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## Self-interest, Social Wealth, and Competition as a Discovery Procedure

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### **Abstract**

In Economics, as in any social science, empirical tests of theoretical results face a problem: researchers are unable to reproduce the whole economy (or at least its relevant parts) in their laboratories. Nowadays, Experimental Economics uses stylized experiments, drawing on the experience of Psychology, to test at least the basic assumptions of the economic theory of human behavior. Even classroom experiments may serve this purpose. This paper describes a simple classroom experiment that serves as an empirical test of Adam Smith's invisible-hand hypothesis. Furthermore, it demonstrates to the students that competition acts as a discovery procedure. The experiment is of high didactical value, since the students gain insights into empirical research and experience how markets work.

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# Self-interest, Social Wealth, and Competition as a Discovery Procedure.

A classroom experiment that makes the “invisible hand” visible.

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In Economics, as in any social science, empirical tests of theoretical results face a problem: researchers are unable to reproduce the whole economy (or at least its relevant parts) in their laboratories. Nowadays, Experimental Economics uses stylized experiments, drawing on the experience of Psychology, to test at least the basic assumptions of the economic theory of human behavior. Even classroom experiments may serve this purpose. This paper describes a simple classroom experiment that serves as an empirical test of Adam Smith's invisible-hand hypothesis. Furthermore, it demonstrates to the students that competition acts as a discovery procedure. The experiment is of high didactical value, since the students gain insights into empirical research and experience how markets work.

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*Keywords: Hayek-Hypothesis, Efficiency, Double Oral Auctions*

Die empirische Prüfung theoretischer Forschungsergebnisse wirft in der Ökonomie - wie bei jeder Sozialwissenschaft - Probleme auf. Anders als in den Naturwissenschaften können volkswirtschaftliche Problemstellungen kaum in Labors nachgestellt werden. Seit einigen Jahren nutzen Ökonomen allerdings die Erfahrungen der Psychologie mit stilisierten Experimenten, um zumindest ihre grundlegenden Verhaltenshypothesen testen zu können. Dieser Beitrag stellt ein einfaches Hörsaal-Experiment vor, das Adam Smiths Hypothese von der „unsichtbaren Hand“ im Marktgeschehen empirisch überprüft. Das Experiment zeigt zudem, wie Wettbewerb als Entdeckungsverfahren funktioniert, und besitzt hohen didaktischen Wert: Die Studenten erhalten Einblick in empirische Forschung und erleben hautnah das Funktionieren des Marktes.

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\* Assistant professor of Economics and corresponding author. Research on this paper was finished while I enjoyed the hospitality of the Economics Department of the University of California in Santa Barbara. I am grateful to Jennifer Brown (UCSB) for helping to improve our use of the English language.

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## 1. Self-interest and general wealth

The Scottish moral philosopher and founding father of economics Adam Smith made, in his famous work “The Wealth of Nations”, an assertion about this new discipline that even nowadays may sound strange and auspicious to outsiders. Its starting point is the realization that humans act out of self-interest, thus that no one should rely on the benevolence of others: *“It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner, but from their regard of their own interest. We address ourselves not to their humanity, but to their self-love, and never talk to them of our necessities, but of their advantage.”* (Smith, A. 1776/1911, 13). If every economic agent pursues his own interests, chaos and anarchy do not follow. To the contrary, the participants will achieve the greatest wealth as if an “invisible hand” guided them. It is not required for them to have this specific goal in mind, as Smith has pointed out: *“... every individual ... neither intends to promote the public interest, nor knows how much he is promoting it ....he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention.”* (Smith, A. 1776/1911, 400)

Thus, for Adam Smith self-interest (and not altruism) is the driving force for the general economic wealth and efficiency. Smith was even extremely skeptical towards agents who proclaimed to have nothing but the common good in mind: *“I have never known much good done by those who affected to trade for the public good”*. Rather the opposite is true, according to Smith, because an economic actor, by *“pursuing his own interest ... frequently promotes that of society more effectually than when he really intends to promote it”* (Smith, A. 1776/1911, 400). The connection between egoism and efficiency is based on the mutual benefit derived from voluntary trade: the exchange of goods is not a zero sum game, since both sides receive a share of the profit. Otherwise, such a transaction would not take place. Although everyone tries to gain the greatest possible part of the gains from trade, the interaction brings about general economic efficiency.

Modern Economics has rephrased the “invisible hand”-hypothesis as the “First Theorem of Welfare-Economics”: competitive equilibria are Pareto-efficient. The welfare of a society is maximal when all possibilities for trade are exhausted. Then, all goods and resources are in the hands of those who value them most. This is equivalent to maximizing the sum of consumer- and producer-rent, called the social surplus. The seminal contributions of Walras (1954/1874) and Arrow/Debreu (1954) did more than only transfer the idea of the invisible hand into the language of modern microeconomics. Their works have also clarified

that the invisible hand is not purely utopian. In the framework of a general equilibrium model, it is at least a theoretical possibility. Assume individuals to decide autonomously, to maximize utility and to have a decentralized knowledge about valuation, technologies and resource endowments. For the competitive equilibrium to yield efficient coordination, it is only required that the participants are aware of the price system.

However, this theory has difficulty explaining how competition brings about equilibrium prices. The solution was the invention of the “Walrasian” auctioneer, who brings the markets into equilibrium by announcing price vectors and comparing the supply and demand. Still, this explanation leaves unanswered how the competition process in reality leads to equilibrium prices.<sup>1</sup> It was in particular the Nobel laureate in Economics, Friedrich August von Hayek, who emphasized this dynamic aspect of the “invisible hand”-hypothesis (Hayek 1952). In a spontaneous order,<sup>2</sup> the “market” is a self-organizing system in which the invisible hand regulates prices via negative feedback. Competition, as a discovery procedure, creates “a kind of order of which the equilibrium is a kind of idealized type” (Hayek 1969, 256). In the process of competition, prices do not only accomplish coordination (as in a general equilibrium model), but also serve as an instrument of discovery (Kirzner 1985).

Moreover, modern Economics has pointed out that unfettered self-interest is not a sufficient prerequisite for maximizing the welfare of a society. The rules of the economic system play a decisive role determining whether self-interest promotes wealth or turns against the interests of the society.<sup>3</sup> The competitive order, as a non-authoritarian system of social control, is supposed to limit abuses of freedom. Economic theory has formulated several standard reasons for limiting the egoism of individuals. Problems like environmental pollution and asymmetric information are just two prominent examples. Nonetheless, Smith’s assumption continues to pose a challenge for modern economics: Is it merely a conjecture, or rather a valid prediction?

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<sup>1</sup> The general equilibrium theory has been criticized by the “Austrian Economics” for not giving the creative entrepreneur any room. Makowski/Ostroy (2001) have attempted to rephrase the theory by considering the possibility that agents could create new markets.

<sup>2</sup> According to a famous phrase of David Hume, a spontaneous order is the result of human action, but not of human design.

<sup>3</sup> This is the reason why Smith (1982b, 924) defines a “microeconomic system” as a combination of an environment (agents, their utility, available resources) and an institution, which defines the rules under which

In theory, it is possible to derive efficient equilibria, using rather heroic assumptions such as an ideally organized market, complete information about all trade options, and the ability of all participating individuals to compute with infinite velocity, as well as the absence (or internalization) of all external effects. Based on these prerequisites, the connection between self-interest and efficiency as postulated by Smith is a prediction. In reality, however, situations that fulfill these prerequisites are scarce. Thus, economic research should busy itself with determining whether such a prediction can remain valid even under “weaker” assumptions.

This article presents an experiment as an example for a system of rules that does not fulfill the strict requirements of perfect equilibrium theory. Even though, this competition order has encouraged the self-interested participants to behave in a wealth-maximizing way. The experiment illustrates the coordination- as well as the discovery effect of the price system. It shows how market participants create order even without the existence of a “Walrasian Auctioneer”. We will use the competition equilibrium as a reference point according to Hayek (1952, 63): *“Regardless of what might occasionally have been said by all to ‘pure’ theoreticians of economics, there seems to be no doubts that the only justification is the assumed tendency towards equilibrium. Only by stating that such a tendency exists does economics stop being a purely logical exercise and becomes an empirical science.”*

Section 2 gives a general description of the classroom experiment. Section 3 presents the sequence of events and the results of the experiment. Section 4 evaluates the observations. In section 5, we will interpret the results in light of the theory of competition as a discovery procedure. Section 6 is the conclusion.

## 2. The experiment

We have conducted repeated classroom experiments with students of the University of Saarland to test empirically Adam Smiths “invisible hand” prognosis. The experimental economist and Nobel laureate Vernon Smith has conducted similar experiments decades ago, see Smith (1962). The design of our experiment followed, with the necessary modifi-

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agents can communicate and exchange. The experiment described in the next section sets up a microeconomic system in this sense.

cations, the standard work of Davis and Holt (1993).<sup>4</sup> The conclusion of the surprised participants: The “invisible hand” actually works.

The participants of this experiment were supposed to trade with a good, which was purposely not specified. This avoided the influence of personal tastes and distastes, which might have subconsciously played a role, had the traded good of the experiment have been, for example, chocolate or oranges. The participants were divided into 12 teams. Half of the teams were given two units of the goods each; this was the group of sellers. The other half of the teams constituted the group of buyers who wanted to buy up to two units of the goods. Subsequently, we refer to the teams as if they were individual players. All prices, costs and valuations were stated in “Marks”, the German currency before the introduction of the Euro. Two Marks are about one Euro or one US Dollar.

Each seller was given a sheet that indicated his costs for the two units in his possession. This information was to be kept secret from the other groups. It was explained that these costs had to be taken into consideration in his individual calculations. If a seller had to consider three Marks for his first unit, then he could only make a profit if he sold that unit for more than three Marks. These costs constituted for the seller his minimum willingness to accept (reservation price of the seller). If he was able to sell for a price of five Marks, then he made a profit of two Marks.

Accordingly, each buyer was told what utility, expressed in money, he valued the good at. This valuation set for the buyer his maximum willingness to buy, i.e., the reservation price of the buyer. If the buyer valued the good at nine Marks, and this unit was traded at five Marks, then his profit accrued to four Marks. The realized profits of the buyer- and seller teams were paid in cash at the end of the game.

Table 1 shows the complete information of the costs and valuations of all participants. These values make operational the term “general economic welfare”: the gauge for the welfare of the participants is given by the difference between utility and costs, insofar as trade takes place. E.g., should buyer E purchase his first unit from seller 3 (who therefore relinquishes his first unit), then this transaction creates a surplus of 4.20 Marks, thus 10.80 Marks utility minus 6.60 Marks costs.

A fundamental criticism with such experiments in economics is that the experimentalists assign valuations and costs to the participants, while such predetermination might not re-

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<sup>4</sup> Therefore we do not present the instructions here. They are (in German language) available from the authors.

flect the actual motivation of the participants. This criticism however, is not applicable to our experiment, since the monetary outcome each participant gains only depends on the predetermined costs and valuation. Thus, the participants are exclusively motivated by the goal of making an individual profit by concluding a transaction, if this is advantageous with respect to their predetermined reservation prices.<sup>5</sup>

*Table 1: Valuations and costs*

<b>Buyer</b>	<b>1. Unit</b>	<b>2. Unit</b>
A	8.40	8.40
B	9.00	7.80
C	9.60	7.20
D	10.20	6.60
E	10.80	6.00
F	11.40	5.40
<b>Seller</b>	<b>1. Unit</b>	<b>2. Unit</b>
1	7.80	8.40
2	7.20	9.00
3	6.60	9.60
4	6.00	10.20
5	5.40	10.80
6	4.80	7.80

If a buyer and a seller conclude a transaction, then a transaction rent is created. The transaction rent consists of the respective buyer's willingness to buy, net of the respective seller's reservation price. The efficient solution is reached when the sum of transaction rents is maximized. In the experimental situation, efficiency requires that all sellers sell their first unit and seller 6 additionally sells his second unit. Furthermore, all buyers must buy their respective first unit, and buyer A additionally his second unit. This can easily be ascertained when one transforms table 1 into a market diagram. The horizontal axis of figure 1 shows units, the vertical axis shows the participants' reservation prices in Marks per unit. The reservation prices of the sellers are drawn as an ascending stair function (dashed), the buyers' valuations as a declining stair function (solid). When the participants trade seven units, then they are realizing the maximum possible social surplus. All potential obtainable gains from trade are realized then. In order to reach the optimal solution it is irrelevant which Buyer- and Seller teams come together to participate in transactions.

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<sup>5</sup> Plott (1982) points out that market experiments do not only represent simulations of real-world markets.

The situation in the laboratory is a real market. Thus, the observed behavior of the participants is behavior in a real market. However, the question remains unanswered to what extent the pattern of behavior in one mar-

**Figure 1 about here**

The ascending curve in figure 1 looks like the usual supply curve and the declining one looks like a demand curve. However, for this experiment, such an interpretation would be erroneous. In traditional microeconomic theory, the derivation of supply- and demand curves is based on the assumption of price taking behavior. However, the participants in this experiment are not passive but rather set the prices through their bidding and accepting behavior.<sup>6</sup> Textbook microeconomics assumes that all transactions are conducted at the same price. This experiment differs from such an ideal solution in the sense that transactions can indeed be made at varying prices. In each transaction, the price is set through the participants. One market side suggests a price and one participant of the other market side accepts it, thereby concluding a transaction.

If one could interpret the curves of figure 1 as supply- and demand curves of price takers in a perfect market, then the traditional micro-economics would not only predict that the efficient volume (seven units) would be traded in equilibrium, but would also make a prediction about the price. The equilibrium price, at which all seven units of the goods would be traded would lie between 7.80 und 8.40 Marks. The equilibrium price, due to the 0.60-Mark leaps in the valuations and costs can only be given as an interval;<sup>7</sup> in an “atomistic” market with continuous valuations and costs, an exact prediction of a single price could be derived. The predicted price-quantity combination is represented in figure 1 by a dotted line. We refer to this price interval as the “equilibrium interval”. Furthermore, we call the combination of the equilibrium interval and the welfare-maximizing amount the “reference allocation”.

Should a central planner want to determine the optimal volume (and perhaps even the optimal unit price) for this market at his desk, then he would require all of the information contained in table 1. It is here that he would encounter two problems: On the one hand, he

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ket provides a sound foundation for making predictions about the behavior (of different actors) in other markets.

<sup>6</sup>Here one can see a parallelism between the double-oral auction and the rephrasing of the general equilibrium theory by Makowski/Ostroy (2001). They also assume that the market participants are not price takers, but actively shape the prices.

<sup>7</sup>In Smith (1962, 113), the equilibrium price is unique, but not the quantity. As in our experiment, Ruffle (2003, 132) has assumed a market where the equilibrium quantity is unique, but not the market price. However, his experiment is not based on a double-oral auction.

would have to get the buyer and the seller to reveal their valuations and costs truthfully. In practical terms however, merely identifying the agents and their roles already presents a problem, not to mention accessing their arcane knowledge. Nevertheless, even if the planner could gain this information, he had to deal with more than one market. The attempt to generate optimal plans for the several million markets of an economy is doomed to failure from the beginning.<sup>8</sup>

The participants of our experiment knew neither the valuations nor the costs of the other teams; communication between the teams was strictly prohibited. The only information available to the teams was their own valuation or costs, respectively. Furthermore, they could conclude from the description of the experiment that there must be agents on the other side of the market, but they were unable to infer the other teams' identities or their number. Table 2 consists of an excerpt of table 1 and shows, as an example, the information available to the buyers team C. Thus, the relevant economic knowledge in table 1 is decentralized. With his available information, no single participant could derive the socially optimal solution, even if he attempted to.

*Table 2: Available information of team C*

Buyer	1. Unit	2. Unit
C	9.60	7.20

The experimental question is as follows: Can the market coordinate the decentralized knowledge efficiently? Another way of posing this question would be, does the interaction of self-interested participants approximate the socially optimal solution?

The game consisted of two trade periods of 10 minutes each. In each period, the participants could make as many offers as they pleased. There was only one condition: up until the conclusion of a transaction, the offers of the sellers had to be lower and those of the buyers had to be higher than the previous offers of the same market side.<sup>9</sup> Only after a

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<sup>8</sup> These are the problems that Hayek had already indicated in his essay from 1945 "*The Use of Knowledge in Society*". The collapse of the socialistic, centrally planned economies about 15 years ago gave impressive proof of Hayek's thesis. A further problem is addressed by Public Choice theory, namely the incentives of the central planner to carry out his function.

<sup>9</sup> In later runs of the experiment, we dropped this rule. The outcomes did not differ substantially – the participants also traded almost efficiently, with transaction prices from within the reference interval or in its vicin-

transaction was concluded, the next offer could be freely made. The experimentalist-team remained completely passive, not interfering in the operation of the market. We limited our activities to writing a protocol of the offers and concluded transactions on the blackboard, and we ensured that the participants obeyed the rules of the experiment. A computer could have easily done this task. Thus, no (Walrasian) Auctioneer was active, and the creation of prices resulted solely from the interaction of the participants.

### 3. The course of trade

During the experiment, the participants did not instantaneously “pounce” – contrary to textbook microeconomics – into the optimal solution. Rather they slowly groped towards it. The transaction prices were formed because of overbidding by the sellers and underbidding by the buyers. Market participants felt their way towards the price at which the transaction then finally took place. This was impressively observable from the list of the events during the first trading period. It started with the opening bid of a seller: for 25 Marks, team 1 would be willing to relinquish one unit of the good. The first counteroffer of the buyer team D seemed rather humble in contrast: only 0.50 Mark (see table 3).

*Table 3: First round of the first trading period*

<b>1. Trading period</b>			
Buyer		Seller	
D	0.50	1	25.00
C	7.50	6	11.00
A	7.70		
C	<b>8.00</b>	2	accepted

The next offer of the buyer team C, 7.50 Marks, already reached the theoretically predicted price range. The somewhat more active buyer side had to make two more offers before the first trade at 8 Marks took place. This contract price falls within the theoretically predicted equilibrium interval.

After the experiences of the first round, the other buyer-teams became active, too. The sellers simply waited until the buyers quickly bartered their way up to the sales price of the

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ity. The bidding process, however, took longer and did oscillated more erratically around the equilibrium interval.

first round. In the second and third round, the only offer made by a seller received no attention; two units in a row changed their owners at the price of 8 Marks, as indicated in table 4. The upper portion of this table shows the events of the second round, the shaded portion shows the third round, and the bottom portion refers to the fourth round. The transaction price of 8 Marks seems to have established itself as a standard, for in the fourth round the buyer-side began with this offer. However, a higher transaction price was reached here, namely 9 Marks. Note that this price lies above the theoretically predicted price interval.

*Table 4: First trading period, second through fourth round*

Buyer		Seller	
B	5.00		
C	5.50		
D	<b>8.00</b>	6	accepted
F	5.00	4	11.00
C	5.50		
F	7.00		
E	<b>8.00</b>	3	accepted
B	8.00	2	15.00
F	accepted	1	<b>9.00</b>

There was a fierce contest for the fifth unit. Both market sides groped their way towards each other in tiny steps. Altogether, teams A and B on the buyer-side and teams 4 and 6 on the seller-side called out 15 price suggestions before a transaction was concluded at 8 Marks, a price which falls again within the theoretical interval (table 5, upper part). Teams A and 6 concluded round six amongst themselves, again at the price of 8 Marks (table 5, shaded part).

*Table 5: First trading period, fifth and sixth round*

Buyer		Seller	
A	7.00	4	9.50
B	7.20	6	9.00
A	7.40	4	8.90
B	7.50	6	8.50
A	7.60	4	8.40
B	7.70	6	8.30
A	7.80	4	8.20
B	<b>8.00</b>	4	accepted
C	6.00	5	10.00
B	7.50	6	8.10
A	7.70	6	<b>8.00</b>
A	7.80		
A	accepted		

Surprisingly, the first trading period ended without any further transaction. Even though further gains from trade would have been obtainable and the last three offers of the buyers were still within the reference-interval, the sellers seemed to take a time-out (see table 6). The ringing of the bell ended the prevailing silence and announced the end to the first trading period. After a short break the second trading period began, which was conducted in similar manner as the first.

*Table 6: First trading period, seventh round*

Buyer		Seller	
F	5.00	2	11.00
B	6.00	5	9.00
C	6.50	5	8.50
B	7.00	<b>No transaction</b>	
C	7.10		
B	7.50		
A	7.80		
A	8.00		
A	8.10		

#### 4. Evaluation of the experiment

The transaction prices of both trading periods are summarized in table 7. Additionally, table 7 comprises the valuations and costs, which allows us to compute the transaction rent realized by each of the concluded transactions. The observed transactions are an impressive confirmation of the optimal functioning of the invisible hand. Deviation from the socially efficient amount, namely 7 units, could have taken place above or below that amount. The actual amount that was traded in each of the two periods was six units. Aside from two exceptions, the transaction prices were actually within the reference-interval: in the fourth round of the first period, team F paid 9 Marks, and in the third round of the second period, the same team paid 8.50 Marks. The most common transaction price was 8 Marks.

The reference allocation, whereby seven units traded for prices between 7.80 und 8.40 Marks, was deduced under the condition of an ideally organized market. In the experimental situation, however, one condition was violated, namely that all participants have complete information about all trading options. The buyers and sellers hence had to determine by themselves, through the process of bidding and spontaneous order, what the efficient

allocation was. It is therefore quite remarkable that the competition between the participants, even in this imperfect situation, nearly lead to the efficient result.<sup>10</sup>

*Table 7: Transactions in both trading periods*

Unit	Buyer	Valuation	Seller	Cost	Transaction rent	Transaction price
1.	C	9.60	2	7.20	2.40	8.00
2.	D	10.20	6	4.80	5.40	8.00
3.	E	10.80	3	6.60	4.20	8.00
4.	F	11.40	1	7.80	3.60	9.00
5.	B	9.00	4	6.00	3.00	8.00
6.	A	8.40	6	7.80	0.60	8.00
<b>Sum of benefits in 1. transaction period</b>					<b>19.20</b>	
1.	C	9.60	2	7.20	2.40	8.20
2.	D	10.20	6	4.80	5.40	8.40
3.	F	11.40	4	6.00	5.40	8.50
4.	A	8.40	3	6.60	1.80	8.00
5.	E	10.80	6	7.80	3.00	8.30
6.	B	9.00	5	5.40	3.60	8.40
<b>Sum of benefits in 2. transaction period</b>					<b>21.60</b>	

In both periods, the seventh unit could still have been traded: The last offers of the buyer-side were at 8.10 Marks in the first period and 8.30 Marks in the second period, respectively. By selling at this price, it would have been possible to make a profit for team 5 in the first period and team 1 in the second period. Team 5 valued their first unit with only 5.40 Marks and could therefore have made a profit of 2.70 Marks, had they accepted the last offer of buyer A. However, the ringing of the bell impeded any further possible (and bilaterally profitable) transaction, so that team 5 left the first period empty-handed. In the second period, it was team 1 which did not agree to trade with A, even though such trade would have been bilaterally profitable.

In both periods the seller-teams were marked by a wait and see behavior – most offers were made by the buyers. This observation would deserve a closer study. Should participants in future runs exhibit this behavior again, then that would be a reason to seek a theoretical explanation. This theory would require a focused empirical testing in new experiments.

<sup>10</sup> This is not to claim that spontaneous order always leads to optimal results. Moreover, it is possible to derive the theoretical equilibrium result for an ideally organized market; it is still an unsolved problem how to derive a game theoretical equilibrium for the double-oral auction game presented in this experiment. Therefore, we are unable to test experimentally a theoretical prediction of the participants' behavior. The experiment, however, allows for testing whether the participants bring about an efficient outcome.

## 5. Competition as a discovery procedure

Economic theory often defines competition in terms of price-taking behavior. However, the “Austrian” school interprets competition rather as a market process, which leads towards equilibrium, see Kirzner (1997). Our experiment demonstrates how competition, on the one hand, operates as a parallel process of two interlocking sequences of bidding: the overbidding by the buyers, and the underbidding by the sellers. The process of price building is a discovery procedure based on negative feedback (Hayek 1978, 184). On the other hand, competition operates as an exchange process that leads to a series of transactions; the process of price finding serves here as a coordination procedure.

The competition processes in the experiment lead to dispersed knowledge being used as if it were available at a central authority. This is what Vernon Smith (1982a) has called the “Hayek-Hypothesis”: “*Strict privacy together with the trading rules of a market institution are sufficient to produce ... near 100 % efficiency*”. This hypothesis is related to Hayek’s interpretation of competition as a “discovery procedure”. Hayek pointed out that “...it is salutary to remember that, *wherever* the use of competition can be rationally justified, it is on the ground that we do *not* know in advance the facts that determine the actions of competitors” (Hayek 1978, 179, italics in the original). Hayek proposed “...to consider competition as a procedure of such facts as, without resort to it, would not be known to anyone, or at least would not be utilized” (Hayek 1978, 179).

As the organizers of the experiment, we knew the essential facts, namely the parties’ respective costs and valuations. In the position of a central planner, we could have used this superior knowledge to simply dictate the market equilibrium (and, thus, allocate seven units in both periods). However, such knowledge of outsiders is not the subject of Hayek’s verdict. It is important to keep the purpose of this experiment in mind. Adam Smith and Hayek assigned welfare-increasing attributes to competition. Thus, competition does not only reveal what it reveals; rather, it discovers what is desirable. It exposes to the participants the existing options for an efficient coordination of their plans.

If Hayek’s hypothesis, according to which competition discovers what is socially optimal, claims to be a scientific statement, then it must be empirically testable. This is what our

experiment shows: Hayek's hypothesis is in fact empirically testable and thus falsifiable.<sup>11</sup> The experiment could have produced a result deviating far from the efficient equilibrium derived by traditional price theory. Given the relatively simple circumstances (only trade, not production) of the experimental situation, one would have to be skeptical about the validity of this hypothesis if it had been falsified in this simple environment, since real-world markets are even more complex.<sup>12</sup> This falsification, however, has failed. Therefore, we can infer that at least those real-world markets in which the rules of the experiment apply produce nearly efficient results, even if the information remains decentralized.<sup>13</sup> Of course, this insight does not provide yet positive proof that the Hayek hypothesis would also be true with respect to more complex markets in the real world.

Our experiment provided a further insight. It demonstrated that the market participants brought about another end even though no one was consciously aiming towards this: competition induced them to keep each other in check. Thus, the market functioned as a system of social control that is not organized by authorities. Who ever tried to increase his own payoff had to offer the other market-side a better trade opportunity than his competitors. At the same time, each participant expected the other participants to be profit maximizing, too, which made their behaviors more predictable for all participants.

Furthermore, the participants went through a learning process. They observed the results of the previous rounds and knew that the other teams had the same experiences. This observation led us to a new research hypothesis which might explain why the contract-price of 8 Marks was the most common, even though the theory does not prefer any of the prices between 7,80 and 8,40 Marks. Having observed that 8 Marks was the contract price in the first rounds may have increased the participants' willingness, in the following rounds, to

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<sup>11</sup> This only applies to the non-trivial interpretation; the trivial interpretation ("competition reveals what it reveals") shields itself from any possibility of falsification.

<sup>12</sup> Evidence for the validity of the Hayek hypothesis has also been found with respect to interdependent markets and to changes in the exogenous data through experiments. Furthermore, experiments show that monopoly positions deliver the theoretically predicted results; see. Smith, V. (2000). The participants were not just in a static, but also a dynamic and changing environment: every transaction causes a change in the constellation of figure 1. Thus the result, that the participants approximated the reference situation of an ideally organized market, becomes all the more important.

<sup>13</sup> See the similar inference in Plott (2000).

agree to this contract price again.<sup>14</sup> This hypothesis is in need of further theoretic work and deserves new experimental testing.

## 6. Conclusion

The introduced experiment is not just a test of Adam Smith's hypothesis that egoism and competition can promote general welfare. Beyond its research value, the classroom experiment has a high didactic value.<sup>15</sup> On the one hand, it offers students the chance to participate directly in an empirical study. On the other hand, they can see how information, even though decentralized, can be made useful through the market mechanism. They observe how a result is achieved that no individual could have planned or realized. The students discover first hand how the market economy works. Enthusiastic participation of all teams and the excitement during the final rounds of both trading periods showed that even in an experimental situation the hope for mere pennies was able to influence substantially the behavior of the participants.

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<sup>14</sup> See Plott/Williamson (2000) for an experiment on embedded games, where each transaction is embedded into a larger game.

<sup>15</sup> Wells (1991) gives a general introduction into the use of experiments and classroom activities in teaching economics. Recent examples for very useful classroom experiments are Bodo (2002) on the prisoners' dilemma, Dickinson (2002) on bargaining and fairness, and Eckalbar (2002) on duopoly markets. The Journal of Economic Perspectives contains a section ("Classroom Games") that presents simple experiments covering different fields of Economics, e.g., see Holt/Laury (1997).

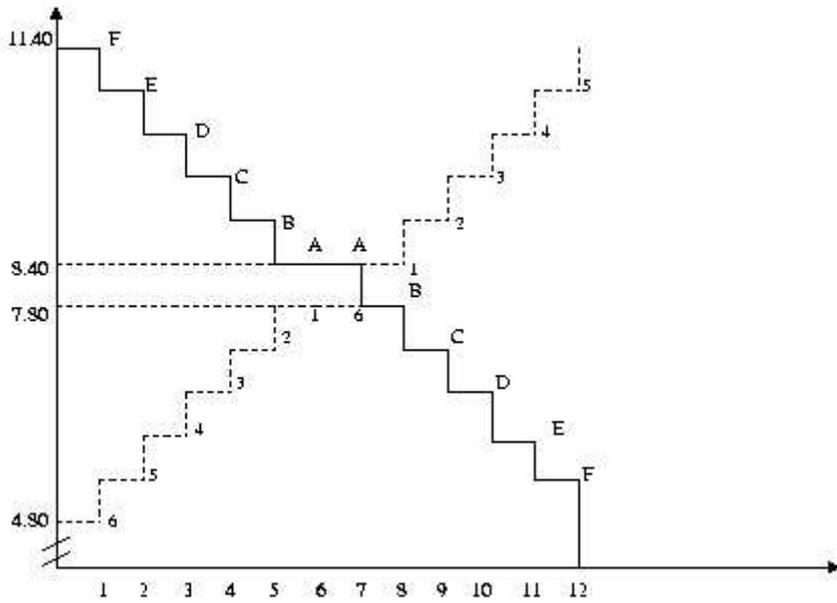
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**Figure 1: Reservation prices of buyers and sellers**

Reservation prices



Units