefficient A_0 on profit (3) is determined by conditions: $\partial A_0/\partial k > 0$, $\partial A_0/\partial d < 0$, $sign\left(A_0 - 1\right) = sign\left(k - \sqrt{d}\right)$. Because of location asymmetry, the low-quality seller benefits from the Akerlof asymmetry only when $k > \sqrt{d}$. At $k = \sqrt{d}$, the Akerlof asymmetry does not affect profit: $F_0^{mono}\left(q_0^C\right) = F_0^C\left(q_0^C\right)$.

To analyze the impact of the asymmetry Akerlof on profit of the high-quality seller, we calculate the coefficient: $A_1 = p^C/p_1^C = d\cdot(k+1)/\left(k\cdot(k+d)\right)$, where p_1^C – the selling price of the high-quality good in volume q_1^C in the absence of the Akerlof asymmetry. Then the profit of the high-quality seller can be represented in the form:

$$F_1^C = q_1^C \cdot \left(m\cdot A_1 \cdot p_1^C - t\cdot k\cdot L\right). \qquad (4)$$

The impact of the coefficient A_1 on profit (4) is determined by conditions: $\partial A_1/\partial k < 0$, $\partial A_1/\partial d > 0$, $sign\left(1 - A_1\right) = sign\left(k - \sqrt{d}\right)$. With the Akerlof asymmetry, the high-quality seller benefits from location asymmetry only up to $k < \sqrt{d}$. At $k = \sqrt{d}$, the Akerlof asymmetry does not affect profit: $F_1^{mono}\left(q_1^C\right) = F_1^C\left(q_1^C\right)$.

From Table 1 it follows that sale volumes and profits at the Cournot equilibrium are always positive. To find the Akerlof point, we will analyze the equilibrium stability. Let's consider the two-dimensional map:

$$q_0^*\left(t+1\right) = \sqrt{\frac{m\cdot(k+1)\cdot q_1(t)}{t\cdot d\cdot L}} - q_1(t),$$
$$q_1^*\left(t+1\right) = \sqrt{\frac{m\cdot(k+1)\cdot q_0(t)}{t\cdot k\cdot L}} - q_0(t). \qquad (5)$$

The stability of the map fixed point (5), $\left(q_0^C, q_1^C\right)$, is defined by multiplicators μ_1, μ_2, which are eigenvalues of Jacobian matrix at the fixed point: $J = \begin{pmatrix} 0 & \dfrac{k-d}{2\cdot d} \\ -\dfrac{k-d}{2\cdot k} & 0 \end{pmatrix}$. The multiplicators are roots of the characteristic equation

$$\mu^2 + |J| = \mu^2 + \frac{\left(k-d\right)^2}{4\cdot k\cdot d} = 0. \qquad (6)$$

From (6) it follows that the eigenvalues are pure imaginary. As is known, the boundary of the stability region of a two-dimensional map for pure imaginary multiplicators is found from condition $|J| = 1$. Equating $|J| = 1$, we find the value of the quality asymmetry coefficient at which the Cournot equilibrium loses stability: $k^C = d\cdot P$, where $P = 3 + 2\cdot\sqrt{2}$ – the Puu point (bifurcation point in a duopoly model with one market [8]).

Equating $\mu_1 = \mu_2 = 0$, we find the value of the quality asymmetry coefficient at which the Cournot equilibrium is a superstable: $k = d$.

The relationship between equilibrium sales volumes depends on the superstable point: $sign\left(q_0^C - q_1^C\right) = sign\left(k - d\right)$. Dynamics of equilibrium sales volumes, depending on the quality asymmetry coefficient, is shown in Fig. 2 (a). Data: $t = 1$, $l = 0,1$, $m = 3$, $k \in \left(1; 9,375\right]$. The

Table 1

The Cournot equilibrium

Seller	k	q^C	Q^C	F^C		
low quality	$1 < k < d\cdot P$	$\dfrac{m\cdot k\cdot(k+1)}{t\cdot L\cdot(k+d)^2}$	$\dfrac{m\cdot(k+1)}{t\cdot L\cdot(k+d)}$	$\dfrac{m\cdot k^2\cdot(k+1)}{(k+d)^2}$		
high quality		$\dfrac{m\cdot d\cdot(k+1)}{t\cdot L\cdot(k+d)^2}$		$\dfrac{m\cdot d^2\cdot(k+1)}{(k+d)^2}$		
p_0^C		p^C	p_1^C	α^C	k^C	$\alpha^C\left(k^C\right)$
$\dfrac{t\cdot L\cdot(k+d)^2}{m\cdot k\cdot(k+1)}$		$\dfrac{t\cdot L\cdot(k+d)}{m}$	$\dfrac{t\cdot k\cdot L\cdot(k+d)^2}{m\cdot d\cdot(k+1)}$	$\dfrac{d}{k+d}$	$d\cdot P$	$\dfrac{1}{P+1} = 14,6\%$

Akerlof point: $k^C = 8,74$, the superstable point: $k = d = 1,5$. An increase in the number of markets leads to a decrease in equilibrium sales volumes and an increase in the level of the Akerlof point. This is clearly seen in the bifurcation diagrams of the high-quality seller (Fig. 2 (b)). Data: $t = 1$, $l = 0,1$, $m = 3$, $m = 5$, $k \in [8; 10,415]$. The points of Akerlof: $k^C (m = 3) = 8,74$, $k^C (m = 5) = 9,71$.

From Fig. 2 we see that an increase of investment in quality paradoxically leads to the ousting of high-quality goods from the market. If consumers can't distinguish the quality of goods, then the high-quality seller will either have to leave the market or switch to sale of the low-quality good. As a result, the duopoly is reduced to the market of low-quality goods. Thus, given model illustrates the adverse selection that results from the information asymmetry about quality [1].

The impact of Stackelberg information asymmetry. Now we introduce into the model the Stackelberg information asymmetry. Stackelberg information asymmetry arises when one of the sellers (leader) knows the competitor's reaction curve, and competitor (follower) does not own such information. Assume that the low-quality seller is a leader, and the high-quality seller is a follower. The new profit function of the low-quality seller is:
$$F_0 = \sqrt{t \cdot k \cdot L \cdot m \cdot (k+1) \cdot q_0} - t \cdot d \cdot L \cdot q_0 \to \max_{q_0}.$$

Using the standard procedure, we find the equilibrium indicators (Table 2).

Let's analyze how a leadership of the low-quality seller affects the Cournot equilibrium. The impact on the equilibrium price we express in the form of a coefficient, which is defined as: $S_p^0 = p^{S_0}/p^C = 2 \cdot d/(k+d)$, where the superscript indicates the leader, and the lower index indicates the influence indicator. The impact of real asymmetries on the equilibrium price is determined by conditions: $\partial S_p^0/\partial k < 0$, $\partial S_p^0/\partial d > 0$, $sign(1 - S_p^0) = sign(k - d)$.

The impact on the sales volume of the low-quality seller we express in the form of a coefficient, which is defined as: $S_{q_0}^0 = q_0^{S_0}/q_0^C = (k+d)^2/(4 \cdot d^2)$. Then the profit of the low-quality seller can be represented in the form:
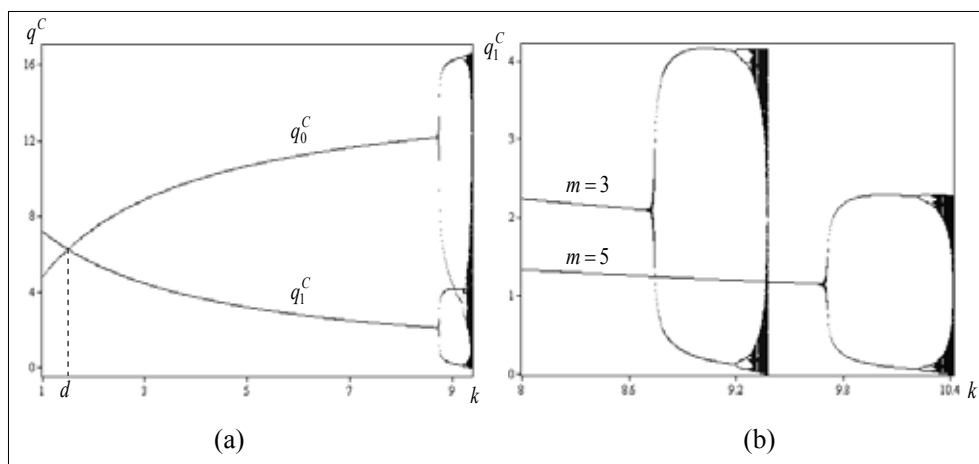

Figure 2. Bifurcation diagrams of sellers

Table 2

The Stackelberg equilibrium, leader is the low-quality seller

Seller	k	q^{S_0}	Q^{S_0}	F^{S_0}
low quality	$1 < k < 2 \cdot d$	$\dfrac{m \cdot k \cdot (k+1)}{4 \cdot t \cdot L \cdot d^2}$	$\dfrac{m \cdot (k+1)}{2 \cdot t \cdot L \cdot d}$	$\dfrac{m \cdot k \cdot (k+1)}{4 \cdot d}$
high quality		$\dfrac{m \cdot (k+1) \cdot (2 \cdot d - k)}{4 \cdot t \cdot L \cdot d^2}$		$\dfrac{m \cdot (k+1) \cdot (2 \cdot d - k)^2}{4 \cdot d^2}$

$p_0^{S_0}$	p^{S_0}	$p_1^{S_0}$	α^{S_0}	k^{S_0}	$\alpha^{S_0}(k^{S_0})$
$\dfrac{4 \cdot t \cdot L \cdot d^2}{m \cdot k \cdot (k+1)}$	$\dfrac{2 \cdot t \cdot L \cdot d}{m}$	$\dfrac{4 \cdot k \cdot t \cdot L \cdot d^2}{m \cdot (k+1) \cdot (2 \cdot d - k)}$	$\dfrac{2 \cdot d - k}{2 \cdot d}$	$2 \cdot d$	0%

$$F_0^{S_0} = S_{q_0}^0 \cdot q_0^C \cdot \left(m \cdot S_p^0 \cdot p^C - t \cdot d \cdot L \right). \qquad (7)$$

The impact of the coefficient $S_{q_0}^0$ on profit (7) is determined by conditions: $\partial S_{q_0}^0 / \partial k > 0$, $\partial S_{q_0}^0 / \partial d < 0$, $sign\left(S_{q_0}^0 - 1 \right) = sign(k - d)$. At $k = d$, the Stackelberg asymmetry does not affect profit: $F_0^{S_0} \left(q_0^{S_0} \right) = F_0^C \left(q_0^C \right)$.

The impact on the sales volume of the high-quality seller we express in the form of a coefficient, which is defined as: $S_{q_1}^0 = q_1^{S_0} / q_1^C = (2 \cdot d - k) \cdot (k + d)^2 / \left(4 \cdot d^3 \right)$. Then the profit of the high-quality seller can be represented in the form:

$$F_1^{S_0} = S_{q_1}^0 \cdot q_1^C \cdot \left(m \cdot S_p^0 \cdot p^C - t \cdot k \cdot L \right). \qquad (8)$$

The impact of the coefficient $S_{q_1}^0$ on profit (8) is determined by conditions: $sign\left(\partial S_{q_1}^0 / \partial d \right) = sign(k - d)$, $sign\left(\partial S_{q_1}^0 / \partial k \right) = sign(d - k)$, $S_{q_1}^0 \leq 1$. At $k = d$, the Stackelberg asymmetry does not affect profit: $F_1^{S_0} \left(q_1^{S_0} \right) = F_1^C \left(q_1^C \right)$.

Assume that the high-quality seller is a leader, and the low-quality seller is a follower. The new profit function of the high-quality seller is: $F_1 = \sqrt{t \cdot d \cdot L \cdot m \cdot (k + 1)} \cdot q_1 - t \cdot k \cdot L \cdot q_1 \to \max_{q_1}$.

Using the standard procedure, we find the equilibrium indicators (Table 3).

To determine the Akerlof point in the Stackelberg equilibrium $\left(q_0^{S_1}, q_1^{S_1} \right)$, it is necessary to specify the lower boundary of a market share of the high-quality good, at which the seller will leave the market.

Let's analyze how the leadership of the high-quality seller impacted the Cournot equilibrium. The impact on the equilibrium price we express in the form of a coefficient, which is defined as: $S_p^1 = p^{S_1} / p^C = 2 \cdot k / (k + d)$. The impact of the real asymmetries on the equilibrium price is determined by conditions: $\partial S_p^1 / \partial k > 0$, $\partial S_p^1 / \partial d < 0$, $sign\left(S_p^1 - 1 \right) = sign(k - d)$.

The impact on the sales volume of the low-quality seller we express in the form of a coefficient, which is defined as: $S_{q_0}^1 = q_0^{S_1} / q_0^C = (2 \cdot k - d) \cdot (k + d)^2 / \left(4 \cdot k^3 \right)$. Then the profit of the low-quality seller can be represented in the form:

$$F_0^{S_1} = S_{q_0}^1 \cdot q_0^C \cdot \left(m \cdot S_p^1 \cdot p^C - t \cdot d \cdot L \right). \qquad (9)$$

The impact of the coefficient $S_{q_0}^1$ on profit (9) is determined by conditions: $sign\left(\partial S_{q_0}^1 / \partial k \right) = sign(d - k)$, $sign\left(\partial S_{q_0}^1 / \partial d \right) = sign(k - d)$, $S_{q_0}^1 \leq 1$. At $k = d$, the Stackelberg asymmetry does not affect profit: $F_0^{S_1} \left(q_0^{S_1} \right) = F_0^C \left(q_0^C \right)$.

The impact on the sales volume of the high-quality seller we express in the form of a coefficient, which is defined as: $S_{q_1}^1 = q_1^{S_1} / q_1^C = (k + d)^2 / \left(4 \cdot k^2 \right)$. Then the profit of the high-quality seller can be represented in the form:

$$F_1^{S_1} = S_{q_1}^1 \cdot q_1^C \cdot \left(m \cdot S_p^1 \cdot p^C - t \cdot k \cdot L \right). \qquad (10)$$

The impact of the coefficient $S_{q_1}^1$ on profit (10) is determined by conditions: $\partial S_{q_1}^1 / \partial k < 0$, $\partial S_{q_1}^1 / \partial d > 0$, $sign\left(1 - S_{q_1}^1 \right) = sign(k - d)$. At $k = d$, the Stackelberg asymmetry does not affect profit: $F_1^{S_1} \left(q_1^{S_1} \right) = F_1^C \left(q_1^C \right)$.

Thus, information asymmetries can change an action direction of real asymmetries, and real asymmetries can dwindle ("turn off") an action of information asymmetries.

The comparative analysis of equilibria. The relationship between sales volumes and profits in different equilibrium states depends significantly on the superstable point. Let's consider all cases.

1) $1 < k < d$. The sellers' volumes sales: $q_1^{S_1} > q_1^C > q_0^{S_0} > q_0^C > \left\{ q_0^{S_0}; q_0^{S_1} \right\}$, $sign\left(q_0^{S_0} - q_0^{S_1} \right) = sign\left(d \cdot (\Phi - 1) - k \right)$, where $\Phi = \left(1 + \sqrt{5} \right) / 2$ − the golden ratio.

The profits: $F_1^{S_0} > F_1^{S_1} > F_1^C > F_0^{S_0} > F_0^C > F_0^{S_1}$. The prices and total sales: $p^{S_0} > p^C > p^{S_1}$, $Q^{S_0} < Q^C < Q^{S_1}$.

Table 3

The Stackelberg equilibrium, leader is the high-quality seller

Seller	k	q^{S_1}	Q^{S_1}	F^{S_1}
low quality		$\dfrac{m \cdot (k + 1) \cdot (2 \cdot k - d)}{4 \cdot t \cdot L \cdot k^2}$	$\dfrac{m \cdot (k + 1)}{2 \cdot t \cdot L \cdot k}$	$\dfrac{m \cdot (k + 1) \cdot (2 \cdot k - d)^2}{4 \cdot k^2}$
high quality	$k > 1$	$\dfrac{m \cdot d \cdot (k + 1)}{4 \cdot t \cdot L \cdot k^2}$		$\dfrac{m \cdot d \cdot (k + 1)}{4 \cdot k}$
$p_0^{S_1}$		p^{S_1}	$p_1^{S_1}$	α^{S_1}
$\dfrac{4 \cdot t \cdot L \cdot k^2}{m \cdot (k + 1) \cdot (2 \cdot k - d)}$		$\dfrac{2 \cdot t \cdot L \cdot k}{m}$	$\dfrac{4 \cdot t \cdot L \cdot k^3}{m \cdot d \cdot (k + 1)}$	$\dfrac{d}{2 \cdot k}$

Table 4

Numerical example

Indicators	States of equilibrium								
	$1 < k < d$, $k = d \cdot (\Phi - 1)$			$k = d = 1,8$			$k > d$, $k = 2,2$		
	C	S0	S1	C	S0	S1	C	S0	S1
q_0^e	1,247	0,816	0,816	1,750	1,750	1,750	1,980	2,444	1,934
q_1^e	2,017	1,825	3,457	1,750	1,750	1,750	1,620	1,556	1,339
Q^e	3,264	2,641	4,273	3,500	3,500	3,500	3,600	4,000	3,273
F_0^e	2,774	2,938	0,693	6,300	6,300	6,300	8,712	8,800	10,056
F_1^e	7,262	9,077	7,691	6,300	6,300	6,300	5,832	4,356	5,891
$p_0\left(q_0^e\right)$	0,802	1,226	1,226	0,571	0,571	0,571	0,505	0,409	0,517
p^e	0,647	0,800	0,494	0,800	0,800	0,800	0,889	0,800	0,978
$p_1\left(q_1^e\right)$	0,551	0,610	0,322	1,029	1,029	1,029	1,358	1,414	1,643
α	0,618	0,691	0,809	0,500	0,500	0,500	0,450	0,389	0,409
$A_0\ \left(A_1\right)$	0,807 (1,174)			1,400 (0,778)			1,760 (0,655)		
$S_p^0\ \left(S_p^1\right)$	1,236 (0,764)			1,000 (1,000)			0,900 (1,100)		
$S_{q_0}^0\ \left(S_{q_0}^1\right)$	0,655 (0,655)			1,000 (1,000)			1,235 (0,977)		
$S_{q_1}^0\ \left(S_{q_1}^1\right)$	0,905 (1,714)			1,000 (1,000)			0,960 (0,826)		

Thanks to the location asymmetry, the high-quality seller sells more and receives more profit. Note that the optimal for both duopolists is the equilibrium $\left(F_0^{S_0}, F_1^{S_0}\right)$. Thus, the profit of the high-quality seller on the follower position turned out to be greater than on the leader position.

2) $k = d$. The sellers' volumes sales: $q_0^C = q_0^{S_0} = q_0^{S_1} = q_1^C = q_1^{S_0} = q_1^{S_1} = m \cdot (k+1)/(4 \cdot t \cdot L \cdot k)$. The profits: $F_0^C = F_0^{S_0} = F_0^{S_1} = F_1^C = F_1^{S_0} = F_1^{S_1} = m \cdot (k+1)/4$. The prices and total sales: $p^C = p^{S_0} = p^{S_1}$, $Q^C = Q^{S_0} = Q^{S_1}$.

It is obtained that in a state of the superstable Cournot equilibrium duopolists can not increase their profits with the help of the Stackelberg asymmetry. In this equilibrium state, a transport costs of the sellers are equalized, and the real asymmetries compensate each other.

3) $k > d$. The volumes sales: $q_0^{S_0} > q_0^C > q_0^{S_1} > > q_1^C > \left\{ q_1^{S_0}, q_1^{S_1} \right\}$, $sign\left(q_1^{S_1} - q_1^{S_0}\right) = sign(k - d \cdot \Phi)$. The profits: $F_0^{S_1} > F_0^{S_0} > F_0^C > F_1^{S_1} > F_1^C > F_1^{S_0}$. The prices and total sales: $p^{S_0} < p^C < p^{S_1}$, $Q^{S_0} > Q^C > Q^{S_1}$.

It is obtained that the high-quality seller can not overcome the Akerlof information asymmetry

with the help of the Stackelberg asymmetry. Note that the optimal for both duopolists is the equilibrium $\left(F_0^{S_1}, F_1^{S_1}\right)$. Thus, the profit of the low-quality seller on the follower position turned out to be greater than on the leader position.

Let's illustrate the comparative analysis of the equilibria on a numerical example (Table 4). Data: $m = 9$, $t = 1$, $l = 0,1$, $d = 1,8$.

Conclusions and prospects for further research. As a result of the analysis it was found that asymmetries exert a significant influence not only on a market equilibrium, but also on a market structure. Also, asymmetries affect each other: information asymmetries can change an action direction of real asymmetries, and real asymmetries can dwindle ("turn off") an action of information asymmetries. It is received that in the Akerlof model with location asymmetry, profit of the high-quality seller can exceed profit of the low-quality seller. With a small difference in quality, the high-quality seller benefits from its location. A superstable state is defined in which the solutions of duopolists in the Cournot and Stackelberg equilibria coincide.

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